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Electronics Australia

NDD

FEBRUARY 1990

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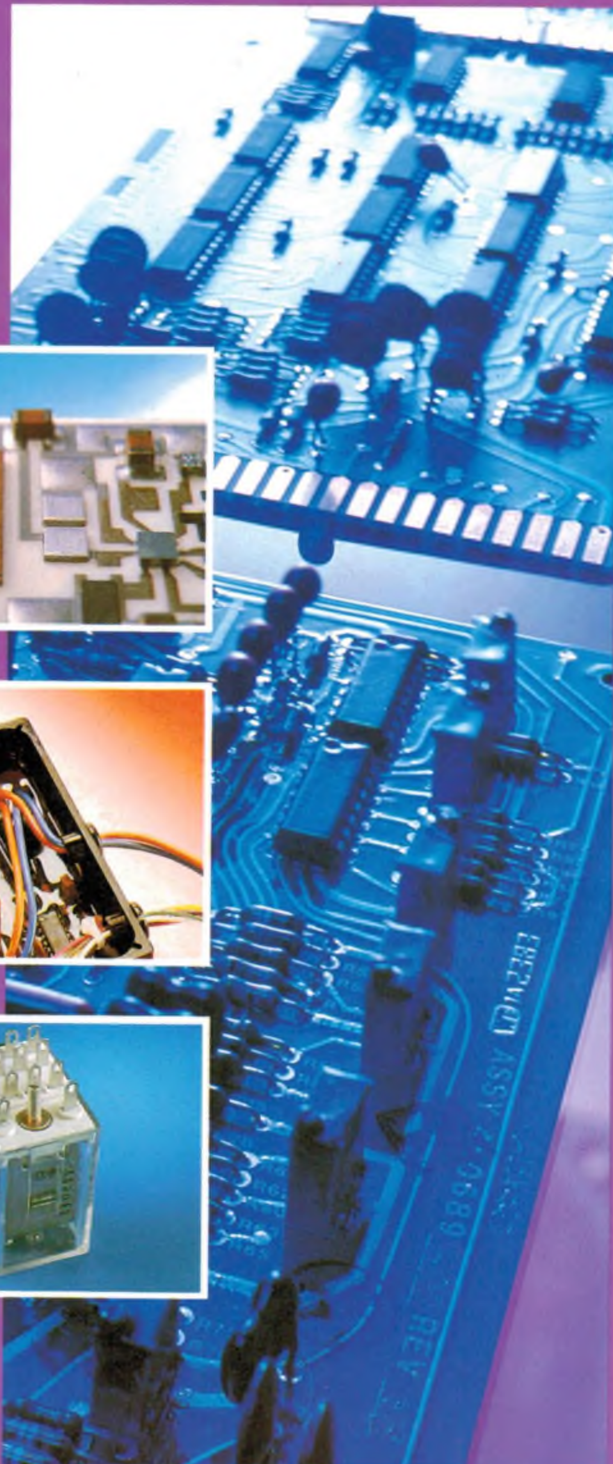

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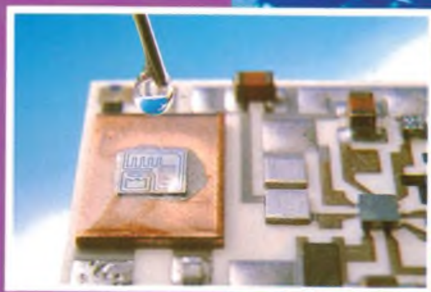

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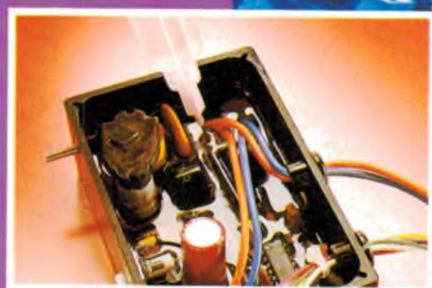

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Electronics Australia
February 1990
AUSTRALIA'S LARGEST SELLING ELECTRONICS MAGAZINE – ESTABLISHED IN 1922

New sound to light display

A popular way to liven up parties is to have coloured lights which pulse in time with your music. Our new Chromavox project lets you do this very easily and economically – see page 58.

Low cost solid state relay

Need to control 240V AC with low-power DC logic signals from your computer, or other equipment? This project lets you do so safely and at lower cost.

On the cover

You don't have to use our new Chromavox unit for parties. It can also add extra enjoyment to a relaxed evening at home listening to music, as Joanne Gabbe demonstrates. (Picture by Leon Faivre)

Features

Entertainment Electronics

Projects and Technical

News and Comment

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LETTERS TO THE EDITOR

Improving TV sound

The television we have at home does not have stereo output, and we have to put up with 'tinny' sound. As no TV or VCR on the market has stereo output other than large and expensive ones, we would like to have some kind of audio tuner that tunes the signal and then either provides stereo output for input to a hifi amplifier, or shifts frequencies so that a normal FM receiver will pick them up.

I have searched around shops, but have found no tuner bits. I suggest that one of your designers design a project that does as is suggested above. Apart from providing stereo sound, it would also eliminate the 'tinny' sound from the 2-1/2" speakers inside the TV set. As I am 13 years old, I do not have the skill to design and build a set myself.

Ben Buxton

Edgecliffe, NSW

Comment: We'll see what we can do, Ben, although such a project won't be cheap. You're really talking about a complete TV 'front end,' IF strip, and stereo audio decoder.

Multiple TV screen display

Would it be possible for *EA* to run an article on the method used to make nine TV screens, grouped in the now familiar 3 x 3 format, display a single large picture? To date I have not been able to find this information anywhere.

I enjoy Peter Phillips' little puzzles, but find it a bit difficult to solve when the problem is incorrectly printed – as was the one in the October issue, where the diagram indicated the voltage across the wrong resistor. Perhaps this was to make it all the harder!

Jim Wilkinson,

Bunbury, WA.

Comment: We'll see what we can do about an article on multi-screen displays, Jim. But don't expect a simple 'how to build one' article – this kind of system is quite complicated, involving digitising of the incoming video, storing it in a large memory, and then reading out the data in each segment of the memory for D-to-A conversion and then display on the separate monitors. All of this has to be done in 'real time', and with all of the output video processing done in parallel!

Our apologies for the error in the October puzzler. We check everything many times over, but that one just slipped through...

Superhet invention

After reading the letter from Mr G H Rance in the October 1989 issue of *EA*, I cannot be certain that he has in fact seen the correction which appeared in the February 1989 issue, pointing out the omission of the sentence 'By comparison, Levy's patent was filed in Paris on 4th August 1917' from my letter to which he refers.

I cannot respond to all of Mr Rance's queries but I can offer some additional information. The Australian Patent No. referring to the Levy patent is 16552/20. The document is dated 10th July 1920 and shows that the original date claimed for the patent is 4th August 1917, being the date of the first foreign application (in France, No. 493660).

An abstract from the Australian Register of Patents also confirms the subsequent assignment to the Western Electric Company of London on 25th June 1924 and thence to STC in Sydney on 2nd June 1926.

The Levy/Armstrong controversy seems never-ending but, from all that I have been able to put together over the years, I submit the following hypothesis:

It is well known that Levy and Armstrong worked fairly closely together in France during World War 1. They both faced the same problem, namely to get more gain out of receivers using the triode valves of the day. Thus, it could well be that they reached the conclusion together (or, at least, simultaneously) that the incoming signal should be heterodyned to a lower frequency.

If this did in fact happen, it seems to me that Levy may have pressed on with the paper-work to establish his claim, while Armstrong remained obsessed with his pursuit of even greater gain by using super-regeneration, thus delaying his submission of documentation on the superheterodyne. From past reading, I have gained the impression that Armstrong believed that super-regeneration offered more promise than the superhet. In that day and age, he may well have been right, but long term, how wrong that idea was!

My suggestion may be a long way out. However, if anyone can come forward with a more feasible explanation, I would be very interested to learn of it.

Winston T.Muscio,
Lumeah, NSW

Photonics research

First, let me thank you for the extensive and generous article published recently in your magazine (November 1989, pp14-17) describing photonics research at Telecom Australia Research Laboratories.

The main purpose of this letter is to clarify some apparent misunderstandings in the 'Editorial Viewpoint' where the above article was introduced and described. In particular I would like to stress that at the present time we have only observed laser action from optically pumped vertical cavity lasers, but we have not succeeded yet with electrical pumping. Since groups in both Japan and the USA have reported stimulated emission from electrically pumped devices, I don't think it is fair to say that the Telecom Australia devices "...are probably further advanced than any yet produced overseas, even in Japan and the USA...". Similarly, we have not yet demonstrated functioning modulators, although devices closely related to ours have been reported by workers at Stanford University and the University of California Santa Barbara.

More generally, and from an entirely personal point of view, I share your enthusiasm for technological endeavours in Australia and I feel that it is most important that the Australian public is informed accurately regarding the present state of our technological development and not given an over optimistic view. With the present low level of activity in this country it is unlikely that we will achieve and maintain preeminence in commercially significant technologies. I don't believe that this is due to an Australia 'collective inferiority complex' but rather to a collective unwillingness to address the difficult decisions which need to be made if technology export is ever to have an appreciable impact on our present economic difficulties.

Peter C. Kemeny,
Senior Principal Research Scientist,
Telecom Australia Research Laboratories
Clayton, Victoria

EDITORIAL VIEWPOINT

Why ARE we thinking of privatising Telecom?

I've just been able to read a report comparing the performance of five major telecommunications systems overseas, against our own Telecom Australia. The report was written by independant management consultant Mr Jack Keavney, following a trip through New Zealand, Canada, the USA, the UK and West Germany – all countries whose telecom systems have been described in relatively glowing terms by Telecom's critics.

Jack Keavney is a former national director of Freedom from Hunger, the first director of Enterprise Australia and also first director of the 'Australia for Quality' program. He is a man of undoubted integrity, committed to building a better Australia for future generations.

While planning a trip last year, at his own expense, he decided to check out for himself what the telecom situation was really like in the countries concerned. He was especially keen to find out if the recent exercises in privatisation by countries like the USA and the UK had been as successful as have been described. And during the trip he talked not just to managers and regulators, but to unions as well – to ensure a balanced picture.

I for one found his report a real eye-opener. On the whole, the much-vaunted benefits of privatisation and increased competition in these countries look to be *far* outweighed by the greater confusion, poorer service and higher costs. While telephone rental fees may have dropped in some cases, the down side is that this is always accompanied by much higher call fees – particularly for domestic subscribers away from big cities. In fact what seems to have happened is that big business may be a little better off, while just about everyone else is much worse off.

Overall, the countries concerned seem to have many reasons to regret having made the recent dramatic changes to their telecom systems. In fact the situation seems well summarised in a quote by Mr Keavney from an article in the *New York Times*, where David Wagenhaufer of the Telecommunications Research Action Centre in Washington says "People continue to believe that we should never have tried to fix a system that wasn't broken".

As I write this, Jack Keavney is actually overseas again, on a second trip to find out more regarding the *quality of service* provided in overseas telecom networks. This will no doubt provide further food for thought.

But already, he has done us all a valuable service by drawing attention to what has *really* happened overseas, as a result of the currently fashionable trend towards privatisation. And what he has found already shows that Australia should be *extremely* cautious about joining that trend.

PS: Sadly, and due to circumstances beyond our control, we're no longer able to run BeeJay's cartoons in our 'Forum' column. However the good news is that we've been able to secure the services of the *Sydney Morning Herald's* very well-known cartoonist Alan Moir, whose first cartoon appears this month.

Jim Rowe

What's New In HOME ELECTRONICS

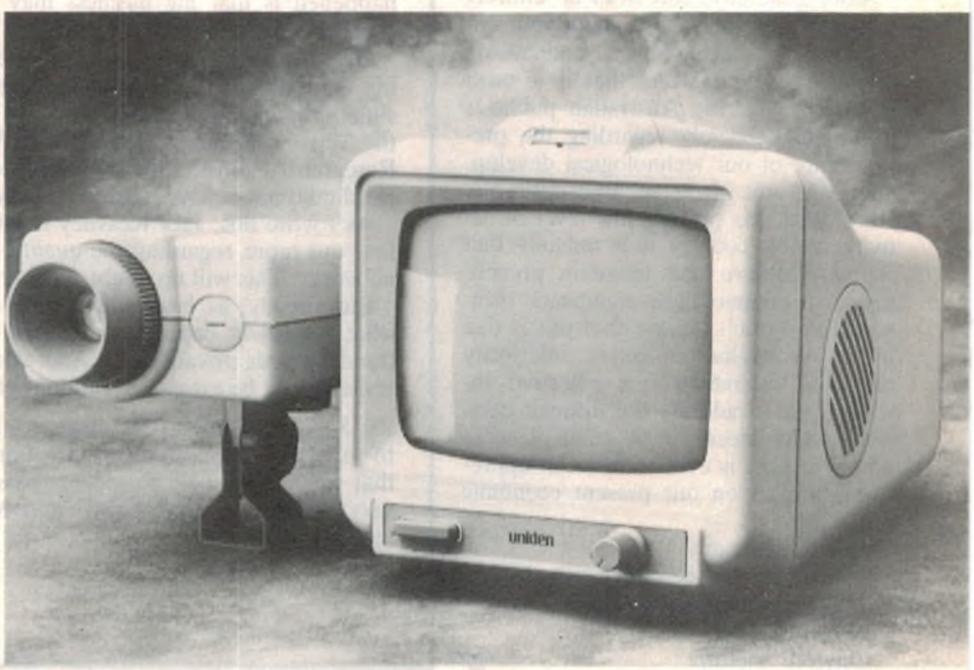
JVC previews its 'new era' video products

At a recent media conference in Sydney, representatives of JVC and its Australian distributor Hagemeyer previewed some of the innovative new video products which the company expects to release later this year. All are based on the VHS format, which is perhaps not surprising as JVC was the original inventor of this system.

Perhaps the most exciting product previewed was 'Concept C', described as a dramatic new concept in shooting, recording and viewing domestic video. Rather than use either separate self-contained video equipment, or combined equipment as in the past, Concept C is being developed as a modular 'mix-n-match' system.

Main component in the system is a surprisingly compact stand-alone HiFi S-VHS-C recorder player, measuring around 130 x 130 x 40mm. Other components include a tiny high resolution active-matrix LCD colour monitor, a palm-sized CCD high resolution colour camera, a snap-on TV tuner and a battery pack. All components either clip together or connect via cables as desired, to function as a single integrated system. This gives great flexibility, for

Security OnSight



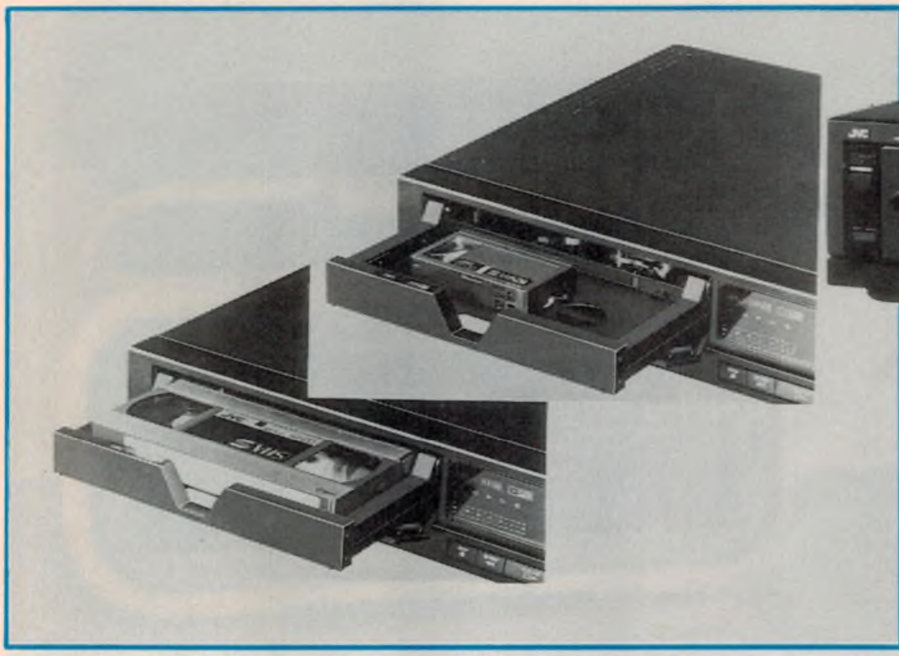
With the audio and video monitoring system called OnSight, it is possible to see and hear or even converse 'through' walls, around corners and over distances.

Both the VM100 and VM200 models are cost effective and allow for extra cameras to be added as desired. The VM200 has a built-in microphone to allow conversation to take place between both the remote viewing location and wherever the camera is installed.

With OnSight, the owner and/or staff of any business can keep an eye and ear on what's happening at any time.

The VM100 Audio/Video monitoring system retails from $599, while the VM200 Audio/Video/Intercom system retails from $699.

For further information, contact Uniden Australia, 345 Princes Highway, Rockdale 2216 or phone (02) 599 3355.



almost any kind of video recording and/or viewing.

Also previewed was a SE-C45 compact VHS-C tape cassette, taking advantage of new tape technology to provide 50% longer recording time than the current SE-C30 size. The new SE-C45 will also be an S-VHS cassette, compatible with both S-VHS and regular VHS machines.

Another coming product range previewed was a series of VCR's using a new 'F/C' deck mechanism, capable of accepting both standard full-sized VHS cassettes and the smaller VHS-C cassettes. The deck has a front-loading tray system, and has automatic sensors to detect full/compact cassettes and regular/Super systems – making the new 'VHS F/C Compatible' VCR's capable of operating with all four possibilities.

The final new product previewed was a new Super LCD video projector,

capable of providing pictures up to 3m diagonal on any suitable flat, white screen or wall. Based on a metal halide lamp, three high-resolution LCD panels and a dichroic prism system with a single zoom lens, the new projector is much easier to set up than conventional three-CRT projectors. It also accepts an anamorphic adaptor for widescreen presentation.

Although no firm technical details were given regarding resolution, JVC said that the projector is capable of performance sufficient for S-VHS – i.e., around 400 lines. The projector also includes a built-in surround sound amplifier.

No firm dates were given for the Australian release of these products.

Low cost surround sound

Marantz Australia has launched a cinema-style surround sound system which retails for a mere $499. The Marantz SP35 Dolby Surround Processor can decode the Dolby surround information coded into nearly all video movies.

A built-in 30 watt amplifier provides the power to drive two rear speakers, recreating special effects and soundtracks with all the special atmosphere and impact of a cinema performance. A variable time delay enables the sound to be adjusted to suit any room.

The SP35 needs two rear speakers in addition to a normal amplifier and front speaker hifi setup.

For further information, contact Marantz Australia, Australia Centre, Figtree Drive, Homebush 2140 or phone (02) 742 8480.

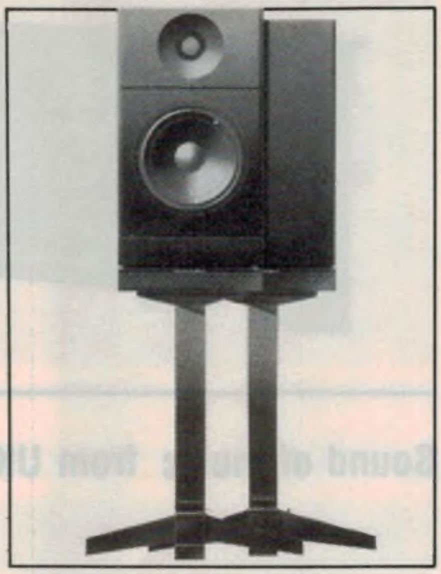
New range of speakers from Mordaunt-Short

Mordaunt-Short has unveiled a new range of speakers: the Series 3, which replaces the highly regarded Series 2.

There are five speakers in the new Series, ranging from the ultra compact MS3.10 to the substantial MS3.50. All five speakers benefit from the stability and precision of injection-moulded polypropylene baffles – not fibreboard and chipboard – around which are fabricated precision-machined enclosures of the highest quality. Each speaker features an entirely new bass driver, with a rugged high temperature voice coil of larger than average diameter and there is a new aluminium dome tweeter fitted to the three larger speakers for better quality reproduction and less chassis resonance.

Other technical 'plus points' include an optimum drive unit design which facilitates a simple crossover network for enhanced information retrieval, and gold plated input terminals and binding posts for 4mm sockets. All models feature Mordaunt-Short's 'positec' protection against damage through overleading or mismatching.

The cabinets are finished in black ash



and can be supplied with a complementary support stand which incorporates Mordaunt-Short's innovative 'backbone' system.

Mordaunt-Short Series 3 speakers have price points ranging from $499 through to $1750. Further information can be obtained from Concept Audio, 32 Roger Street, Brookvale 2100 – telephone (02) 938 3700 or fax (02) 938 3836.

Home Electronics

Car sound systems

Pioneer's KEH-M5000QR car sound system provides four channels, each with a rated power output of 25 watts, and is said to give very clear sound even at high volume, without risk of distortion.

With the automatic volume leveller, no difference will be noticed when moving from radio to compact disc to tape. Radio Intercept allows tapes to be rewound or fast forwarded whilst simultaneously listening to the radio.

A 'quick release' feature allows the complete system unit to be slid out from its dash mounting and transferred to a caravan or boat by fitting additional cradles and speakers. The infra-red remote control can be fitted at a convenient position with velcro and tuning can be done without eyes straying from the road.

Also available from Pioneer are the KEH-5656 with 25 watts x 2 or 15 watts x 4, and KEH-4646 with 25 watts x 2 or 6.5 watts x 4.

For further information, contact Pioneer Electronics Australia, 178 Boundary Road, Braeside 3195 or phone (03) 580 9911.

Multiple discs on CD player

The VCD-600R compact disc player from Vector Research can hold 6 discs and can play any tracks from any of the discs in any order. Up to 32 tracks can be programmed to play in a desired sequence, or one can choose a 'shuffle play' function which selects tracks from any disc completely at random and for an indefinite length of time, never repeating the sequence.

Other features include remote control facilities; 3-beam laser pickup; digital filtering with 88.2kHz oversampling and dual digital-to-analog converters.

For further information,contact NZ Marketing, 8 Tengah Crescent, Mona Vale or phone (02) 997 4666.

Sound of music from UK

Audio Products has become the Australian distributor for the UK company Musical Fidelity, which produces a number of loudspeaker models based on the latest in acoustic design technology, and some very impressive power amplifiers.

The latest B1 integrated amplifier is the basis of a new product range from Musical Fidelity, which will include a matching stereo tuner and compact disc player, as well as preamp and power amp separates.

For further information, contact Audio Products, 8 Tengah Crescent, Monavale 2103 or phone (02) 997 4666.

Fluke 80 Series – Top of the Line in Digital Multimeters

The Fluke 80 series offers a huge range of extra features like a 200kHz frequency counter, capacitance meter, combined analog and digital scales plus the ability to automatically record max and min and average readings and store them for up to 36 hours
Check the features and check the value!

80 Series Features
- 4 3/4 digit 4000 count resolution
- Digital Display updates 4 times/s
- 87 has analog pointer
- 83/85 have analog bargraph with zoom mode. Analog display updates 40 times/sec
- 0.5Hz to 200kHz Counter with duty cycle from 0.1% to 99.9%
- 10pF to 5µF Capacitance range
- Input alert warns of incorrect connections
- 87 is a true rms 1ms Peak Min Max hold meter with backlit display
- Touch Hold and Relative modes

Fluke 83
- Analog Bargraph and Digital Display (4000 count)
- Measures Volts, Current, Ohms, Frequency, Capacitance and Diode Test
- Touch Hold and Relative Modes
- Min/Max and Average Recording with Min/Max Alert
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- Audible Continuity

Fluke 85
As above but offers
- 0.1% Accuracy

Fluke 87
As above but offers
- 4 1/2 digit display
- Backlighting
- Analog Pointer

Model	Tax Paid	Tax Free
83	**$446.40**	**$372.00**
85	**$525.60**	**$438.00**
87	**$630.00**	**$525.00**

NEW Auto-Ranging Bar Graph Digital Multimeter

Value at $144.00

- *3 3/4 digit large LCD display*
- *4000 count resolution*
- *41 segment analog bar graph*
- *Data Hold*
- *Max/Min stores highest and lowest readings*
- *Relative display (Offset)*
- *Continuity beeper*
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- *Frequency to 40kHz*

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3 1/2 Filesafe DS HD	**$69.95**

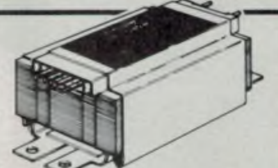
All Prices per Pack of Ten Disks

Disk Cases

DD50L	50 x 5 1/4	**$25.80**
DD100L	100 x 5 1/4	**$29.95**
DD40L	40 x 3 1/2	**$25.40**
DD80L	80 x 3 1/2	**$29.95**
DD10	10 x 5 1/4	**$2.95**

Disk Cleaners

FDC1	5 1/4	**$6.95**
FDC3	3 1/2	**$6.95**



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PL12/40VA	6-0-6V @ 3.33A	31.55
PL12/60VA	12V @ 5A	38.70
PL15/20VA	7.5-0-7.5V @ 1.67A	28.75
PL15/40VA	7.5-0-7.5V @ 2.67A	31.55
PL15/60VA	15V @ 4A	38.70
PL18/20VA	9-0-9V @ 1.11A	28.75
PL18/40VA	9-0-9V @ 2.22A	31.55
PL18/60VA	9-0-9V @ 3.33A	46.75
PL24/20VA	12-0-12V @ 0.83A	28.75
PL24/40VA	12-0-12V @ 1.67A	31.50
PL24/60VA	12-0-12V @ 2.5A	46.65
PL30-9/40VA	9V @ 3A, 15-0-15 @ 500m	48.35
PL30-9/60VA	9V @ 5A, 15-0-15 @ 500m	49.50
PL30/20VA	15-0-15V @ 0.67A	28.75
PL30/40VA	15-0-15V @ 1.33A	31.50
PL30/60VA	15-0-15V @ 2A	46.65
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Low cost accessory for your scope. Converts incoming analog signals up to 20kHz into a stream of 8-bit data words for storage in 2048 word memory. Ideal for one-shot observations. Replay as many times as you like. See description in E.A. December. This is a quality locally developed AT&M kit. Complete kit (AT&M17) using top quality components and with full instructions is just **$193.80**
Matching case (ATM17-01) **$27.60**

Kikusui COS5020 20MHz scope **$979.25** (Tax Free $839.40)
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We carry the full range of AT&M Kits - Refer to our catalogue for details. Haven't got one? Call in and pick one up or request one with your next order!

UP604 IBM Breadboard Card

See Review in Silicon Chip November 89.
Accommodates up to 24 14-pin ICs and has all the IBM signals brought out to pin sockets on the board. Includes DB25 female socket for external connections. Suits AT/XT or compatibles. **$87.99**

ULTRASONIC CLEANER

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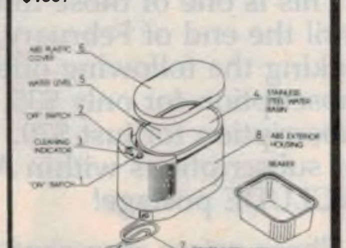

TOOL BOX

Witte Screwdriver Sets

We get many enquiries for a decent set of screwdrivers. Well we've found them – Witte screwdrivers are the very highest quality. Made in Germany. Chrome Vanadium with a five year guarantee! Philips head and conventional in a range of sizes.
Electronic Set **$31.50**
1000Volt Electrician's Set **$49.50**

Heavy Duty Ratchet Crimper

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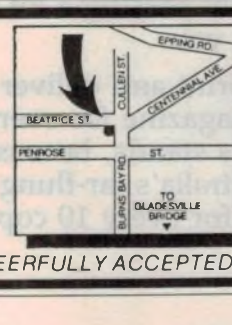

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Special message from our Managing Editor:

If you're a regular reader of Australia's largest-selling electronics magazine, taking out a subscription is always a good idea. It gives you the convenience of delivery right to your letterbox each month, plus a very healthy saving on the price you'd normally have to pay for the magazine over the counter.

Most of the time, the saving for subscribers is around 17 per cent, with the added bonus of the opportunity to win a valuable prize. However, every so often we are able to offer an even larger discount, for those who are really only interested in getting the magazine itself — at the best possible price.

This is one of those times. From now until the end of February, 1990, we are making the following offer: a full 12-month subscription for only $35, or a 24-month subscription for just $70. These figures are for subscriptions within Australia, and INCLUDE postage!

These prices represent a discount of OVER 35 per cent compared with the normal cover price. In other words, by accepting this offer you can save almost $20 for a 12-month subscription, and almost $40 for a 24-month subscription.

Not only that, but in return for making your commitment 'up front' to the magazine for the period concerned, you are also buying protection against the inevitable rises in cover price that occur from time to time, with all goods. Your subscription buys you either 12 or 24 issues, all at the special offer price and regardless of what happens to the cover price during the period concerned. How's that for hedging against inflation!

What's the catch? There isn't any. When you buy a subscription, you save us money, and we're simply passing a lot of those savings back to you.

We have to print and deliver just on two copies of the magazine for every copy we sell on the news stands, because of the wastage in Australia's far-flung distribution system. In fact for every 10 copies we sell on the news stands, nine extra copies must be printed and sent out — only to be wasted. You can imagine what this does to our costs (not to mention the world's dwindling forests).

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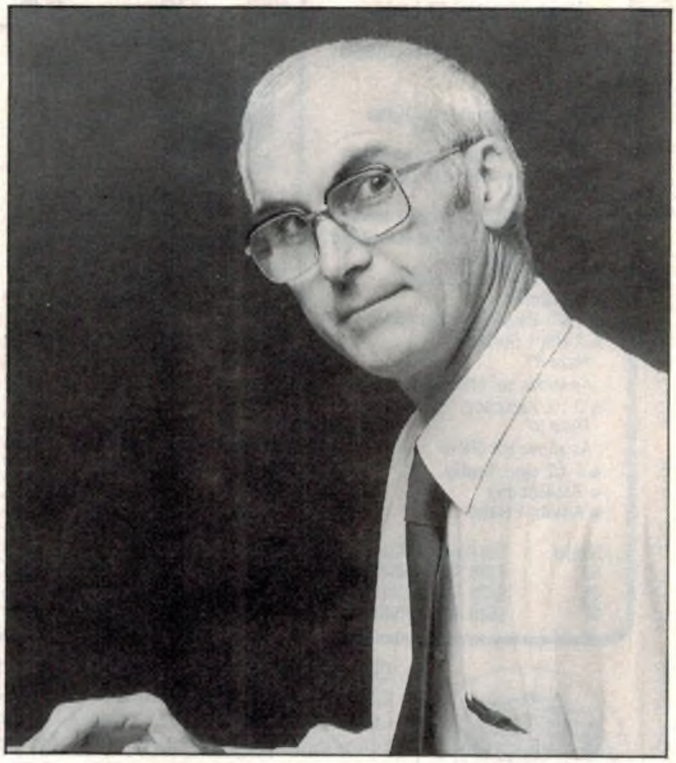

Jim Rowe

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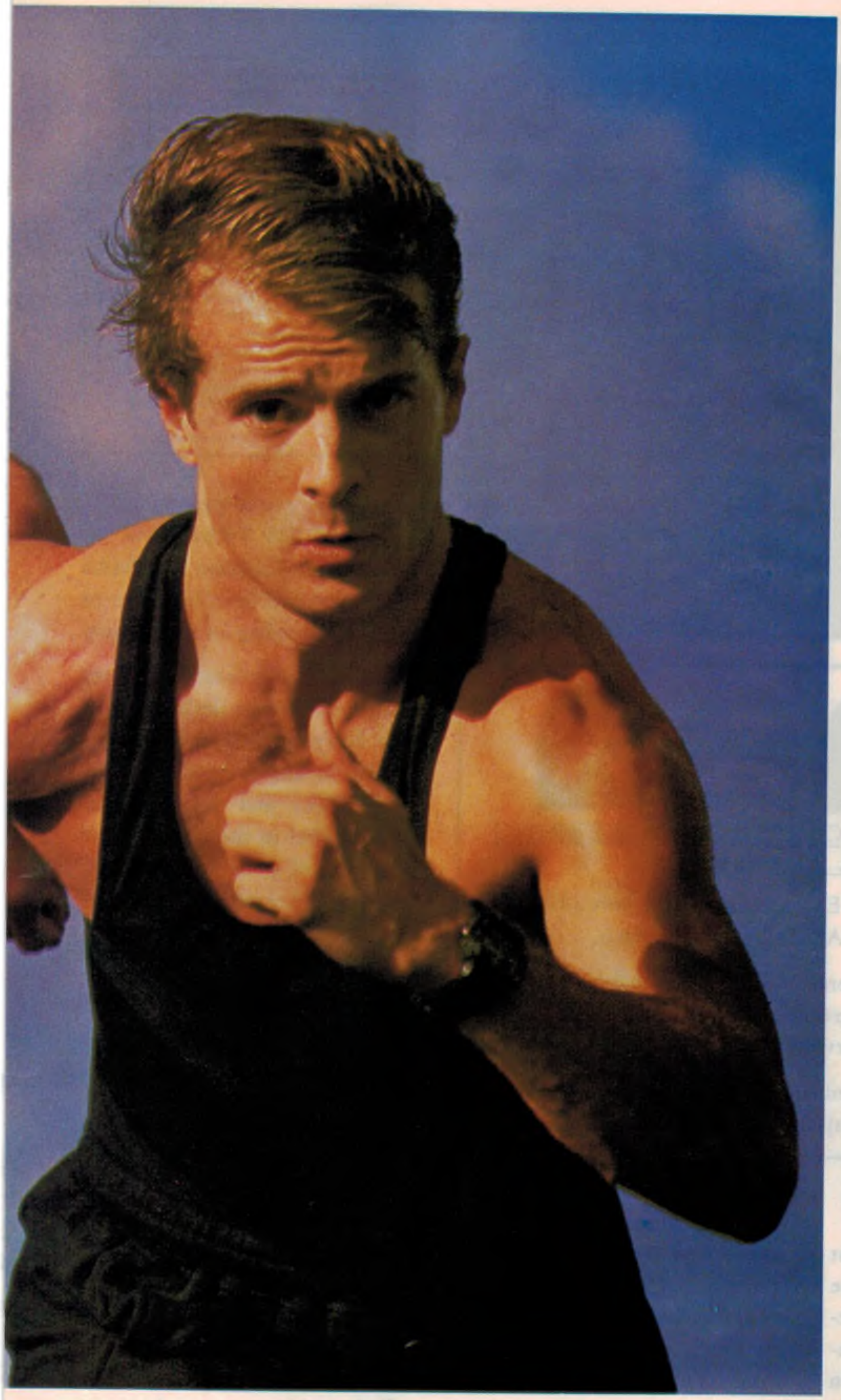

NAVY CATEGORY	JOB SPECIFICATION
*ETW. Electrical technical weapons.	Hydraulic, electrical and underwater weapons systems.
ETP. Electrical technical power.	Power generation AC–DC motors, generators, hand appliances.
*ETS. Electronic technical systems.	Radars – sonar navigational aids weapon control systems
ETC. Electronic Technical Communications	Radio-teletype satellite navigation cryptographic direction finding internal/external communications.

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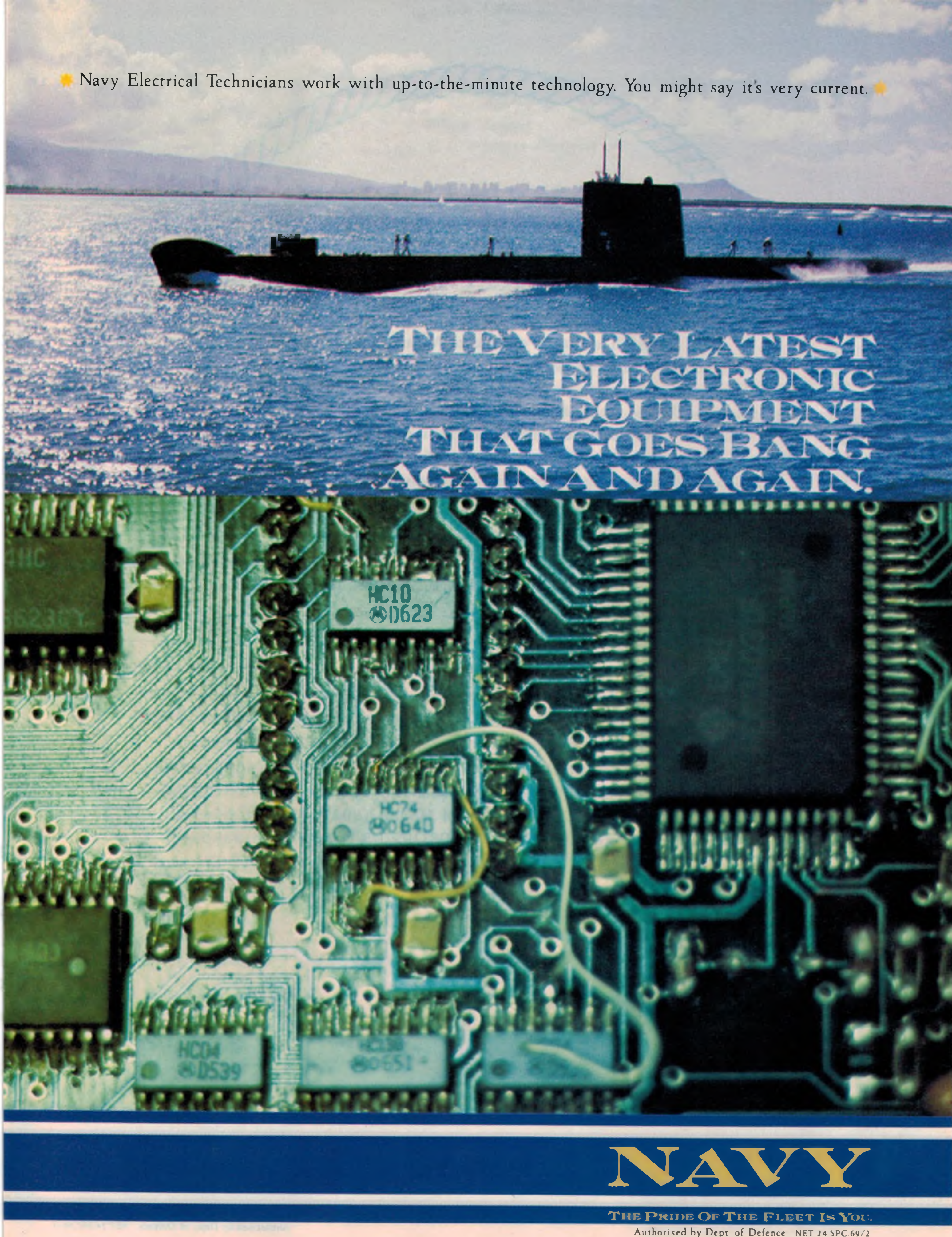

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Learn electronics by correspondence

Correspondence courses have long been popular in Australia, probably as a result of its population being spread thinly over a large continent. Learning electronics by correspondence can be very practical, whether you're just beginning or looking to upgrade your existing skills.

by MARGARET CAMPION
Stotts Correspondence College, Melbourne.

For many electronics enthusiastists their introduction to the subject was through tinkering with simple kits in their garage or workshop. Taking old radios apart and trying to put them back together is probably the way most people begin to nut out the mysteries of electronics for themselves.

To take this initial interest a step beyond the hobby stage, it is necessary to expand your theoretical, and practical knowledge with some research or study. While textbooks can teach the enthusiast a great deal, there is no substitute for the guidance of an equally enthusiastic expert. For some, night classes are the answer, but this is not always possible or convenient. A practical alternative can be a correspondence or home-study course.

Stott's Correspondence College is one of the few providers of correspondence courses in electronics. It is an Australian owned and operated college and has been offering a huge range of correspondence courses for over 80 years. The college has branches in every state, with its head office in Melbourne.

Stott's offer courses in Introductory Electronics, Digital Electronics, Microcomputers, Industrial Electronics, Radio and Television Servicing, and a new course in Video Cassette Recording Servicing. There are also courses available in amateur radio certificates, marine radio, computer programming and over 300 other subjects.

The method of tuition is simple and effective. Students receive specially prepared lesson manuals, textbooks and practical kits. There is a balanced combination of theoretical and practical training. The study materials are received through the mail and the student must complete an assignment at the end of every lesson. This work is then sent to the College for evaluation by a highly qualified electronics instructor. Written advice and answers to questions are returned to the student with his or her corrected assignment.

When every assignment has been successfully completed a certificate is awarded. Students may then take examinations for associate membership of The Electronic Technicians' Institute of Australia (TETIA) to enhance their professional standing, if they wish.

The instructors are professionally trained technical teachers and the head instructor has written two published textbooks used for technician training throughout Australia, and sold successfully in the USA.

Why did over 140 students enrol in Electronics courses with Stott's in 1989 alone? The answer of course, lies in the technology explosion which has occurred in recent years and will continue into the 1990's. Jobs abound for trained electronics technicians and career-conscious students are trying to keep up with recent innovations. People are being turned away from technical colleges when seeking training in electrotechnology, so Stott's provides a viable alternative for beginners and technicians alike.

For those beginning their careers, the training Stott's provides forms a sound general preparation for company traineeships, where the trainee moves into the company mainstream. The opportunities are wide open, including the computer service field.

A typical example of the technology explosion is the humble cash register. No longer the mechanical machine that it used to be, this common retail function may now be carried out by the Electronic Funds Transfer Point of Sale Network (EFTPOS) and therefore requires electronics expertise for routine preventative maintenance as well as fault-finding. Similarly, the common mechanical typewriter is now the sophisticated electronic word processor desktop publishing system. Someone has to maintain it! So the employment opportunities continue to widen for qualified technicians.

Most of Stott's electronics courses incorporate an introduction to the subject, suitable for complete beginners. People who have no need for this training may be exempt from this subject and move straight into the more advanced subjects.

For those who do need it, this introduction involves practical experience with equipment such as the multimeter, circuitboards, transistor tester, signal generator and power supply. During the course, a cathode ray oscilloscope is loaned to the student when required.

This subject gives thorough training in the fundamentals of circuits, soldering, transistors, measurement, transformers, power supplies, oscillators and other basic knowledge.

The Digital Electronics subject involves the Digital Trainer ET3200 and covers topics such as logic gates, flip-flops, counters, decoders, data transfer, and others. Digital electronics has had a tremendous impact on the domestic and working lives of millions of people. In industry the use of digital electronic control systems in materials handling, air conditioning, lift control, research, transport and computers is standard practice.

This course can lead on to the Microcomputers course. Microcomputers are used in items as diverse as petrol pumps, cash registers, scales, traffic lights, microwave ovens, washing machines and television sets. The course involves practical work with the Z80 processor and covers topics such as

Continued on page 106

Antenna test range uses scale model ships

If you've ever seen a Navy ship at close quarters, you've probably wondered how anyone could possibly predict the performance of its antennas – jammed in a forest of other antennas and assorted metalwork. Here's how it's done, at the Australian Defence Industries antenna test range.

by DAVID NARULA

Let's start with a bit of background, because things have changed recently in the area of Australia's defence production arrangements.

Until May 3rd last year, the Guided Weapons and Electronic Support Facility (GWESF) was grouped along with 10 other establishments, which together formed the Australian Defence Department's Office of Defence Production (ODP). Following an efficiency review by the Federal Government, the decision was made to transfer these factories into a company, called Australian Defence Industries Pty Ltd (ADI).

Today, Australian Defence Industries is the nation's largest defence manufacturing and support organisation, with a turnover in excess of $500 million. It employs over 6800 people in 11 plants and facilities, one of which is at St Marys – an outer western suburb of Sydney.

Within these changes the original GWESF became the St Marys Facility of ADI's Naval Engineering Division. It consists of five major groups, including a Measurement Laboratory, a Systems Development group, an Antenna Test Group, an Environmental Laboratory and a Manufacturing Workshop.

Antenna testing

The Antenna Test Group has the capacity to perform antenna measurements comprising boresight accuracy, directivity, gain, voltage standing wave ratio (VSWR) and radiation patterns on a wide variety of military and commercial antennas and radomes.

Full-size antennas operating in the frequency range of 100MHz to 40GHz and weighing up to 3000kg can be tested in the far field region, on one of the many test ranges located within the facility. However in addition to these 'full scale' test ranges the facility also has a special and very interesting Antenna Modelling test range, which is used to test the performance of marine antennas, using scale models of the vessels concerned.

The topside of a modern Navy ship is a hostile environment for a radio transmission site. By the time all the ship's communication antennas, radar antennas, navigational and fire control antennas and all the other myriad topside structures are placed, the simple radio transmission formulae become quite complicated and even ineffectual.

The Antenna Modelling range provides the means to make order out of the complex topside maze – to measure, evaluate, design and predict the performance of shipboard communication systems.

Whenever a superstructure or antenna

Adjusting a scale-model antenna on a ship model, in preparation for testing on the range. (Photo by George Hicks) change is made to a ship, however minor, the effects of this change may require the ship to undergo sea trials, which are time consuming and uneconomical. However, with the aid of the Modelling Range, 'state of the art' technology, antenna design and location may be optimised, interactions between antenna systems minimized and performance predicted in terms of radiating characteristics, without the need for expensive sea trials that would otherwise be required. The necessary testing can be performed before changes to the ship are implemented.

The models, built to a 1:50 scale, simulate every detail that would be expected in a full size vessel. The replicas of Navy ships are accurate in detail from the waterline upward. All metallic details greater than about one foot in size at full scale are included on the model. The ship's superstructure elements (masts, stacks etc), which are part of the scattering and re-radiation environment, thereby become part of the measurement conditions.

The model environment provides the ability to study the effects of degradation due to the proximity of ship's structural components to the antenna and to optimise results through interactive design techniques. The ease of changing the small parts of the model facilitates these capabilities.

The facility has full access to models of most Australian Naval vessels. This miniature fleet can be called upon at short notice and at low cost to provide reliable performance predictions. These models are also used to develop solutions to existing problems.

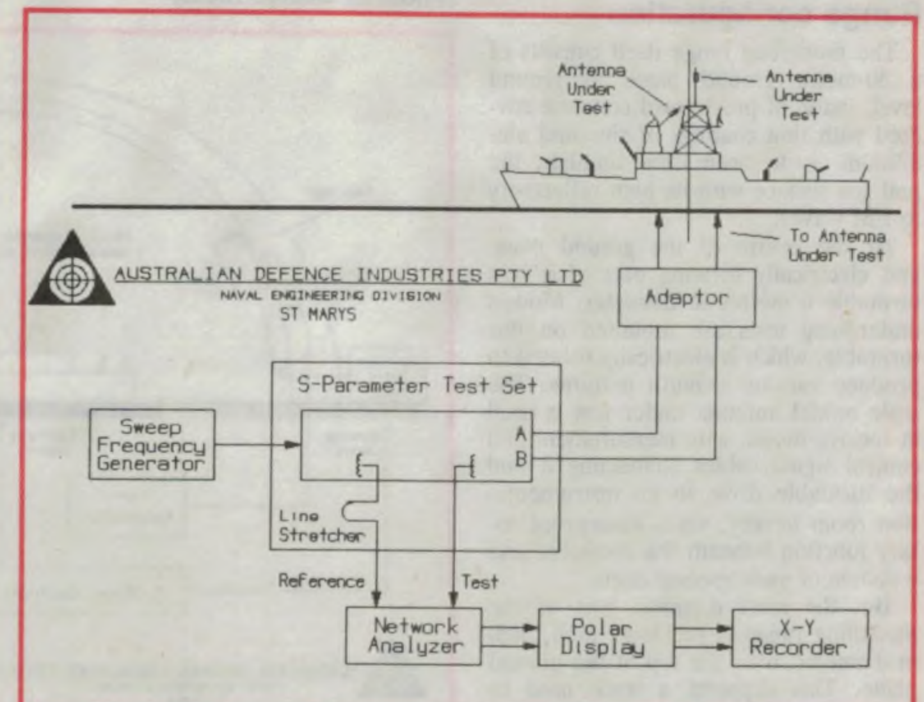
The models are made primarily from high-conductivity copper, although some of the smaller details are made from brass. The use of these materials is to ensure an accurate representation of electromagnetic behaviour at the testing frequencies concerned.

Test results from model shipboard antennas have shown excellent correlation to actual performance of the full-size antennas at sea. Significantly better detailed correlation, in fact, than other simulation techniques of shipboard environment, allowing significant savings in Naval resources.

Operating capabilities

The antenna modelling range provides capability for measuring the electrical and electromagnetic characteristics of antennas, including their radiation patterns and impedance, as the model test antennas have equivalent impedance and radiating characteristics to their full size counterparts.

An overview of the test range, showing the large non-metallic arch used to support the moving transmitter antenna. Its plastic support cables are also visible. (Photo by George Hicks)



The main system elements used for impedance measurement of a scale model ship antenna, at the ADI modelling range at St Marys.

Antenna test range

The testing of these scale models is performed under controlled conditions which closely approximate the environment at sea. Such a measurement environment, coupled with the model rendition of the shipboard topside, duplicates the total electromagnetic (EM) environment, including the effects of signal scattering and re-radiation.

To correspond to the 1:50 size reduction, the operating radio frequency must be scaled up (i.e., wavelength scaled down), by an equivalent amount e.g., at 1:50 scale the 2-30MHz HF communications band is tested at 100-1500MHz on the model range.

In addition, the investigation of shipboard electromagnetic incompatibility problems are overcome via one or a combination of the following procedures:

1. Performance of model studies using alternate locations criteria, i.e., isolating shipboard locations where unwanted superstructure effects are minimised.
2. The determination of the degree of isolation between antennas.
3. Finalising optimum locations based on measured and observed frequency and power operating envelopes.
4. Evolution of the ship's topside design through interactive placements of the various elements within the particular ship environment.

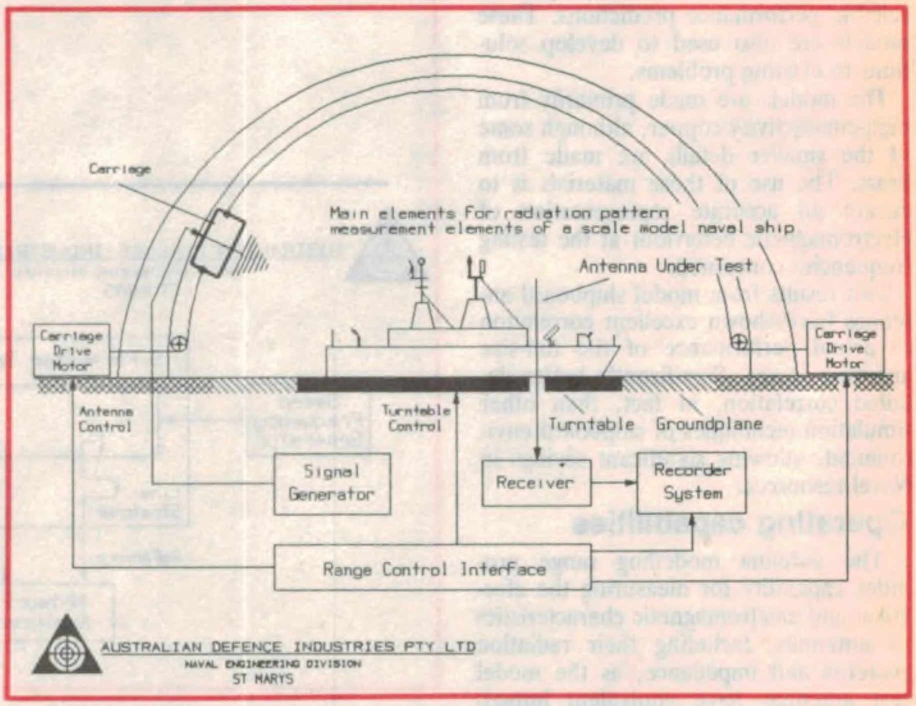
Range configuration

The modelling range itself consists of a 30-metre ground plane at ground level, made of prestressed concrete covered with thin coatings of zinc and aluminium – to accurately simulate the real sea surface with its high reflectivity to EM waves.

At the centre of the ground plane and electrically forming part of it is a turntable 6 metres in diameter. Models undergoing tests are mounted on this turntable, which is electrically rotated to produce various azimuth patterns. The scale model antenna under test is used in receive mode, with measurement and control signal cables connecting it and the turntable drive to an instrumentation room nearby, via a waterproof rotary junction beneath the turntable and a system of underground ducts.

But the most dramatic part of the modelling range is the large arch, 30m in diameter, over the top of the ground plane. This supports a track used to convey the transmitting antenna over a full 180° arc of elevation, at constant radius from the centre of the turntable.

Making further adjustments on a model antenna. Note the log-periodic transmitting antenna on its moving trolley, just below the first guy cables. (Photo by George Hicks)



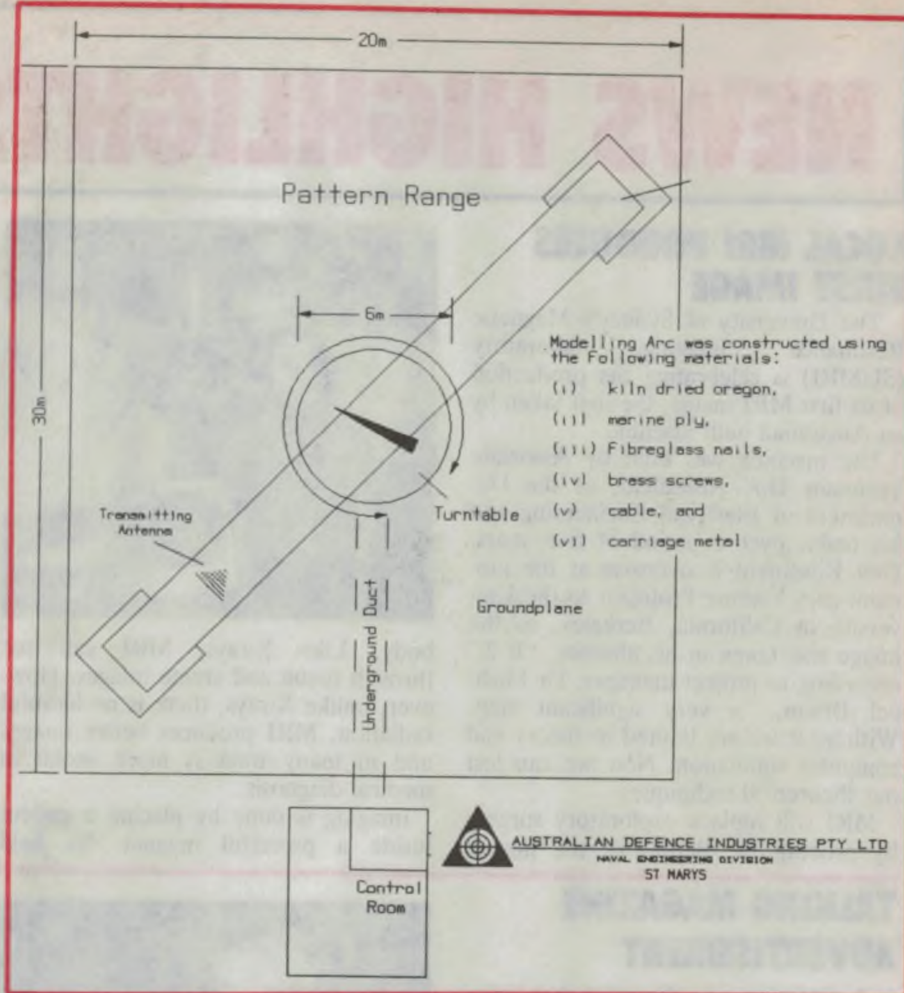
The basic arrangement for measuring the radiation pattern of a ship's antenna, on the modelling range.

A remotely controlled drive system allows the transmitting antenna to be located accurately at any desired angle of elevation, and also rotated on its axis to measure polarisation.

The antenna supporting arch and track structure is completely non-metallic in construction, to ensure minimal disturbance to the transmitting antenna radiation pattern. The arch itself is made from multi-layer marine plywood and fibre-reinforced plastic, and similar materials are used for the antenna support trolley. Even the array of guy 'wires' which steady the arch are of plastic rope, as are the cables used to move and position the antenna trolley.

The control room adjacent to the range itself contains the receiver, signal measuring and processing equipment and also the controls for antenna and turntable. A solid state custom designed range interface board provides for manual or computer controlled command of all range functions.

A dedicated computer system is being implemented to control the measuring instrumentation, plus the antenna polarisation and movement in both azimuth and elevation. It also processes the measurements and generates hard copy graphical and tabular data presentations. Data is then stored for future reference.



Plan view of the modelling range. The model antenna on the ship connects to the control room instrumentation via rotary joints beneath the rotating turntable, and underground cables.

Testing methods

Scale model radiation patterns yield data that is required for predicting the expected operating characteristics of the shipboard antenna system. These patterns are measured as a function of both horizontal and vertical planes. For a given set of conditions, the distribution of the radiation depicts relative gain, deviations from the desired circularity, location of deep nulls and the degree of adherence to theoretical performance.

The model shipborne antennas are operated as receiving antennas throughout the measurement, since the transmitting and receiving patterns are identical. The transmitting antenna mounted on the arch is moved vertically to achieve full elevation and rotated to test vertical and horizontal polarisation. To develop each pattern, the model ship is rotated through 360° on the turntable.

During the tests, superstructure elements which move under normal service conditions (i.e., radar and fire control antennas, landing pad guard rails, or missile launchers) can be rotated to determine any adverse effect upon the patterns. Initial radiation pattern measurements are recorded for the complete system and the data analyzed to ascertain whether the configuration fulfills the system requirements.

A separate Impedance Measuring Range provides a uniform ground plane during impedance measurements. The measurement lab in this case is located directly below the model ship, assuring that the measurement signal paths are as short as possible, and do not distort the electromagnetic environment.

The complex impedance characteristics of an antenna will determine its bandwidth, the match between the antenna and its feedline and its power transfer, thus effecting the total noise of hjthe system. As a direct result, this affects pattern modification by the EM environment in which each antenna operates, especially the near field perturbations.

The transmission and/or reflection coefficients are some of the parameters normally measured. The reflection coefficients are usually observed since they are directly related to impedance and voltage standing wave ratio (VSWR), the operating characteristics of primary interest. Comparisons between model measurements and full scale measurements made at sea show a correlation well within normal measurement and operational tolerances.

The Marine Antenna Modelling Range is only one of the facilities available at Australian Defence Industries' St Marys Naval Engineering Division. However it illustrates well the kind of facilities and resources that are available, for evaluation of commercial as well as military antenna systems. The Division also has available a very comprehensive environmental testing facility, for example, which can be used for rigorous testing of almost any kind of electronic equipment and systems.

The company is happy to discuss its resources and capabilities with any company or organisation with requirements in this area. For further information please contact Australian Defence Industries, Naval Engineering Division, Forester Road, St Marys NSW 2760, or phone (02) 673 8374.

NEWS HIGHLIGHTS

LOCAL MRI PRODUCES FIRST IMAGE

The University of Sydney's Magnetic Resonance Imaging laboratory (SUMRI) is celebrating the production of its first MRI image, the first taken by an Australian built machine.

The machine was built by Associate Professor Dov Rosenfeld, of the Department of Electrical Engineering and his team, over a period of five years. Dov Rosenfeld is overseas at the moment as a Visiting Professor to the University of California, Berkeley, so the image was taken in his absence. "It is"' according to project manager, Dr Michael Braun, "a very significant step. Without it we are limited to theory and computer simulation. Now we can test our theoretical techniques.

MRI will replace exploratory surgery by probing the depths of the human body. Like X-rays, MRI can see through tissue and create images. However, unlike X-rays, there is no harmful radiation. MRI produces better images and in many ways is more useful in medical diagnosis.

Imaging is done by placing a patient inside a powerful magnet. Its field creates a 'resonance' condition which can be probed by pulses of radio frequency. From the signal, an image can be created.

Six years ago the priority was to produce MRI machines as quickly as possible. The machines were expensive and crude and could only be afforded by major hospitals or clincs.

Professor Rosenfeld decided to research a new generation of MRI machines which would be cheaper and produce better images. One approach was to find better image processing techniques.

Present technology requires a highly uniform magnetic field to produce an acceptable image and magnets that can do this are expensive. If computers are used to correct distortions in cheaper magnets, the cost of MRI is much reduced. SUMRI has developed techniques to do just that.

TALKING MAGAZINE ADVERTISEMENT

A magazine advertisement that 'talks' may sound far fetched, but recently Australian and Asian/Pacific subscribers to the international edition of *Business Week* magazine were able to listen to the world's first talking advertisement, thanks to semiconductor technology developed by Texas Instruments.

The advertisement, a four page insert, triggered a male voice which for 15 seconds delivered a 42-word script. The advertisement was activated when a label covering the switch was removed.

The advertisement's electronic message was delivered by a module the size of a credit card. The heart of the module is a TI integrated circuit chip no larger than a baby's finger nail. Three tablet-sized batteries provide the power enough for 4000 plays through 1" piezoelectric speakers in the module.

The TI speech synthesiser chip, which made the advertisement possible, was designed in Dallas in conjunction with Varsity Electronics in Hong Kong, an affiliate of Intervisual Communications Inc in Los Angeles, who are responsible for electronic module development and assembly. TI offices in the Asia/Pacific region were also involved in the design and development of this unique technology.

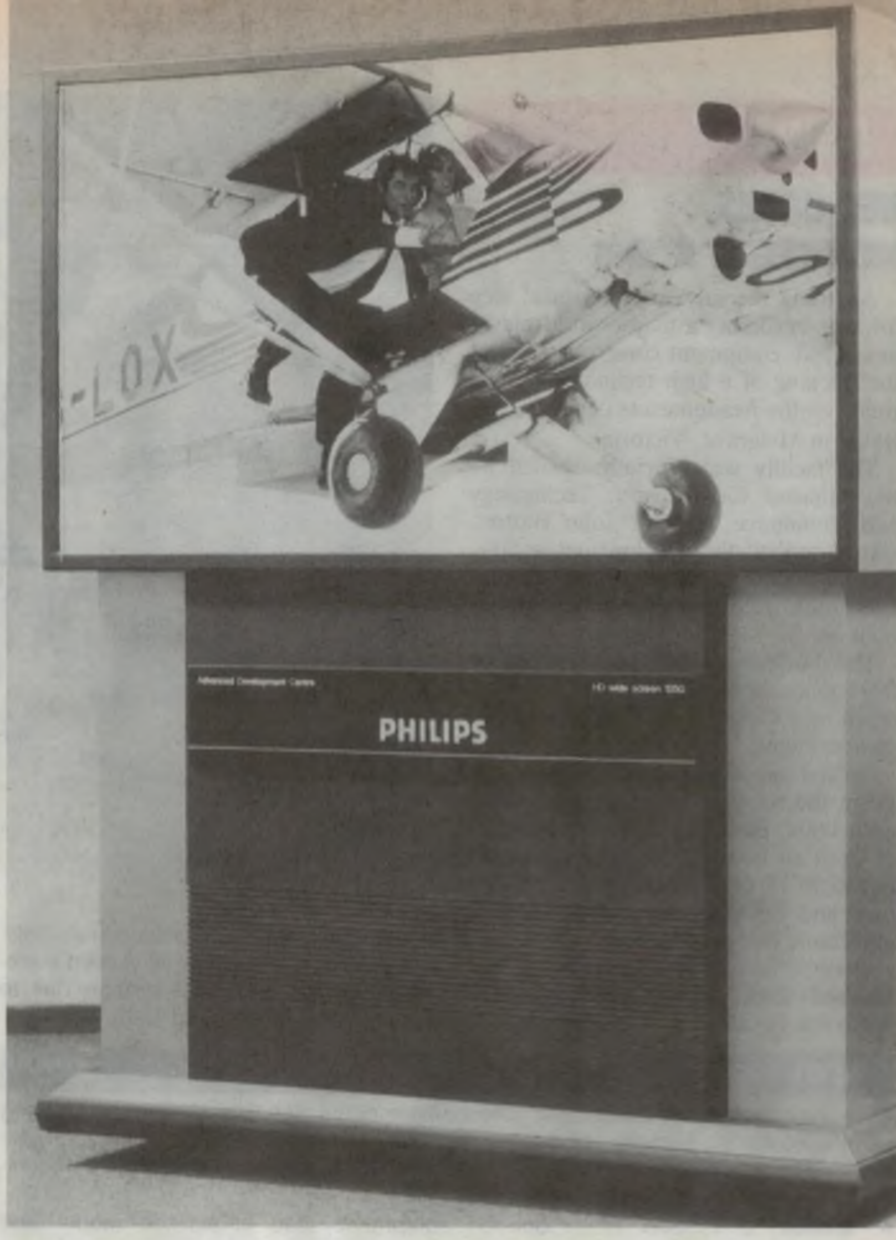
HIGH SCHOOL WINS TEKTRONIX TEST GEAR

The happy winner of our *Electronics Australia* July-October 1989 subscription promotion competition was Birrong Boys' High School, in Sydney. The school's science lab is now the proud possessor of the Tektronix CRS2225 Test Instrumentation Package, worth over $4800 and including a Tek 2225 50MHz dual-trace oscilloscope, CPS250 triple-output DC power supply, CMD250 digital multimeter, CFG250 2MHz function generator and CFC250 100MHz frequency counter.

Our picture shows BBHS principal Mr Gary Briggs and the school's librarian Ms Gwen Felice discussing the DMM with *EA* managing editor Jim Rowe (left). Looking on are Victor Bendevski, a student at the school, science master Terry Goodwin and Mr Ron Milton, national sales manager of Tektronix Australia, who jointly presented the prize.

Principal Mr Briggs said that the school was delighted to win the Tektronix instruments, as they would normally be way beyond its budget allocation. "Now our science lab is the envy of the other schools. You may well see other schools taking out subscriptions to your magazine in future, hoping to win the same kind of prize!", he added.

EUREKA DEMONSTRATES D2MAC, HDTV IN SYDNEY



The Eureka HDTV group, an association of some 30 European organisations and companies, staged a demonstration of its D2MAC satellite television system in Sydney late last year, at the Opera House. Demonstrations of 1250 line/50Hz high-definition TV were also given, although not directly linked with the D2MAC system as an HDMAC decoder was not available.

D2MAC is a European development, designed to allow high-quality transmission by either satellite or fibre-optic cable, and also to allow a high compatibility, smooth path from existing 625-line/50Hz 5:4 aspect ratio systems through 625l/50Hz 16:9 widescreen format to a 1250l/50Hz 16:9 HDTV format. The basic D2MAC signal requires a minimum bandwidth of 5MHz, with 8.4MHz considered optimum. HDMAC involves a minimum bandwidth of 10.125MHz. Both offer up to eight digital sound channels, with a choice of either two stereo channels with CD quality, or a larger number of lower bandwidth channels.

A part of the Sydney demonstrations, D2MAC signals were sent from Paris via satellite, microwave and fibre-optic links – the longest D2MAC link ever attempted. The signals were then displayed on standard PAL receivers, D2MAC standard 5:4 format and widescreen 16:9 format receivers, of both the CRT and back-projection variety. HDTV cameras, video recorders and receivers were also demonstrated.

Speaking at the demonstrations, Eureka HDTV Directorate president Mr Piet Bogels urged Australia to take a closer look at the high-compatibility D2MAC upgrade path to HDTV.

Mr Bogels noted "It has long been recognised that the Japanese HDTV scenario is not the best choice, taking into account the demands of professional users and consumers who, if it were adopted, would have to buy completely new systems and make use of additional precious spectrum space."

"The Eureka proposal for a *single* world production standard of 1250 lines, 50Hz provides not only the best link to existing, high quality media such as film, but also provides the easiest conversion to transmission standards – especially those used in 50Hz countries, such as Australia", he added.

AWA MOVES CALIBRATION LAB

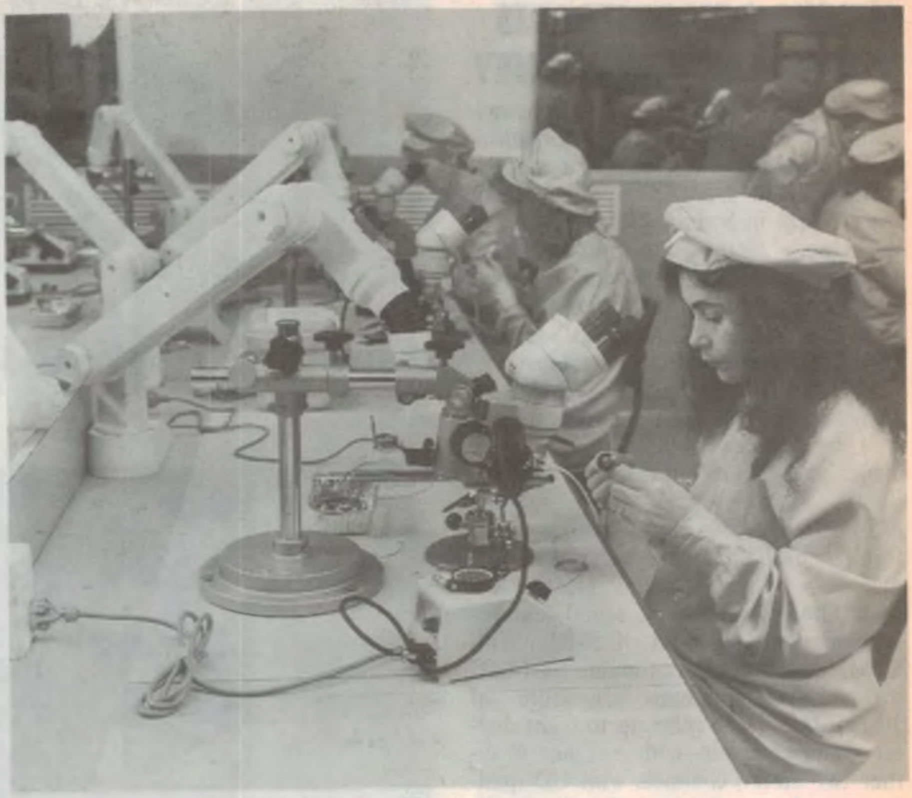
AWA's Calibration and Repair Facility has moved from North Ryde NSW and is now located in a larger, modernised area of the AWA Electronic Services complex at Leichhardt NSW. The high class laboratory provides an essential commercial service to users whose test instruments need repair or more importantly, need confirmation of accuracy.

Australian Standards have been introduced to enable the evaluation of suppliers' Quality Assurance procedures. AWA's calibration service implements AS1822, AS2415 and AS3902.

In addition to these, AWA has operated its laboratory for almost 40 years under registration from the National Association of Testing Authorities Australia (NATA). This NATA registration, and its stringent requirements, confirms the high calibre of technical expertise, test standards and instrumentation, and laboratory management procedures including documentation and maintenance of records. Measurement standards are traceable to the CSIRO's National Measurements Laboratory.

NEWS

NEC OPENS NEW CLEAN ROOM



Australia recently took a crucial step towards becoming a major world player in satellite equipment construction, with the opening of a high technology 'clean room' at the headquarters of NEC Australia, in Mulgrave, Victoria.

The facility was officially opened by the Minister for Industry, Technology and Commerce, Senator John Button, who described the development as having 'profound importance' for Australia's future role in space satellite development.

The Mulgrave 'clean room' takes up 300 square metres, and is formally classified as a Class 100,000 dust-controlled environment.

Special air conditioning enables the air in the room to be changed 20 times each hour, providing 3600 cubic metres of fresh air hourly. Special filters screen out 99.997% of dust particles. Temperature and humidity are also constantly monitored and regulated.

Construction of the 'clean room' has resulted from the selection of NEC Australia by Hughes Aircraft Company USA as the main Australia sub-contractor in the construction of Aussat's second generation satellite systems due to be launched in 1991 and 1992.

NEWS BRIEFS

- A new company, ***Electronic Alternatives*** offers services in custom tailoring communications, security, electronic or audio-visual systems for home or business. The proprieters Mark Moran and Peter Morris are highly qualified technicians and can be contacted at (02) 546 7699.
- ***Meltec***, a supplier of production equipment used in surface mount and through-put applications, has opened a new showroom at 15-17 Beresford Avenue, Greenacre 2190, phone (02) 708 4300.
- Metal Manufactures formed a new division, ***MM Cables*** last year, by combining cable operations of various companies. Now it has announced further expansion to its optic fibre communications cable factory at Clayton, Victoria.
- Australia's first consumer electronics show, ***Aust-Ces '90*** will be held at Darling Harbour from 2-4 October, 1990. Alongside the exhibition, there will be a seminar and workshop programmme on current issues in consumer electronics. For more information, contact XPO Exhibitions on (02) 906 2077.
- ***RCS Cadcentres*** of Alphington, Victoria has been appointed as a licensee and distributor for MicroSim, and thus adds PSpice circuit simulation to its growing range of computer aided engineering solutions.
- A new company, ***Innovative Sound & Media Technologies*** has been awarded an Apple VAR status for audio marketplaces in Australia. It will supply mainly Macintosh systems and is located at 188 Plenty Road, Preston 3072, phone (03) 416 9688.
- All seventy retail outlets of ***Dick Smith Electronics*** will be either refurbished or relocated to larger 2500 sq ft space, by the shop fixtures manufacturer Odlin International, within the next two years.
- A major contract by the Electricity Commission of NSW has been awarded to ***NEC Australia*** for the replacement of the existing analog Northern Microwave Communications System with a new digital system.
- ***AWA*** and ***Computer Sciences of Australia*** have jointly won the 1989 Quality and Achievement Award organised by the Department of Defence for upgrading and refurbishing the Jindalee over-the-horizon radar, in Alice Springs.

SECOND CELLULAR PHONE NETWORK PROPOSED

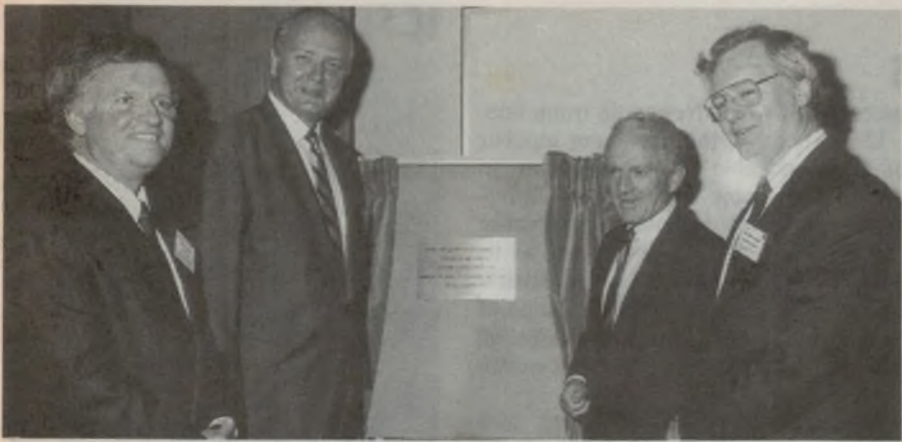
Shadow minister for Telecommunications Senator Richard Alston recently criticised the cost of mobile phones in Australia, and suggested that under a coalition government the cost of mobile phones would plummet. Apparently the coalition would also consider setting up a second cellular network in competition with Telecom.

Telecom national marketing manager for mobile communications services Ms Candice Gartner responded to Senator Alston by noting that the lower cost of mobile phones in the UK was more than offset by the much higher cost of calls, and by the poorer service than was provided by Telecom in Australia. Ms Gartner also pointed out that independant surveys had shown competition by a second operator was no guarantee of lower costs or better services.

"On the contrary, countries in which operating companies share the market give ample proof of the inefficiencies and increased costs involved. In the United Kingdom, the two cellular mobile telephone companies charge almost the same tariff, call costs and connection costs – being considerably higher than in Australia", she noted.

Private operators overseas have also demonstrated an unwillingness to invest in low traffic, low profit areas.

UNIQUE ELECTRONICS EDUCATION CENTRE

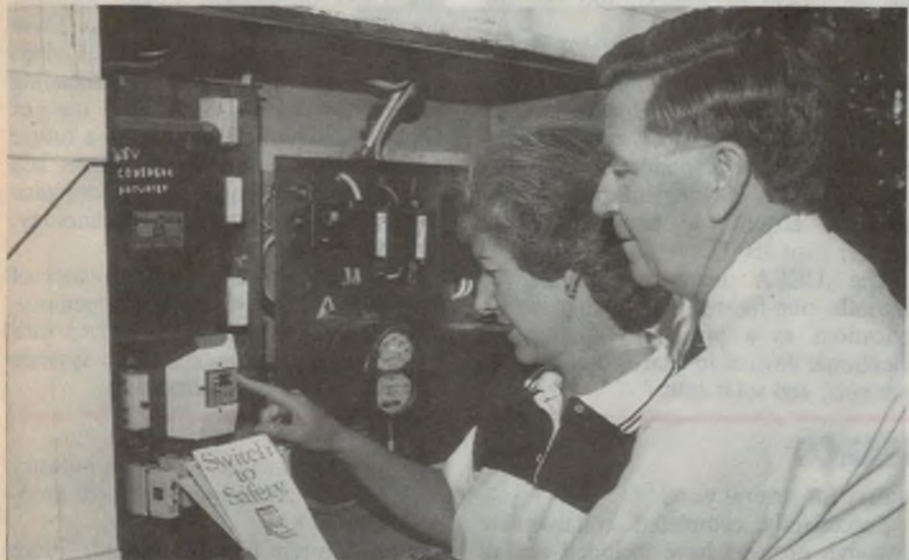


The first national electronics education centre of its kind has been officially opened by the Minister for Industry, Technology and Commerce, Senator John Button.

The Australian Electronics Development Centre, which is situated adjacent to Ericsson Australia's manufacturing operations in Broadmeadows, Victoria, has been established as a non-profit venture operating on a user-pay basis.

The $4 million centre is a professional self-help electronics product development training facility, designed to help industry and education face the challenges of the 1990s.

EARTH LEAKAGE BREAKERS SOON MANDATORY IN NSW



Installation of earth leakage circuit breakers will be mandatory in all new homes built in NSW from July this year.

Announcing the move, NSW Minister for Minerals and Energy, Neil Pickard, said it was a positive action to reduce the tragic toll of electrical accidents in and around the home. Last year 22 people died and hundreds more were seriously injured in preventable electrical accidents. Eleven of the fatal accidents could have been prevented by the operation of safety switches, Mr Pickard said.

Mr Pickard's announcement came with the launching in Sydney of the $1 million second stage of the State Government's electrical safety campaign.

"Residual current devices – or safety switches, as we are calling them – are proven lifesavers in around 80% of the electrical accidents which occur in and around the home," Mr Pickard said.

"The other states of Australia are moving to make their installation mandatory in 1991, but we can see no real reason to delay this essential safety move in NSW."

VICOM ACHIEVES DEFENCE STANDARD

Vicom Australia has been recently assessed by the Quality Assurance staff of the Department of Defence and accredited with meeting Australian Standard AS1822 relating to quality. The assessment now results in Vicom being placed on the current Defence Register of Assessed Suppliers.

A certificate indicating conformance was presented by Mr Ken Conolan, Director General, Defence Quality Assurance to Mr Russell Kelly, Managing Director of Vicom Australia. Senior Vicom staff including General Manager, Fred Grossman and Mike Chitty, who were responsible for the project, were also present at the ceremony.

The company is now working on an enhancement to AS1821 by early 1990 and this will generate opportunities in exporting to overseas countries who accept international standards related to quality assurance.

AWA WINS AIR NAVIGATION CONTRACT

AWA Defence & Aerospace, part of the AWA Defence Group, has signed a $15 million contract with the Indonesian government's Directorate General of Air Communications (DGAC) to supply sophisticated navigation equipment for its civil aviation network.

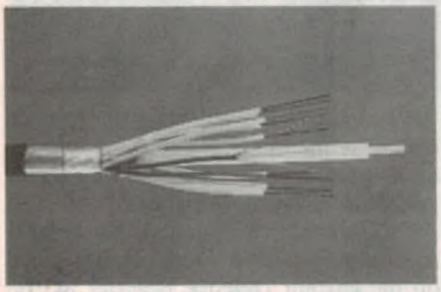
The contract with AWA for 23 Doppler VHF Omnirange VORs and five Distance Measuring Equipment (DME) systems is one of the largest single purchases of aviation equipment made by the DGAC. It will replace existing equipment in 16 locations in Indonesia, including Yogyakarta, Surabaya and Pontianak.

Despite strong international competition, AWA Defence & Aerospace won the contract due to the exceptional reliability of its DME and DVORs, which have already been sold around the world including such places as China, Papua New Guinea, Changi Airport, Singapore and the Antarctic.

NEWS

BIGGER FIBRE-OPTIC CABLES

The first 120-fibre 'Loose Tube' optical fibre cable has been manufactured in Australia, by Pirelli Cables Australia at Dee Why, NSW. The cable was despatched to Telecom late last year as part of the Sydney-Newcastle trunk line.



Until recently, the maximum number of fibres possible in Australia, in an optical fibre cable was up to 60 fibres. With the latest technology, expertise and a world leader in fibre optics as its partent company, Pirelli Cables Australia can now offer an extended range of optical fibre cable which includes all sizes up to 120 fibres – the first manufacturer in Australia to do so.

Each pair of fibres can carry over 8000 telephone lines. That means the 120-fibre cable can carry over 480,000 lines – impressive, considering that the cable is only some 20mm in diameter.

UCLA TEAM DEVELOPS LOW-TEMPERATURE DIAMOND FILM

A UCLA (University of California at Los Angeles), research team has developed a new process for depositing a very smooth, transparent diamond film on a variety of surfaces at far lower temperatures than existing processes.

"This development has the potential for revolutionising the electronics, optical and communications industries," says Professor Roitan Bunshah, head of the four-man team in the materials science department of UCLA's School of Engineering and Applied Science.

For many years, Japanese and Soviet materials scientists have been the most successful in exploiting the diamond films' hardness, high thermal conductivity and electron mobility, and high resistance to electrical current, corrosion and radiation. Their processes, however, created uneven coatings that, when magnified, were found to consist of multi-faceted particles rather than a smooth, non-faceted film.

In addition, applications of the coatings required high temperatures, ranging from 850 to 1000°C, too hot for many surface materials.

The new UCLA process, however, can be used at room temperature on a wide spectrum of surface materials, including metals, insulators, ceramic compounds and semiconductor materials such as silicon. During the process, the surfaces acquire a temperature no greater than 350°C.

The UCLA team has created a smooth, non-faceted film with new applications as a protective coating for electronic devices in space, optical components, and solar cells.

MILLIONTH GaAs IC SHIPPED

GigaBit Logic, a world leader in the design and sale of digital gallium arsenide integrated circuits (GaAs ICs), passed a milestone in the GaAs industry when it shipped its 1,000,000th IC – a GaAs logic chip that was among the first GigaBit products delivered to Sun Microsystems Inc.

John Heightley, chairman, president and CEO of GigaBit Logic, formally presented the ASIC devices to Dave Ditzel, director of advanced development at Sun. Ditzel is spearheading Sun's investigation into the use of GigaBit standard cell devices in a future generation of workstations. GaAs ICs deliver two to 10 times the performance of comparable silicon-based technology, at half the power consumption.

"We chose GigaBit Logic because of its expertise in GaAs logic and memory, and its demonstrated track record with Cray Computer and other systems manufacturers," said Ditzel.

CSIRO EXPANDS VISION RESEARCH

The CSIRO Division of Manufacturing Technology's Integrated Manufacture Program has recently established a Vision Applications Group to develop and apply vision technologies in industry. Operating from the Division's Melbourne Laboratory in Preston, Victoria, the Group will work with industry on a consultative basis. Capabilities include the development of specialised image acquisition and processing systems, machine vision applications, motion-analysis studies, and quality control inspection systems.

Through its well established Vision Research Group led by Dr Paul Dunn, the Division has been engaged in vision systems development with Australian industry for several years.

Successfully completed collaborative research projects have included a real-time video rate image processing board (APA-512) suitable for robotics applications, developed with Vision Systems Ltd, and a joint development with BHP Steel's Coated Product Division and the BHP Co Pty Ltd Melbourne Research Laboratories to produce a system for on-line inspection of painted strip for defects.

With the Vision Research Group's proven expertise complemented by the additional skills and research experience of its Vision Applications Group colleagues, the CSIRO Division of Manufacturing Technology is extremely well equipped to provide Australian industry with a broad and unique resource in vision R and D.

Ian Macintyre (formerly Head, Image Technology Group at the DSTO's Materials Research Laboratory) and Ben Simons (from the University of Sydney) have recently joined the Division's Vision team to participate in Vision Applications Group activities. They are currently assembling advanced image processing systems. These will allow the validity of new applied techniques to be quickly proven in a laboratory environment. Once feasible hardware and software is devised, customised or prototype equipment will be designed and configured for installation in industrial environments.

ROD IRVING ELECTRONICS

OSCILLOSCOPES

20MHZ DUAL TRACE OSCILLOSCOPE

CRT DISPLAY
- 150mm rectangular

VERTICAL DEFLECTION
- Deflection Factor: 5mV to 20V/ Div on 12 ranges in 1-2-5 step with fine control
- Bandwidth DC: DC to 20MHz (-3dB)
  AC: 10Hz to 20MHz (-3dB)
- Operating Modes: CH-A, CH-B, DUAL and ADD (ALT/CHOP L202 only)
- Chop Frequency: 200KHz Approx.
- Channel Separation: Better than 60dB at 1KHz

TIME BASE
- Type: Automatic and normal triggered in automatic mode, sweep is obtained without input signal
- Sweep Time: 0.2μ Sec to 0.5 Sec/ Div on 20 ranges in 1-2-5 step with fine control and X-Y
- Magnifier: X5 at all ranges

TRIGGERING
- Sensitivity Int: 1 Div or more
  Ext: 1Vp-p or more
- Source: INT, CH-B, LINE or EXT
- Triggering Level: Positive and Negative, continuously variable level; Pull for Auto
- Sync: AC, HF Rej, TV (each + or -) at TV Sync. TV-H (line) and TV-V (Frame) sync. are switched automatically by SWEEP TIME/Div switch.

HORIZONTAL DEFLECTION
- Deflection factor: 5mV to 20V/ Div on 12 ranges in 1-2-5 step with fine control
- Frequency Response: DC to MHz (-3dB)
- Max Input Voltage: 300V DC + AC Peak of 600Vp-p
- X-Y Operation: X-Y mode is selected by SWEEP TIME/ Div switch
- Intensity Modulation Z Axis: TTL Level (3Vp-p~50V) + bright, - dark

OTHER SPECIFICATIONS
- Weight: 7Kg Approx
- Dimensions: 162(H) x 294(W) x 352(D) mm

Q12105..$695

40MHZ READ-OUT OSCILLOSCOPE

CRT DISPLAY
- 150mm rectangular

VERTICAL AMPLIFIER (CH1 and CH2 identical)
- Operational Modes: CH1, CH2, ADD, DUAL, ALT, CHOP
- Sensitivity: 5mV-5V/ Div 3% in 1-2-5 steps
  1mV-1V/ Div x5% x5MAG
- Bandwidth DC: DC to 40MHz (-3dB)
  AC: 5Hz to 40MHz (-3dB)
- Rise Time: Less than 8.7nS

HORIZONTAL AMPLIFIER
- Operating Modes: X-Y operation CH1-X axis, CH2-Y axis
- Sensitivity: 5mV-5V/ Div± 3% in 1-2-5 steps
- Input Impedance: 1MΩ±2%, 25pF±3%
- Bandwidth DC: DC to 1MHz (-3dB)
  AC: 5Hz to 1MHz (-3dB)

TIME BASE
- Sweep Method: AUTO, NORM, SINGLE
- Sweep Time (A): 0.2μs-0.5S/ Div±3% in 1-2-5 steps (X1 only)
  (B): 0.2μS-0.5mS/ Div±3% in 1-2-5 steps (X1 only)
- Magnified Sweep: 10 times±5%, Max 20ns
- Linearity: ±3% or better

Q12107..$1,695

TEST EQUIPMENT

LOGIC PROBE (LP-2800)

- Useful for TTL or CMOS has high and low indicator leds and also with pulse memory.
- This is a very handy tool for the hobbyist or serious technician for tracing those hard to find faults on logic boards.

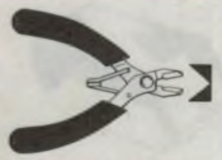
Q11272..................$34.95

LOGIC PULSER (LP-540H)

- Can be used directly to inject a signal into logic circuits without removing IC
- Compatible with TTL, DTL, RTL HTL, MOS and CMOS

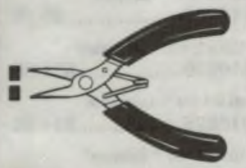
Q11274..................$42.95

GENERAL TOOLS



MICRO CUTTING PLIERS

Great for detailed cutting. These have a stainless steel head and plastic insulated handles.
Length: 90mm
T12050..................$9.95



MICRO BENT NOSE PLIERS

For delicate or high precision electronic work. Stainless steel head with plastic insulated handles.
Length: 10cm
T12040..................$9.95

HALF ROUND NOSE PLIERS

Plastic insulated handles with stainless steel head.
Length: 10cm
T12044..................$9.95

BENT NOSE PLIERS

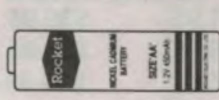
It has a long tip angled at 45°, for complicated or delicate work. Stainless steel head with plastic insulated handles.
Length: 10cm
T12046..................$9.95

SPEAKERS BOXES

SERIES 4000 SPEAKER BOXES

FOR AN AMAZING...........$250

BATTERIES



AA SIZE NICAD

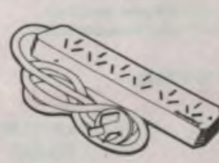
Nominal Voltage: 1.2V 450mAH
S15020.........ONLY $1.50

SURGE PROTECTOR

THE BUTTON SPIKE PROTECTOR

Simply plug the button into an outlet and it will protect all equipment plugged into adjacent outlets on the same branch circuit.

SPECIFICATIONS:
Voltage: 240V Nominal
Total Energy Rating: 150 joules
Response Time: 10ns
Protection Level: 350V peak
X10087..................$39.95



CLICK SURGE BUSTER

6 PROTECTED POWER OUTLETS
Ideal for protecting personal computers, video equipment, colour TVs, amplifiers, tuners, graphic equalisers, CD players etc

SPECIFICATIONS:
- Electrical rating: 240V AC, 50Hz, 10A
- 3 x Metal Oxide Varistors (MOV)
- Maximum clamping Voltage: each MOV: 710 volts at 50 amps
- Response time: Less than 25 Nanoseconds

X10086..................$69.95

SOLDERING IRON

ROYEL SOLDERING STATION

The all solid-state heat sensor and control unit allows the selection of the appropriate soldering tip idling temperature. The very high-powered element (relative to the size of the tool) will replenish heat drained from the tip during each soldering operation and will recover the tip tempreture moments after the tip is lifted.
- Zero voltage switching
- Zero tip potential
- Aux ground connection
- For soldering irons- CT6 (3mm Tip), CT7 (5mm Tip)

T12570..................$225

rie
ROD IRVING ELECTRONICS

Please quote this advertisement for the prices listed for this month.

SYDNEY: 74 Parramatta Rd. Stanmore 2048
Phone: (02) 519 3134
Fax: (02) 519 3868

MELBOURNE: 48 A'Beckett St
Phone: (03) 663 6151

NORTHCOTE: 425 High St.
Phone: (03) 489 8866

BRISBANE:
(V.C.R Computer Services)
647 Lutwyche Rd. Lutwyche.
Phone: (07) 857 5617

MAIL ORDER & CORRESPONDENCE:
P.O. Box 620, CLAYTON 3168
Order Hotline: 008 33 5757
(Toll free, strictly orders only)
Inquiries: (03) 543 7877
Telex: AA 151938
Fax: (03) 543 2648

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56 Renver Road, Clayton.
Phone:(03) 543 2166 (3 lines)
Fax: (03) 543 2648

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(TOLL FREE)
STRICTLY ORDERS ONLY

LOCAL ORDERS & INQUIRES
(03) 543 7877

POSTAGE RATES:

$1 - $9.99	$2.00
$10 - $24.99	$3.00
$25 - $49.99	$4.00
$50 - $99.99	$5.00
$100 +	$7.50

The above postage rates are for basic postage only. Road Freight, bulky and fragile items will be charged at different rates.

Errors and omissions excepted. Prices and specifications subject to change.

VISA MasterCard

ROD IRVING ELECTRONICS

ROD IRVING ELECTRONICS

VERBATIM DISKS

(ALL PRICES PER BOX OF 10 DISKS)

DESCRIPTION	1-9 BOXES	10+ BOXES
3 1/2" 2S/2D	$37.95	$34.95
3 1/2" 2S/HD	$78.95	$74.95
5 1/4" 2S/2D	$25.95	$23.95
5 1/4" 2S/4D	$33.95	$31.95
5 1/4" 2S/HD	$33.95	$31.95

COLOURED VERBATIM DISKS

(Each pack of 10 consists of 2 Red, Blue, Yellow, Green & Orange Disks)

3 1/2" 2S/2D	$41.95	$39.95
5 1/4" 2S/2D	$28.95	$26.95
5 1/4" 2S/HD	$37.50	$35.50

VERBATIM DATALIFE PLUS

Teflon* Coated

(ALL PRICES PER BOX OF 10 DISKS)

	1-9	10+
5 1/4" DS/DD	$29.95	$27.95
5 1/4" DS/DD	$38.95	$35.95

"NO BRAND" DISKS

Now you can buy absolute top quality disks that are also the cheapest in Australia! They even come with a lifetime warranty, which indicates the quality of these disks. So why pay 2-3 times the price for the same quality?
Packs of 10, D/S D/D without boxes, or brand name, just their whitepaper jacket, and index label. (5 1/4" disks includes write protects)

(ALL PRICES PER 10 DISKS)

5 1/4" 2S/2D "NO BRAND" DISKS

10+ DISKS	100+ DISKS	1,000+ DISKS
$5.50	$5.25	$5.00

5 1/4" HIGH DENSITY DISKS

(DOUBLE SIDED)

10+ DISKS	100+ DISKS	1,000+ DISKS
$18.50	$18.25	$18.00

3 1/2" 2S/2D "NO BRAND" DISKS

$19.95

3 1/2" 2S/HD "NO BRAND" DISKS

10+ DISKS	100+ DISKS	1,000+ DISKS
$49.95	$45.95	$41.95

Suitable for IBM, PS/2, Macintosh, Atari, etc.

"OOPS!"

AMAZING GOOF!

1/2 PRICE DISKS

These disks don't format to a full 360K. You will get over 300K. We made the mistake, you get the benefit. Ideal for games etc.

ONLY $2.50

FOR 10 x 5 1/4" Double Sided, Double Density Disks

DISK BOXES

DISK STORAGE UNITS

- 80 x 3 1/2" - Lockable
C16038..................$16.95
- 40 x 3 1/2 "- Lockable
C16035..................$14.95
- 40 x 3 1/2 " "Eclipse"
C16040..................$8.99
- 120 x 3 1/2 "- Lockable
C16039..................$21.95
- 50 x 5 1/4 "- Lockable
C16025..................$14.95
- 100 x 5 1/4 ""Eclipse"
C16042..................$9.95
- 100 x 5 1/4 "- Lockable
C16020..................$15.95
- 120 x 5 1/4 "- Lockable
C16028..................$19.95

HARD DISK

REMOVABLE CARTRIDGE HARD DISK

Ricoh R260 20 M/Byte Removable Hard Disk is a sub-system for AT or 386 systems. Extra 20 M/Byte cartridges are available. To enable the end user to build a library that can be safely locked away. Or taken to another site that is using the same sub-system. It's the ultimate in hard disk back up systems or for transport ability of data.

Includes a cartridge
X20022..................$1,150

Extra 5 1/4" 20 M/Byte cartridge for disk (Ricoh RH5260)
X20024..................$220

DISK DRIVES

5 1/4" 360K COPAL DRIVE

- 500K unformatted
- IBM* XT* compatible

C11901..................$175

5 1/4"1.2 M/BYTE COPAL DRIVE

- 1.6 M/Byte unformatted
- IBM* AT* compatible

C11906..................$225

EXTENSION CARD

IBM* PC*/XT* EXTENSION BOARD

This board will fit in the standard IBM* PC*/XT* expansion slot and allows you to repair and test IBM* PC*/XT* add on cards. It extends the add-on cards above the motherboard for easy access. Standard IBM* PC*/XT* bus edge connector.

H19115..................$54

IBM* PC*/XT*/AT* WIRE WRAPPING BOARD

This is a half size wire wrap board suitable for research and development.

- Standard IBM* PC*/XT* bus edge connector
- Tinned plated through holes
- 2.54mm spacing
- 19.4cm x 10cm wire wrapping area

H19130..................$89.95

IBM* PC/XT* WIRE WRAPPING BOARD

H19117..................$59.95

IBM* PC*/AT* EXTENSION BOARD

This allows the user to raise add on cards above the mother-board for ease of repair and testing + -5 Volt fuses as power protection.
IBM* PC* AT* edge connector
IDC connector for expansion to other interfaces via ribbon cable.

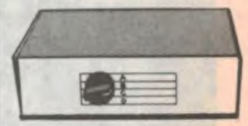
H19120..................$90

IBM* PC/AT* DECODED I/O CARD

This card is designed for the IBM* PC/AT* expansion slot and includes data buffering and address selection. The wire wrap area features plated through holes. Extremely useful for R&D, it's address range is 0280H to 72 F7H. + -5V, + -12V fuse protection and has location for D type 37 pin or D type 25 pin connector.

H19125..................$84

I/O ACCESSORIES

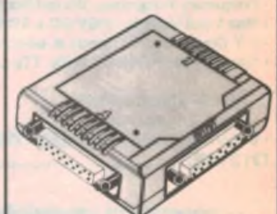


DATA TRANSFER SWITCHES

If you have two or four compatible devices that need to share a third or fifth, then these inexpensive data transfer switches will save you the time and hassle of constantly changing cables and leads around.

- No power required
- Speed and code transparent
- Two/Four position rotary switch on front panel
- Three/Five interface connections on rear panel
- Switch comes standard with female connector

2 Way RS232
X19120..................$59
4 Way RS232
X19125..................$79
2 Way Centronics
X19130..................$69
4 Way Centronics
X19135..................$79
RS232 2 X 2 Switch
X19140..................$79
Centronics 2 x 2 Switch
X19145..................$79



POCKET AUTO AB SWITCHES

- Pocket size, auto-scanning
- Allows 2 PCs to share one Printer

Serial model:
MS-201 - Host-powered
X19150..................$79.95
Parellel model: MP-201
Protocol transparent
X19155..................$89.95

CL21 COMPUTER LEAD

- 25 pin D Plug to 25 pin D plug
- All pins wired straight through (removable terminals)
- Length 1.5metres.

P19007..................$36.95

CL23 COMPUTER LEAD

- 25 pin "D"plug to 25 'D'socket
- All pins wired straight through (removable terminals)
- Length 3 metres

P19012..................$49.95

CENTRONICS CABLE

- 36 Way Centronics Plug to 36 Way Centronics Plug
- Shielded cable
- Length: 6 metre

P19013..................$29.95

ROD IRVING ELECTRONICS

IBM* CARDS

386SX 16MHz MOTHERBOARD

- Processor: 80386SX-16MHz (0/1 wait state)
- Co-processor:80387SX-16 (optional)
- CHIPS & TECH NEAT chipsets
- (SMT) Surface Mount Technology for chipsets & CPU
- Supports up to 2MB on board, (Sixteen 44256 and Eight 41256 sockets)
- Three 8 BIT slots
- Five 16 BIT slots
- Memory Expansion Slot
- Optional 2-8MB memory card
- Supports LOTUS-INTEL-MICROSOFT (LIM) Expanded Memory Spec. (EMS) version 4.0
- Supports Page Interleave Mode using 100NS DRAM
- BIOS: AMI or PHOENIX
- Turbo Light and Hardware Reset connector
- Keyboard or Hardware Reset connector
- Power Good Signal on board
- Baby size main board
- Without Ram

X18094......................$900

286 NEAT MOTHERBOARD

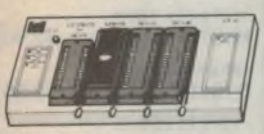
- Processor: 80286-12, -16MHz or -20MHz (0/1 wait state)
- Co-processor: 80287 (optional)
- CHIPS & TECH NEAT chipsets
- 1-4MB dual RAM socket
- 1-4MB module RAM socket on board
- 640KB-384KB memory relocation
- Three 8 BIT expansion slots
- Five 16 BIT expansion slots
- Memory expansion to 8MB
- Supports EMS 4.0
- Page Interleave Technology
- BIOS: AMI or PHOENIX
- Hardware and keyboard switchable Clock Speed
- LED speed display
- Power Good Signal on board
- Baby size main board

- 16MHz

X18090......................$700

- 20MHz

X18092......................$895



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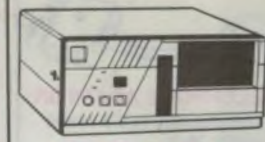

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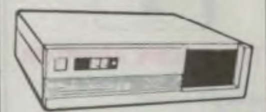
Size: 360(W) x175(H) x405(D)mm

X11093......................$99



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JOYSTICK FOR IBM*

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Ideal for games or word processing. Fits most 6502 "compatible" computers.

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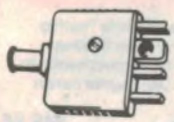
ROD IRVING ELECTRONICS

TELEPHONE CONNECTORS



TELEPHONE PLUG
AUSTRALIAN
- Solderless Terminal lugs
- Colour: Cream

Y16016....................$4.95

TELEPHONE INLINE SOCKET
AUSTRALIAN
- Solderless terminal lugs
- Colour: Cream

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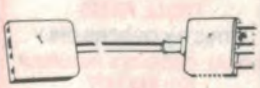
TELEPHONE DUAL ADAPTOR
- Australian plug to 2 Australian sockets
- Length: 10cm
- Colour: Cream

Y16014..................$12.95

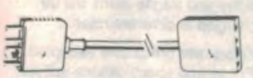
TELEPHONE DUAL ADAPTOR
- Australian socket to 2 Australian plug/ socket
- Length: 10 metres
- Colour: Cream

Y16015..................$11.95



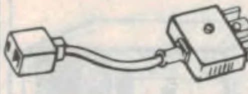
TELEPHONE EXTENSION CABLES
- Australian plug to Australian socket
- Colour: Cream
- Length: 10 metres

Y16012..................$11.95



TELEPHONE EXTENSION CABLES
- Australian plug to Australian socket
- Colour: Cream
- Length: 5 metres

Y16010..................$12.50



TELEPHONE ADAPTOR
- Australian plug to U.S socket
- Length: 10cm
- 6 way/ 4 contact
- Colour: Cream

Y16026....................$6.95

TELEPHONE ADAPTOR
- U.S. modular wall socket
- 6 way/ 6 contact
- Screw terminating
- Colour: Cream

Y16002....................$3.95

MODULAR DUAL OUTLETS
- Single cable input to 2 modular socket outputs
- Surface mounting
- Screw terminating
- Colour: Cream
- 6 way/ 6 contact

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SURFACE MOUNT SOCKET
- U.S. modular surface mount socket
- 6 way/ 6 contact

Y16003....................$4.95

FLUSH MOUNT - SINGLE SOCKET
- Wall plate with modular socket
- Standard Australian size plate
- 6 way/ 6 contact
- Colour: Cream

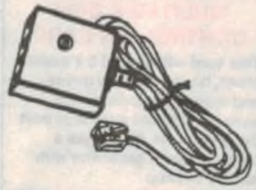
Y16005....................$3.95

FLUSH MOUNT - DUAL SOCKET
- Wallplate with two modular sockets
- Standard Australian size plate
- 6 way/ 6 contact
- Colour: cream

Y16006....................$4.95

TELEPHONE EXTENSION CABLE WITH REEL
- Allows 15 metres of telephone cable to be neatly wound in a portable storage container
- Colour: Cream

Y16013..................$24.95

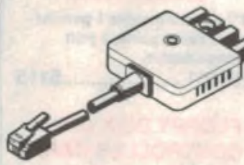


TELEPHONE EXTENSION CABLE
- Australian socket to U.S. plug
- 6 way/ 4 contact
- Length: 5 metres
- Colour: Cream

Y16017....................$8.95

TELEPHONE CURL CORD
- Length: 1.8 metres
- Colour: Black

Y16020....................$3.45

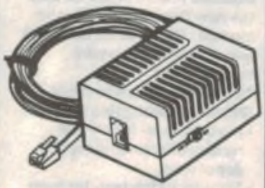


TELEPHONE EXTENSION CABLE
- Australian plug to U.S. plug
- 6 way/ 4 contact
- Colour: Cream
- Length: 2.5 metres

Y16029....................$6.95

TELEPHONE INLINE JOINER
- U.S. socket to U.S. socket
- Colour: Cream

Y16037....................$3.95



TELEPHONE EXTENSION BELL
- Allows you to hear the phone ringing when you are outside
- Colour: Cream

Y16042..................$29.95

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CENTRONICS GENDER CHANGERS
- Saves modifying or replacing non- mating centronics cables.
- All 36 pins wired straight through.

X15663 Male to Male
X15661 Male to Female
X15664 Female to Female
..............................$29.95

RS232 GENDER CHANGERS
- Saves modifying or replacing non-mating RS232 cables
- All 25 pins wired straight through

X15650 Male to Male
X15651 Male to Female
X15652 Female to Female
...................$11.95 each

DB15 GENDER CHANGERS
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X15646 Male to Female
X15647 Female to Female
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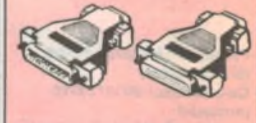
DB9 GENDER CHANGERS
- Saves modifying or replacing non-mating DB9 connections
- All 9 pins wired straight through

X15640 Male to Male
X15641 Male to Female
X15642 Female to Female
..............................$14.95

RS232 NULL MODEM ADAPTORS
- Pins 2 and 3 reversed
- All 25 pins connected

X15657 Male to Male
X15658 Male to Female
X15659 Female to Female
..............................$11.95



9 PIN TO 25 PIN CONNECTOR ADAPTORS
The perfect solution!
Features gold plated pins
- DB9 Plug to DB25Socket

X15668...............$10.95
- DB9 Socket to DB25 Plug

X15669...............$10.95

RS232 MINI PATCH BOX
- Interface RS232 divices
- With male to female 25 pin inputs
- 25 leads with tinned end supplied

X15653 Male to Male
X15654 Male to Female
X15655 Female to Female
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H10105....................$1.95
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- 195 x 113 x 60mm

H10112....................$6.95
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Q10516	MU45 0-20A	$16.50
Q10518	MU45 0-1A	$16.50
Q10520	MU45 0-20V	$16.50
Q10525	MU45 0-30V	$16.50
Q10530	MU52E 0-1A	$18.95
Q10533	MU52E 0-5A	$18.95
Q10535	MU45 VU Metre	$17.95
Q10538	MU65 0-50uA	$23.50
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Q10550	MU65 0-100uA	$23.50
Q10560	MU65 0-20V	$23.50

Headphones fit for a king!

A few weeks ago we had the opportunity to try out a sample pair of Sony's new MDR-R10 stereo headphones – not just top of the range, but well beyond. In fact Sony describes them as simply 'the very best in the world'. Here's what we found...

Sony has been pretty active in the stereo headphones area since around 1979, when it introduced the lightweight foam-pad type MDR-3 phones to go with the original Walkman. The MDR-3's weighed only 40 grams, yet delivered a performance that compared very favourably with much larger and heavier conventional models. In fact they were undoubtedly part of the reason why the Walkman became so phenomenally successful, by ensuring that it delivered high quality sound right to the user's ears.

If Sony hadn't done a thorough job, developing matching phones as part of the package, it's quite possible that the Walkman might not have made anything like the impact it did.

In the 10 years since the MDR-3's were introduced, the company has spent quite a lot of effort making further improvements in headphone technology. In 1982 it introduced the MDR-E252's, the first really high quality phones which were small enough to fit right inside the ears. Not requiring a headband, these weighed only 4.8 grams for the pair, and gave Walkman users even more freedom – again without sacrificing quality.

The following year, it introduced the MDR-W30L phones. These were of the headband type again, but significantly smaller and lighter (14g) than the original MDR-3's. The actual phones were also rather different from any previous type, with a 'vertical' construction which allowed them to slip inside the ear canal for close acoustic coupling.

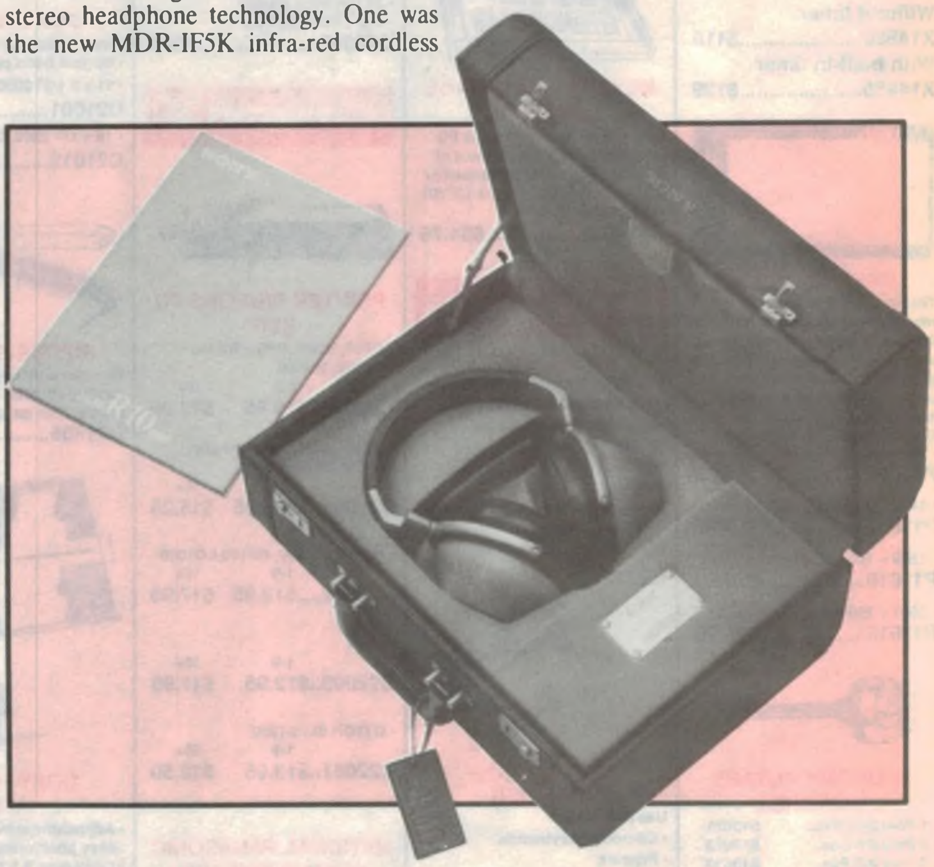
Then in 1984 came versions of the tiny ear-insertion phones with Sony's 'Acoustic Turbo Circuit', using small chambers and tubular ports to enhance the response. This principle was enhanced more recently to produce the 'SATC Twin Aero System', used in models such as the MDR-A21L.

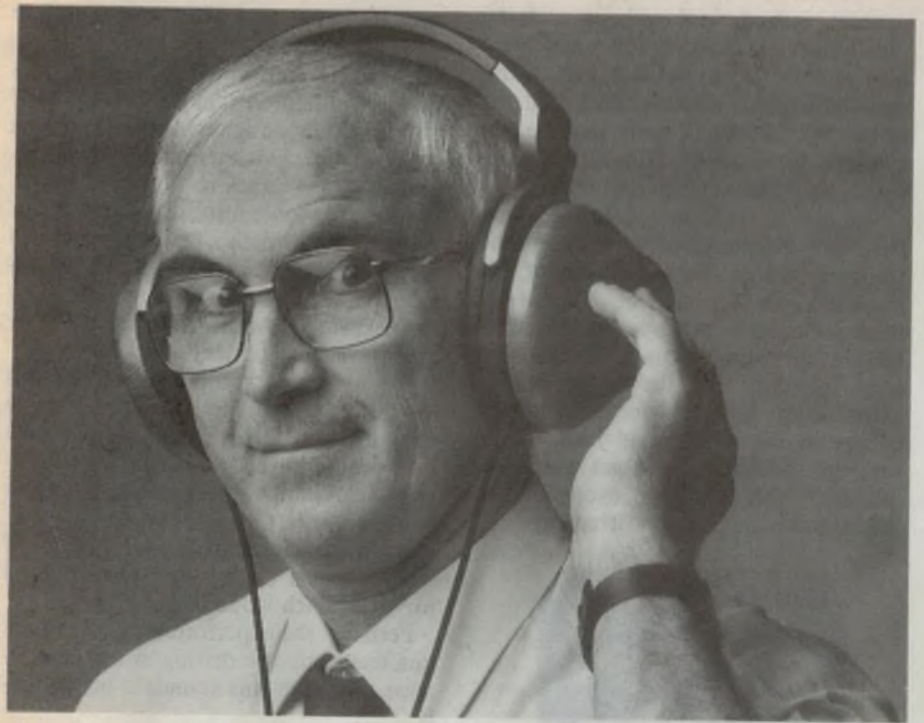
All this effort seems to have paid off, because Sony has apparently sold more than *one hundred million* sets of MDR phones in the last 10 years. Quite an achievement...

Last year there were two further additions to the MDR range, both of which made further significant contributions to stereo headphone technology. One was the new MDR-IF5K infra-red cordless phones, which use digital encoding on the IR beams to provide full range and low distortion operation, via a tiny receiver/decoder built into the top of the headband. (We haven't had a chance to try these out yet, but hopefully our turn will come!)

The other new addition was Sony's *magnum opus* among stereo headphones, the MDR-R10's.

Anything but miniature, the MDR-R10's are what Sony describes with quotes such as 'the headphones that were meant to be the very best in the world' and 'the creation of a new dimension in audio'. In short, not just the top-of-the-range model, but an all out





no-holds-barred attempt to produce the 'ultimate' stereo headphones – based on the latest technology and finest available materials, without any compromises!

Finest materials

Just what kind of construction and materials *do* you end up with for stereo headphones, when your brief is to use the best and finest available, regardless of cost?

Interestingly enough, Sony's engineers didn't go for fancy electrostatic drivers, or multiple woofer/tweeter electrodynamic drivers complete with crossover networks. Instead they seem to have decided upon relatively conventional single moving-coil drivers, using 50mm diameter domed diaphragms – but with a lot of effort spent on achieving exceptionally high linearity and smooth response, using carefully chosen materials and design parameters.

In short, they seem to have gone for a kind of 'elegant simplicity' engineering design solution, perhaps one which also reflects traditional Japanese emphasis on *mottainai*, or reverence for natural materials and their efficient use.

One of the stated aims of the Sony designers was to produce headphones which had the broad, deep sound of a full-sized speaker system in a room. And they decided that in order to achieve this, they would need to come up with a diaphragm that was much stiffer than one of conventional plastic, while at the same time being exceptionally light and acoustically 'warm'.

After testing a great many different materials, they came up with 'bio-cellulose'. This is apparently a natural cellulose fibre, produced by feeding saccharides to bacteria called *Acetobacter aceti*. Under the right conditions, using modern biotechology, the bacteria produce very fine cellulose fibres about 20-40 nanometres in diameter, in a culture which becomes about 2mm thick after about two days.

After this time the Sony technologists dry the culture, and then compress it down a thickness of only 20 microns in a die, which directly produces the final diaphragms for the MDR-R10 drivers. The result is diaphragms which are said to have the stiffness and rigidity of aluminium or titanium, but with the lightness and 'natural warmth and delicacy' of paper.

Once they had settled on the right material for the diaphragms, the next challenge was the actual headphone enclosures. Most conventional 'phones use cases of plastic or metal, but the Sony engineers believed these materials were also rather less than ideal for producing compact sonic enclosures.

After exhaustive testing of a great many materials, they finally settled for the solid red-brown heartwood from the Zelkova tree, a tall deciduous member of the elm family which is native to the Japanese archipelago and Korean peninsula. In particular they found the best results came from the heartwood of 200-year old Zelkova trees from forests in the Chubu and Tohoku regions of Japan. Zelkova wood is apparently highly prized for its decorative properties, having a very attractive grain structure.

But it wasn't enough just to use this rare and expensive material. To get the right performance, they also had to find a way to form it into suitably non-resonant acoustic chambers. Both the walls and the interior volume had to be very carefully designed using a 3-D CAD system, and turned out to require very accurate complex compound curves – virtually impossible to produce using conventional machinery.

The solution was to use a 3-D computer-controlled milling machine, driven by the same 'FRESDAM' CAD system used for their design. Each driver enclosure is milled directly out of a solid section of Zelkova heartwood, with about 300cc removed to produce the interior chamber and almost as much to produce the complex outer shape.

Of course the resulting headphones are rather on the large side, and not exactly as light as a feather. And traditionally, larger headphones tend to be hard on both the user's outer ears and head, simply by virtue of their weight and the pressure they exert.

So Sony's engineers had to find ways of solving these problems, too – no good producing the 'ultimate' headphones in terms of performance, if no-one could bear to wear them for more than 10 minutes at a stretch!

They ended up with a fairly bulky *looking* headband, but one whose simple look is quite deceptive. The main band itself is made from a carbon-fibre composite material, designed to combine light weight with great flexibility and freedom from spurious resonances. It is also designed to provide just the right inward pressure on the ears; enough to ensure correct acoustic coupling, for good bass response, but not enough to cause discomfort.

Across the inside of the main arch there is a light strap, in the shape of a long oval with its ends disappearing into slots in the main band – just above the offset swivels for the driver hangers. And inside the main band, attached to the ends of the strap, is a flat tension spring made from a special shape-memory alloy of titanium and nickel. The idea is that this special spring allows the headband to adjust itself automatically to virtually any sized head, with virtually no more pressure exerted with a larger head than with a smaller one.

In addition to these special properties of the headband, the MDR-R10 drivers

Sony superphones

themselves are fitted with specially contoured earpads, designed to minimise pressure on the external ear while still maintaining close coupling. The pads are covered in Greek lambskin, treated to produce a particularly soft texture, and have a long oval-shaped centre aperture. There's also a special 'shock absorber' buffer between each earpad and its baffle plate, to isolate and dampen any externally-produced vibration.

The combined qualities of the headband, spring and earpads are claimed to make the MDR-R10's fit virtually anyone perfectly, and with the greatest possible comfort.

As if that wasn't enough, even the semicircular hangers used to support the drivers themselves are rather special. They're made from magnesium, for lightness and strength combined with freedom from spurious resonances.

Needless to say, the connection cables weren't forgotten either. The conductors are of linear-crystal oxygen-free copper (LC-OFC), for minimum losses, with the primary insulation of soft silicone plastic for high flexibility and durability. The outer covering is double-woven silk. The 6.5mm stereo plug at the end has LC-OFC conductors, which are first rhodium plated and then gold plated for freedom from oxidation.

On the technical side, the MDR-R10's have an impedance of 40 ohms and a pressure sensitivity of 100dB/mW. Rated frequency response is 20Hz to 20kHz, with a rated input power of 300mW and a maximum input of 1W.

The MDR-R10's come in a special presentation case, about the size of a hatbox. They also come with a special Operating Instructions Manual, printed on special acid-free paper using the collotype process and bound in linen and jute cloth. The presentation is very similar to that for a violin, concert flute or other musical instrument.

Trying them out

Enough of this mundane description, I hear you ask. Headphones are for listening – so how did they *sound*?

A couple of us tried them out during the time we had them, using a wide range of familiar musical test pieces. And we're both fairly familiar with the performance of conventional stereo headphones, from the compact ear-canal type to professional monitoring 'phones.

Frankly, we both found them very impressive indeed, and without a doubt the most satisfying headphones we'd ever heard. The sound was rich, warm and full-bodied – much more like the sound from a pair of good loudspeaker systems in a well damped listening room, than like other headphones.

The overall response seems exceptionally well balanced, with a crisp and transparent high end and a smooth and extended bass register. Not only this but there seems to be much lower intermodulation distortion than is evident on most 'phones, with the treble staying clean even when there's significant energy in the middle and bass. There isn't the 'muddiness' you get with most 'phones, with anything except single voices and monophonic instruments.

So performance-wise, the MDR-R10's do indeed seem pretty exceptional. And all of that effort spent by Sony's engineers on user comfort seem to have paid off, too.

Even though the MDR-R10's must be about the biggest and weirdest-looking phones we've ever tried, they certainly turned out to be comfortable. The special materials used have kept the weight to a relatively modest level (400g, or about 14oz), while the inner head strap and tension spring arrangement seems to spread this weight very evenly over the head.

The end result is that there's very little obvious pressure on either your head or your ears, and you're only mildly conscious of wearing them. Except perhaps in very hot and sticky weather – although even then, they're a lot more comfortable than any other phones we've ever tried!

In short, our reaction is that in the MDR-R10's, Sony really does seem to have produced something very, very close to the 'ultimate' stereo headphones.

Our only real quibble is that after spending so much obvious effort on extracting improved performance out of almost every aspect of the MDR-R10's, Sony's engineers seem to have totally ignored the matter of correct electrical drive conditions. For example nowhere in the manual is there any inkling of the kind of drive for which the headphones were designed, and which will therefore give the optimum results.

This is an area which occupies a great deal of attention among loudspeaker and amplifier designers, but one which is generally glossed over for headphones. Yet they're electrodynamic transducers too, just like loudspeaker drivers, and their performance will inevitably be affected by driving impedance. It seems strange to us that Sony too seems to have overlooked this – or at least makes no mention of it.

For example should the MDR-R10's be driven from the usual reasonably constant-current circuit, or should they be driven from a low impedance, relatively constant-voltage circuit, like a loudspeaker? Or doesn't it matter? There's no mention in the manual of which type of drive they were designed for, and which is recommended.

Perhaps their performance *is* totally unaffected by the driving circuit impedance, although this sounds a bit unlikely.

Mind you, we tested them with standard 'semi-constant-current' type driving circuits, and they certainly sounded very impressive. But we didn't have time to try them with low-impedance drive, to see if that made them even better.

Perhaps it would be a good idea for Sony to explain clearly the optimum drive system, because after spending the kind of money the MDR-R10's cost, one would very definitely want to make sure you were using them to their best advantage.

And that brings us to the real rub: a pair of MDR-R10's cost a mind-numbing $5,800, making them not just the *best*, but also the most *expensive* stereo headphones we've ever seen. It figures, we suppose, when Sony deliberately set out to produce the finest possible 'no compromise' headphones. Headphones fit for a king, in more ways than one...

All the same, it's a pity that probably the only people who'll be able to afford the MDR-R10's will be a small number of wealthy folk of advanced years, whose hearing may well not allow them to tell the difference.

One thing's certain: magazine editors and writers certainly *won't* be able to afford them. Still, we did get to have a brief listen – just enough to make us totally dissatisfied with our existing headphones!

For those who *can* afford the ultimate in headphones, you can find out more about the MDR-R10's by contacting Sony Australia, 33-39 Talavera Road, North Ryde 2113 or phone (02) 887 6666. (J.R. and R.E.)

When I Think Back...

by Neville Williams

FM broadcasting in Australia – Chronic loser, ultimate winner!

FM broadcasting has had a chequered history in Australia. Hailed as a breakthrough into high-quality, noise-free radio, it was delayed by World War II, pushed aside by television and then scuttled by short-sighted planning. But it staged an amazing comeback and is now rapidly overhauling the established AM system.

In practical terms, the story of FM broadcasting, worldwide, dates from a paper by Major Edwin H. Armstrong published in May 1936 in the *Proceedings of the IRE* (USA) entitled: 'A method of reducing disturbances in radio signalling by a system of frequency modulation'. Referred to in my previous biography of Raymond Allsop, I mention to it again here for the sake of continuity.

Armstrong's claims were supported by a practical demonstration to the Radio Club of America in the Pupin Hall of the Columbia University, and by papers delivered by Messrs Weir, Flyer and Worcester of GE (the General Electric Co, Schenectady).

Impressed by the potential of the new system and, with the grudging consent of the FCC (US Federal Communications Commission), GE set up a number of experimental FM transmitters, operating mainly in the 40-60MHz range. Some were later granted commercial licences and receivers made available to the public.

Radio Craft (USA) published a progress report on the new technology in its April 1939 issue, in an article entitled 'At long last – STATIC-FREE RADIO'. It mentioned two experimental stations already in operation (Albany, N.Y. and Storrs, Conn.), with six others in construction in the eastern states. This was in addition to Armstrong's own W2XMN (atop the Pallisades, N.J.) and an application for an FM licence by New York's 'high fidelity' station WQXR.

These developments were watched with considerable interest in Britain, Europe and Japan where, as in the USA, the number of stations on the AM broadcast band had reached saturation level. Here was a system that exploited a less crowded part of the spectrum and which offered high quality reproduction, plus comparative freedom from mutual interference and from both man-made and atmospheric noise.

Australian reaction

Interest was also apparent in Australia, with *Radio & Hobbies* directing attention to the new technology several times in 1939/40, the magazine's first year of publication. An editorial by John Moyle in March 1940 emphasised its importance but pointed out that, for countries like Australia, possible development of FM broadcasting had been effectively blocked by the outbreak of war.

FM broadcasting gradually came into its own in the postwar years, particularly in America, Europe and Japan.

In Britain, the BBC set up a full-scale research transmitter on Wrotham Hill, 30km southeast of London. Sited 220m above sea level, its function was to provide experience with VHF broadcasting in the 90-100MHz region, using either amplitude or frequency modulation. The experiments were destined to have long-term repercussions in Australia.

Britain formally adopted FM broadcasting in the mid 1950s, based on their Band II, 87.5-100MHz. Gradually, however, 88-108MHz gained international recognition as the logical FM broadcast band, to be cleared for that purpose as and when individual nations could reshuffle their domestic allocations.

In Australia, events followed a very different pattern, due largely to our dual system of A- (national) and B-class (commercial) broadcasting stations.

While established commercial broad-

Announcer Julie Moore in the St Leonards, Sydney studios of 2MBS-FM, in May 1988 – much better facilities than when the station began! (Courtesy 2MBS-FM)

casters competed vigorously for advertising revenue, they found common cause in discouraging a technology which would accommodate further competitors. Such was their combined political clout that, when the ABCB (Australian Broadcasting Control Board) was set up in 1948, one of its early policy decisions was to rule against commercial FM stations. (*R,TV & H* Nov. 1961, p.19)

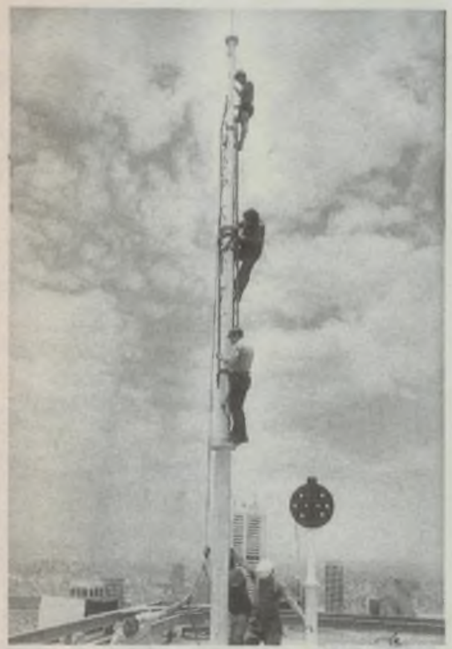
FM only for ABC

The Board's one concession to technical progress was to accept that FM broadcasting might be developed in stages by the ABC (Australian Broadcasting Commission) for its government-funded 'national' services. It was better than nothing – but only just!

The PMG's Department was not impressed by the compromise. It had inherited the job of providing technical services for the ABC, back-up services for the industry as a whole and, through their Radio Branch, the task of dealing with listener complaints about mutual and noise interference with radio reception. They understood better than most that FM technology could solve many of the problems and ensure better audio quality into the bargain.

The best they could do was to co-operate with the ABC in setting up 'experimental' FM transmitters in Sydney and Melbourne in 1947, Adelaide in 1948, and another in Brisbane in 1952. These served to provide practical experience and a measure of public interest. But they also posed a problem for the ABC, in that a viable service could not be built up on one station per city and a sprinkling of tuners operated mainly by hifi enthusiasts.

Mr B.E. Cabena, who played a leading role in the establishment of 3MBS-FM. (Courtesy B.E. Cabena)



Assembling the 2MBS-FM transmitting antenna on the top of the AMP building in Sydney, in 1977.

So the FM outlets operated for the next 10-odd years on an 'experimental' basis, with little publicity or formal programming, taking a 'split' from one or other of the ABC's AM program lines, often at the discretion of the duty engineer.

Well known electronics engineer Neville Thiele, now retired, recalls that this was the situation when he was a trainee with the PMG Dept. The FM transmitter, he said, was often fed with what the 'techs' described as the 'anti-regional' program. In the absence of a self-evident choice, it became common practice simply to feed the FM transmitter with the signals that weren't being fed to the regionals!

Again, in his Stirling Memorial Lecture (Broadcast by 5UV Adelaide, March 2, 1981) Professor Ken Inglis (University of Adelaide) recalled that "in PMG folklore, the FM transmitter in Sydney was known as the iron lung, because it kept two men alive for ten years!"

Public unaware

The Australian public remained largely unaware of the FM transmissions, and local receiver manufacturers made no attempt to change that. Admittedly, there was no cheap and easy way of extending a valve-type AM receiver to cover FM and, in any case, simple FM receivers of the period needed to be critically tuned to receive a distortion-free signal.

"Neither scope nor justification" – apply elsewhere!

September 14,1970

Dear Senator McClelland,

I refer to your representations on behalf of Mr B. Cabena, Chairman of the Music Broadcasting Society of Victoria, which is desirous of obtaining a licence to operate a broadcasting station in Melbourne to provide music for members of the Society.

I have discussed this matter with the Chairman of the ABCB. As they pointed out when they recently replied to the Society on this matter, the Broadcasting & Television Act 1942-69 makes provision only for national and commercial broadcasting stations.

Your letter on behalf of the Society raises questions of either amendment to the above Act to permit the grant of a licence such as the Society seeks, or alternatively grant of a licence under the Wireless Telegraphy Act, seeing that the frequency which the Society desires to use is outside the broadcast bands.

In either case the proposal raises questions in regard to the broadcasting services, namely whether specialised services such as the Society has in mind should be authorised. It is the view that there is neither sufficient scope nor justification for such services.

In regard to the first factor, Melbourne is well provided with broadcasting service with two national and six commercial stations. The wide activity of the national stations in the musical field is relevant. As to the second aspect, operating frequencies are a valuable resource and, having regard to demands for broadcasting service throughout the Commonwealth, their use for a sectional audience could not be justified.

Similar considerations apply in respect of the Wireless Telegraphy Act.

The Inquiry in regard to frequency modulation broadcasting will examine questions in regard to the development of the broadcasting services and, as the Board has suggested, this would present an opportunity for the Society to put forward its views.

Alan S. Hulme
(Postmaster-General)

When I Think Back

Nevertheless, quite a few hifi devotees built or bought imported tuners to take advantage of the experimental transmissions, in the hope that they would one day be formalised. A typical contemporary circuit for home constructors is reproduced herewith, from the UK magazine *The Home Constructor*.

Television was launched in Australia in 1956, and while it was allocated to channels above and below the segment 88-108MHz, the FM band remained intact except for a 4MHz overlap from television channel 3. Few seemed to be concerned about this incursion, the impact of television being such that the experimental FM stations receded even further from public awareness.

In 1960, however, a technical conference was convened by the ABCB to consider the options for expanding the TV services. As it happened, the problem was also being examined by a Radio Frequency Allocations Review Committee, appointed by the Postmaster-General and headed up by Professor L.G.H. Huxley. As one of its findings, the Huxley Committee recommended that additional TV channels should be accommodated in the still largely vacant FM band, and that FM broadcasting should be allocated to UHF, if and when the need arose.

The recommendation was adopted and formalised in a statement by the Postmaster-General in May 1961. The ABC's VHF FM transmissions were discontinued in the following month, with no provision to transfer them to UHF.

AM broadcasters were pleased, as also were the TV purveyors, receiver manufacturers, and the viewers who stood to gain an extra channel. The dissenters were mainly those whom I described in an editorial (*Radio,TV & Hobbies*, April '62) as "a very large group of listeners who were dismayed by the termination of FM broadcasting". A prophetic statement in that same editorial read:

"Any time from now on, the sound broadcasting industry is going to wake up to the fact that the most potent answer to television is high quality, noise-free, compatible stereo; that it should have been radiated, not on the still problematical UHF band, but on the very VHF band that they were glad to see cut up."

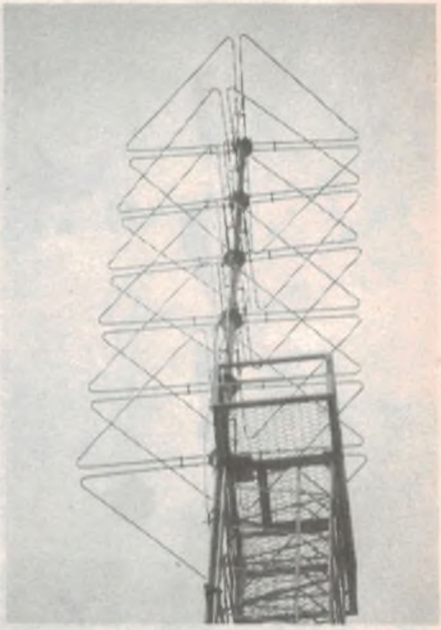
In the wilderness

For ten-odd years, that read like a piece of pie-in-the-sky journalese, although there were still a few optimists who dared to hope for a better deal. But more of that later.

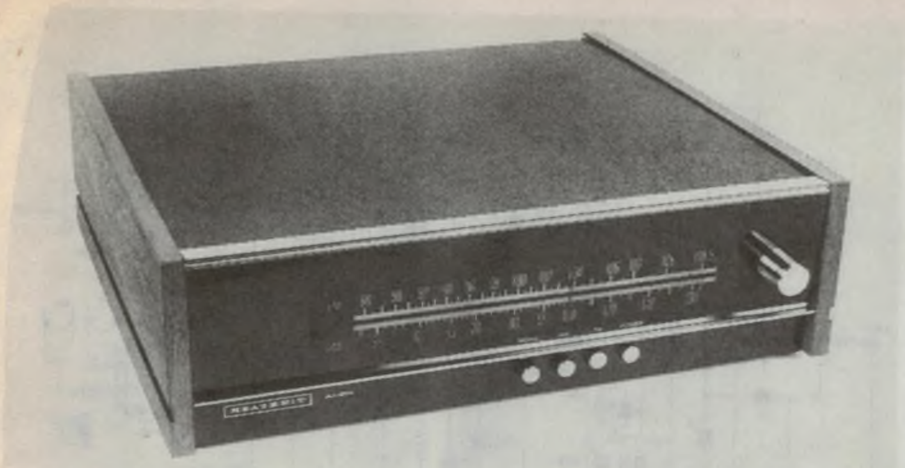
From the outset, the decision to abandon VHF FM broadcasting proved to be an uncomfortable one because:

- It had political overtones, in that a conservative government had effectively reversed a policy endorsed by the Chifley labor government in 1948. Disgruntled hifi/music lovers, as a result, found common cause with the opposition!
- It could well prove to be flawed, with the extra channels so gained providing, in practice, only a short-term solution to TV bandspace problems.
- Sound broadcasters had traded an internationally recognised band and proven technology for a temporary extension of the status quo in an overcrowded AM band.
- Talk of a UHF FM band peculiar to Australia was at odds with efforts being made to rationalise use of the

Inside 2MBS-FM's first studio in Chandos Street, St Leonards, in 1976. To play a tape, one of the turntables had to be unplugged! (Courtesy 2MBS-FM)



3MBS-FM's antenna when it was located at Kew, atop a 30m tower. (Photo by C.W. Gliddon)



An early solid state AM-FM tuner marketed as a kit by Heathkit. Manually tuned, it lacked both crystal lock and AFC (automatic frequency control).

spectrum worldwide. World standard AM/FM tuners and receivers would be unsuitable for Australia

The insecurity generated by such reservations created a high level of paranoia in relation to anything that even vaguely threatened conventional broadcasting.

Ray Allsop's enthusiasm for FM was ridiculed by his peers, on the grounds that his real motive was to get himself a private radio station in the guise of 'experimental'.

When Manager Maurice Brown had Mullard Australia's lab team design a prototype UHF FM tuner, to evaluate its overall performance, it was rumoured that he was 'up to something'. Two large companies even co-operated in monitoring the UHF sector for a clandestine FM transmitter!

When licences were sought, even for educational AM transmitters, a precondition was that the stations must not broadcast music – not even as a marker between program segments. Gongs yes, but musical passages no. They might be mistaken for entertainment! And so on – *ad absurdum*!

The comeback trail

As I remarked earlier, even in this restricted environment, there were still a few optimists who dared to hope for more imaginative use of the airwaves and, in a roundabout way, they helped turn the tide in favour of FM.

Mr B.E. Cabena of Mount Eliza, Victoria, was one of them. In recent correspondence, signed as 'The Pioneer of Public Broadcasting', he reminds me of a letter to 'Forum' we published in the April 1967 issue of this magazine. It was headed 'Radio Station for Music Lovers'.

Says Mr Cabena: "I shall be forever grateful to Mr Williams, as it was the turning point that led to the establishment of Community Radio".

Back in 1962, according to Mr Cabena, he had come up with what he believed to be a workable plan for a listener-owned broadcasting station; one presenting continuous and balanced programs of classical/serious music and financed by a subscription to program notes. Keen to promote the idea, he called a public meeting in Melbourne – but only two people turned up!

For the next five years he tried in vain to interest others and finally, in sheer desperation, addressed the abovementioned letter to 'Forum'. It produced four replies, including a long and enthusiastic letter from T.J. (Trevor) Jarvie, then a research student at Monash University. One other respondent was prepared to assist and, after a meeting of the trio, it was left to Mr Cabena to round up three more people to form a committee of six.

It took until July 1968 to assemble the requisite number and, formalities having been attended to, they drafted a letter to the Melbourne *Age* outlining their plans. The signatories were B.E. Cabena, T.D. Jarvie, (Ms) M. Carey, W. Ruffley, R.C. Sneddon and J. Moorehead.

Music Society

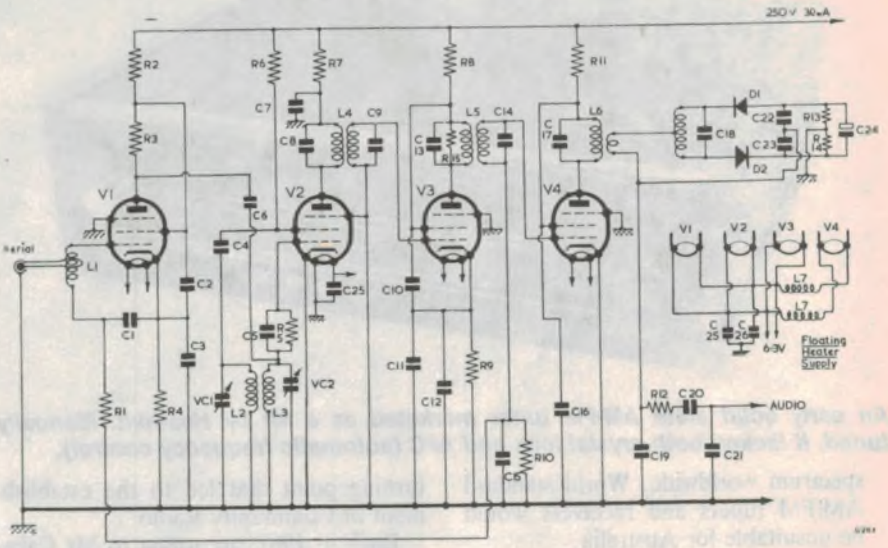
The letter was duly published and in September (1968) 50 people attended what became the inaugural meeting of the Music Broadcasting Society of Victoria. The elected officers were B.E. Cabena chairman, T.D. Jarvie secretary and L. Vermeeran treasurer.

In November 1968, Mr Jarvie returned to his native Sydney intent on forming the Music Broadcasting Society of NSW. Inaugurated in February of the next year, the NSW MBS reportedly set about building up its own separate membership and 'making its presence felt in appropriate places'.

It would have been about this time that Trevor Jarvie called to see me in the *EA* office, to outline Society plans for independent listener-financed music broadcasting stations. As I recall, it wasn't a very cordial session because, faced with his boundless enthusiasm, I could not but remind him of the conservative forces lined up behind the Huxley formula.

I was also aware of educational, community, church and other groups who were pushing for time or channels to promote their various objectives. In the climate of the day, I couldn't see the ABCB granting a concession to the Music Broadcasting Society which

Inside one of the 3MBS-FM studios as they are today. Note the compact disc players. (Courtesy B.E. Cabena)



Reproduced from 'The Radio Constructor' (UK), this simple FM tuner circuit of the 1950's was intended for home construction.

would become an immediate precedent for other groups.

Problems notwithstanding, Mr Cabena recalls that the MBS group spent much of 1969 preparing a formal submission to the ABCB. By that time, the Victorian Society comprised 700 members with more than $4000 in the bank.

Their objective, at the time, was a special licence for an AM channel near the high frequency end of the MW broadcast band. The University of NSW had held just such licence since April 1961 (*R,TV & H* December 1962) but it was expressly forbidden to broadcast music. Now the MBS of Vic, the MBS of NSW and the University of Adelaide were all seeking AM licences – without the music ban.

Mission impossible?

The Victorian application was despatched to the ABCB in November 1969, backed up by a personal letter to every member of the Federal Parliament with detailed information about the Society and its objectives. The Board replied in June 1970 and, in September, the Society received a copy of a further letter that had been addressed to Senator D. McLelland from the then Postmaster-General Alan S. Hume.

A copy of that letter, slightly abbreviated, is reproduced herewith. While reflecting the contemporary attitude of the Administration it also includes an interesting reference to FM – presumably in the UHF sector.

Having been refused an AM licence, the MBS group had no option but to prepare a further submission to the forthcoming inquiry into broadcasting services, which opened on March 1, 1971. At the same time, according to Mr Cabena, there was considerable doubt as to whether anything would come of it.

A Senate Standing Committee on Education, Science and the Arts offered a potentially more sympathetic audience when it set up a hearing into Television and Broadcasting. The NSW MBS had already had put its case, and Mr Cabena was invited to appear for the Victorian group in Adelaide in August 1972.

So also was the Adelaide University which, by then, had accepted a licence to operate an AM station (5UV) on 1630kHz. Because they wanted to use music bridges between program segments, PMG authorities had insisted that the high musical frequencies be filtered out to render it unacceptable as entertainment!

But in December 1972, right in the middle of the game, the rules changed with the election of a Federal Labor government under Gough Whitlam.

After 23 years on the opposition benches, there were old scores to settle and new approaches to be implemented. They ranged right across the political spectrum, but in the realm of electronics and broadcasting Whitlam's ministers had no love for companies which, for decades, had been operating in a protected environment. And they had scant respect for the conservative officials who manned the administrative barricades.

FM reinstated

What was all this, for example, about grabbing the FM band for television and protecting AM broadcasters and local radio factories? Apart from anything else, it was at odds with the new Government's policy of freeing up imports.

An Independant Inquiry into FM Broadcasting was promptly set up under Sir Francis McLean, the former head of BBC research, and Professor Cyril Renwick, of the Hunter Valley Research Foundation.

To industry observers, the findings of the new committee were a foregone conclusion. McLean had seen Britain set up its new 625-line colour TV service on UHF, leaving the VHF FM band open for high quality stereo broadcasting. What more natural than his recommendations for Australia should be along similar lines?

And this they certainly were. Turning the clock back to the 1948 decision by the Chifley Government, the Whitlam government ruled that the FM band should be progressively cleared; that TV services should expand, or be redeployed as necessary, into the UHF bands; that new colour receivers – and by inference VCRs – should provide UHF coverage to ensure future compatibility.

The TV expansion/redeployment process is still going on, although less smoothly than had originally been hoped, because of technical and financial problems.

But, back in 1974, the urge was to support the decision with action – in short, to get at least token FM signals to air. What more fitting than to give the nod to the Music Broadcasting Societies which had been organising for years?

Mr Cabena records that, having represented the Society at all hearings, he felt reasonably convinced by January 1974 that they would get a licence – not on medium-frequency AM, but on the resurrected VHF FM band. He set about raising more capital and, by August of that year, working more or less alone, had assembled studio equipment and was addressing the design of a 2.5kW transmitter.

The invitation for the Melbourne MBS to apply for a licence came that September, in line with Mr Cabena's expectation. A similar invitation was extended to the Sydney MBS in the December – according to *2MBS-FM* magazine – much to the astonishment of Trevor Jarvie.

But the Sydney group were in the fortunate position of having on hand a couple of small stereo FM transmitters. The handiwork of Trevor Jarvie, Grahame Wilson and Max Benyon, they were originally intended to demonstrate FM stereo at the '75 Sounds Fantastic' hifi show (August 1974) and at other such exhibitions.

They were also fortunate in having a keen back-up group on call, and in obtaining an interim 2-room office in Alexander Street, Crows Nest.

When the okay came through, 'mid December' was nominated as the target date for the first transmission. This was set in official concrete when it was interpreted as December 15 and read into Hansard by the then Minister for the Media, Senator Douglas McLelland.

The office in Alexander St was transformed into a temporary studio, a makeshift antenna was erected on the roof and 2MBS became a radio station – with an output power of 15W!

Two weeks later, the transmitter was moved to the Telecom Tower in West St, North Sydney, and the power increased to 400W. On January 25, 1975 the stereo decoder was switched on and 2MBS became Australia's first FM-stereo broadcaster. Today, it is a modern 5kW public broadcasting station, well respected on Sydney's airwaves.

In Melbourne, according to Mr Cabena, they took a different approach. With a transmitter site available and a permanent studio, they determined not to go to air until they had a fully operational stereo broadcast facility, complete with record library and office system. 3MBS went to air on July 1, 1975 with a start-up power of 200W, which was increased to 4kW two months later – making them, at the time, the highest-powered public broadcaster on the air.

The two MBS groups had not only blazed the trail for listener-financed public broadcasting but, in the process, had also helped win back and populate the VHF FM band.

In due course, 2MBS in Sydney was joined by two other high-power public stations, 2SER and 2CBA (Christian Broadcasting Association), the latter of which had been supplying pre-recorded religious programs for years to AM stations around Australia. In Melbourne, 3MBS was joined by 3PBS and 3RRR – all on 10kW.

Since then, licences have been issued for public or community stations all over Australia, mostly FM and ranging in power from 20kW down to 10W for restricted local coverage. The January 1989 issue of *EA*, which is at hand as I write, lists 75-odd public FM stations, with more to come. It would probably not be too far from the truth to suggest that, behind them, are 75-odd stories of personal and communal initiative.

Not to be outdone, the ABC opened its official FM network in January 1986, based in Adelaide and with outlets in Melbourne, Canberra and Sydney. That was just the beginning; when the above-mentioned list was compiled, the number of AM outlets (101) had already been overtaken by their FM outlets (125) ranging in power from 150kW in Mt Gambier (SA) to a couple of 5W outlets at Galiwinku (NT).

The VHF FM band is up and running, in no uncertain manner.

The ultimate irony in all this is that the 13-odd commercial FM stations licenced to date have done so well that AM stations have been forced to upgrade to stereo, in an effort to compete. Moreover, as I write, several established AM broadcasters in Sydney are debating whether to tender megadollars for an alternative spot in the FM band!

As I forecast in April 1962: for a spot in "the very VHF band that they were once glad to see cut up". EA

Silicon Valley NEWSLETTER

Bush to drop Sematech finding?

A Democratic congressman from Los Angeles, Mel Levine, has sent shockwaves through the US semiconductor and other high-tech industries with a report that the Bush Administration may be planning to drastically scale back, if not eliminate Pentagon funding for Sematech, the year-old chip manufacturing research consortium.

Levine announced before the House Committee on Science, Space & Technology that he has learned from high government officials that the Administration was seeking ways to eliminate money for Sematech. Levine also alleged that the Bush Administration is planning to eliminate the Pentagon's funding of HDTV research projects, and cut support to the Technology Assessment Program of the Commerce Department.

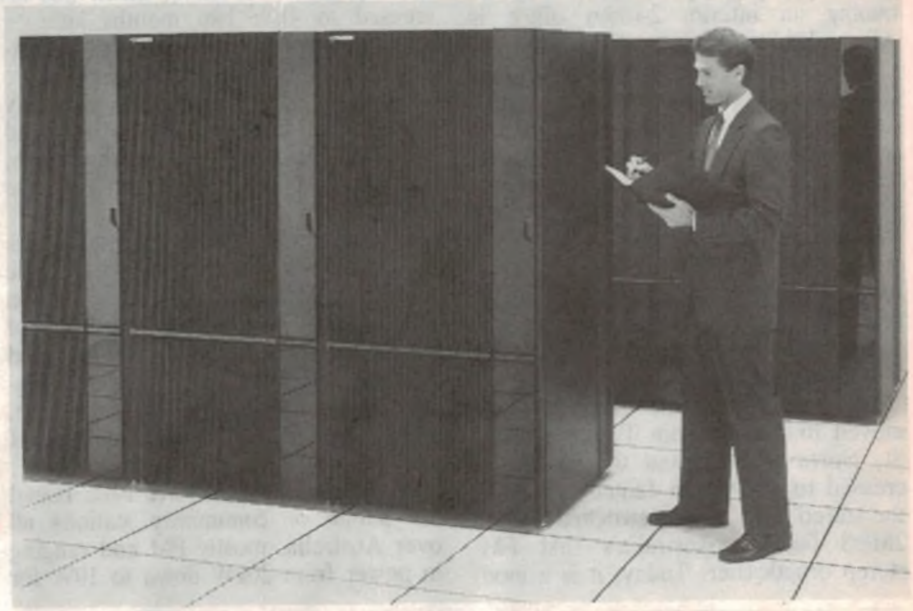
"My office has received numerous leaks indicating that high administration officials are conducting a 'slash-and-burn' campaign, seeking to systematically eliminate most of the major initiatives designed to return this country to the industrial cutting edge," Levine told the Congressional committee.

He added that America's powerful foreign competitors could not have designed or envisioned a more effective strategy to undermine the health and strength of the US industrial base. "If we had intelligence indicating such a plan to dismantle the key industry-government R&D programs upon which much of our future depends, we would regard it as an act of economic warfare."

Levine made his statements as the committee was in the process of considering future funding proposals for Sematech, which is receiving US$100 million a year in federal funds to develop advanced new semiconductor manufacturing technology.

At the Pentagon, Robert McCormack, the acting deputy undersecretary of defense for acquisition, denied that the Defense department was about to cut its commitments to Sematech and the HDTV project which is managed by DARPA (Defense Advanced Research Projects Agency). "No way," McCormack said about the congressman's allegations.

Industry observers noted that it would seem politically inconceivable for the Bush Administration to cut funds for programs designed to help American industry regain its ability to compete worldwide in a variety of industry sectors.



The new 'NonStop Cyclone' mainframe computer from Tandem Computers, which features 4-16 high performance processors and a fibre-optic bus.

Sony chairman angers Americans

Most Americans who read excerpts of *The Japan That Can Say No*, a best-selling Japanese book that contains essays by Sony chairman, Akio Morita and politician Ishihara, are infuriated, and it's easy to see why.

Morita and Ishihara – who finished third in his party's recent election to choose Japan's prime minister – are said to lash out at the United States and make some 'incredible, antagonistic and bitter' statements. For example, Ishihara says the US dropped atomic bombs on Japan and not on Germany during World War II, because of its racial attitude towards the Japanese.

The book is so anti-American that the authors have supposedly refused to allow it to be translated into English. Nonetheless, a 65-page unauthorised translation of some of the chapters is circulating on Capitol Hill and among corporate executives, and it's well worth reading.

If you can overlook the political rhetoric and focus on what the two Japanese leaders write about the US and Japanese economies, you'll find many observations more accurate than what Americans usually hear from their own politicians and corporate executives.

"The American economy appears to be deteriorating," Morita writes. "Instead of making products, Americans focus much of their energy on playing 'money games' such as mergers and acquisitions by moving money back and forth."

He's absolutely right, of course. The way to make the most money through most of the 1980's as an investor, was to play the mergers and acquisition game. And the most lucrative, glamorous careers available to people who weren't world-class athletes or entertainers were in investment banking. That's why that profession attracted the cream of the crop from the nation's business schools.

Even in Silicon Valley, where chief executives profess to be enlightened, mid-level and senior manufacturing jobs usually pay less than the same-level jobs in other areas, such as finance and marketing. And manufacturing jobs are far less likely to propel you into the chief executive position.

Morita also points out the danger of the emphasis on the short run. "We are focusing on business 10 years in advance, while you seem to be concerned only with profits 10 minutes from now. At that rate, you may well never be able to compete with us," he says.

That short-run focus is particularly-harmful to high-tech companies because they often need considerable capital and patience before their products become successful.

Morita also correctly lashes out at the amazingly high salaries and other benefits that many top US executives give themselves and their cronies – a process that alienates employees and weakens the companies.

IBM accepts Rodgers' challenge

A couple of months ago, T.J. Rodgers, president of relatively tiny Cypress Semiconductor, put giant IBM on the diplomatic defensive when he challenged IBM president Jack Kuehler to give Cypress the same DRAM know-how IBM has agreed to provide to US Memories. Rodgers boldly claimed Cypress would be able to put the technology into production in less than a year and for a fraction of the $1+ billion that the industry consortium plans on spending.

Of course, IBM could have simply ignored the diplomatic ping-pong ball and no one would have ever remembered the incident.

But IBM has taken the unusual step of taking Rodgers up on his challenge and it has launched the equivalent of a canon ball at tiny Cypress.

In a move that probably came as much as a surprise to Rodgers as anyone else in the industry, IBM announced it has invited Rogers to meet with its top semiconductor executives, to present his business plan for producing IBM's DRAMs.

So far, Rodgers is not showing signs that his bluff may have been called. Rodgers said he is optimistic that he may soon find himself in the DRAM business and has accepted the IBM invitation. Other industry executives and observers are not so sure, saying they think Rodgers may have gotten a lot more than he bargained for when he put up his bold challenge. If he has to back off, IBM will have effectively quieted the chip industry's most vocal sideline heckler.

"Mr Rodgers is in for an education," commented Sandy Kane, the president of US Memories and the former chief of IBM's semiconductor operations. "It seems he is saying he can get into the memory business for US$10-15 million. And he is dead wrong! You just can't do a big product like DRAMs in a little fab in Round Rock, Texas (the Cypress Fab where Rodgers says he can produce the DRAMs.) You just cannot do this in a small way."

Still, Kane said if Rodgers can somehow pull off the scheme, he would welcome the additional competition. "If he can pull if off, it's terrific."

At IBM, a company representative said IBM is definitely not trying to show its DRAM know-how around the industry. But he added, "We are open to proposals and discussions with anyone."

Corrigan named SIA chairman

Wilf Corrigan, who as president of Fairchild Camera & Instruments in the early 1970's, spearheaded the formation of the Semiconductor Industry Association, has become the group's 1990 chairman. Joseph Parkinson, chairman of Micron Technology was named as the group's vice chairman.

"1990 will be a very important year for the SIA, because it will set the tone for the 1990s," Corrigan said. "In the area of trade, we need to achieve greater access to foreign markets such as Japan and prevent any reoccurrence of dumping. We must also pay close attention to the unification of Europe to assure that the fair trade conditions prevail."

Corrigan also noted that as chairman of the SIA he will work hard to help strengthen the US manufacturing base before the country becomes completely dependent on foreign suppliers for strategic products and technologies. "Our success in the areas of trade and manufacturing will ultimately hinge on our ability to work as a team with the other segments of the American electronics industry. One of our most important goals will be to reach a consensus with US system producers on a variety of issues."

Kasparov trounces chess computer

Mankind can rest assured that while today's top-of-the-line computers may be faster than humans at calculating things and processing large volumes of data, they're not smarter than us. At least not at the ultimate express of human intellect, the game of chess.

After defeating several low-ranking grandmasters earlier this year, mankind, in the person of world chess champion Gary Kasparov, put computer world champion 'Deep Thought' back into its own world of silicon reality.

Kasparov won both games of a two-game demonstration chess-off with Deep Thought, a chess computer designed by a team of researchers at Carnegie-Mellon University. In the first game, Kasparov took 52 moves and 3.5 hours to force the computer to retire from the game. The second game lasted only 37 moves when Deep Thought surrendered.

"I expected it. It is a good player, but without position and experience," said the outspoken Russian chess champ, who hasn't lost a chess tournament since 1981.

IBM licenses DRAM technology to Micron

In yet another unexpected announcement from IBM, the Armonk computer giant said it has licenced its world-class 4-megabit DRAM technology to Micron Technology, the Boise, Idaho-based memory chip maker.

The announcement comes only a few months after IBM said it would provide its DRAM technology to start-up US Memories.

Under the terms of the Micron deal, the chip maker will pay IBM royalties on the sale of DRAM products made under the DRAM technology licence. In addition, the two companies have agreed to share patents on each other's memory product technologies and cooperate on the development of new memory chip technology.

Although it was speculated that Micron may have paid IBM a certain cash sum for the DRAM technology as well, neither company would comment on that aspect of the transaction.

The licence agreement with Micron is 'non-exclusive,' and IBM officials indicated the company may enter into similar agreements with other companies.

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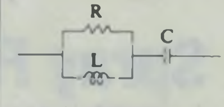
The powerful impedance calculation keys of the fx-61F allow one-touch calculations of composite impedance for AC circuits (parallel/serial/mixed) that include resistors, coils, and condensers. This function also lets you calculate the absolute value and deviation angle of the calculated composite impedance.



$f = f_0\,[\mathrm{Hz}]$

$$\frac{1}{\dfrac{1}{R}+\dfrac{1}{j\omega L}}+1/j\omega C$$

⇩

$$\frac{\omega^2RL^2}{R^2+\omega^2L^2}+j\left(\frac{\omega R^2L}{R^2+\omega^2L^2}-\frac{1}{\omega C}\right)$$

■ **Key operation using a conventional scientific calculator**

2 [×] π [×] f_0 [=] [Min]
[MR] [x²] [×] R [×] L [x²] [÷] [(] R [x²] [+] [MR] [x²] [×] L [x²] [)] [=] [x↔y]
[MR] [×] R [x²] [×] L [÷] [(] R [x²] [+] [MR] [x²] [×] L [x²] [)] [−] [(]
[MR] [×] C [)] [1/x] [=]

■ **Key operation using fx-61F**

f_0 [f/ω]
R [//] L [⏚] [+] C [⊣⊢] [=]
[Re↔Im]

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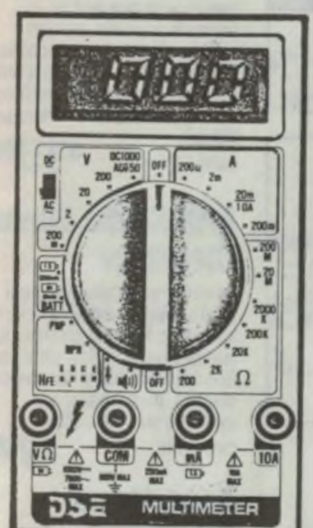

Ranges:
DCV: 0.2, 2, 20, 200, 1000
ACV: 0.2, 2, 20, 200, 650V
DC: 200uA, 2, 20, 200mA, 10A
AC: 200uA, 2, 20, 200mA, 10A
Resistance: 200, 2k, 20k, 200k, 2M, 20M, 200M
Transistor Check: Hfe
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-20 to +22dB

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250 mA DC
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Batt 1.5 and 9v
-20 to +62 dB

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Scale area — 58 x 31mm
Overall — 58 x 52mm
Mounting: Hole required - 44mm
Bolt holes: 38mm square

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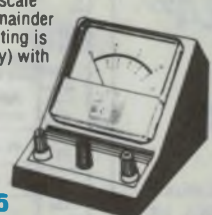

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KITS KITS KITS

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Add colour to your music at parties and dances! Our new Chroma Vox uses the latest technology in Triac Driver IC's and gives you three channels which can be connected directly to speaker or headphone outlet. There's a master level control and each channel has adjustable sensitivity. With a high level of insulation between mains and signal output, insulated case and front panel, and specially selected potentiometers for the maximum safety. Will drive up to 2400W of incandescent lamps. Kit comes complete with a pre-punched, silk screened front panel and pre-punched rear panel.
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$139

Simple FM Receiver For The 6M Band NEW

Here's a great new project that's very simple and produces amazing results! An easy to build receiver which lets you listen to amateur radio on the 50 to 54MHz band. It uses a low noise MosFet front-end and a single IC performs most of the receiver functions (The new MC3363). It will even form the a basic 'tuneable IF' receiver module for future converters to cover other amateur bands. Full form kit comes with all components and hardware.
Cat K-6005
Please contact your nearest Dick Smith store for the price and availability

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Universal UHF Remote Control Switch

It's easy to build and can be used for switching security systems, lights, doors... almost anything you can think of! The kit consists of a 304mHz receiver, decoder IC and output relay driver on a single board. Full form kit, including pre-punched panel, panel label, PCB and all necessary components. Also comes with Department Of Communications (DOC) approved transmitter!
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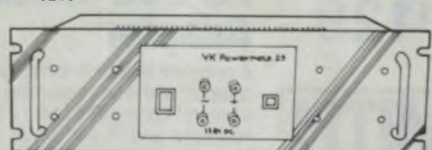
$249



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CASE (Cat H-2481) &
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The transmitter and receiver are housed in a small case which fits in the jacket pocket. The speaker and microphone are fitted in the helmet. As well, the microphone is voice activated to save switching. Beware though, it is not easy to build and is best tackled by someone with a sound knowledge of kit construction. Comes complete -ready to assemble with all components, PCB, mics, speaker, case and a Pre-punched silk screened front panel. Powered by three penlight batteries (not included).
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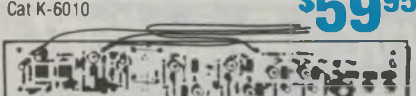
Simple FM Transmitter For The 2M Band

The first in a great new series of easy to build projects for the amateur radio enthusiast. The solid state NBFM transmitter module produces over 1 Watt at 144MHz. The oscillator frequency, around 24MHz, is multiplied in two stages, first a tripler... then a doubler to 144MHz. The resulting signal is amplified through several stages before being fed to an antenna. Short form kit contains components and PCB.
Cat K-6010

$59.95



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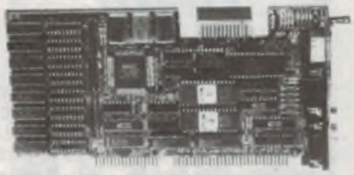

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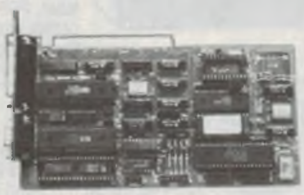

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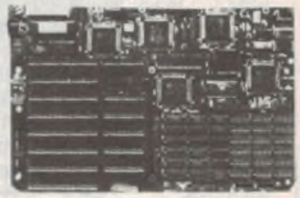

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High quality disk drives which are suitable for use with IBM compatible computers.

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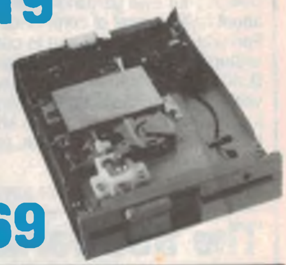

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FORUM

Conducted by Jim Rowe

The thick wire is for bass, and the thin wire for treble...

Yes, I've had some further letters on the subject of fancy hifi cables and the claims made for them. There's also a somewhat ironic letter pointing out a subtle but embarrassing error in one of my own project designs (gulp!).

A few weeks ago a letter turned up from Maurice Findlay, who was a staff member of the magazine back in the days of John Moyle, when it was called *Radio and Hobbies*. Since leaving the magazine (just before I joined it myself), Maurie has made quite a reputation for himself as a designer of communications equipment, and I gather his services as a consultant are in heavy demand.

Apparently his letter was prompted by our discussion in the November issue of some of the claims made for exotic audio cables. In general he seems to agree with my own skepticism, and to emphasise that the claims I quoted were by no means isolated, he sent in a clipping from the Sydney *Sunday Telegraph* dated November 5, 1989.

The article concerned is headed 'Quality Cable Pays Off', and is credited to a contributor or staff member by the name of Rod Easdown.

Most of what Mr Easdown has written is fairly mild and generalised stuff in broad support of fancy cables, not too different from what we've seen to date. But there were a few sections to which Maurie Findlay had drawn particular attention, because he believed they either took existing claims further than before, or made claims that were even *more* dubious. And having read them myself, I can see what he means.

Here are the sections concerned:

Speaker cable is just that – cable designed to carry a signal from the amplifier to the speakers. Interlinks are designed specifically to connect one component, say a CD player or a turntable, to the amplifier.

Some interlinks are so specialised they are designed to carry the signal in one direction only, and heaven help you if you connect them up the wrong way around...

...If you're not convinced any cable can be worth $50 a metre – or even $5 a metre – go into a good dealership and ask the salesman to show you some. Better still, ask him to start unwinding the insides of some.

You'll find differing wires of such intricacy it really is mind-blowing. The thicker copper wire is wound specifically to carry bass while the thinner, more delicate wire is reserved for the higher signals.

You don't need golden ears to hear the effect. In fact, the distributors of one brand of cable offer a money-back guarantee on their products, and in the several years that it has existed, they have only once given money back.

That was to a buyer who was so impressed he brought his cable back to swap it for some that was more expensive.

Well – what do you think of *those* claims, eh? I'd never struck that one about the different frequency handling characteristics of thick and thin wire before – it's certainly a doozy.

You can see where someone with little more than a modicum of technical knowledge might have been led to make the deduction, though: speakers designed for high frequencies are generally fairly small, while those designed for low frequencies are often rather larger. So *ergo*, thick wire must be right for the bass notes, and thin wire for the treble!

Somehow I doubt that even the people who market and/or sell the fancy cables would be game to make that kind of claim, for fear of being laughed out of court. Still, perhaps I'm wrong – after all, they do claim that their interconnecting cables are directional!

Could there be any truth in the claim? Not that I can conceive, at least. About the only possible support might come from considerations of skin effect, although as we've agreed before this is not likely to have any real significance at audio frequencies. In any case, the way to minimise the influence of skin effect on cable impedance is to provide the cable with as much effective surface area as possible – which would tend to mean that a relatively thick or multi-stranded cable would be even more important for the treble than for the bass.

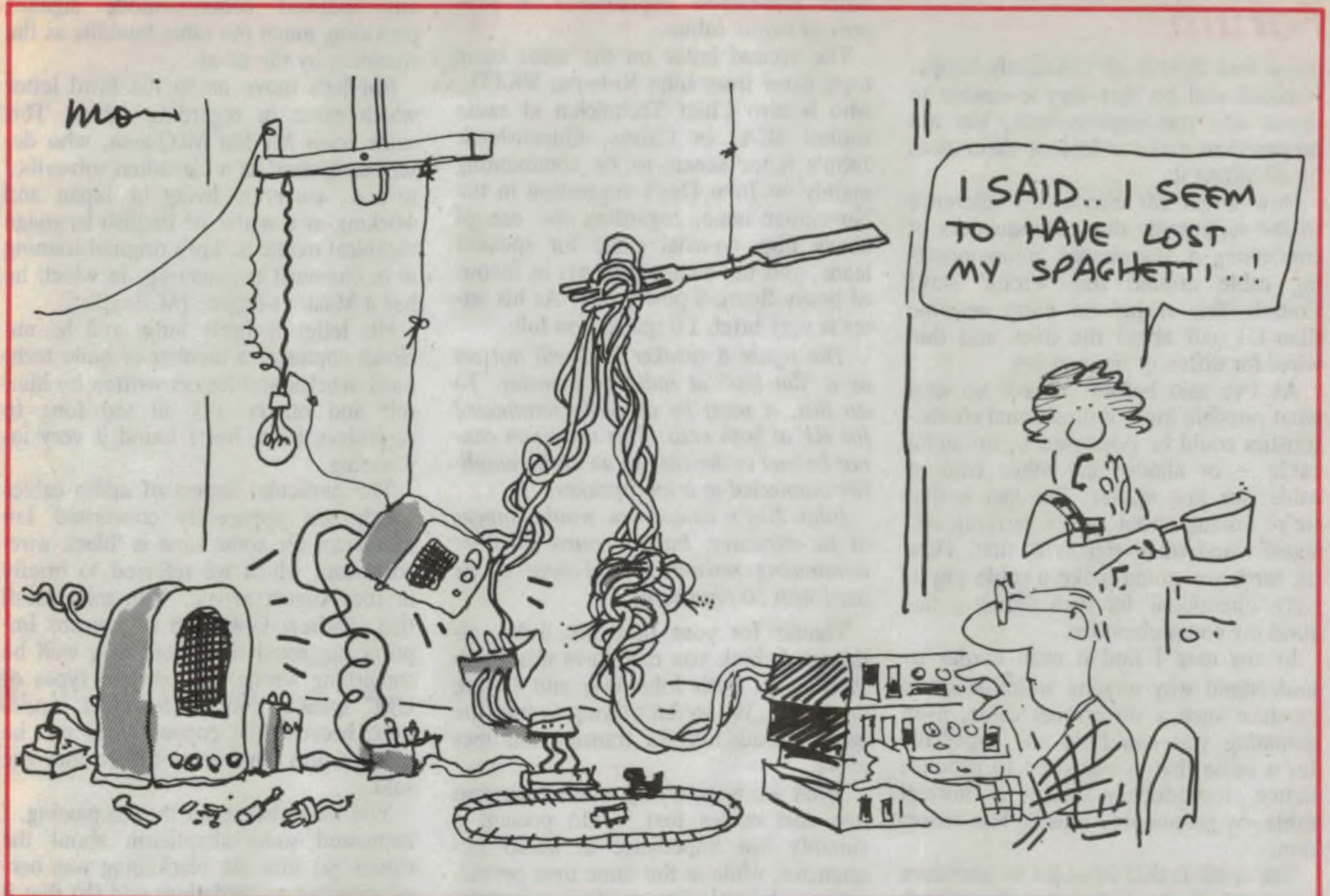
This is assuming for the moment that low cable impedance is just as important for the high frequencies as it is for the low frequencies, of course. Which is probably a moot point in itself; as I understand it, the behaviour of the loudspeaker is in any case less influenced by the electrical driving impedance at high frequencies than at low frequencies.

In other words, while the behaviour of a loudspeaker tends to be determined fairly strongly by the external electrical circuit connected to its voice coil at low frequencies (i.e., in the vicinity of its primary resonance), this is generally much less so at higher frequencies. Here there are inevitable decoupling effects, introduced by such things as leakage inductance and higher-order cone resonances. As a result, what happens at the higher frequencies is much less subject to 'control' via electrical means.

So a low effective driving impedance, preserved by ensuring that the cable impedance itself remains low, is probably less effective at controlling speaker behaviour at the higher frequencies than for the bass end.

Could this be what Mr Easdown was suggesting? Frankly I doubt it. I think it's much more likely that he was drawing the crude and highly dubious 'woofer-tweeter' analogy.

In any case, the reduced controlling effect of low driving impedance on speaker behaviour at high frequencies is not an argument for using some combination of thick and thin wires, in the misguided hope that the higher frequencies will somehow be encouraged to run along the thin and 'delicate' wires. We're talking about a regrettable secondary complication, and one that simply makes it less easy to control speaker



behaviour.

The fact is that even though we can't exert as much electrical control over a speaker at high frequencies, there's still every reason for making the most of the reduced opportunity.

In other words, it's still a good deal better to have the lowest possible driving impedance, by using fat cables, rather than deliberately allowing it to rise – by using thinner and 'more delicate' wires. It's just that even a fat, umpteen-stranded cable can inevitably provide less benefit at high frequencies than at low frequencies, that's all.

Why then do makers of fancy speaker cable provide thick and thin wires, in complex configurations? I'm blessed if I know, although I can make a few guesses.

Perhaps they do it to justify the fancy prices, by making the cables *look* more elaborate and 'scientific' than a plain umpteen-stranded cable. Or perhaps they do it for a more down to earth reason: to make the cable a little more flexible, and allow greater movement before fracture of the many strands of copper.

Let's forget the thick bass wire and thin treble wire, though, and pass on to Mr Easdown's claim about no one having ever wanted their money back. Except one customer, who apparently got his money back even though he swapped the cable for one that was more expensive. (Presumably *he's* not complaining, for a start – he got the dearer cable AND his money back!)

This is a claim that tends to be made fairly often. In fact I remember it was made by Andrew Goldfinch of Leisure Imports, in his letter published back in the August 1989 issue, although I didn't get around to commenting on it before.

Does the fact that supposedly no-one has availed themselves of the money-back guarantee mean that (a) the cables do everything claimed of them, and (b) everyone who buys them is therefore delighted with the dramatic improvement in sound quality? Not at all, I suggest.

In fact it seems to me that this is one of those situations where the old 'emperor with no clothes on' phenomenon applies perfectly.

Let's face it. Say *you* let yourself be persuaded by not-too-informed media 'experts' and fast-talking salesmen into shelling out hundreds of bucks for exotic fancy speaker and/or inteconnecting cables, which are supposed to make a dramatic improvement to the sound quality of your stereo system. You then take them home, hook them up and sit back, listening for the expected improvements.

What if you really can't hear the difference? Are YOU going to admit this to your family and friends? Worse still, are you going to take those fancy cables back to the store, and demand your money back because you can't hear the difference?

Not a bit of it, of course. Taking them back is basically admitting that you have cloth ears – that you couldn't recognise *really* clean sound if it hit you squarely between the ears and from a great height.

Not only that, but taking them back is also admitting that you were conned. And no one likes to admit that, do they? It's a bit like banks or finance companies refusing to prosecute white-collar criminals, because doing so means public admission that their security systems are fallible. Better to grit your teeth and quietly bear it, in both cases.

What I'm suggesting, then, is that even if no-one has ever returned one of these cables for a refund, this doesn't mean that they're all deliriously happy. It could well be that they're unable to detect any real improvement, but not prepared to make a fool of themselves by admitting it.

How about Mr Easdown's reference to the supposedly dire consequences of connecting a 'directional' interconnecting cable around the 'wrong' way? Frankly this seems no more sensible than his gaff about the thick and thin wires for different frequencies.

As I've said before, I have no idea what possible kind of directional characteristics could be possessed by an audio cable – or almost any other kind of cable, for that matter. The fact is that we're talking about cables carrying AC signals, and small signals at that. How on earth you could make a cable physically 'directional' for such signals is beyond my comprehension.

In any case I find it even harder to understand why anyone would *want* to produce such a directional cable, even assuming you could do so. Especially for a cable that is supposed to produce better reproduction than a normal cable, by presumably causing less distortion.

The truth is that in order to introduce any kind of physical power directionality, a cable would have to possess some kind of *nonlinearity*. And the result of nonlinearity is signal distortion. So a 'directional' cable would produce not *less* distortion, but *more* – just the opposite of what one would want, surely.

So what Mr Easdown is driving at, when he writes "heaven help you if you connect them up the wrong way around", I can't imagine. Frankly I doubt if the outcome could be much worse than the result of connecting them up the 'right' way around!

What's *my* position on these 'directional' interconnecting cables? Well, I've never seen any real and objective evidence in support of the claims made for them. And frankly until I do, I'm remaining very skeptical. I doubt very much if they're 'directional' at all, in any real sense, or if they do anything at all different from a normal high quality cable – regardless of which way you hook 'em up.

In short, I put them in much the same category as those 'polariser' gadgets which have a lump of quartz crystal, and are supposed to make your car run 'more sweetly' by making all of its molecules line up properly.

But anyway, my thanks to Maurie Findlay for drawing attention to yet another half-baked 'explanation' in support of exotic cables.

The second letter on the same basic topic came from John Roberts, VK4TL, who is also Chief Technician at radio station 4CA, in Cairns, Queensland. John's letter seems to be commenting mainly on John Day's suggestion in the November issue, regarding the use of heavy duty co-axial cable for speaker leads, and my own comments in favour of heavy figure-8 power flex. As his letter is very brief, I'll quote it in full:

The figure 8 speaker lead will not act as a 'flat line' at radio frequencies. To do this, it must be correctly terminated for RF at both ends. This condition cannot be met in the case of an audio amplifier connected to a loudspeaker.

John Day's co-ax idea would appear to be attractive, but of course 50 ohm terminating resistors would need to be used with 50-ohm co-ax.

Thanks for your thoughts, John, although I think you may have misunderstood what both John Day and I were driving at. We weren't trying to turn the speaker leads into RF transmission lines at all.

What we were trying to do is suggest low cost cables that would present a suitably low impedance at audio frequencies, while at the same time providing a high level of protection against the entry of external interference such as RFI, back into the amplifier via the speaker leads and negative feedback loop.

Hence John Day's suggestion to use heavy duty co-ax. This has a stout solid copper centre conductor, to provide our low impedance audio path, while the outer braid would provide shielding against the entry of RFI. But the cable wouldn't be used as an RF transmission line – purely as a heavy duty shielded cable.

I agree that it would be quite difficult to terminate the cable properly, at either end, as a RF transmission line. But that wouldn't be necessary. In fact it mightn't even be *desirable* – assuming some RF did still find its way into the cable, it would be better if it was reflected back rather than absorbed, especially at the amplifier end!

And the same general idea was behind my suggestion about heavy duty figure-8 cable. Again this provides a suitably low impedance audio path, while the close spacing of the conductors ensures that any RFI which may be induced into one conductor will be balanced by a virtually identical signal induced into the other, to cancel it out. In other words, there is a high rejection of any induced common-mode signals, providing much the same benefits as the shielding by the co-ax.

But let's move on to the third letter which came in regarding cables. This came from Mr Ian McQueen, who describes himself as a Canadian subscriber to *EA*, currently living in Japan and working as a writer of English-language technical manuals. Ian's original training is in chemical engineering, in which he has a Master's degree (M.Eng.Sc).

His letter is fairly long, and he encloses copies of a number of quite technical articles and letters written by himself and others. It's all too long to reproduce here, but I found it very interesting.

The particular aspect of audio cables which has apparently concerned Ian McQueen for some time is 'black wire' corrosion, which we referred to briefly in the August article. You may recall that Andrew Goldfinch of Leisure Imports suggested that there may well be something wrong with certain types of OFC speaker cables with clear insulation, because the copper wires can be seen to turn black even before they are sold.

You may also recall that in passing, I expressed some skepticism about the claims (a) that the blackening was necessarily due to oxidation; and (b) that it doesn't also happen to cables with black opaque insulation – possibly the only difference being that you can't see it.

Well, it turns out that Ian McQueen has done quite a lot of research into the 'black wire' phenomenon, and consulted with various specialists in the area of corrosion and polymer chemistry. And his conclusion is that the blackening is due to corrosion of the copper, caused by chemical breakdown of the PVC (polyvinyl chloride) insulation.

Apparently PVC is basically an unstable compound, and requires stabilisers to prevent (or perhaps only delay) its decomposition. And when it does break down, it releases either HCl (hydrochloric acid) gas, or possibly chlorine itself – either of which is quite corrosive and accordingly attacks the copper.

How about clear insulation versus the black opaque variety? Here Ian McQueen comes up with a verdict which certainly won't give many of us much joy – but especially Andrew Goldfinch.

It turns out that the 'black wire' effect has actually been found to occur *most frequently* in wire with PVC insulation that is coloured (you guessed it!) BLACK. Although it has also been found to a lesser extent in cable with insulation of other colours as well...

Apparently the black pigment often used in black PVC is finely-divided carbon, which seems to have some kind of catalytic action in speeding up the decomposition of the PVC itself.

So it looks as if the copper wire in a cable with black opaque may well be *more* likely to go black faster than with other cables – even though you can't *see* it happening, as you can with a clear cable.

Perhaps it is better to have a cable with clear insulation, after all. Hopefully without any pigments the PVC will be rather more stable, and release corrosive vapours much more slowly. In any case you'll at least be able to *see* if the copper is being corroded!

My thanks to Ian McQueen for taking the trouble to write, and shine some light on this rather specialised topic.

Humble pie time

Now for our last letter this month, the one which draws attention to an embarrassing gaff by yours truly.

What makes it even more embarrassing is that the letter comes from our old friend Mr Len Spyker, of Karrinyup in Western Australia. Yes, that's right – the very Mr Spyker who has been trying to get us to have all of our project designs checked out by a panel of independent experts, before we publish them.

Well, the same Mr Spyker must be quietly smiling away to himself at the moment, as a result of discovering a design mistake in my 'Simple DC Voltage Reference' project, as described in the October 1989 issue. And I don't blame him in the least – he's entitled to at least a few chuckles, at the irony in the situation.

Mind you, he's far too urbane to rub my nose in it. On the contrary, in fact. Here's what he wrote:

One of my lecturers in a computer software course would ask me – teeth gritted together – when looking at my obscure programmes: "How would you go about explaining your programme to Professor Dykstra?" (Dykstra the world-famous guru on structured programming). I would then rethink it rather quickly.

I don't know who you revere as a good electronics designer – maybe Williamson, of valve hi-fi amplifier fame. Please mentally try to explain to that personage why you would place a leaky tantalum capacitor across the only bit of a circuit where its leakage current really matters.

I refer to the article 'Simple DC Voltage Reference', in EA for October 1989. The noise reduction capacitor C3 on pin 8 of the AD689 is directly across the effective reference voltage fed to the comparator op amp. As a result ANY leakage in C3 will drop the reference voltage – upsetting the stability and long term accuracy of the otherwise very neat project. A green cap or mylar 1uF capacitor is needed here, to guarantee the standard's long term value.

I would have filled a few tea cups with dead and leaking TAG tantalums in my years of fixing electronics and computers. Especially in high resistance value power-up reset circuits, which then totally cripple the machine – all caused by a leaky little TAG style tantalum. What unnecessary grief to all concerned!

While working in the Telecom Research Labs in my apprenticeship, the aim there was the design of gear for a 25 year life span. They had tables of MTBF on all components – very illuminating indeed. You could probably get copies of these reports from TRL staff, if need be.

Please publish an errata note. Also for RV1 you should really have specified a 10k CERMET trim pot. It's probably what you used, anyway.

Well now – wasn't that a good way to make the point?

My hat's off to Len Spyker, for drawing attention to the error. He's perfectly correct; if there was one place where I *shouldn't* have used a tantalum (or any other kind of electro) in the circuit, that was it. No excuses – it was a stupid mistake. And as you may have noticed, I managed to squeeze an erratum note into last month's issue, just before it went to press.

The idea is, as Len Spyker writes, to use a metallised polyester or mylar capacitor for C3, to ensure that there is much lower leakage. It doesn't really have to be 1uF, though; even a 0.1uF offers reasonable noise reduction, and you mightn't be able to fit in physically a capacitor larger than 0.33uF.

Mr Spyker is also quite right about the CERMET trim pot. I did use one in the prototype, and for stability this type is certainly to be preferred.

I like the suggestion that we should study MTBF data more closely, too. It sounds like we should even try publishing an article on the subject – although it would have to be very well written. Just about all of those I've ever seen have been incredibly boring and off-putting. Perhaps Len Spyker would be able to present it in a more interesting and relevant fashion.

As to which circuit design guru I would like to try justifying my mistake, my answer must of course be "none" – because it can't *be* justified. But if you ask which circuit designers I really respect, the names that spring to mind are Bob Pease (the legendary in-house designer and troubleshooter at National Semiconductor in the USA) and Bob Webb, an old friend of mine from our uni days.

I haven't seen the latter Bob for many years; he used to work at the old Mullard laboratory in Sydney, but then he moved to Melbourne (to the TRL, if I remember rightly) and we lost contact. I do remember that Bob Webb was an absolute whizz at circuit design and analysis, standing head and shoulders above everyone else. No wonder he topped our year!

But why on earth would I want to explain my feeble little design mistake to one of these design gurus? It would be even more embarrassing than having to confess it here, to all of you!

By the way, if anyone down in Melbourne knows Bob Webb, you might let him know that I'd be delighted to hear from him. But for gorsake don't tell him I advised people to put a tantalum bypass on pin 8 of an AD689 voltage reference chip...

The Serviceman

The set that pleased itself about turning on and off

Our main story this month comes from my own bench. It's about a confusing set of symptoms, and the difficulties one can have in separating two different faults in the same general area of a system. There's also an interesting story from a colleague in Queensland, regarding VCR head replacement.

The set was an oldish AWA remote control model, fitted with the Mitsubishi 'K' chassis. The complaint was that it kept switching itself off, or sometimes wouldn't switch on. Then at other times, it would change channels for no apparent reason.

When I first saw the set, it was working perfectly and continued to do so for half an hour or more.

It was likely to go on this way for hours, so I decided to do something nasty to it, internally, in the hope that it might be provoked into playing up.

As the back came off, the first thing I saw was the line output board and this reminded me of a common trouble with all of these early Mitsubishi chassis, which could explain the 'switching off' part of the symptoms.

There are a series of small capacitors, inductors and spark gaps attached to the back of the board in the vicinity of the line output transformer. The components are solidly soldered into circuit, but to make them even more secure they are glued to the board with a yellowish, rubbery cement.

This cement has a habit of breaking down in time and developing a conductive path. It's used in other parts of the chassis and wherever there's a few volts across the cement it shorts out. I've known it to short out the chroma or the video, or both at once. I've also known it to load down the line stage until the set dies.

And in this set there was a generous dollop of the same yellowish cement on the line board. There was a good reason to believe that this could be the source of the present trouble.

Without further ado, I unglued the parts on the line board and scraped away the cement. It took quite a bit of doing, because the glue had hardened over the years and was as tough as old boots. But I got it all off in the end and tidied up the components.

(I can't imagine why Mitsubishi used this glue stuff all over their sets. In the case of the line output components, they were securely attached by their short, stiff pigtails and wouldn't have moved easily if they'd been jumped on.)

I switched the set back on again and that's when it started.

First, the set came on with the top channel button illuminated and the appropriate sound playing from the speaker. Then the sound went off and it started to change channels, working down the panel to the bottom button – then jumping back to the top.

Then it stopped on one of the middle buttons, but wouldn't play the sound. Then it switched itself off, then back on again. But this time it was changing channels, with sound, working UP the panel from bottom to top!

This performance continued for ten minutes or more, then stopped and the set was working as well as it ever had done. By this time I had spent more than an hour in the customer's home, and I couldn't stay any longer. I packed the set into the van and took it back to the workshop.

On the bench it was three days before the set played up again, with a repeat performance of that in the customer's home.

The set uses a six function ultrasonic remote control, with a mechanical relay to switch the power on and off. The remote control receiver is quite a 'busy' little panel, with two integrated circuits, a dozen transistors and half a hundred other components, as well as the big black relay.

My first thought was to isolate the remote control receiver and run the set as a manual model. But the circuit arrangement is such that some set functions appear to be on the remocon board, and it cannot be isolated without stopping the set.

In fact, the interboard wiring in this set is quite complicated and I could get no more than a general idea of the arrangements. (A detailed knowledge might have helped me to explain the cure when I eventually solved the problem. As it is, I only *think* I've fixed it!)

During one of the set's more lucid moments, I spent a minute or two bashing the chassis, all over, with the butt end of a small screwdriver. When I tapped the remocon board, the set went into its crazy performance. It only stopped when I tapped the power supply board, which is firmly mounted on the cabinet base.

Later, I started the show again by tapping the tuner, then stopped it with a tap to the remocon board. In other words, there was no uniformity in the cause of the trouble, except that the remocon board was usually involved with either the starting or stopping.

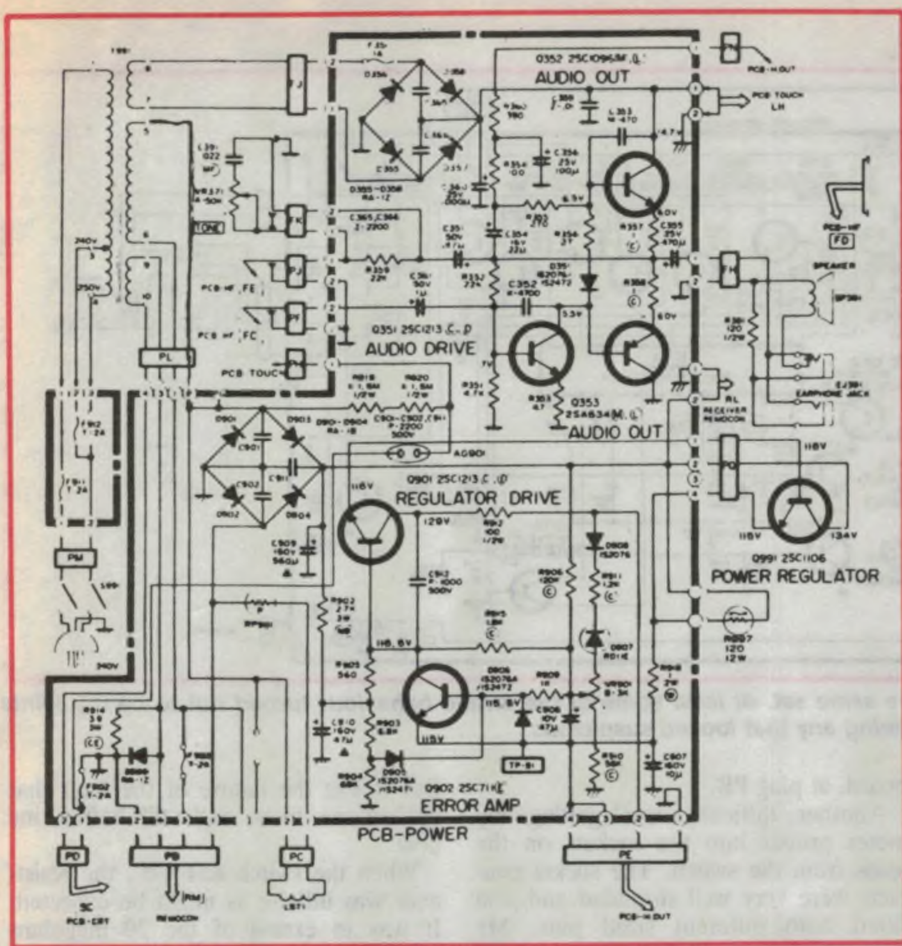
At one stage, tapping the power supply board produced a dramatic change in the picture on the screen. The picture suddenly became smaller and darker, and the sides curved inwards quite menacingly.

It seemed that I had disturbed a solder joint under the board. I might have damaged a component on top of the board, but this was unlikely as I had been gentle with all the small components and not all that rough on the large ones.

As it was, I didn't find a definite dry joint on the power board, but a quick 'once over' of all the joints with a hot iron soon put the power supply back into normal operation.

The ease with which I had opened up an (invisible) dry joint on the power board made me wonder if a similar problem might exist on the remocon board.

This board was the only one in the set where all the malfunctioning functions came together. Channel change, sound muting and power on/off all work off this board and although I couldn't trace a direct connection, I felt that there had to be a fault common to each function.



The power supply board of the AWA/Mitsubishi model K. One problem turned out to be in the power switch itself – part of a switch pot.

The fact that all of my bumping and thumping was not delivering definite evidence of a dry joint made me wonder if I was chasing an electrical fault. It could have been an intermittent IC, transistor or other component. If so, it was going to be a long search...

I decided to start from the beginning, and the beginning is the remote control microphone. I have heard of ultrasonic remocons playing up because of a faulty mike capsule, so I unplugged the lead from the mike and waited for a result.

It wasn't long in coming, and soon the set was playing up just as badly as before. So it didn't seem to be the mike.

The next component in the chain of command was an IC shown as a band-pass amplifier. This was a type number which I didn't recognise and certainly didn't have in stock. Neither did I have the next IC, the 'remocon processor'. So if either of those were faulty, I was in for a bit of a delay while replacements were obtained.

As I looked at the remocon board I realised that I might have overlooked the most likely cause of the trouble – the electrolytic capacitors. There were half a dozen or so on this board and some of them looked funny – like discoloured, as electros sometimes go when they fail. So I replaced them all.

None of those that I took out showed any signs of fault. None of them showed any leakage and all seemed to have the right capacity. And the new ones didn't seem to be any better than the old ones – the set was still playing up just as before.

But while I was working on the electros I noticed that many of the solder joints on the remocon board had a coarse, granular appearance. This is often seen in really 'dry' joints and although I could see no breaks among the joints on this board, it still looked as though resoldering them all might be a worthwhile exercise.

And worthwhile it was, because from that time on there was no more channel changing or sound muting. Once on channel, the set was rock steady. However, it was still intermittent go and no go. Sometimes it wouldn't start, and at other times it switched itself off for no reason at all.

Up to this point I had felt that I was chasing a single fault, all concerned with the remote control board, but it had became apparent that the troubles had been caused by two separate faults. I had only to find the second fault and the job would be done – or so I hoped!

It was about this time that I realised that the set was becoming more and more reluctant to switch on, while at the same time it was becoming so sensitive to pressure on the on/off switch that even strong language was enough to turn it off.

I recalled that the customer had complained that the switch was erratic, but then customers complain about the switch whenever the set won't turn on. They probably hope that fixing the switch will be an easier and cheaper repair than, say, a new line output transformer.

I had dismissed the switch complaint in favour of a gluey line output board or a remote control problem, but now I was forced back to the customer's point of view. The switch was definitely suspect, and becoming more so every time it was used.

Ultimately it failed completely, and would not switch on at all. Instead of a 'click on, click off', it now made a soft 'thunk' when pulled out, and no sound at all when pushed back in.

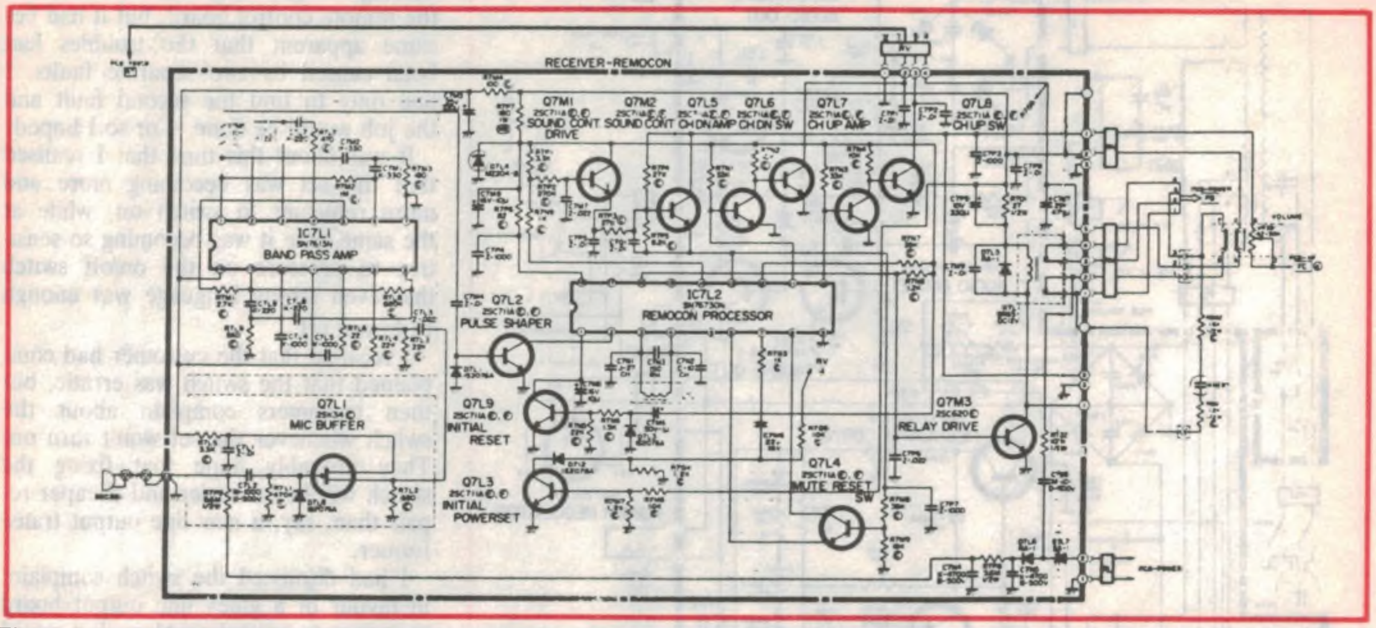
Once I had decided that I had to change the switch, the search for a suitable replacement began. The pull on/-push off switch was combined with a 50k volume potentiometer, quite unlike anything I had in the parts drawer.

For starters, the pot was labelled '50K AC' and this produced considerable confusion. I didn't know if it was a 50K C (log) taper as used as a volume control in earlier sets, or if it was an A (linear) taper as used in those sets with a DC volume control.

As it turned out, it was a 50k AC taper, neither A nor C. A 50k 'C' pot left the set with virtually no control of volume. It was off for 99% of its rotation, then flat out for the last 1%. The customer wouldn't have liked that.

Then I tried a 50k 'A' taper, and this gave a similar though not so drastic result. The full volume range was available over only about the last 20% of pot rotation. This was a barely acceptable solution, but tolerable because the remote control eliminated the need for anything but occasional adjustments of the volume.

At this point I thought I had solved the problems with the fitting of a brand new switch pot. The set seemed to work perfectly – until once, I switched it on



The remote control receiver board, for the same set. At least some of the erratic behaviour turned out to be dry joints on this board – cured by patiently resoldering any that looked suspicious.

and nothing happened.

I hammered the switch in and out a dozen times and still nothing happened. Then, while the switch was pulled out (the 'on' position) and I was scratching my head wondering what gave, the set suddenly came on without me touching it.

It took me some time to come to the realisation that the new switch might be faulty – but I couldn't imagine in what way. The two sets of contacts involved different parts of the power supply and both appeared to be, well, less than 100% reliable.

One pair of contacts switch the 24V rail, which is present at all times on the remocon receiver board. The other contacts switch the ground return of the main bridge rectifier, by way of the relay contacts on the remocon board. A fault in either set of contacts would effectively stop the set.

Unfortunately, with the switch in its normal position, there was no easy way to get at its contacts past the array of circuit boards behind the control panel. I decided that it might be easier to get at the contacts by way of their terminals on the remote control or power supply boards.

The circuit diagram showed that one pair of contacts were easily accessible on the remote control receiver board, through pins on plugs RM and RN. The other pair of contacts were not so easy to get at, because one was on plug RM on the remocon board and the other was some distance away on the power board, at plug PB.

Another difficulty was getting my meter probes into the sockets on the leads from the switch. The socket contacts were very well shrouded and also fitted onto different sized pins. My meter probes would fit into one set of contacts, but were too tight in one case and too loose in another.

Eventually, I got good contact by cutting up an old telescopic antenna. I was able to get short metal rods and tubes that fitted the sockets perfectly, and gave me easy access for the meter probes.

(This shows two characteristics that are useful to any serviceman. One is the ability to devise ways to do the impossible. The other is not to throw away anything. Broken TV antennas might be junk to some folk, but they're made of gold to a desperate TV serviceman.)

I connected two meters to the switch, one across each set of contacts, then started to operate the switch and observe the results on the meters. For the first 20 or so cycles there was no indication that anything was wrong with the switch. The resistance went from infinity when 'off' down to a few hundred milliohms when 'on', the milliohms being just the resistance of the meter and switch leads.

I was just about resolved that the switch must have been OK and that my trouble lay elsewhere, when first one set of contacts played up, then both together. They stayed faulty through a number of on/off cycles, then came good. But it was the nature of the fault that baffled me then, and still baffles me now.

When the switch was 'off', the resistance was infinite as might be expected. It was in excess of the 20 megohms which is the top range of my digital multimeter, and was as good an indication of an open circuit as one might wish for.

On the other hand, with the switch 'on', the resistance was not zero ohms but somewhere between 40 and 100 ohms. And what's more, it was different in each set of contacts, and different each time the contacts closed. (This was a new, never used switch, remember!)

At this point I was about to contact the manufacturers to see if I could get an original replacement switch pot. As mentioned earlier, the taper in my unit was a compromise and if I had to get a new switch, I might as well get the right taper as well. However, the customer stymied this action by calling in to ask how much longer the set was going to be.

They had been without it for 10 days or so, and were suffering withdrawal symptoms. So I explained the situation and said that I would do what I could with the baulky switch.

In fact, the rest of the story is a bit of an anticlimax. I removed the switch from the set, gave it a good squirt of contact cleaner spray then refitted it. There has been no further trouble over hundreds of on/off cycles.

It would be nice to be able to say

exactly what had caused the troubles that I suffered at the hands of this set. The channel changing responded to resoldering some doubtful solder joints. The switch problem responded to a squirt of cleaner spray. But neither problem is properly explained by dry joints or dirty contacts.

These sort of jobs worry me. My treatment may only have masked the real faults, and they could return to haunt me in the weeks or months to come.

VCR heads

To round out this month's tale of workshop woes and worries, here is a short story from a contributor, Mr W.N. of Blackwater, Queensland. I'll let him tell his story, more or less in his own words:

A Sharp VCR, model VC-488 came in recently. It was a fairly new Hi-Fi machine but according to its owner, the playback picture was far from acceptable.

I put it on the bench and ran a test tape. It didn't take a genius to see that the heads were either dirty or faulty. I hadn't had much to do with this model previously, but I felt confident that I was capaple of cleaning the heads, if that was indeed the problem. But no amount of cleaning could improve the picture.

I told the customer that the heads were faulty and he sanctioned the fitting of a replacement assembly.

This particular model has the Hi-Fi audio heads incorporated on the upper video drum, and because of this both upper and lower drums have to be replaced as a complete unit. (I shudder every time I think of the replacement cost.) The unit is factory aligned and is not especially hard to install.

However, I was really shocked by the poor quality of the playback picture delivered by the new heads.

The top two-thirds of the picture were quite satisfactory, but the bottom of the screen was totally obscured by noise. I checked the installation several times, but could find nothing wrong. At this point I had to put the VCR aside to clear up some other work that had accumulated.

A week later another VC-488 came in for a quite different repair and I took the opportunity to swap the heads over. The first machine now had a perfect picture, while the fault had been transferred to the second VCR!

To make a short story longer, I sent the heads back as faulty and asked for a replacement. It was several months before I was able to install a new head assembly and I just couldn't believe the results. Now the BOTTOM of the picture was perfect, while the TOP was lost in noise!

I discussed the problem with a colleague, but he had never come across this symptom. I resorted to reading about the finer arts of video processing, and eventually it clicked.

The video heads were not switching at the correct times. Even though the tracking and electrical adjustments had some effect, I could not get enough to eliminate all the noise on the screen.

It was at this point that I compared the old head assembly with the new. And sure enough, there was a difference.

The drum motor is bolted directly to the drum unit, and so is the Hall sensor device for the head switching circuitry. It didn't take long to determine that the magnet on the motor was totally out of phase with the pick-up, even though this is supposed to be factory aligned.

On aligning it roughly to the old drum assembly, I found that I had enough fine electrical adjustment to properly align the switching point and get a perfect picture.

Perhaps someone else may have picked up this fault a lot sooner than I did, but when you are pressed for time, and the replacement is supposed to be factory aligned, who would suspect that the replacement would need further alignment?

The moral of this story is not to put all your trust in brand new replacements and to look at every angle, even if it seems unlikely to have any relevance to the fault at the time.

Thank you, W.N. Your story is most revealing and not at all unlike one that cropped up in my own workshop recently.

I had to replace a capstan motor in a common Sharp video recorder, and ordered a replacement through my usual source. On fitting the new motor, I found the tape running very fast and both sound and picture garbled and almost unrecognisable.

I eventually traced the fault to a lack of capstan servo pulses, and the reason was a break in the printed tracks leading from the Hall device to the MDA. The Hall device was mounted on a small section of circuit board about 5mm wide projecting from the side of the motor, and this tiny PCB was cracked right through.

The motor had been very well packed when received, so I don't think the damage could have occured in transit. The motor must have been faulty before dispatch.

It's pure coincidence that both of these stories refer to Sharp products. The same problems could occur with any brand, but as W.N. says, it doesn't pay to be complacent about new parts.

I'll be back with another tale from the workbench next month.

Fault of the Month

National CP2000

SYMPTOM: Faint hum bars in picture. The bars might not be noticed for much of the time, but they are revealed when vertical lines at edge of the screen show a nipped-in effect that moves slowly up and down.

CURE: This is not a dried-out electro, as might be expected, but a shorted TR851 (2SC647) regulator transistor. This chassis has a thyristor main regulator and a series transistor ripple filter and works quite normally with the filter shorted out. A 2N3055 can be used in place of the 2SC647.

This information is supplied by courtesy of the Tasmanian Branch of The Electronic Technicians' Institute of Australia (TETIA). Contributions should be sent to J. Lawler, 16 Adina Street, Geilston Bay, Tasmania 7015.

Construction Project:

Chromavox – a new sound/light display

Here is a new design for a three channel sound-to-coloured-light display unit, which offers plenty of features yet can be built for significantly less than many earlier designs. It provides an inbuilt microphone for convenience, but also connects directly to a stereo amplifier.

by JIM ROWE

We have presented designs for quite a number of sound-to-coloured-light displays or 'colour organs' in the past, including the well-known and very popular 'Musicolour' series. However the more recent of these designs have been fairly elaborate, combining various other facilities with the basic sound-to-light conversion function.

While not in itself a problem, this added complexity has tended to drive up the cost of building the designs concerned – making them less attractive for those on a limited budget. Nowadays that means almost all of us!

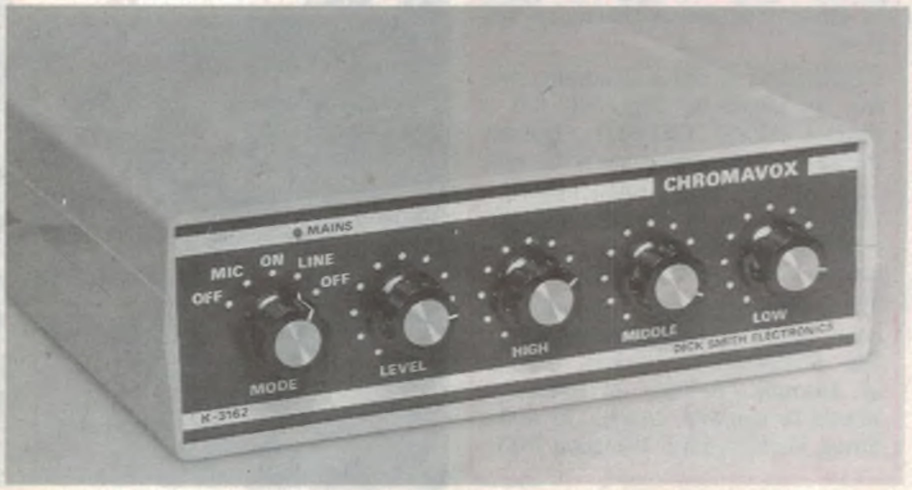
The new design presented here is designed to get 'back to basics', in a sense, by concentrating on the original sound-to-light function. At the same time, it takes advantage of recent advances in IC's, to achieve this basic function rather more elegantly and economically than before.

The nett result is a three-channel design which is very easy to build and get going. It also offers particularly smooth and reliable operation, plus the ability to operate either from a built-in microphone or from audio fed in directly, via a connection to your stereo amplifier.

Each of the three channels of the Chromavox can drive a lamp load drawing up to 6 amps, determined by the rating of the SC141 triacs used to perform the actual switching. This corresponds to more than 1000 watts per channel, although the total loading on all three channels must not exceed 10 amps – corresponding to 2400W total, or 800W per channel.

This should be more than enough for most applications, such as domestic parties and even small disco's. For those that need more power again, you could always use a second unit to drive another three sets of lamps.

In addition to a master level control, to adjust the overall lighting level for a given level of sound (or audio signal input), each of the three channels – responding to bass, middle and treble frequencies respectively – has its own individual level control. This allows the lighting balance between the three channels to be adjusted, for the most pleasing results with each kind of audio programme material.



And the cost of all this? You'll be able to buy a complete kit for only $139.00, significantly less than most other recent designs of the 'all singing, all dancing' variety.

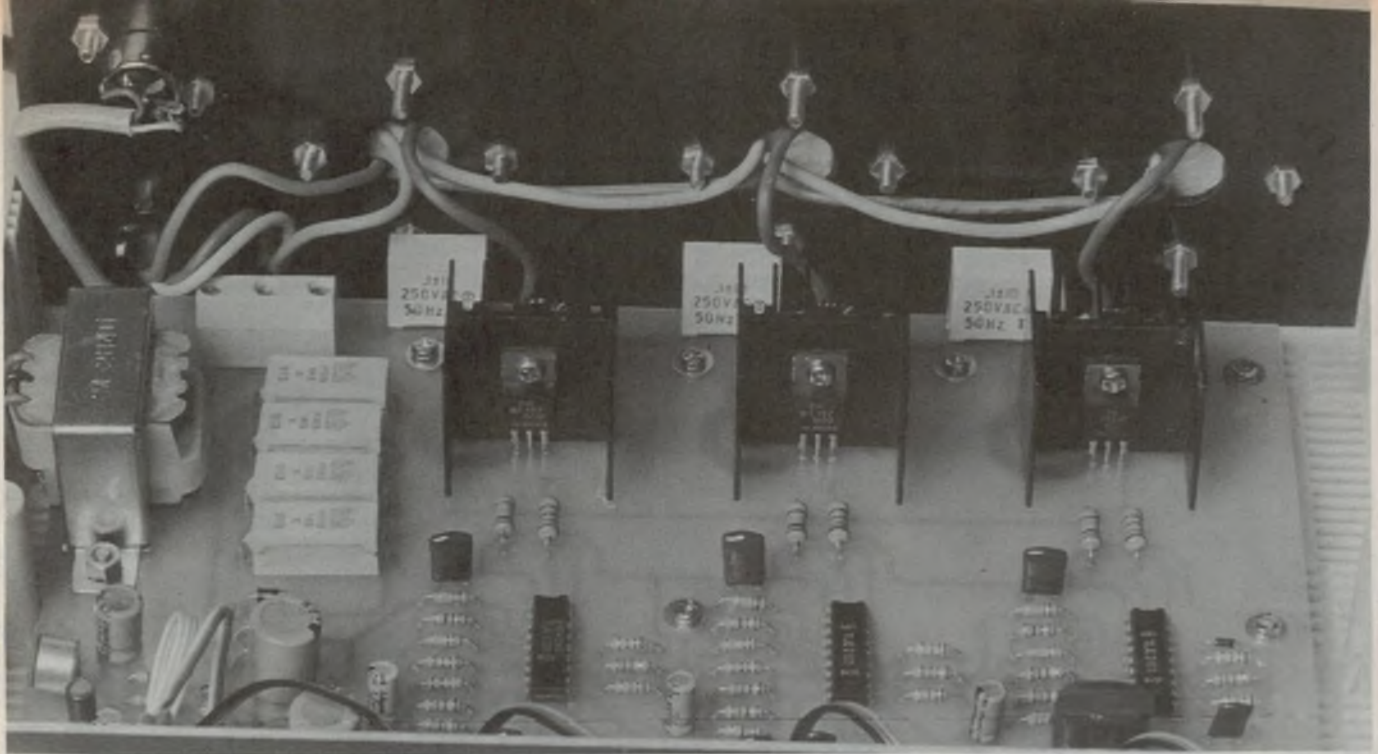
Incidentally, *EA* can't take the credit for the Chromavox design. It comes from those ever-busy R&D people at Dick Smith Electronics, although we did make a few suggestions which have hopefully contributed to the final design. And needless to say the DSE organisation has produced a kit of parts for the new project, with the catalog number K-3162.

Logically the Chromavox forms a complementary 'mate' to the Improved Light Chaser design, which we described in the November 1989 issue.

There were two basic reasons for producing the two separate units, rather than combine both functions as previously. The first, and undoubtedly the more important, was to lower the cost of either function individually – to please the many people who only want either one function or the other.

The other reason was in response to the readers who have expressed a wish to be able to have *both* the 'chasing' and 'sound-to-light' functions operating simultaneously (for example at parties). With a single combined unit, this simply can't be done; however with two smaller and separate function units it becomes quite feasible, and for a total cost which is not a great deal more than for a single combination unit.

As with other similar designs, please note that copyright to the PCB pattern



Inside the case, looking towards the rear. The three triacs are visible along the centre, on their small extruded heatsinks. Note the electret microphone, in the lower left-hand corner.

and front-panel artwork for this project are held by Dick Smith Electronics. This means that other firms will not be able to provide these items, although individual readers are of course free to make their own if they wish to do so.

How it works

The circuit of the Chromavox can be divided into the following blocks: power supply circuitry, input stages (isolation transformer or pick-up microphone), automatic gain control circuit (IC1), active filters (IC2a, IC3a, IC4a), rectifiers (IC2b, IC3b, IC4b) and triac switching circuits (IC2c, IC3c, IC4c), together with the actual triacs TH1, TH2 and TH3.

The power supply for the circuitry is derived directly from the 240V mains supply, without the use of a step-down power transformer. This was done because suitable devices needed to isolate the triacs from the control circuits are not readily available, hence the use of a power transformer would have achieved very little.

Needless to say, this means that in operation, all of the circuitry inside the unit is 'live'. So the unit must NOT be operated with its case removed. Should the need for troubleshooting arise, suggestions as to how this can be safely carried out are given later.

The mains voltage is current limited by series resistors R51 to R54, which are 5W wire-wound types. Diode D6 is a half-wave rectifier. The rectified voltage is filtered by capacitors C24 to C27 and stabilised at a total of 20V DC by two zener diodes, ZD1 and ZD2. The capacitors and zeners are centre tapped to provide a mid-supply reference at the 10V level. Or if you like, the two supply rails become +10V and -10V relative to the reference level.

The input audio signal can be selected from either the built-in electret microphone or an external line input by switch SW1a. The microphone is of the electret type, with its own built-in preamp stage; hence the use of resistor R3 and capacitor C1, which form a power supply decoupling circuit, and resistor R4 which forms the mic preamp load resistor.

When using the external input, the signal source is isolated from the internal live circuitry by transformer TR1, which is a double-insulated mains transformer used 'back to front' (i.e., the signal is applied to what is normally the low-voltage secondary of the transformer, with the output taken from what is normally used as the high-voltage primary).

In this configuration, the transformer has a frequency response which is reasonably flat to about 2kHz and then falls about 6dB per octave. Subjectively, this roll-off causes no problem and simply modifies the high-pass response of the 'high' channel filter to a band-pass response.

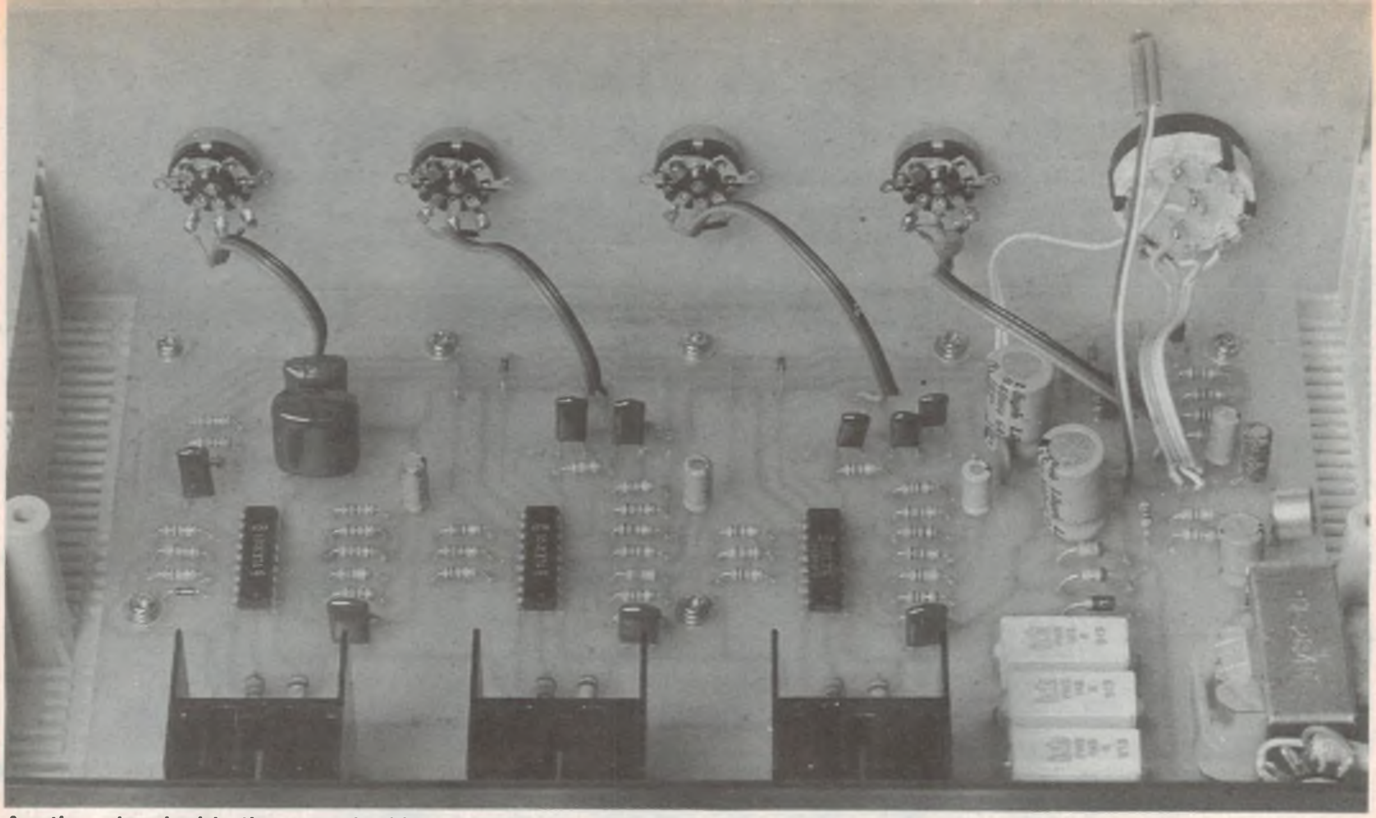
Resistors R1 and R2 form a simple mixing circuit, used to combine the 'left' and 'right' signals of an incoming stereo signal, at the primary of the isolation transformer.

Input selector switch SW1 actually has five positions, with the two end positions switching all three lamp channels 'off'. In these positions the input circuit is connected to the common reference line via SW1a. In the fifth and centre position, all three lamp channels are turned 'on' at full brilliance, by SW1b; more about this later.

Potentiomenter P1 is the master gain control, which adjusts the incoming audio signal to a suitable level for application to the AGC stage.

Incidentally all of the pots and the rotary switch used in this project should be of fully insulated construction, for safety. Normal metal bodied pots and switches will not provide enough insulation to withstand mains voltage stresses, and could result in the control spindles and knob grubscrews becoming 'live', to present a safety hazard. For the same reason, the complete case – including front and rear panels – should be of insulating plastic material.

The AGC circuit consists of a non-inverting op-amp, IC1a, with feedback determined by R5 and FET Q1. The FET functions as a variable resistor, which is controlled by the rectified audio signal derived via D1, D2 and IC1b. As the voltage applied to the gate of the FET is driven more negative by an increasing rectified audio signal, the resistance of its drain-source channel increases, which in turn increases the negative feedback around IC1a and hence reduces the gain.



Another view inside the case, looking towards the front. The control pots used in this prototype were not of the correct fully-insulated variety, as will be supplied with the production kits.

The time constants of the AGC, which are determined by the values of R8, R9 and C5, are made quite long so that the AGC does not track the envelope of the audio signal.

The main ICs in the Chromavox are three Siemens type TLE3101 triac control devices. In addition to having voltage-controlled triac triggering circuitry, each IC also contains an uncommitted compensated op-amp and an uncommitted voltage comparator. In this circuit these have been configured as an active filter and an active half-wave rectifier stage respectively, for each channel. The use of these ICs therefore results in a significant reduction in the overall component count, and consequently a more reliable, uncluttered and easy-to-build design.

The active filters employ the operational amplifiers of IC2-4. The bass channel uses a unity-gain three-pole low-pass filter (IC2a). The middle channel uses a two-pole band-pass configuration, with a gain of two (IC3a). The high channel filter is a two-pole high-pass stage (IC4a), also with a gain of two. As noted previously this results in an overall bandpass response, when combined with the low pass characteristic of the input transformer.

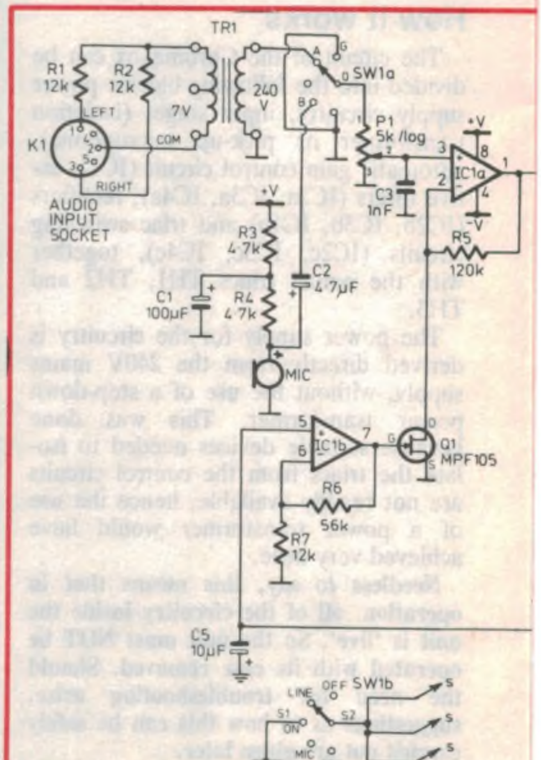
The output of each filter passes through a potentiometer to that channel's rectifier circuit. The purpose of the these pots (P2-4) is to balance the individual channel sensitivities, to suit the particular musical source material.

The comparator sections of the three controller ICs (IC2b, IC3b abd IC4b) are used for rectifying the filtered audio signals. The output stage of each comparator is an open-collector, NPN transistor which is tied to the mid-supply reference voltage via a 12k resistor. In this configuration, as each comparator has no means of pulling its output positive, only negative half-cycles appear at the comparator outputs; hence the comparator is made to function as an active (half-wave) rectifier.

The voltage gain of the rectifiers is set at about 6.5 by resistors R17-18, R21-22 and R25-26. The negative-going half-waves from each rectifier are filtered by a 120 ohm resistor (R20, R24 and R28) and a capacitor which is varied in value (C15, C16, C17) according to the range of frequencies in its particular channel.

The DC voltage swing at the rectifier outputs is from +10V at no signal, to almost 0V at full signal. Voltage divider resistors R29-34 scale this DC control voltage to 3.6V at no signal to under 1V with maximum signal, this being the required range for the triggering circuitry in triac control circuits IC2c-4c.

The triac triggering circuits provide what is known as *phase control*. At no signal, each triac is triggered into conduction very late in each mains half-cycle. This results in a very low average voltage being applied to the lamps, insufficient to cause their filaments to glow. At high signal levels the triacs are triggered early in each mains half cycle, applying almost full mains voltage to the lamps, which results in maximum brightness. Varying signal levels cause the triacs to be triggered at proportionally varying positions in the mains half-



The complete circuit schematic. Most of the work is done by the three TLE3101 chips, driving the triacs.

cyles, resulting in modulated lamp brightness.

The passive components around the trigger circuits have the following functions. Components C18-R37, C19-R40 and C20-R43 determine the width of the trigger pulse applied to the triac gates. The values shown yield a pulse width of about 120us, which should suit all common triacs.

Resistors R46, R48 and R50, which are 1/2 watt types in order to withstand mains voltage, provide the trigger circuits with a replica of the mains waveform for synchronization purposes. The trigger current applied to the triac gates is limited by resistors R45, R47 and R49 to around 80mA. Resistors R35-36, R38-39 and R41-42 provide a reference voltage to the internal comparators, to limit the maximum firing angle (maximum lamp brightness).

Finally, L1-C21, L2-C22 and L3-C23 are low pass filters which reduce the high-frequency RF noise typical of phase-controlled triac switching.

As noted previously, function switch SW1 is a 5 position 2 pole type which has two 'lights off' positions at its extremes and two positions for modulated lights – one for the internal microphone and the other for the external source. There is also a centre 'lights full on' position. In the latter position, the audio source is disconnected by SW1a, while SW1b is used to pull the control voltage inputs of the output stages IC2c, IC3c and IC4c to the negative rail via diodes D3-D5, resulting in early triggering of the triacs.

Construction

As with the Light Chaser described a few months ago, all of the circuitry for the Chromavox is housed in an all-plastic utility case, measuring 256 x 190 x 82mm. Even the front and rear panels are of plastic, instead of the usual metal.

In fact the front-panel controls should all have plastic bushes and spindles, to ensure that there is no chance of even the grubscrews in knobs can become 'live'. Those supplied in the DSE kits will have this feature, ensuring that the assembled Chromavox is effectively double insulated for safety.

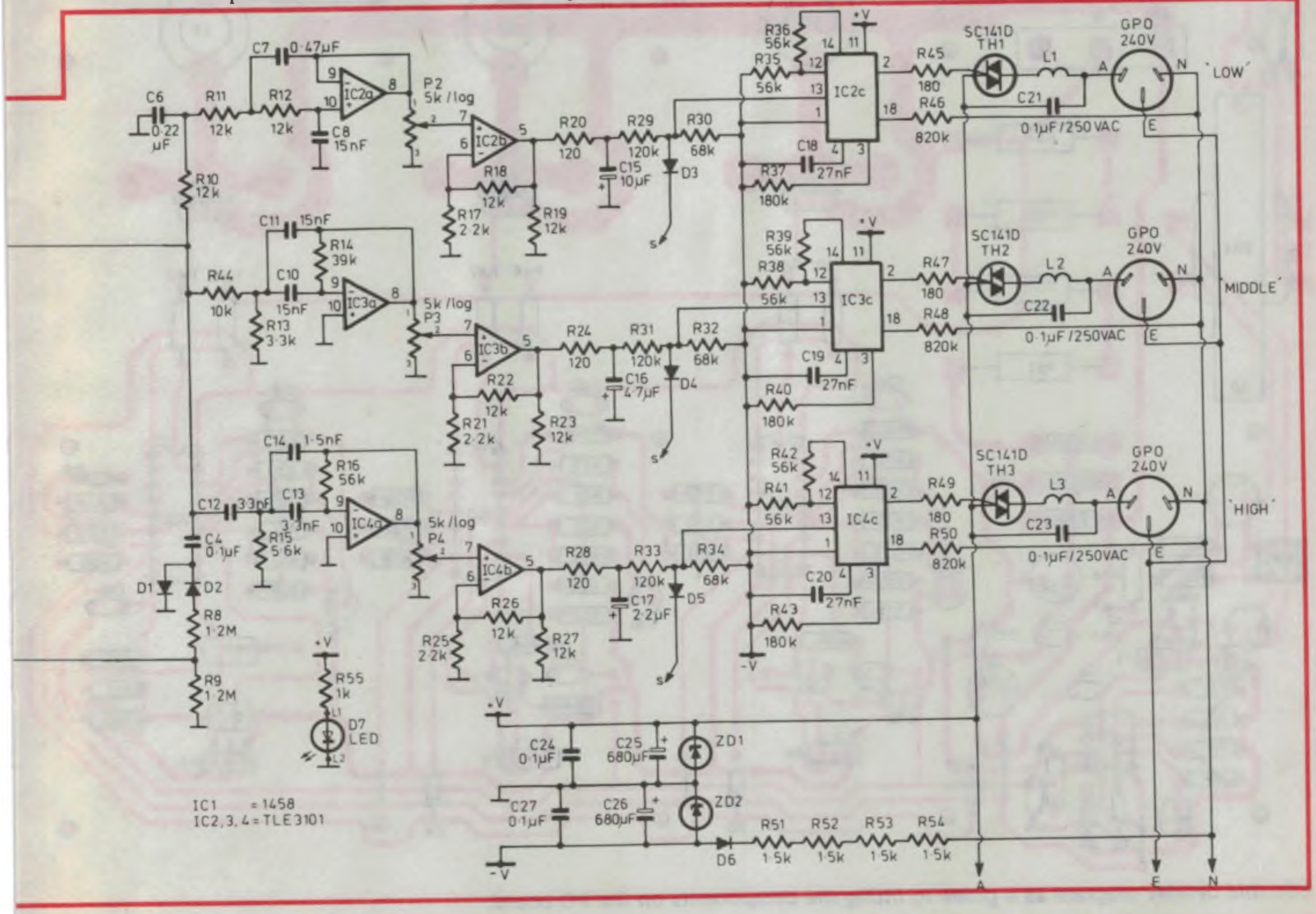
As you can see from the photographs, the front panel carries the four level control pots, the function switch and the mains indicator LED. The rear panel in turn carries the three mains outlet sockets, the direct audio signal input socket and the mains cord entry.

All of the remaining components are mounted on one reasonably large single-sided PC board, measuring 220mm x 165mm and coded ZA-1436.

The PCB's generous size means that the layout is open and uncluttered, and it should therefore be quite easy to fit the components. The three triacs fit along the board towards the rear, with their respective triggering ICs in front and their L-C filtering components behind.

The small transformer used for isolation of the direct input signal is mounted at the far left of the PCB, looking from the front. To the front of this is the electret microphone, and the AGC amplifier circuitry around IC1. Between the input transformer and the triacs are the voltage dropping resistors R51-R54, and the other power supply components. The mains cord itself has its active and neutral wires terminated at a terminal block, near the input transformer.

The location and orientation of the



components mounted on the PCB are shown in the overlay diagram, so that assembly should be quite straightforward. As usual the best components to begin with are the low-profile resistors and diodes.

Before mounting any components, it would be a good idea to fit the five PCB links to the top of the board, so that you don't forget them. Use 18G SWG, 0.5mm or similar tinned copper wire, bending each link by 90° at each end to ensure that it lies flat against the top of the PCB.

Mount the smaller low-power resistors right down on the surface of the board also, noting that R45/47/49 (180 ohms) and R46/48/50 (820k) are all 1/2W types, and a little larger than the other small 1/4W resistors. However the much larger 'cement potted' 5W resistors R51-R54 should be mounted so that their bodies are about 3mm above the surface. This is to allow a small amount of air circulation, to assist in cooling – they dissipate about 2W each in operation.

Similarly mount the power diode D6 and zener diodes ZD1/2 a few millimetres clear of the board as well, for the same reason, taking care to mount them with the correct orientation. The signal diodes D1-D5 can all be mounted on the board surface, again taking care with their orientation.

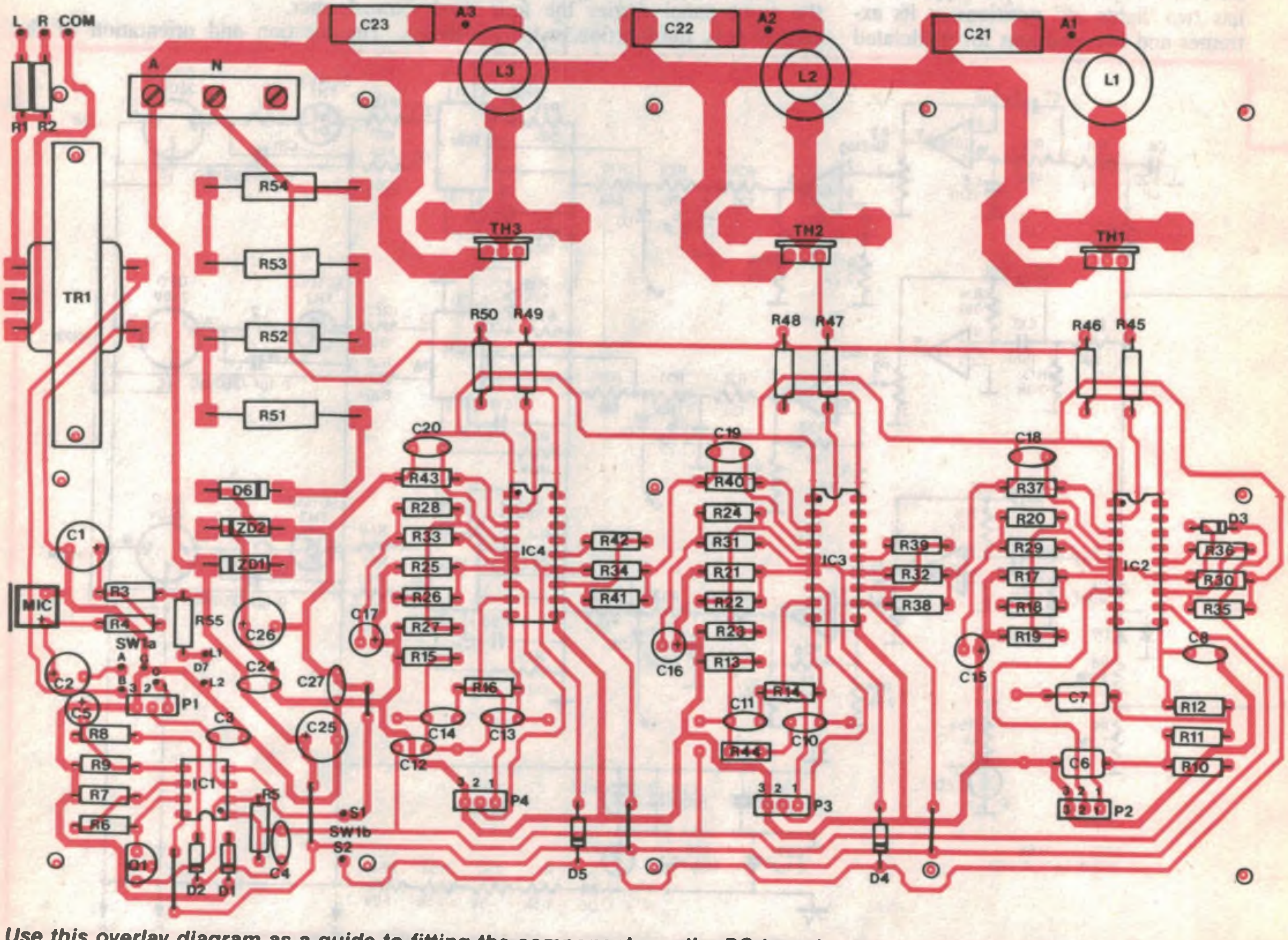
The smaller ceramic and metallised polyester capacitors can be mounted next, followed by the electrolytics – watching the polarity. Then you can mount the three 250V rated filter capacitors C21, C22 and C23, along the rear of the board.

At this stage it would be a good idea to mount the mains terminal block, taking care to ensure that its wire openings are towards the *rear* of the board.

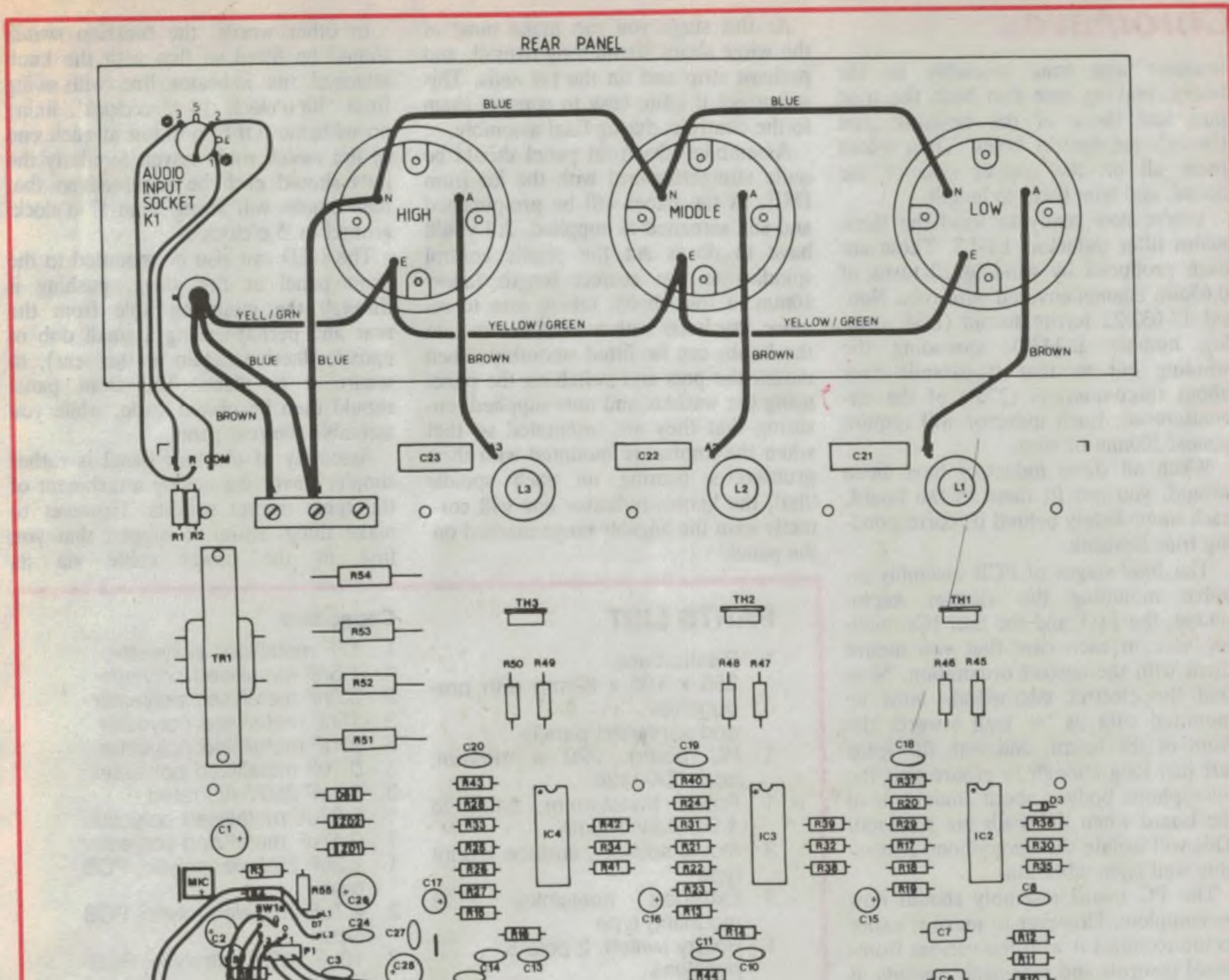
Then you can mount the input transformer TR1, after first cutting its leads and stripping back their insulation so that they will just reach the copper side of PCB through the holes provided. Note that the two 'lower' transformer leads are those which correspond to the PCB holes on the side nearest the 5W dropping resistors, while the three 'upper' leads mate with the holes on the left-hand edge. The transformer itself mounts on the board using two 1/8" x 10mm nuts with matching star washers and nuts.

The next step is to mount the three triacs on their respective heatsink extrusions, coating them first on their flat 'back' sides with a thin smear of silicone grease to ensure a good thermal contact. The triacs are screwed to the flat side of the heatsinks using small self-tapping screws, and orientated so that their trio of pins will be able to pass through the PCB and be soldered to the corresponding copper pads when the heatsinks are mounted.

The heatsink assemblies have wire PCB pins staked into one end, to attach them to the board. So offer up each



Use this overlay diagram as a guide to fitting the components on the PC board.



And here's a diagram showing the rest of the wiring for the Chromavox. We strongly recommend that you follow the colour coding shown, for the mains wiring.

heatsink and triac assembly to the board, making sure that both the triac pins and those of the heatsink pass through the correct holes. Then solder them all on the copper side of the board, and trim them to length.

You're now ready to wind the three mains filter inductors L1-L3. These are each produced by winding 20 turns of 0.63mm enamel-covered wire on a Neosid 17-632-22 ferrite toroid (DSE catalog number L-1439), spreading the winding out so that it extends over about three-quarters (270°) of the circumference. Each inductor will require almost 500mm of wire.

When all three inductors have been wound, you can fit them to the board, each immediately behind its corresponding triac heatsink.

The final stages of PCB assembly involve mounting the electret microphone, the FET and the four ICs, making sure in each case that you mount them with the correct orientation. Note that the electret microphone must be mounted with its '+' lead towards the front of the board, and with the leads left just long enough to ensure that the microphone body is about 3mm clear of the board when the leads are soldered. This will isolate the microphone reasonably well from vibration.

The PC board assembly should now be complete. However to make it easier to interconnect it with the various front-panel controls and rear-panel sockets, it would be a good idea at this stage to prepare the interconnecting wires and attach them at their PCB ends.

For details of the various wires, refer to the wiring diagram. There are not all that many wires involved, but it would still be a good idea to colour-code them to make things easier.

Note that the wires which run from the rear of the board to the output sockets must be of the mains-rated type, and strictly speaking the three 'active' wires should have *brown* insulation, while the 'neutral' which runs from the terminal block to the three sockets in 'daisy-chain' fashion should have *blue* insulation. Similarly the wire used for linking the earth connections of the output sockets should have *yellow/green* striped insulation, matching the earth wire of the input mains cable.

All of the other interconnecting wires can be of lightweight hookup wire. A convenient type to use is that taken from 'rainbow ribbon' cable, which will also provide colour coding automatically.

At this stage you can make most of the wires about 80mm long overall, and perhaps strip and tin the far ends. This will make it quite easy to connect them to the controls, during final assembly.

Assembling the front panel should be quite straightforward with the kit from DSE, as the panel will be pre-punched and silk screened as supplied. All you'll have to do is cut the plastic control spindles to the correct length (allow 10mm of free shaft), taking care to remove any burrs with a small file so that the knobs can be fitted smoothly. Then mount the pots and switch on the panel using the washers and nuts supplied, ensuring that they are orientated so that when the knobs are mounted with their grubscrews bearing on each spindle 'flat', the knob's indicator line will correctly span the angular range marked on the panel.

In other words, the function switch should be fitted so that with the knob attached, its indicator line will swing from '10 o'clock' to '2 o'clock', lining up with the 'OFF' position at each end of the switch rotor travel. Similarly the pots should each be mounted so that their knobs will swing from '7 o'clock' around to '5 o'clock'.

The LED can also be mounted to the front panel at this stage, pushing it through the mounting hole from the rear and perhaps using a small dob of epoxy adhesive (again at the rear), to secure it in place. The front panel should then be placed aside, while you assemble the rear panel.

Assembly of the rear panel is rather simpler, involving mainly attachment of the three output sockets. However to make things easier, I suggest that you first fit the power cable via its

PARTS LIST

1 Plastic case, 255 x 190 x 82mm with pre-punched and screened panels
1 PC board, 220 x 165mm, code ZA-1436
1 Power transformer, 240V to 4.5-0-4.5V/150mA
3 Mains sockets, surface mount type
3 Extruded heatsinks, PCB mounting type
1 Rotary switch, 2 pole 5 positions
1 Electret microphone capsule
5 Control knobs, plastic
3 Ferrite toroids, Neosid type 17-632-22
1 5-pin DIN socket

Semiconductors

5 1N914/1N4148 or similar diodes
1 1N4007 or similar diode
1 Red LED, 3mm diameter
2 1N4740 or similar 10V zener
1 MPF105 or similar JFET
3 SC141D or similar triacs
1 1458 dual op amp
3 TLE3101 triac trigger IC

Resistors

All 1/4W, 5%: 3 x 120 ohms; 1 x 1k; 3 x 2.2k; 1 x 3.3k; 2 x 4.7k; 1 x 5.6k; 1 x 10k; 12 x 12k; 1 x 39k; 8 x 56k; 3 x 68k; 4 x 120k; 3 x 180k; 2 x 1.2M.
3 180 ohms 1/2W
3 820k 1/2W
4 1.5k 5W wirewound
4 5k log pots with plastic case, bush and spindle

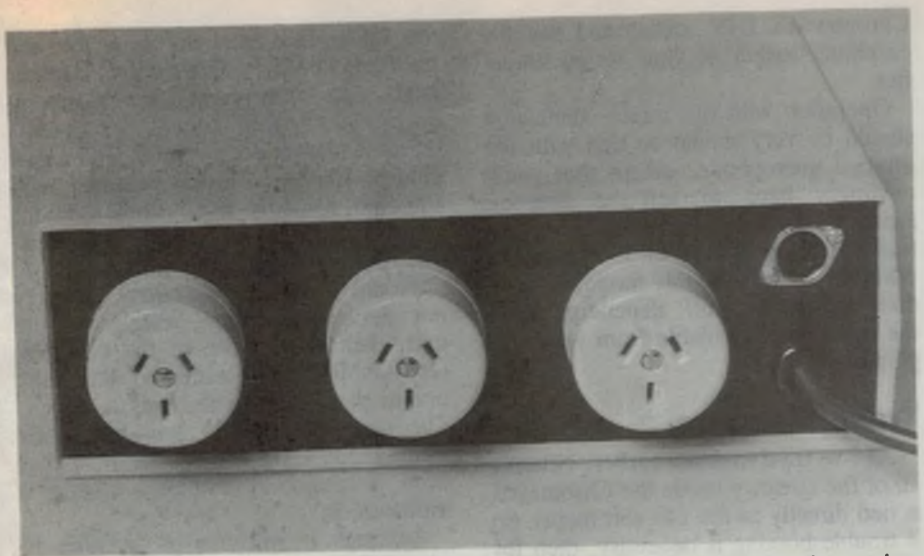
Capacitors

1 1nF metallised polyester
1 1.5nF metallised polyester
2 3.3nF metallised polyester
3 15nF metallised polyester
3 27nF metallised polyester
3 0.1uF metallised polyester
3 0.1uF 250V AC rated
1 0.22uF metallised polyester
1 0.47uF metallised polyester
1 2.2uF 25V electrolytic, PCB type
2 4.7uF 25V electrolytic, PCB type
2 10uF 16V electrolytic, PCB type
1 100uF 16V electrolytic, PCB type
2 680uF 16V electrolytic, PCB type

Miscellaneous

3-way mains terminal block, PCB type; length of 3-core mains cable, 10A rated; 3-pin plug to suit; mains cord clamp/grommet; 6 x 1/8" x 18mm machine screws with star washers and nuts; 12 x 1/8" x 12mm machine screws with star washers and nuts; 3 x 3mm x 6-15mm self-tapping screws; 1 x nylon cable tie; 1.5m of 0.63mm OD enamelled copper wire; varnished cambric sleeving, rainbow cable, connecting wire, solder, etc.

Note: Complete kits for this project will be available from Dick Smith Electronics sales outlets, identified by the catalog number K-3162. Quoted price for the kit is $139.00, including sales tax.



The outside rear of the unit isn't all that exciting, but functional: the mains input, the audio input and the three output sockets.

grommet/clamp – allowing a good 10mm of *unstripped* outer insulation beyond the clamp, and then about 70mm of each insulated mains wire beyond that again. Then strip the end of each wire back by 10mm, and tin them for easy fitting to the screw connectors.

You can then cut the various other interconnecting wires to length, strip and tin their ends (say 10mm) and fit them all to the socket connectors, *before* you screw the sockets into place. It should be fairly clear that you need to remove the socket covers for all of this operation, and then screw them back on only when the sockets are fully installed and connected up.

Now you can fit the 5-pin DIN socket used for the direct audio inputs, mounting it from the outside of the panel using the *shorter* 1/8" screws, star washers and nuts.

You should now be ready for the final assembly stage, which is fitting everything together. I suggest you start this by first mounting the PCB in the bottom of the case, using the 13 short self-tapping screws provided.

The rear panel will have become partly connected to the PCB by this stage, via the three 'active' output leads attached to both the PCB and the output sockets. So logically, the remaining connections can now be made, fitting the active (brown) mains cable wire to the PCB connector block (left-hand end) and the neutral wires (blue) from both the mains cable and the output sockets to the centre connector of the same block.

Note that there are two holes in the PCB just behind the terminal block. These are arranged to allow you to fit a nylon cable tie, looping it through the board holes and over the active and neutral wires once they're fitted to the block. The idea is that should any of the wires break at the connectors, the cable tie will prevent it from moving away and possibly touching something it shouldn't (such as the DIN socket).

The three audio input wires from the PCB can now be connected to the DIN socket, after first slipping over them a 70mm length of 5mm-diameter varnished cambric ('spaghetti') sleeving for protection.

The rear panel will now be fully wired, and can be swung up into its case mounting slots. Then you're ready to fit the front panel into its own slots, and wire up the controls.

Wiring up the controls should be straightforward using the wiring diagram as a guide. The main point to watch is the switch wiring, but this shouldn't present any problems providing you have colour-coded your leads.

When you fit the wires to the back of the LED, take special care to watch the polarity as the LED could easily be damaged if you connect it around the wrong way, once power is applied. The *shorter* of the two LED leads is normally the cathode, which also has a small flat on the side of the moulded case. This is the side of the LED which connects to the common line, or the wire which comes from the hole nearer the *front* of the PCB.

As supplied, however, the LED leads are really too long for safety. So after carefully noting which is which, you should cut them both back to a length of about 8mm before soldering on the wires from the PCB. It's also a good idea to fit 15-20mm lengths of 2mm diameter varnished cambric sleeving over the wires before soldering, so that when the joints are completed the sleeves can be slid over the exposed bare leads and solder joints, for safety.

Your Chromavox should now be completely wired, with all that really remains being to fit the lid to the case and screw it all together. However just before doing so, I suggest strongly that you make a final check of all your connections. This is the time to discover any mistakes, and correct them before any harm is done.

If all seems in order, fit the lid and make sure everything is secure. Don't forget to fit all the control knobs, if you haven't already done so. Then turn all of the pots fully anticlockwise, turn the function switch also to its fully anti-clockwise 'OFF' position, plug the mains cable into a convenient power point, and switch the power on.

At this stage, the only thing that should happen is that the pilot LED should glow. Nothing else!

If the LED doesn't glow, you've probably wired it up with the wrong polarity – so switch off immediately, unplug, remove the case lid, and reverse the LED connections. Then refit the lid and try again. If the LED hasn't been damaged, it will now glow as it should; otherwise, you'll be up for a replacement.

Try turning the function switch clockwise, to the other positions. With no lamp loads plugged into the output sockets, this should not produce any effect at this stage.

Needless to say, if there are any suspicious hissing sounds, wisps of smoke emanating from the case, or other signs of distress, switch off immediately. Then unplug, remove the case lid and investigate. More about troubleshooting shortly.

If all seems well, though, try plugging a lamp (say 100W) into one of the output sockets, via a suitable mains-rated lead. It should remain off with the function switch in either of the two 'OFF' positions of the function switch, but glow at full brilliance in the centre 'ON' position.

Now try turning your radio or stereo on, to provide some music – your choice! Then turn the function switch to the 'MIC' position, the 'LEVEL' pot to about 12 o'clock, and start turning up either the 'HIGH', 'MIDDLE' or 'LOW' pot – whichever corresponds to the socket you've plugged the lamp into. The lamp should begin to pulse in brightness with the music, and especially with the frequency components which correspond to the channel concerned (i.e., treble, middle or bass frequencies).

You should be able to adjust the sensitivity of the channel by adjusting its pot. If this seems OK, you can plug either the same test lamp or two other lamps into the other channels, and try these in the same way. Needless to say all three channels should go off in either of the function switch's 'OFF' positions, while they should all go to full brilliance in the centre 'ON' position.

What if there's simply no pulsing light, in any of the three channels – even with the LEVEL and other pots turned up to their fully clockwise positions? If this happens, the odds are that you've fitted the electret mic to the board with the wrong polarity. So switch off, unplug, remove the case lid, unscrew the PCB and swap over the mic connections. It probably won't have been damaged by the mistake, though, so re-assembling everything should bring correct operation.

Finally, if all is well so far, you're ready to try feeding in a direct audio signal from your stereo system or radio or whatever. This will involve making up a suitable lead, to go between the Chromavox's DIN socket and say the earphone socket of your stereo amplifier.

Operation with this direct connection should be very similar to that with the internal microphone, except that you'll obviously have to set the function switch to the 'LINE' position. You may find that the pots have to be adjusted to different settings in this mode, to produce the same result, depending upon the signal level available from your amplifier.

Troubleshooting

As I've tried to stress earlier, virtually all of the circuitry inside the Chromavox is tied directly to the 240 volt mains. So if troubleshooting is necessary, then for safety's sake, please adhere to the following procedure.

Be absolutely certain that the input mains cable is not plugged into a 240V outlet when the case is removed.

Before carrying out any electrical tests, patiently and carefully inspect the construction of the unit visually. In most cases projects fail to work because (a) there are solder bridges between PCB tracks, (b) insufficient heat has been used when soldering, preventing the solder flux from doing its job and resulting in 'dry' joints, or (c) components are transposed or incorrectly orientated. Typical examples of the latter are zener diodes swapped with signal diodes, 10-ohm resistors swapped with 100-ohm resistors (i.e., similar colour code) and diodes or electrolytic capacitors fitted with reverse polarity.

Should it still be necessary to carry out detailed electrical testing on the unit, then short three of the 1.5k 5W resistors R51-54 together so that only one of them is still effectively in circuit. The unit can now be powered safely from a 30V AC source, such as that from a commonly available stepdown transformer.

Although it will not be possible to trigger the triacs with the circuit running from this low voltage, all of the circuitry up to the trigger stages can be safely tested. Don't forget to remove the short from the 1.5k resistors before reassembly.

If it *is* ever necessary to work on the unit in its mains-powered condition, this should be left to a technician having access to a mains isolating transformer and familiarity and experience with the safety practices needed for troubleshooting in live circuitry.

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75 **$262 inc tax $227 ex tax**

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77 **$352 inc tax $306 ex tax**

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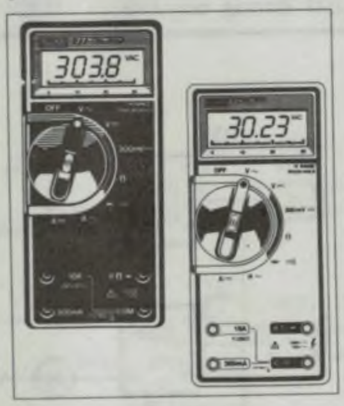

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21 **$264 inc tax $229 ex tax**

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- Fluke 75 features but less 10A range

23 **$357 inc tax $310 ex tax**

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- Fluke 77 features + fused 10A input

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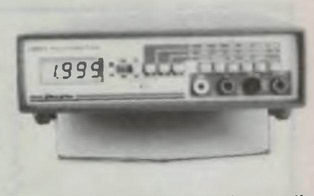

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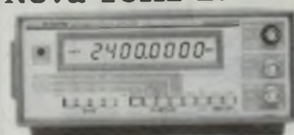

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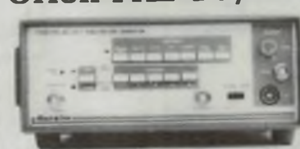

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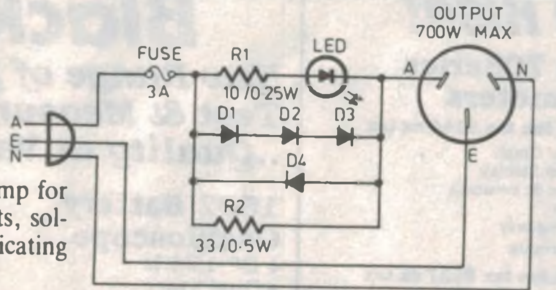
Circuit & Design Ideas

Interesting circuit ideas from readers and technical literature. While this material has been checked as far as possible for feasibility, the circuits have not been built and tested by us. We therefore cannot accept responsibility, enter into correspondence or provide further information.

Current sensing pilot lamp



This circuit will act as a pilot lamp for appliances such as electric blankets, soldering irons, hifi systems etc., indicating when they are drawing current.

When an appliance is plugged into the output socket and switched on, current flows through diodes D1-3 during the positive AC half cycles. This causes a voltage drop across the diodes, of approximately 2.1 volts. This voltage is applied to the LED via R1, causing it to light. R1 limits the LED current to approximately 40mA per positive half cycle.

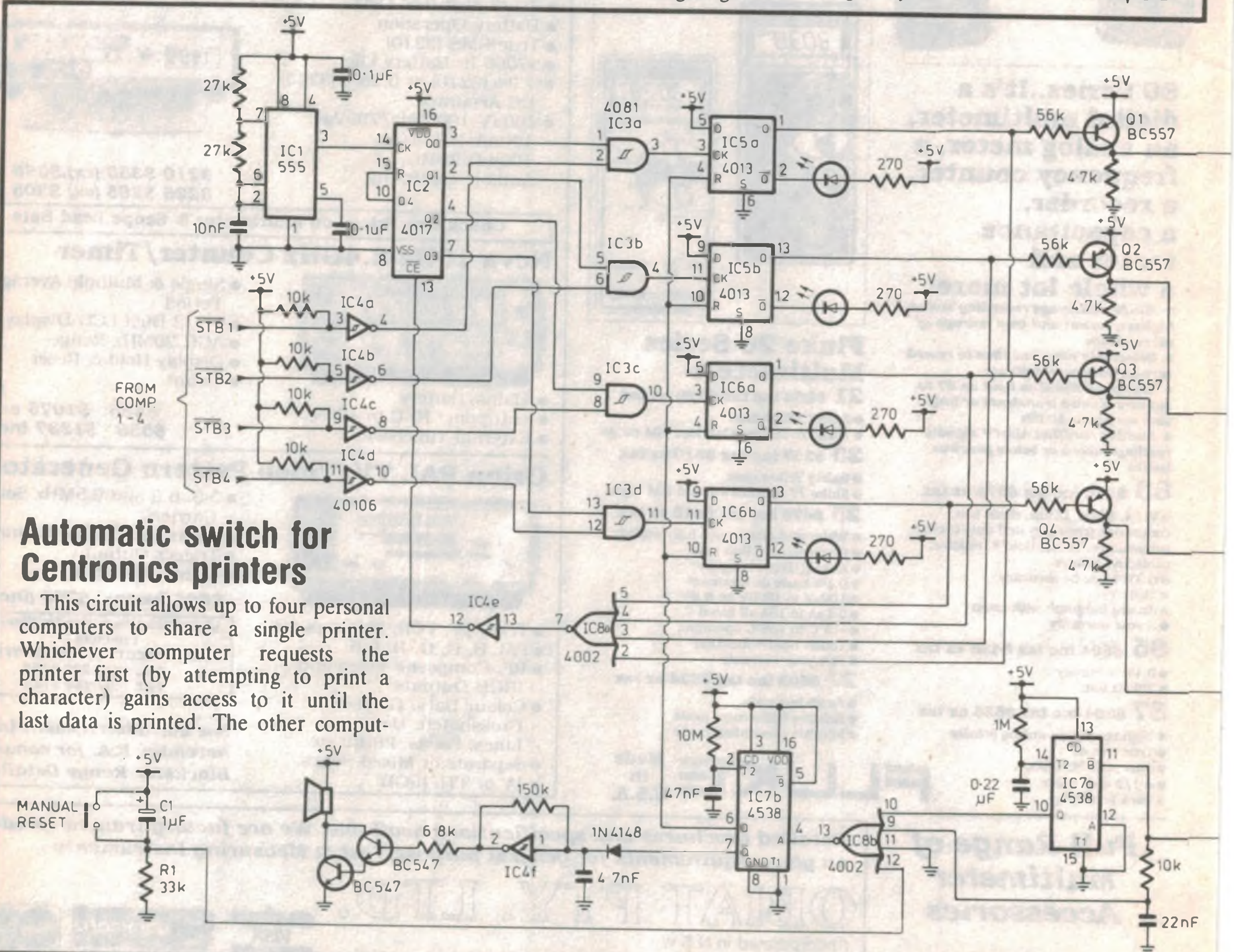
D4 shunts the LED during negative half cycles, protecting it from damage and also providing a current path for the load appliance.

R2 sets the sensitivity of the circuit and prevents false operation due to RFI suppressor capacitors or transformer primary windings in some appliances. R2 may be removed or altered in value for some applications, as desired.

Please note that as the complete circuit operates at mains potential, it should be totally enclosed in a suitable insulated box to ensure the user's safety.

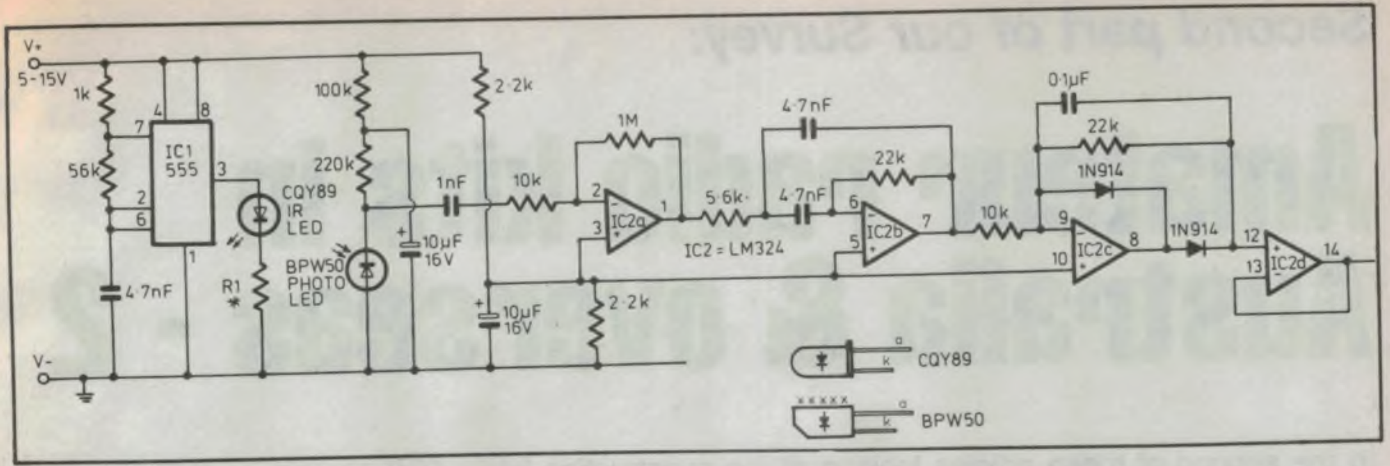
R.Love,
Highbury, SA

$35



Automatic switch for Centronics printers

This circuit allows up to four personal computers to share a single printer. Whichever computer requests the printer first (by attempting to print a character) gains access to it until the last data is printed. The other comput-



IR proximity detector

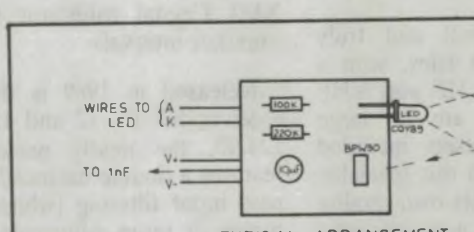
This circuit was originally designed for applications in robotics, but it has other uses as well. The circuit can detect objects reliably up to 300mm away, and further if the object is large and white such as a wall or a sheet of paper.

Operation is as follows: IC1 is a simple oscillator that pulses the IR LED at a calculated frequency of 2711Hz. This light is reflected off the object and is detected by the photodiode.

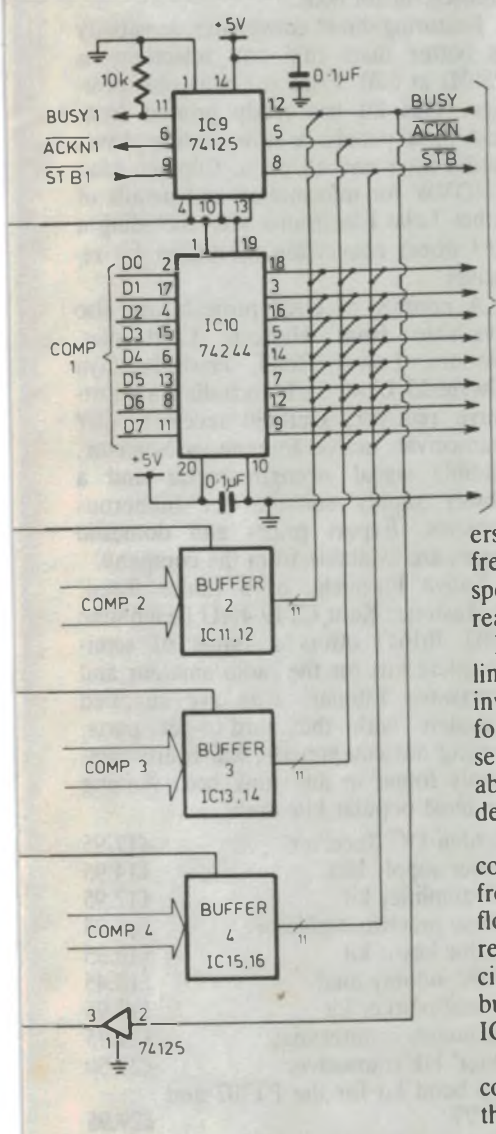
The signal is amplified by IC2a and then filtered by bandpass filter IC2b. This is to remove spurious signals such as the 100Hz from fluorescent lights. The signal is then rectified and integrated by IC2c. IC2c can drive high impedance loads directly, or the signal can be buffered by IC2d.

The voltage at IC2d increases as the object moves closer to the detector.

James Moxham,
Urrbrae, SA **$45**



TYPICAL ARRANGEMENT



TO PRINTER

ers are denied access until the printer is free. A short tone is then sounded via a speaker, to indicate that the printer is ready to receive another print request.

It works as follows. The strobe signal lines from the various computers are inverted by IC4 and gated by IC3. The four gates of IC3 are enabled in sequence by counter IC2, driven by astable IC1; this 'scans' the strobe lines to detect the arrival of the first pulse.

The output of each gate of IC3 connects to four 4013 flipflops, formed from IC5 and IC6. Initially all four flipflops are reset by monostable IC7b, in response to either the power-on reset circuit R1-C1, or the manual reset button. These trigger IC7b via gate IC8b.

The first pulse detected will cause the corresponding flipflop to set, enabling the data buffers for that computer. IC9 and 10 are used for computer channel 1, IC11-12 for channel 2, and so on. The buffers are enabled via inverting buffer transistors Q1 – Q4, respectively. Once one of the flipflops has set, to enable the channel concerned, gate IC8a stops the 4017 scanning counter.

To detect when the printing data stream ends, the printer BUSY/READY-bar line is fed via a buffer to IC7a. While the printing data is being transferred, IC7a triggers continuously, holding pin 10 of IC8b high and preventing IC7b from triggering.

However about 200ms after the trailing edge of the last BUSY pulse, the output of IC7a goes low and that of IC8b goes high, triggering IC7b and generating a 450ms pulse at pin 7. This resets the flipflops, restarting the 4017 counter and allowing the scanning to begin again. At the same time audio oscillator IC4e is enabled, producing a short 'beep' from the speaker via Q5-6.

Mujid Abdurrahman,
Yogyakarta, Indonesia **$50**

Second part of our Survey:

Amateur radio kits in Australia & overseas - 2

In the second of these articles looking at the construction kits that are currently available both here and overseas for the radio amateur, the author looks at the UK, India, Greece, Japan and West Germany.

by THOMAS E. KING, VK2ATJ

We continue our survey with a look at the kits available from firms in England and other parts of the United Kingdom.

United Kingdom

The kit craze has well and truly spread across the British Isles, with a large range of items for HF and VHF enthusiasts. Not only are a large proportion of British kitsets intended for the QRP operator, but this specialist aspect of the hobby has its own quality publication. (Details of new kits and QRP operations plus much more is contained in *SPRAT*, the Journal of the G-QRP Club, edited by George Dobbs G3RJV, St Aldanas Vicarage, 498 Manchester Road, Rochdale, Lanc. 01L 113HE).

There are over 30 different kitsets available from C.M. Howes, of Eydon, Daventry, Northants, NN116PTI (phone 0327 60178). Included are receivers from £14.80 and QRP transmitters from £13.80. Among the most popular kits are:

DcRx20 20m SSB/CW receiver	£15.30
DcRx40 40m SSB/CW receiver	£15.30
DcRx80 80m SSB/CW receiver	£15.30
DcRx16 160m SSB/CW receiver	£15.30
CTX40 40m CW transmitter	£13.40
CTX80 80m SSB/CW receiver	£13.40
MTX20 20m 10W transmitter	£21.90
CVF20/40/80 VFOs for the above transmitters	£9.90
NC220 2m to HF transverters 10W output	£52.50
TRF3 Shortwave broadcast receiver	£14.50
CTU30 HF band ATU for receiving on 30m	£24.90
SWB30 SWR/relative power indicator for 160 to 2m	£11.90
AP3 Automatic speech processor	£15.90
ST2 Sinewave/sidetone/practice oscillator	£8.60
XM1 Crystal calibrator with 8 marker intervals	£16.80

Released in 1989 is the DXR10, a receiver for 10, 12 and 15m. Priced at £24.90, the neatly presented project features a double balanced mixer, bandpass input filtering (which requires no tuning or setup adjustment), active AF filter and sufficient audio output to drive a loudspeaker or headphones.

The new £7.50 AA2 active antenna kit can be used with this receiver or any other rig. The AA2 can be used with a single wire or a miniature dipole, indoors or out and covers the 100kHz to 30MHz band.

Two of the newer VHF additional mono kits from C.M. Howes are the 2m and 6m converter kits, each priced at £17.50. Output is on 20m. While the CV220 and CV620 are designed as companions to the DcRx20 receiver, the two converters can be used with any 20m receiver.

A copy of the Howes catalog and mail order information is available by contacting the Technical Manager. Enclose a suitable SASE or an envelope with IRCs.

John Beech, of 124 Belgrave Road, Wyken, Coventry CW2 5BH (phone 0203 617367) has a three band (80, 40 and 30m) CW/RTTY transceiver kit for £55. A one band kit is £40. Kits have audio filtering, sidetone and key click filter. Also available from John, G8SEQ, is a 6m converter, 6m transverter, 6m transmitter and a 10MHz QRP transmitter and receiver, with prices on application. PCBs are available as separate items.

The leading but not the only kit made by Lake Electronics, 7 Middleton Close, Nuthall, Nottingham NG16 1BX (phone 0602 382509) is the 1.5W DTR3 CW transceiver for 80m.

Featuring direct conversion, sensitivity is better than 1uV and selectivity is 250Hz at 6dB. Price is £76.25 plus postage. This kit has ready printed front and back panels, a slow motion drive, audio filter and all parts. Contact Alan G4DVW for information and details of other Lake Electronics kits, including a £63 direct conversion 80/40/20m kit receiver.

A number of QRP projects are also available from Harlech Electronics, Noddfa, Lower Road, Harlech, Gyn Gwynedd LL46 2UB including a shortwave receiver, DcRx80 receiver, CW transceiver, active antenna, preselector, audible signal strength meter and a power supply suitable for numerous projects. Export prices and domestic prices are available from the company.

Kanga Products, of 3 Limes Road, Folkestone, Kent CT19 4AU (telephone 0303 76161) offers a range of semi-complete kits for the radio amateur and shortwave listener. Kits are supplied complete with the hard-to-get parts, leaving out components which are commonly found in any junk box. Among the most popular kits are:

Sudden DC Receiver	£17.95
Power supply kits	£14.95
AF amplifier kit	£12.95
Morse practice oscillator	£12.95
Iambic keyer kit	£16.95
100W dummy load	£10.45
Crystal marker kit	£13.95
Frequency counter/dial	£21.95
'Oner' HF transceiver	£27.50
Top band kit for the FT707 and FT77	£29.95
Dual band receiver (20m and 80m)	£36.95

A kit we didn't mention last month: A packet radio control board ($60) from Think Tank projects, PO Box 262, Kelmscott 6111.

A free copy of the current Kanga catalog is available to those sending an SASE or IRCs.

Looking for a BFO so that you can receive SSB on that portable shortwave receiver? Corrigan Radiowatch, of 7 York Street, Ayr KA8 8AR has a BFO kit for £11.95.

ACEPW, of 99 Greenheath, Hednesford, Staffs (phone 05438 71902 – 24 hours) has a microtransmitter VHF FM kit for 70/144MHz. Complete with a mini mic, the 1-1/4" by 1/2" mini mitter is priced at £4.50. A list of kits is available to those sending an SASE.

Traps for homebrew triband beams and anti-TVI trap dipoles plus antenna bits and baluns are available from a small but specialised British company. Contact G2DYM, Uplowman, Devon EX16 7PH.

Jandek is a new British company specialising in kits based on a modular approach, so that the homebuilder can not only use as many or as few modules as required, but they can be combined with self designed circuitry. The Jandek Direct Conversion Receiver kit can be built to operate on the 1.8, 3.5, 7, 10 or 14MHz bands. Seven modules are required to complete the receiver (prices on application).

Jandek intends to add basic test equipment kits to its receiver and planned QRP transmitters. A leaflet detailing amateur kits is available from Jandek, 6 Fellows Avenue, Kingswindord, W.Midlands, DY6 9ET (phone 0384 288900 – evenings and weekends).

Specialising in low power amateur kits is Cambridge QRP Components, of 30 Rookery Close, St Ives, Huntingdone, Cambs PE17 4FX (phone 0480 68330). The company has kits for a random wire ATU, SWR bridge, 160/180m receiver, several transmitters and a VFO. Prices on application.

Members of the British Amateur Television Club have access to special kits for all aspects of amateur TV. Write to BATC (G8KZG), 6 East View Close, Wargrave, Berks RG10 8BJ, or phone 073 522 3121 (evenings and weekends only) for more information.

Dave Aislewood G4AWZ, of 36 King Street, Wincanton, Scunthorpe, South Humberside DN15 9TP sells several QRP kits seen in *SPRAT* magazine. Included are the noted 'Oner' rigs and the PCBs for the 'Unichip' kits.

Six metres is a favourite band for CPL Electronics, of 8 Southdean Close, Hemington, Middlesbrough, phone 0642 591157. The company has a 6m converter and a 6m transverter (28/144MHz IF), as well as low power ATU and SWR bridge kits, plus various pieces of test equipment including a UHF prescaler. CPL makes up kits from various magazine articles in the UK and has a good library of reprints featuring numerous amateur kits.

G4TJB, 24 Portishead Road, Worle, Weston-Super-Mare, Avon BS22 OUX (phone 0934 512757) markets a 2m preamp, a 2m preamp with power amp and a 6m VMOS amp kit, as well as low and high pass filter kits and a morse oscillator kit. Prices on application.

Assisting with the conversion of various CB equipment for use on the 10m band is but one area of speciality for kit-maker Spectrum Electronics, of Unit 6B, Marabout Industrial Estate, Poundbury Road, Dorchester, Dorset DT1 1YA (phone 0305 62250). The company has converters for 2/4/6/10/20m, power amps for 2/4/6/10m, a receiver for 20/80m and 6m transmitter and receiver. Prices on application.

Cirkit Distribution, of Park Lane, Broxbourne, Herts. EN10 7NQ (phone 0992 444111) has a wide variety of kits which are virtually unknown in Australia. For starters, there are six converters: 50MHz multiband (10/6/4m), 2m to 10m, 70cm to 2m, 70cm to 10m, an 80m converter for the RC14 receiver and 23cm to 2m or 10m.

There are also 50 and 70MHz converter kits with the output on 28MHz, wideband 14-70MHz and 1.5-30MHz preamp kits, a 2m preamp kit, a wideband 1.8-30MHz (3W PEP) power amp and wideband ATU kits; many test equipment kits, including an SWR meter, a deviation meter, and a crystal calibrator; a number of direct conversion amateur receivers, including the RC14 20m receiver; a CMOS keyer and a speech processor. Prices and ordering details are contained in a catalog, available for £1.30.

Cambridge Kits (not to be confused with Cambridge QRP Components) has a 50-70MHz converter (10MHz IF) and an LF converter (100-600kHz with a 3.5 or 4.1MHz IF). The company also stocks a wideband ATU, noise bridge, two tone oscillator, audio oscillator, crystal calibrator, speech compressor and tunable notch filter kits. More details are available from Cambridge Kits, 45 Old School Lane, Milton, Cambridge CB4 4BS - telephone 0233 860150.

Converter kits for 4/6m, 70cm/2m preamps and 70cm/2/4/6m power amps, FM TV modules and a complete 70cm/2m receiver and transmitter are on offer from Wood and Douglas, Unit 12-13, Youngs Industrial Estate, Aldermaston, Reading, Berks. RG7 4PQ (phone 07356 71444).

Last but not least is FJP Amateur Kits and Components, of 63 Princess Street, Chadsmoore, Cannock, Staffs

Amateur radio kits

WS11 2JT (phone 05435 6487). Topping their kit list is a 50MHz converter for £22, the *Practical Wireless* 'Woodstock' SW converter for £26.50, 1.5W transverters for 6m or 4m (with 2m or 10m IF) for £46, 6m and 2m power amps, an active antenna and various pieces of test equipment in kit form including a crystal tester, a two-tone oscillator and an LCR bridge.

India

It may be surprising to learn that the world's second most populous nation is a 'hot bed' for kit manufacturers. Just about everything electronic is available from a handful of specialised companies centred in Madras and Bombay.

There are two organisations in Madras: Telectron Industries, of 22 Dayalu Nagar, 3rd Street (near Power House), Kodambakkam, Madras 600024 and Teltron Electronics, of 6 Trustpuram, Third Cross, Kodambakkam, Madras 600024. Both firms manufacture and design high quality printed circuit boards, retail electronic kits and supply all types of electronic components. And both outlets produce simple fliers, listing hundreds of kits.

While there are no proper amateur radio kits (a situation which should soon be remedied, as there are now 5000 amateurs in India and many are unable to afford imported Japanese equipment) each company does have (in both PCB-only and kit form) shortwave receivers, TV boosters, test equipment (digital frequency meters, digital LCD multimeters, capacitance meters, etc.), and a good range of power supplies from NiCad chargers to fully regulated bench supplies. Send an SASE and several IRCs for a list of kits.

Across the country in Bombay, Visha Electronics manufactures and sells an incredible 201 different electronic projects. (Prices following are quoted in Rupees, where A$1 = Rs12).

While preamps and power amps have application in many amateur shacks, most hobbyists will find the range of Visha lab instruments and power supplies to be of greatest interest. Select from such kit projects as an LCD digital panel meter (Rs35), a function generator (Rs600), an analog capacitance meter (Rs365) and a power supply delivering +/–15V at 1A (Rs750). A complete list of PCBs is available from Visha Electronics Corporation, 349 Lamington Road, opposite Police Station, Bombay 400007.

Yes, it's Michelle Smith again, still wiring up our transmitter!

Australian amateurs planning a visit to the subcontinent may want to organise their travel so as to arrive in Bombay. Apart from its obvious sightseeing advantages, Bombay has Lamington Road – which is a pandora's box of electronic wholesalers, resellers and miscellaneous outlets, the likes of which have to be seen to be believed!

The most innovative amateur radio club in New Delhi, the Amateur Radio Association, of B2/101 Pachim Vihar, New Delhi 110063 has an impressive line-up of homebrew equipment using locally produced PCBs and Indian-made components.

Among the useful projects which are duplicated by club members of the Delhi Radio Club in weekend get-togethers are a 4-band transceiver, a 2W FM transceiver and a frequency counter. The driving force behind the ARA is Dr Ashutosh Singh, VU2IF, who was responsible for organising communications for an early Indian expedition to the Antarctic. VKs are welcome to attend club meetings, and learn more about how this independent club has been instrumental in providing instruction and inspiration to hundreds of amateurs in the Indian capital.

One of the least expensive ways for Indian amateurs to get on the air is using an indigenously developed 40m AM/CW transmitter with BD139 finals, a TBA810 IC modulator and a 7MHz VFO. Designed by Vasant, VU2VWN, the little-publicised project is basically known only to the ham population of Kerala. However, a number of amateurs in India's most literate state have successfully built the QRP transmitter project, and are using it in combination with a good antenna in regional south India communications.

A set of three PCBs for the project is available for about Rs25, with a kit costing around Rs350. Limited stocks of kits and boards are available through the Institute of Amateur Radio in Kerala, Vandana Sahodaran Ayyapan Road, Kadavanthara, Cochin 683202.

The federally funded National Institute of Amateur Radio 6-3-1092/93, Somajiguda, Hyderabad 500 482, Hyderabad intends to mass produce the above kits and make them widely available at an anticipated lower price. Details of this major project to assist VU2s, as well as news of developments about amateur radio throughout the country are contained in the Institute's monthly newsletter.

Greece

C & A Electronic O.E.

PO Box 25070, Athens 10026, Greece. Phone 5242 867.

Located within sight of the world famous Parthenon, the C & A Electronics Company has the potential to be the kit giant of Europe. Headed by Mr Simeon Krizias, an electrical engineer by profession, C & A is the largest kit company in Greece and one of the largest in Europe. Equipped with in-house R&D facilities and the capacity to manufacture its own PCBs, the 13 year old company has become a household name with radio hobbyists, experimenters and amateurs in Greece.

While most of C & A's kits are mass market electronic hobby and audio items, the company does have a wide range of test equipment kits such as a digital frequency counter (0 – 200MHz), a digital voltmeter (0 – 200V DC) and a crystal controlled frequency standard.

Amateur radio kits are becoming increasingly important. Long established and well known in Europe, C & A's most popular RF and AF kits are No.614, a 6-channel NBFM VHF receiver with 0.5uV input sensitivity using dual-gate MOSFET 3SK88's, dual conversion, for £33.17; No.619A, a 6-channel 3W NBFM VHF Exciter, for £23.43

(both 614 and 619A operate on 11 – 14V DC and can be combined to create a VHF transceiver); No.625, a 115-165MHz narrow band FM receiver with 1uV input sensitivity and dual conversion, price on application; No.626, a single-channel 250/750mW VHF handi-talkie with 0.25uV input sensitivity, dual conversion, 400mW audio output, 9V DC operation, £30; and No.630, a 140-170MHz RF amp with 20W output for 1.5 – 3W input, fully protected for antenna mismatching, £20. (All prices are in Sterling – A$2 is approximately equal to £1)

In addition, there are several assembled C & A kits: 3W and 20W VHF FM transceivers and a 20W base VHF FM transceiver. Price is on application. VHF crystals for any C & A transceiver will be ground for about $4.

C & A welcomes orders from all overseas amateurs. Kits supplied with all components and English instructions will be dispatched overseas by registered air post, for an additional 15% of the total order.

Enquire directly to C & A concerning specifications for a number of recent kit releases: a 6 – 8MHz synthesiser designed for 2m operations, a 70cm transverter and a 70cm fast scan ATV transmitter, an SSTV decoder usable with any amateur receiver, a microprocessor-controlled general coverage shortwave receiver and a 12V 10W triband HF transceiver. Write for an illustrated catalog containing all 125+ C & A kits. Cost is £1 or $2, to cover airmail postage.

Japan

The world's most populated country, in terms of radio amateurs, is a disappointment when it comes to kit manufacturers. You would think that some enterprising manufacturer would see the potential in producing such items especially for the vast market in developing countries!

Mizuho Tsushin, 2-8-6 Morino, Machida-Shi, Tokyo 194 is now the country's only manufacturer of amateur kits. The following kits (priced in Yen, where A$1 = Yen 105) may not be available in commercial quantities: QRP-7, a 7MHz transmitter; QRP-21, a 21MHz transmitter; CW-100, a 7MHz receiver; and MOD 1, a 2W AM modulator.

The original price of these kits was Yen 3000, while the following QRP HF SSB transmitters are priced at Yen 24,000: MX-6S+, 1W 50MHz; MX-28S, 2W 28MHz; MX-21S, 2W 21MHz; MA-14S, 2W 14MHZ; MX-75, 2W 7MHz and MS-3.5S 2W 3.5MHz. Also available is a 10W HF amp for about Yen 10,000 and a power supply for about Yen 3800.

West Germany

While the Deutscher Amateur Radio Club is no longer able to supply its HF transceiver kits, the official magazine of Germany's federal radio organisation *cq-DL* regularly publishes HF/VHF transmitter, receiver and transceiver construction projects.

Elsewhere in Europe there are a number of small companies producing kits. Do you know anything about Josef Frank Elecktronik, of Wasserburger Landstrasse 120, D-8000 Muchen, West Germany, Nuova Electronica, of Bologne, Italy or the Dutch electronics company Velleman? Despite an offer to be included in this *Electronics Australia* survey, they did not respond to my questionaire.

If you do know about these firms and the kits they sell, please write to me: Thomas E. King VK2ATJ, care of the magazine. The same applies if you can supply information about any other kit company, elsewhere in the world. EA

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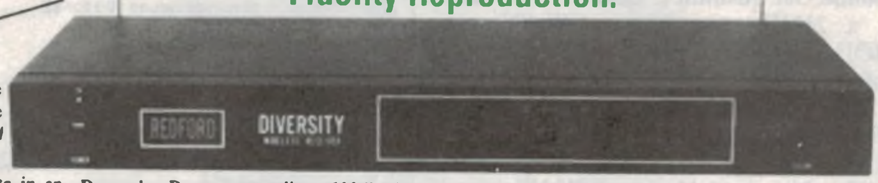

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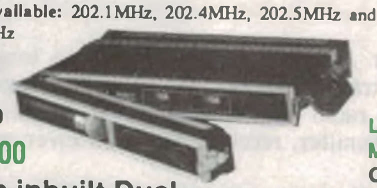

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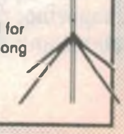

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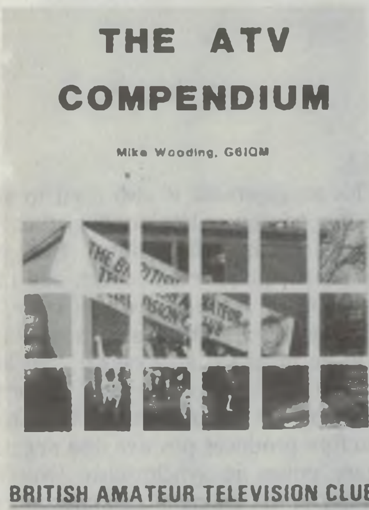


Amateur TV

THE ATV COMPENDIUM, edited by Mike Wooding, G6IQM. Published by the British Amateur Television Club, 1989. Soft covers, 210 x 150mm, 104 pages. ISBN 0-9513779-1-4. Recommended retail price $10.50.

A collection of useful circuits and construction project designs, intended especially for fast-scan amateur TV enthusiasts and produced by that very active British ATV group, the BATC.

The idea has apparently been to provide some up-to-date circuits and projects to encourage home construction, while at the same time not calling for access to a vast range of fancy test equipment or similar resources.

The projects covered include a 625 line/525 line pattern generator; various video switchers; a 'fade to black' circuit; a superimposing caption generator; an electronic test card circuit; an NTSC video display generator; a teletext pattern generator; a dual-standard colour encoder; a video distribution amplifier; a digital frame store; a universal sync generator; an EPROM programmer for the Spectrum computer; a GaAsFET receiving converter for 24cm (1250MHz) ATV; a matching 24cm FM transmitter; and an ATV transceiver for 3cm (10GHz).

Most of the simpler circuits at the start of the book are basically just that – circuits with a few notes. However the designs given later are much more complete, with PCB designs, layout details and other construction details.

The text is generally fairly concise, but quite readable and informative. For anyone with an interest in this area, my impression is that it has a lot of useful information. My only slight quibble is that the cover paper is a bit thin, so that the binding staples pulled through it after opening the book only a couple of times. Still, at the low price involved, it seems excellent value for money.

The review copy came from Stewart Electronic Components, of 44 Stafford Street, Huntingdale 3166 (PO Box 281, Oakleigh, 3166), which can supply it as catalog number BX270 via mail order, for the price quoted. (J.R.)

Packet radio

YOUR GATEWAY TO PACKET RADIO, by Stan Horzempa, WA1LOU. Published by the American Radio Relay League, third printing 1989. Soft covers, 215 x 140mm, 17mm thick (pages not numbered cumulatively). ISBN 0-87259-203-0. Recommended retail price $20.

This is the third printing of this very popular introduction to, and reference book on amateur packet radio, first published by the ARRL in 1987. By now it can probably claim to be almost the 'bible' on this rapidly growing area of amateur radio, having apparently encouraged and helped many thousands of American hams to 'get into it'.

Basically it covers the complete subject, from a rundown on the historical development of 'packet', through the theory of operation, terminal node controllers or 'TNC's' and their facilities, installation and operation, activities on the VHF/UHF bands, HF-DX operation, time shifting, public service communications, space communications and the packet network. The rear of the book also provides a set of data appendices, with details of standard TNC command sets, control codes and messages. There's even a handy glossary of packet radio jargon.

Things are a little US-specific in places, as you'd expect. However a very great deal of the material seems to be just as applicable here, as far as I'm aware from my limited personal knowledge of the area concerned.

On the whole it seems to be a very clearly written and highly readable book, and one that should be both an excellent introduction to the interested newcomer, and a handy reference for the experienced 'packeteer'.

So if you'd like to get into this intriguing area where amateur radio and digital data communications interact, this book should make it easy. And like most other ARRL publications, the price is also very reasonable. What more could you want?

The review copy came from Stewart Electronic Components, of 44 Stafford Street, Huntingdale 3166 (PO Box 281, Oakleigh 3166), which can supply copies by mail as catalog number BX169, for the price quoted. (J.R.)

HF propagation

THE SHORTWAVE PROPAGATION HANDBOOK, second edition, by George Jacobs W3ASK and Theodore J. Cohen, N4XX. Published by CQ Publishing, 1982. Soft covers, 228 x 152mm, 153 pages. ISBN 0-943016-00-2. Recommended retail price $18.50.

This is not a new book, as you can see. In fact the first edition was published just on 10 years ago, with this

Continued on page 106

Construction Project:

Low cost solid state relay

Ever wondered why commercial solid state relays cost so much? Using a different operating principle, the solid state relay described in this project features a very high isolation between the inputs and the mains, yet costs a fraction of a commercial unit. Safe, versatile and cheap, what more could you ask?

by BRANCO JUSTIC and PETER PHILLIPS

The solid state relay (SSR) has been around for a number of years, generally in the form of an encapsulated package with two input and two output terminals. The problem is, they also come with a fairly hefty price tag. The SSR is essentially a device containing a triac capable of being triggered on and off by an external DC signal that is isolated from the mains. Because the switching element is a triac, there is no wear and tear or pitted contacts, as you get with a mechanical relay.

This project has all the characteristics of the commercial models, but is based on a different operating principle. The switching device is still a triac, but otherwise the rest of the circuit is totally different to the general run of solid state relays. So before looking at the project, it is worthwhile to look at solid state relays in general, to see how they work, and perhaps answer the question as to why they are so expensive.

Solid state relays

The main elements of a commercial solid state relay are shown in block diagram form in Fig.1. The first block is the isolation between the input signal and the mains, generally achieved with some form of opto-coupler. With this type of isolation, the input signal must be able to supply enough current to light the internal LED, generally requiring a current of around 10mA at a voltage of between 3 and 30V. The isolation, typically rated at 2kV, is provided by the distance between the LED and the light sensitive device within the opto-coupler.

The next block is the *zero voltage* switch, used to keep radio frequency interference (RFI) radiation to a minimum. Any thyristor, such as a triac will produce RF interference when it switches, and the amount of radiation is proportional to the current being switched. Some brands of light dimmers produce considerable RFI energy, although RFI suppression is now usually fitted to all but the cheapest dimmer units.

However a solid state relay is simply providing on-off control, and is not used to vary the power to the load as in a light dimmer. If the triac is switched on when the voltage across it is virtually zero, then assuming the current is in phase with the voltage, very little RFI energy will be produced. A zero voltage switch produces a trigger pulse each time the mains voltage passes through zero, which is twice per cycle. The usual requirement is to switch the triac on before the voltage across it exceeds five or ten volts, thereby guaranteeing minimal RFI radiation.

The simplest zero voltage switch is a comparator that has a proportion of the mains voltage connected to its input. If the opto-coupler is arranged to control the comparator, then output pulses aligned to the mains will occur on every zero crossing of the mains supply, when there's a DC input signal. This method therefore needs a proportion of the mains voltage to be present at the input of the comparator, as well as providing the DC supply to power it and any associated electronics – usually by way of some form of rectifier, as shown in Fig.1.

This arrangement is also used to supply the trigger pulses to the triac, by forward biasing the bridge, first one way for the positive half cycle, and then the other for the negative half cycle. In fact, the zero voltage switch of Fig.1 could be regarded as a switch, synchronised to pulse shut every time the mains supply passes through zero. This circuit therefore produces positive and negative trigger pulses in synchronism with the polarity of the mains – an important requirement as we will see.

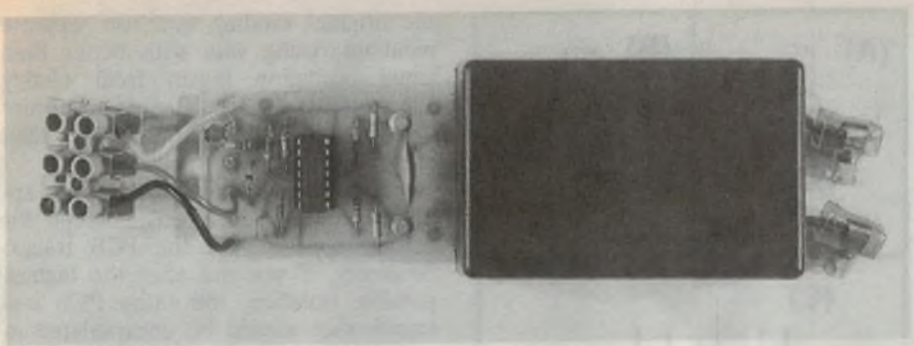
The final block is the triac. In Fig.1, the triac is shown as a device across the output terminals, and the load is connected in series with the triac. But triacs are tricky devices, worthy of a bit more discussion.

The triac

The triac belongs to the *thyristor* family of devices. A thyristor is a switching device, the simplest of which is the Shockley diode. As shown in Fig.2, the Shockley diode is a four-layer device, with the equivalent circuit shown in Fig.2(b). If the voltage across the device is high enough, the leakage current between the collector and emitter of transistor Q1 will be sufficient to provide base-emitter current to Q2. When this happens, Q2 will turn on, allowing Q1 to turn on even more, giving more bias current to Q2, and so on.

In other words, the Shockley diode switches on when the voltage across it exceeds a certain value. It will only turn off when current through the device falls below the *holding current* of the internal structure.

The silicon controlled rectifier (SCR) is a Shockley diode with a third connection, as shown in Fig.3. This extra connection, called the gate, allows transistor Q2 to be *triggered* on by an external pulse of current. Once Q2 is pulsed on, the current from Q1 will keep it on, in the same way as the Shockley diode.



Build our solid state relay for less than $15 and switch mains-operated loads from a computer, PIR detector or any application for an SSR.

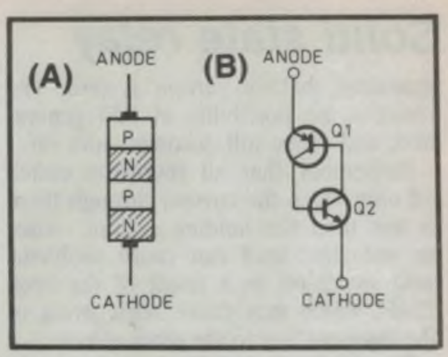


Fig.2: The Shockley diode is the most fundamental thyristor, and switches on if a sufficiently high DC voltage is applied across the anode and cathode terminals. Once triggered, it can only be turned off when the current through it is reduced to virtually zero. (a) shows the construction and (b) the equivalent circuit.

Again, the SCR can only be switched off by reducing the current through the device to a value below the holding current.

However, now there are two ways of turning the device on: by an external trigger pulse into the gate, or with a voltage across it that exceeds the breakover point, as in the Shockley diode. The latter method is generally more a nuisance than useful, and precautions are required to prevent false triggering due to over-voltage.

Another nasty is the *dv/dt* effect. This refers to SCR switching caused by a sharp *change* in the voltage across the device. Here the internal capacitance of the PN junctions is sufficient to pass the change to the base-emitter of Q2. Although the duration of the current will be short, it's still long enough to trigger the SCR. So, there are three ways to turn on an SCR – one of which is useful, the other two being secondary to the intended mode of operation.

The triac, in principle, consists of two SCRs connected in inverse parallel. That is, there are four transistors in the structure, allowing current to flow both ways. And now things start to become more complicated! The requirement now is a trigger pulse not only aligned to each zero crossing of the supply, but with a *polarity* related to the AC cycle.

As shown in Fig.4, a triac operates with the best sensitivity if the gate trigger current is in the same direction as the current through the triac. This is referred to as *first and third quadrant switching*, depicted in Fig.4(c). The implications here are rather interesting, showing that a triac has four possible modes of operation. Some triacs are designed to operate in all four modes, but most are suited only to modes I and III.

For example, sometimes a triac will operate, apparently with no ill effects if it is connected with its main terminals (MT1 and MT2) reversed. This may be the result of a sensitive triac, or because the trigger pulses are unduly strong. But in most cases, it will work sporadically, because it is now operating in the 2nd and 4th quadrants.

A particular problem with thyristors is switching an inductive load, such as a motor or a transformer. Any reactive load will have the voltage and current out of phase, and switching the triac when the *voltage* is zero is therefore no

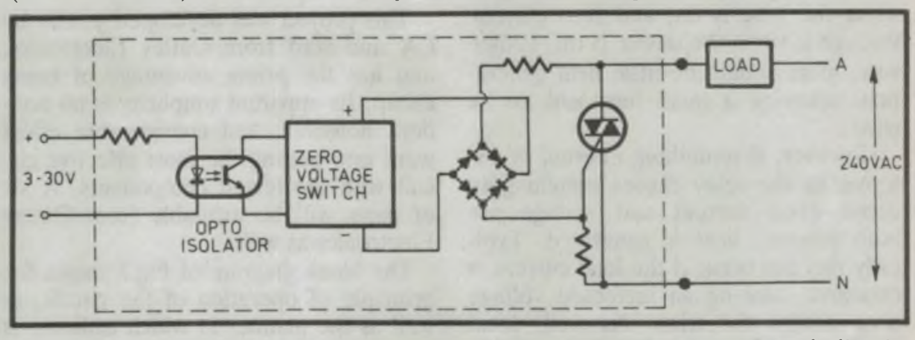
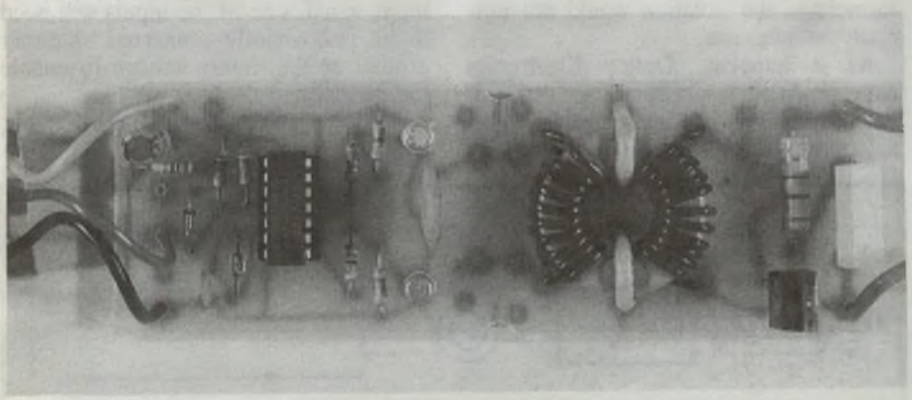


Fig.1: A conventional solid state relay usually contains something similar to this block diagram. The zero voltage switch ensures minimal RFI radiation and triggers the triac to give on-off control by application of a DC input.



This photo shows the printed circuit board and all components. The toroid is wound with 10 turns of insulated wire per winding, and the transformer is attached to the board with insulated wire straps soldered to the pads provided on the PCB.

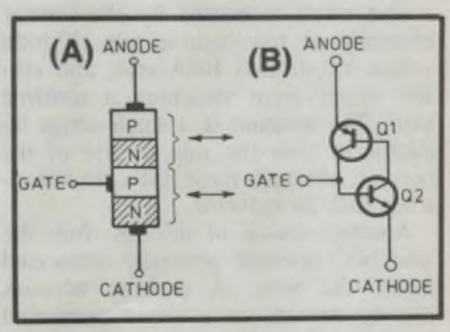


Fig.3: The SCR is a Shockley diode with an extra input added, called the gate. This input allows an external pulse to turn the SCR on. As in all thyristors, the SCR turns off only when the current through it falls below the holding current. The construction is shown in (a), the equivalent circuit in (b).

guarantee that the *current* is zero. The result is the possibility of RFI generation, and worse still, incorrect turn off.

Remember that all thyristors switch off *only* when the current through them is less than the holding current. Also, an inductive load can cause problems with switch-off as a result of the back EMF, which may cause retriggering of the thyristor due to the dv/dt effect.

So, all in all, triacs are rather user 'unfriendly', and some care is required in the design of a circuit using them. Also, triac applications have limitations, as they are not really a replacement for a set of metallic contacts. So a solid state relay has its limitations as well.

SSR limitations

Most solid state relays are characterised by a compact size. The triac, along with everything else will be embedded in the circuit, restricting heat dissipation.

Because leakage current in a PN junction increases with heat, the likelihood of false triggering, or even device failure increases dramatically with heat rise. Ideally, a triac in a solid state relay will have virtually zero volts across it when the triac is on, and zero current through it when the device is off. Either way, there should be little heat generation, allowing a small heat sink to be used.

However, if something internal or external to the relay causes switching to occur when current and voltage are both present, heat is generated. Typically this can occur if the load current is excessive, causing an increased voltage drop across the triac. As well, local heating inside the triac can quickly cause device failure, due to a phenomenon called the *di/dt* effect.

This effect is caused by the *current* changing at too high a rate. Typical values are around 100A/usec, and usually result from switching a *resistive* load. The solution is a small series inductor to slow the rate of rise of the current, although most SSRs do not include such an inductor.

Another source of di/dt is from the 'snubber' network generally connected across the triac. A snubber network usually consists of a series connected resistor and capacitor, fitted across the triac. Its purpose is to provide spike suppression and to guard against dv/dt effects. However if the capacitor is too large, or the resistor too small, the discharge current from the capacitor can, due to di/dt, cause triac failure.

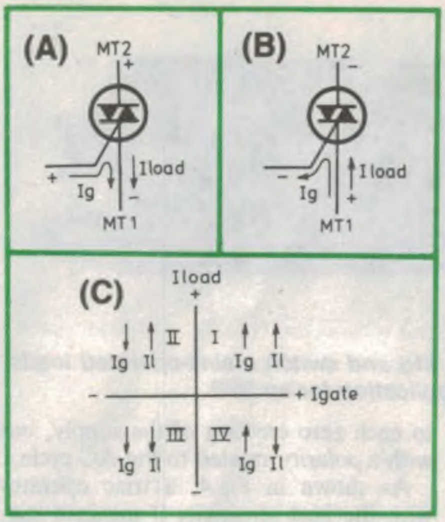


***Fig.4:** A triac can operate in four possible modes, as shown in (c). The usual modes are I and III, shown respectively in (a) and (b).*

So, putting it all together, solid state relays are not as easy as the advertising blurb tends to suggest. If the device has cost you $70 or so, it becomes an expensive exercise if it fails, even though the static load current is within the limits of the device.

Our project

This project was developed jointly by *EA* and staff from Oatley Electronics, and has the prime advantage of being cheap. Its apparent simplicity is no accident however, and considerable effort went into getting the most effective circuit with the fewest components. A kit of parts will be available from Oatley Electronics as well.

The block diagram of Fig.5 shows the principle of operation of the circuit, as well as the manner in which isolation is provided. Rather than employ an optocoupler, a trigger transformer has been used. But not just any old trigger transformer, as the isolation would not normally be adequate.

As it happens, Oatley Electronics have on hand a number of small toroidal transformers featuring a ceramic insulation around the core. By replacing the original winding with two separate windings, using wire with better than usual insulation (again from Oatley Electronics), the result is a transformer with isolation capabilities better than most opto-couplers.

In fact, a test voltage of 10kV was applied with no ill effects, except for corona appearing at the PCB tracks. Naturally, if you are after the highest possible isolation, the entire PCB and transformer should be encapsulated in special high voltage epoxy. In any case, the PCB tracks should be coated with many coats of PCB lacquer after the unit has been constructed. This way, isolation will be extremely high, giving excellent safety characteristics.

To supply the transformer with trigger pulses, an oscillator is used, interfaced to the transformer via a transistor push-pull output stage. Power for the electronics must therefore come from the input signal source.

There are three ways of triggering the unit, giving considerable versatility compared to conventional SSRs. Method one is to use it as you would a conventional SSR. Here a voltage somewhere between five and 15 volts is used, with a current capability of 10mA or so. On application of the supply voltage, the oscillator will start operating, triggering the triac. Removing the voltage stops the oscillator, allowing the triac to turn off.

The other two ways assume the electronics is supplied from a voltage source as already described. However, the oscillator can also be controlled with either of two inputs. One input accepts 0V (or ground) as the signal to turn on the triac, and the other responds to a logic 1. Both inputs are connected to a CMOS gate, therefore consuming almost no current.

If you intend using method one as the input signal, one of the inputs will need to be permanently connected to either ground or the supply voltage to enable the oscillator.

Now for the details of the circuit, which as you will see, is very simple.

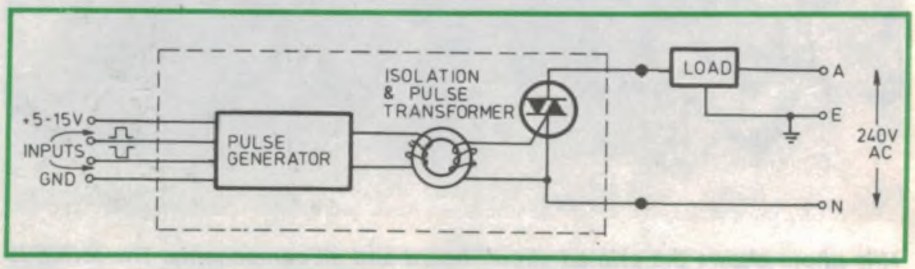
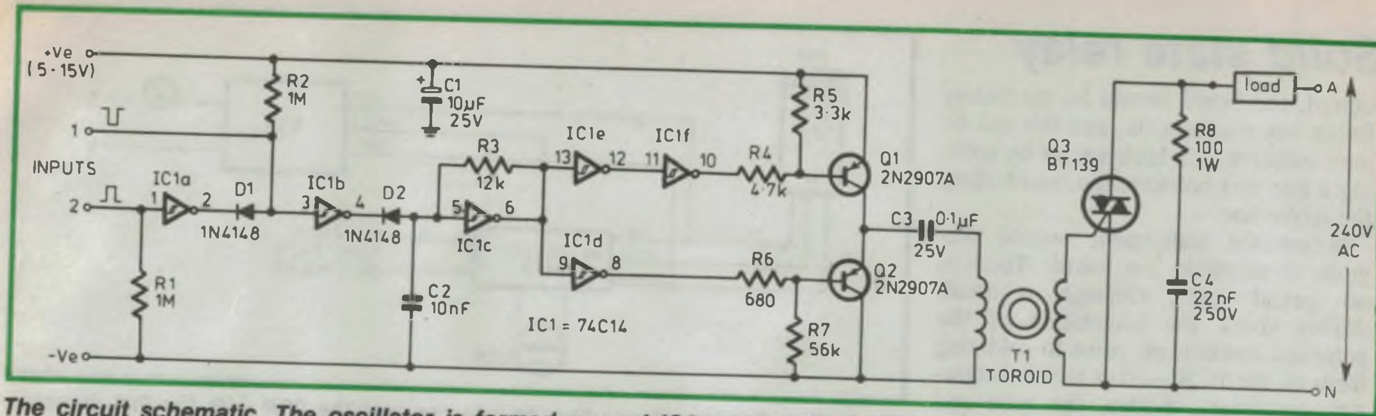


***Fig.5:** The block diagram of the project. An oscillator operating at around 5kHz is used to trigger the triac. Isolation is provided by the toroidal transformer.*



The circuit schematic. The oscillator is formed around IC1c, enabled when D2 is reverse biased by a logic 1 at the output of IC1b. Pulses are supplied to the triac by transformer T1, driven in turn by the push-pull connected transistors.

Circuit details

The heart of the circuit is an oscillator formed by the Schmitt trigger gate IC1c, R3 and C2. This oscillator operates at approximately 5kHz, but only when the output of IC1b is a logic 1. If this output is at a logic 0, the oscillator is disabled, because the input of gate IC1c is permanently held at 0V by the forward biased isolation diode D2.

The oscillator is enabled if a logic 0 (0V, or short to ground) is applied to input 1. In this instance, the inverting action of IC1b produces a logic 1 at its output, allowing the oscillator to function, as D2 is reverse biased, making it behave as an open circuit.

The oscillator can also be enabled by a logic 1 at input 2. A logic 1 is applied by connecting this input to the DC supply voltage, either directly or through a resistor. This will cause the output of IC1a to be a logic 0, in turn producing a logic 1 at the output of IC1b, enabling the oscillator of IC1c as described before.

The output of the oscillator is a square wave, and is connected directly to the Schmitt input inverters IC1d and IC1e. Because IC1e is connected to the inverter of IC1f, the voltages applied to the output transistors Q1 and Q2 are out of phase. Thus, Q1 is on when Q2 is off, and vice versa. The waveform appearing at the junction of the collector of Q1 and emitter of Q2 is therefore identical to the output of IC1c, except it now has sufficient power to supply current to the trigger transformer.

The transformer is coupled to the output transistors through C3, and the charge current through C3 gives short bursts of current in the primary winding of the transformer. The direction of the current will reverse every half cycle, giving alternate positive and negative pulses at the output of the secondary. These pulses are fed to the gate of the triac via the secondary of the transformer, giving around 100 trigger pulses per cycle of the 50Hz mains supply.

The worst case triggering will therefore be 0.2ms after the zero crossing of the 50Hz supply, corresponding to 3.6° within the cycle. This means the instantaneous voltage across the triac will be around 21V, which is 6% of the peak voltage (240V x 1.41 = 338V).

So we get effective zero-voltage triggering of the triac, not by the usual method, but by using relatively high frequency trigger pulses.

The triac has a snubber network comprising R8 and C4 connected across it. Filtering of the DC supply for the triggering electronics is provided by C1. The current required by the electronics will depend on the supply voltage, and for the prototype ranged from 4mA at 5V to 15mA at 15V.

Construction

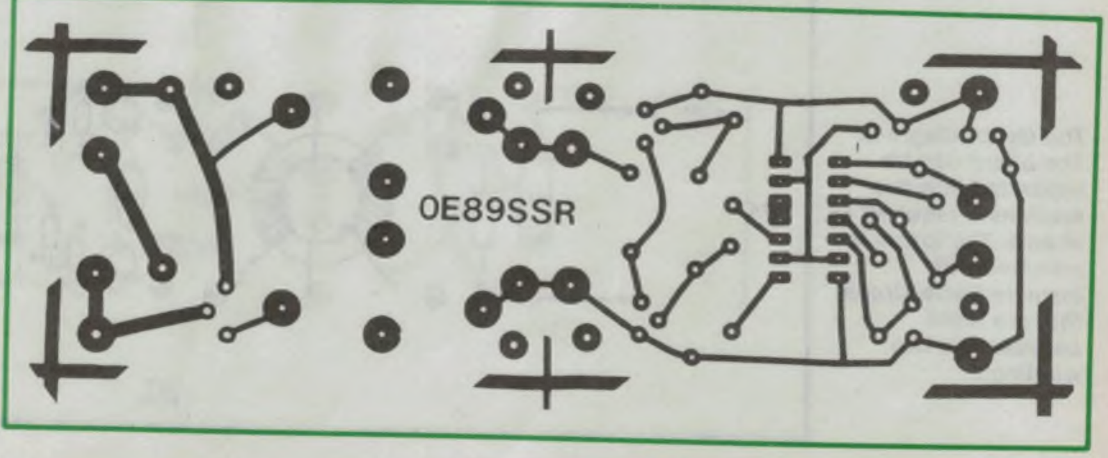
This project is available as a kit from Oatley Electronics, which includes the toroidal ferrite core with a single winding already wound on the core. The existing winding will first have to be removed from the core before the required windings are fitted. The old wire should not be re-used, as it does not have the necessary insulating qualities.

The PCB is designed to be separated into two sections: the trigger oscillator and the mains switching section. If re-

WARNING

This project involves mains wiring and some sections are not isolated from the mains. It should be considered hazardous and only those with appropriate experience should attempt its construction!

The PCB pattern for those who want to make their own PCB.



quired, the board should be cut before fitting any components, and this can be done either with a hacksaw, or by scribing a line and breaking the board along the scribe line.

Follow the component overlay diagram to assemble the board. There is no special order, although as usual, double check the orientation of the polarised components prior to soldering them to the PCB – that is, all electrolytic capacitors, diodes, the triac and the IC. An IC socket is optional, but recommended.

The trigger transformer can now be wound and fitted. Wind two windings, each comprising 10 turns of single strand insulated wire. The direction is not important, but note particularly that the insulating qualities of the wire affect the isolation capabilities of the transformer.

Oatley Electronics will supply the correct wire, but if you are making this unit from your own stock, make sure the selected wire has insulation at least 0.5mm thick. *DO NOT* use telephone wire, bell wire or other low voltage wire. If in doubt, fit another layer of plastic sleeving over the wire you are using. The gauge of the wire is not important, and multistrand wire could also be used. Just be sure that all strands are soldered to the PCB lands. The limitation will be the available room, as space should be left between both windings, and turns should not overlap.

The transformer is attached to the PCB by *insulated* wire straps as shown in the photos of the prototype. Again the wire straps should be heavily insulated for best isolation characteristics. As already mentioned, the track side of the PCB should be coated with lacquer once construction is complete. Use PCB lacquer, and apply numerous coats to get a good thick layer over the board.

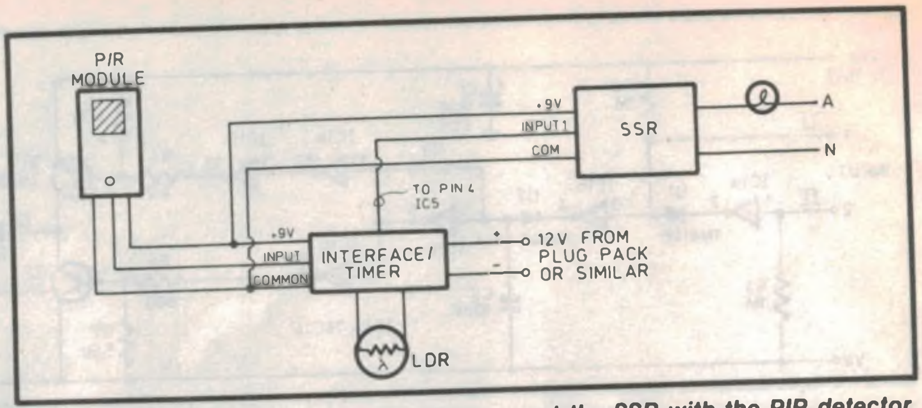


Fig.6: This diagram shows how to interconnect the SSR with the PIR detector project presented in May 1989. The interface allows four PIR detector modules to be attached, allowing one load to be operated from a number of points.

Testing

Once the unit has been assembled, it should be carefully checked to make sure that all mains wiring is properly terminated. While you are at it, double check all the connections to the PCB as well and look for any errors with component mounting. Once satisfied that all is well, the low voltage section can now be tested.

Connect a 10V DC voltage source to the trigger/oscillator section, and verify that the supply current is around 4mA. Then connect input 1 to ground (negative supply lead) and confirm that the supply current is approximately 10mA. If the current is excessive under these conditions, check the values of resistors R4, R5, R6 and R7. Also confirm that both transistors are correctly orientated.

If the current is excessive without the input trigger applied, confirm that IC1 is not in back to front. Fault finding should not be difficult with the unit, as it is very simple, and there is not a lot to go wrong.

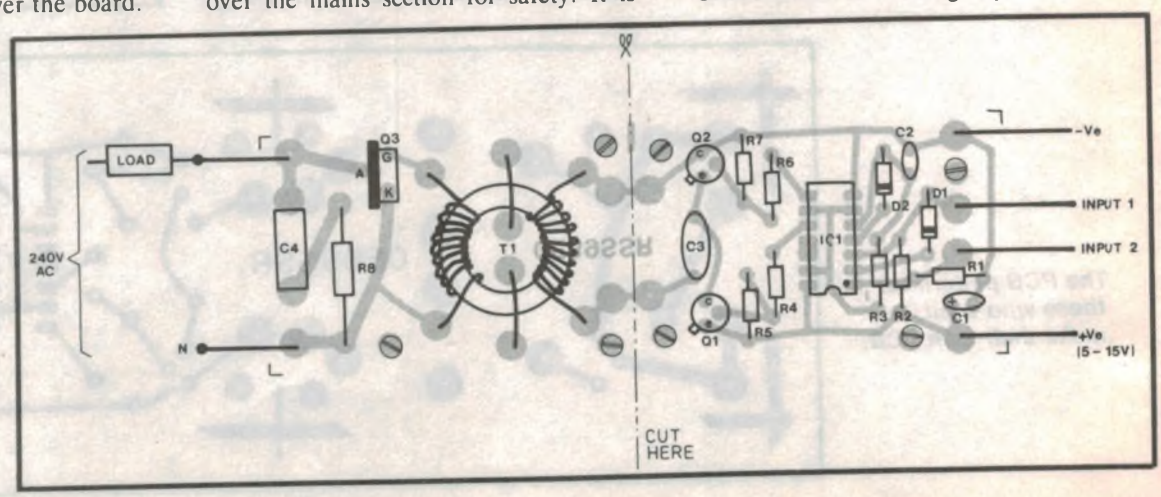
If all is well, the whole unit can now be checked. As shown in the photos of the prototype, a plastic box was fitted over the mains section for safety. It is important to realise that the metal tab of the triac is *live* and great care should be taken when the mains is applied. By following the connections shown in Fig.5, connect a 40W, 240V globe to the unit and position everything out of harm's way.

Switch on the mains and you should now be able to turn the light on or off from the low voltage side. As already described, there are three ways to switch the SSR: input 1 to ground, input 2 to the positive rail, and by connecting either input permanently to its required logic level and switching the supply voltage to the trigger electronics.

If the unit doesn't work, *switch off the mains* and check with a CRO or similar means that the oscillator is functioning when the appropriate input conditions are applied. Also confirm that trigger pulses are actually occurring at the gate of the triac. You should observe a series of very short duration pulses. *Make sure the mains is turned off when you do this!*.

Although unlikely, you may be unlucky enough to have an insensitive triac and replacement is the only answer.

Once the unit is working, try it at dif-



The layout diagram. The board can be separated into two sections if required as shown. The toroid is attached with insulated wire straps that are fitted between the two windings.

ferent DC supply voltages. The prototype worked well for voltages ranging from 5V to 15V, but some triacs may not trigger satisfactorily at the lower supply voltages. The optimum supply voltage is around 10V, as current consumption is consistent with a commercial model, and triggering should be more than adequate.

Applications

A solid state relay should not be seen as a direct replacement for a conventional switch. We tested the unit with a range of appliances, including a TV set, various items of test equipment and, of course, an incandescent globe. The latter is the ideal application, and using the SSR to switch a TV set or similar appliance is not recommended. The problems here are twofold: the TV set is inductive, and the sensitivity of the TV circuitry can respond to the switching transients. As well, some low power appliances may not take sufficient current to hold the triac 'on' once it is triggered.

It is also important not to overload the triac. Although most triacs can pass substantial currents (8A or more), this is only true if a heatsink is fitted. There is not a lot of room for anything other than a fairly small heatsink, and great caution should be exercised if a heatsink is fitted, as the heatsink will now be at mains potential! A load greater than 60W will require some form of heatsink, such as a press fit type available from most parts suppliers.

An ideal application for this project is in conjunction with a PIR detector to give an entry light. We presented a PIR detector project in May 1989, which also includes a small interface board containing a voltage regulator and timer circuit. There is also provision to connect a light dependant resistor (LDR) to the interface board, which will prevent the unit functioning during daylight. The interconnections are shown in Fig.6.

The interface board also contains a relay, which is not needed if it is intended to trigger the SSR. To make up the complete system, connect the SSR's power supply to the 9V output of the interface board (which also powers the PIR module) and connect input 1 of the SSR to pin 4 of IC5 on the interface board. The zener diode, ZD1 on the PIR interface PCB can be removed and a lead from input 1 of the SSR can be connected to the point vacated by the anode of ZD1.

The whole system can be powered by a 12V DC plug pack, but make sure the loaded DC voltage is 12V, and not something considerably higher. Most plug pack voltages are given for the fully loaded condition, and we found a 9V DC plug pack adequate.

Current consumption of the complete PIR system/SSR unit will be in the order of 50mA, allowing almost any plug pack to be used. Fiddle the timing component values to give the required delay, and enjoy the benefits of lighting up the front door when you approach it late at night. It might also discourage the occasional prowler!

Because the interface unit can accept four PIR modules, you can have a number of PIR detectors arranged to trigger the same light if required.

There are numerous applications for this project, such as a mains interface for a computer or any controller required to switch 240V appliances. Just watch the load limitations as already described, particularly if the load exceeds 100W.

PARTS LIST

1 PCB, coded OE89SSR
1 Toroidal ferrite core
1 Plastic case, 83 x 54 x 30mm
Insulated wire for transformer windings, hookup wire, mains wire etc

Resistors

All 1/4W, 5%: 1 x 680 ohm, 1 x 3.3k, 1 x 4.7k, 1 x 56k, 1 x 12k, 2 x 1M
1 100 ohm 1W, 5%

Capacitors

1 10nF ceramic
1 22nF, 250V AC rated
1 0.1uF ceramic
1 10uF, 25V low leakage electrolytic

Semiconductors

2 IN4148 signal diode
1 74C14 (40106) hex Schmitt input inverter IC
1 BT139 triac
2 2N2907 (or equiv) PNP transistors

Kits of parts for this project are available from:

Oatley Electronics
5 Lansdowne Parade,
Oatley West, NSW 2223.
Phone (02) 579 4985

Postal address (mail orders):

PO Box 89, Oatley West NSW 2223.

PCB, all parts and components. $14.95
Post & Packing charge............. $2.50

Resistors

When Ohm formulated his now very famous laws relating resistance, voltage and current, he turned electricity into a science. Technology has since turned the resistor into an item now costing a cent or less. But what's the resistor all about? And how about combining resistors to make a different value? What do all the coloured bands around a resistor mean? Read on, to find the answers to these questions and more...

by PETER PHILLIPS

In part 1, we examined the 'big three': voltage, current and resistance. Voltage was shown to be the force that makes electrical things happen. Current was described as a *flow of electrons* driven by the voltage, with the value of the current dependent on the *resistance* of the circuit as well as the applied voltage. We also presented Ohm's law, the equations that relate these three electrical quantities. Ohm's legacy is not only his three simple and highly useful expressions, but the unit of resistance – the ohm. It is fortuitous he was born with such a simple name, as the term 'ohm' crops up very frequently in electronics!

Our topic now is the resistor. Not only will we explain how they are made and their values are read using a colour code. We will also describe how resistors can be combined to give any value of resistance. On the way, we need to look at *multipliers* and talk about power in an electrical circuit. Quite a lot to do, so let's push on.

The resistor

As described previously, resistance is *opposition* to an electric current, in much the same way as a blockage in a pipe restricts the flow of water in the pipe. However while size of an electrical conductor will affect its resistance, the material the conductor is made of is really the main determining factor. Some materials such as copper, gold, silver and so on are good *conductors*, although they have some resistance – unlike a superconductor, which has none or very very little.

Unfortunately superconductors are only possible at extremely low temperatures (–200°C and below), making their general use somewhat impractical. However as Ohm's law shows, if the resistance is zero, then zero volts are required to sustain an infinitely large current – and experiments have produced extremely large currents within a superconductor with virtually no voltage required to cause it. Almost perpetual motion!

While superconductivity is great for conducting large amounts of current, electronic circuits often require resistance for their very operation.

The simplest way to make a resistor is to wind some resistive wire around an insulating cylindrical former (usually glass or ceramic). Various wires have reasonably high resistance, and even copper can be used if the wire is thin enough. The heating element in an electric radiator is simply a low value resistor, comprising resistance wire wrapped around a ceramic former. The heat that is dissipated is the energy lost, as will be explained further on.

In electronics, resistors are usually made with some form of carbon mixture, either as a compound contained in a plastic former, or as a resistive film deposited around a small ceramic rod. Wire-wound resistors are also manufactured, but their size and cost make them impracticable for general use in an electronic circuit.

The simplest type of resistor is the *carbon composition* resistor. This resistor in made of finely divided carbon or graphite, mixed with a powdered insulating material in the required proportions. The compound is contained in a plastic case with the leads embedded in the resistive element and supported by the case, as shown in Fig.1(a).

Another common type of construction is the *carbon film* resistor, in which the powder is deposited on the *outside* of a small ceramic rod. In fact, most resistors these days are made this way, as they are often more reliable than the carbon composition types.

As Fig.1(b) shows, to allow the resistor size to be kept fairly small, a spiral is cut along the body of the resistor making the effective electrical length of the film much longer than the body of the former. End caps, welded to the pigtails are fitted over the body of the resistor to connect to the film. The whole assembly is then dipped in some form of insulation to protect the resistive film.

An even more reliable resistor construction type is the *metal film* resistor, made in much the same way as the carbon film resistor, but using a metal oxide such as tin oxide. These resistors are usually more expensive than the carbon film types, but are more stable over a period of time. And of course, there are *wire wound* resistors, used mainly where high power must be dissipated. The photos of Fig.2 show a range of resistors that are typical of those available.

Not all resistors are fixed in value, and a range of *variable resistors* are manufactured, with some typical types shown in Fig.3. Variable resistors are often called potentiometers, shortened to 'pots'. For reasons that will become clear in later chapters, this terminology is often incorrect as a potentiometer is a device that varies a *potential* (or voltage), requiring all three terminals to be used, as shown in Fig 3(c). A variable resistor is normally a device that varies current, and uses two terminals only.

The resistive element of the variable resistor usually comprises either a carbon deposit on an insulating surface, or resistive wire which is wound around a suitable former. The moving wiper rests against the resistive element and connects to a fixed terminal through a set of metal to metal contacts – or sometimes a metal spiral.

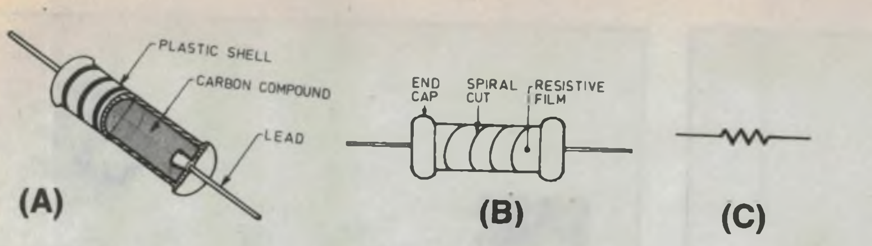


Fig.1: (a) The construction of a carbon composition resistor. A carbon compound is packed into a plastic shell, with leads embedded in the compound. This type of construction is now fairly uncommon. (b) The carbon film resistor has the resistive element bonded to the outside of a ceramic former. End caps connect the leads to the film, which has a spiral groove cut along its axis to give an effective length longer than that of the ceramic former. Most resistors today use this type of construction. (c) The symbol for a resistor. An alternative symbol is a rectangle.

Variable resistors, or 'pots' as we will (incorrectly) call them, often have a resistive element that follows a certain mathematical 'law'. This refers to the way their resistance changes with angle of rotation, as a proportion of the total.

Most PCB-mounting types are *linear*, so called because the resistance change is directly proportional to how far the wiper is moved. Another law, or curve, follows a roughly *logarithmic* relationship. This type of pot is used in a volume control for an amplifier, and is often denoted by the letter C on the body of pot. A linear pot is normally called an 'A' curve, although some manufacturers stamp their logarithmic pots 'A' to indicate audio. Confusing to say the least!

When in doubt regarding the law of a pot, set the wiper to the mid position and measure the resistance between the wiper (centre terminal) and one of the end terminals. The resistance should be around half the value of that between the two end terminals, if it's a linear type. There are other resistance 'curves', but the linear and the logarithmic are the most common.

Wire wound resistive elements in either fixed or variable resistors are used where the power dissipation exceeds a watt or more. But what's a watt you say? OK, we'll divert our attention for a short time to discuss electrical power.

Power

The combination of a voltage and a current is electrical *power*. A voltage or a current on their own do not represent power – you need both. Thus a circulating current of many amps in a superconductor is relatively useless if there is no voltage as well, as no power is present.

To cause a current to pass through a normal resistor there needs to be a voltage, meaning that because both a current and a voltage are present, power is being dissipated. The energy source for the power comes from the battery or the power supply which is delivering the voltage and the current in the first place.

There is a very simple relationship between voltage and current as far as power is concerned – you simply multiply them together. In other words, if a circuit has 10 volts applied to it and a current of 2 amps is flowing, then 20 *watts* of power is being dissipated by the circuit. Expressed as an equation, power (P) equals volts (V) times current (I), or:

$$P = V \times I$$

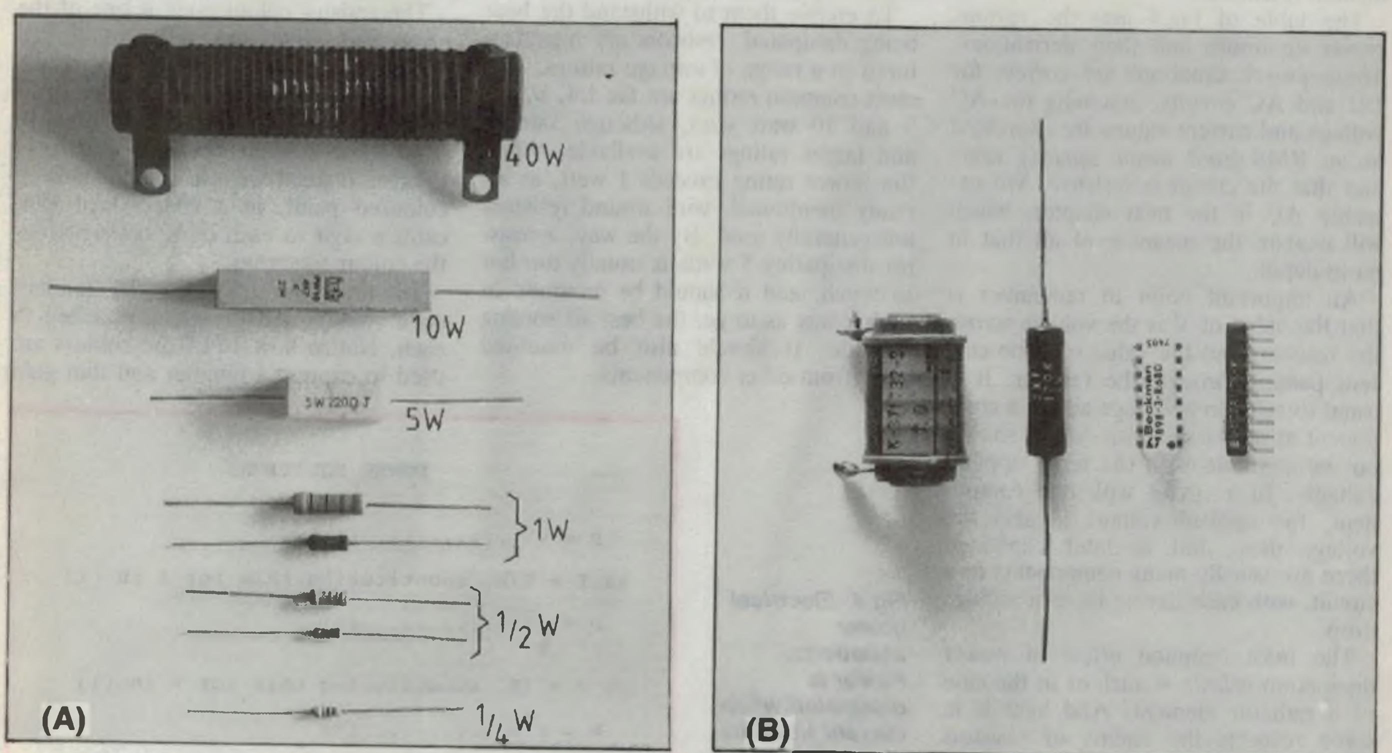
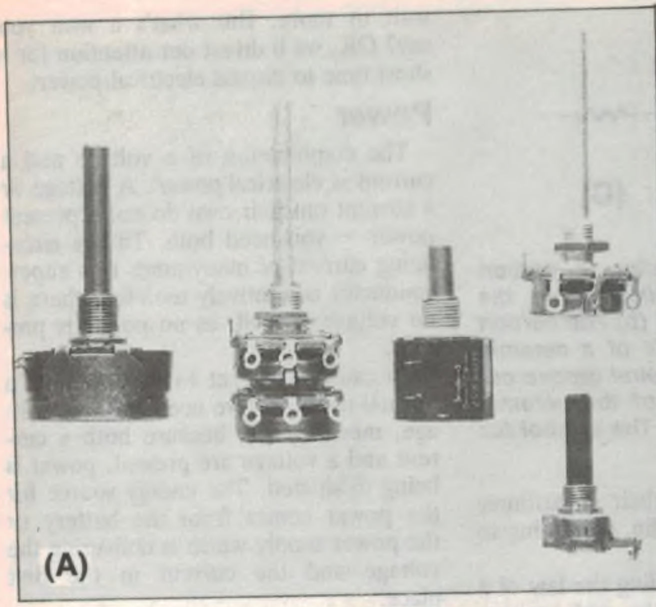
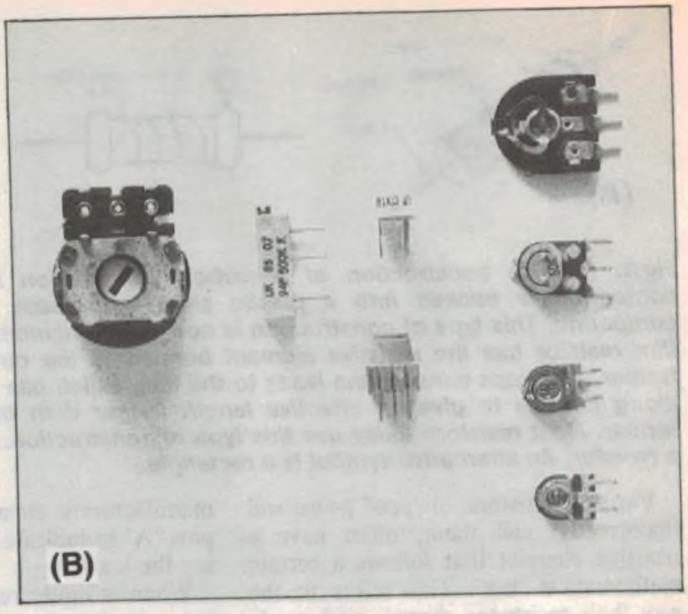


Fig.2: (a) This photo shows a range of resistor types. The top resistor is a wire-wound 4 ohm, 40W device, the next two are also wire-wound types, and the rest are carbon film resistors. Note that there are various sizes for a given power rating. (b) These resistors are more specialised and show (top to bottom) a precision wire-wound 1M ohm resistor; a 1%, 100k carbon film type; an IC-type pack containing eight independent 680 ohm resistors; and a SIL resistor pack containing nine 4.7k resistors, one end of each connected to a common line.





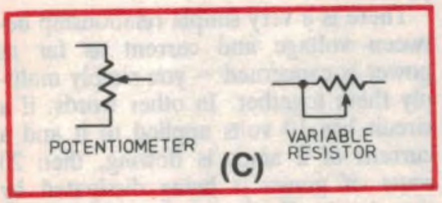


Fig.3: (a) A range of panel mount 'pots'. From the top: 1k wire wound; dual ganged carbon; 10 turn precision wire wound; two typical carbon types. (b) These pots are all PCB mounting types. The second from the top is a cermet 10 turn type. (c) Left: a variable resistor connected as a potentiometer in which all three terminals are used independently. Right: a variable resistor or 'rheostat'. The term 'pot' is now generally used for all applications of a variable resistor.

However because V, I and R are all related (courtesy of Ohm's law), equations for power can be also derived that include resistance.

The table of Fig.4 lists the various power equations and their derivations. These power equations are correct for DC and AC circuits, assuming the AC voltage and current values are expressed as an RMS (*root mean square*) value and that the circuit is resistive. We examine AC in the next chapter, which will explain the meaning of all that in more detail.

An important point to remember is that the value of V is the voltage *across* the resistor, and the value of I the current passing *through* the resistor. It is usual to refer to a voltage across a component as its *voltage drop*, which should not be confused with the term 'applied voltage'. In a circuit with one component, the applied voltage is also the voltage drop, but as later explained there are usually many components in a circuit, with each having its own voltage drop.

The most common effect of power dissipation is *heat* – such as in the case of a radiator element. And heat is in some respects the enemy of resistors and electronics in general.

Resistor power rating

Whenever voltage, current and resistance are combined, heat is generated. Sometimes, as in a heating element or an incandescent light, heat is the reason for the circuit, but usually it is an unwanted by-product.

To enable them to withstand the heat being dissipated, resistors are manufactured in a range of *wattage ratings*. The most common ratings are the 1/4, 1/2, 1, 5 and 10 watt sizes, although smaller and larger ratings are available. When the power rating exceeds 1 watt, as already mentioned, wire wound resistors are generally used. By the way, a resistor dissipating 5 watts is usually too hot to touch, and it should be mounted in such a way as to get the best air cooling possible. It should also be mounted away from other components.

Resistor values

The topic of resistor values involves two discussions: the colour code and the *preferred* range of values.

The resistor colour code is one of the most successful and well established codes in electronics. Because low power resistors in particular can be very small physically, it is really not feasible to mark them with their resistance value in figures. Instead we use small bands of coloured paint, in a code which allocates a digit to each of 12 colours from the colour spectrum.

The table of Fig.5(a) lists the standard code colours and the value attached to each. Notice how 10 of the colours are used to express a number and that gold

Fig.4: Electrical power equations. Power is dissipated when current flows in a resistor, which can only happen in the first place if a voltage is present.

POWER EQUATIONS

$$P = VI \quad \ldots\ldots\ldots\ (1)$$

as $I = V/R$, substituting this for I in (1)

$$P = \frac{V^2}{R} \quad \ldots\ldots\ldots\ (2)$$

as $V = IR$, substituting this for V in (1)

$$P = I^2R \quad \ldots\ldots\ldots\ (3)$$

where: P = power in watts
V = voltage in volts
I = current in amps
R = resistance in ohms

RESISTOR IDENTIFICATION - THE COLOUR CODE

COLOUR	NUMBER	MULTIPLIER	TOLERANCE
BLACK	0	$x10^0$ (= x1)	
BROWN	1	$x10^1$ (= x10)	1%
RED	2	$x10^2$ (= x100)	2%
ORANGE	3	$x10^3$ (= x1,000)	
YELLOW	4	$x10^4$ (= x10,000)	
GREEN	5	$x10^5$ (= x100,000)	
BLUE	6	$x10^6$ (= x1,000,000)	
VIOLET	7		
GREY	8		
WHITE	9		
GOLD		$x10^{-1}$ (= x0.1)	5%
SILVER		$x10^{-2}$ (= x0.01)	10%
NO COLOUR			20%

Examples:

Red, Violet, Yellow, Gold (4 bands)
2 7 $x10^4$ 5% = 270,000 = 270k ohms, 5%

Green, Blue, Gold, Gold (4 bands)
5 6 $x10^{-1}$ 5% = 5.6 ohms, 5%

Orange, White, Silver, Red (4 bands)
3 9 $x10^{-2}$ 2% = 0.39 ohms, 2%

Brown, Grey, Black, Red, Red (5 bands)
1 8 0 $x10^2$ 2% = 18,000 = 18k ohms, 2%

Fig.5: The resistor colour code. (a) lists the colours and (b) shows how they are applied. With practice, the colour code becomes easy to read, but if in doubt measure the resistance with an ohmmeter.

and silver are only used as a multiplier or tolerance value.

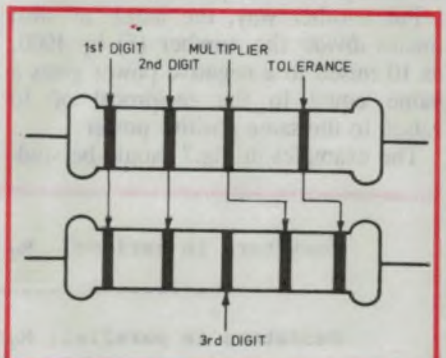
The success of the colour code is due to its simplicity. For most resistors, the first two bands give the first two digits of the value, while the third band (the multiplier) gives the number of zeroes that follow the two digits.

If a three-digit value is required, such as in a special high precision resistor, an extra band is used, so that the first three bands give the three digits and the fourth gives the number of zeroes.

The *tolerance* of the resistor is indicated by the final band, usually spaced further away from the value bands. Tolerance is the manufacturer's guarantee on the actual value of the resistor. For example, a 1000 ohm, 10% resistor could have an actual value of anywhere between 900 ohms to 1100 ohms. That is, its *nominal* value of 1000 ohms, plus or minus up to 10% of that value.

Most commonly-used resistors have a 5% tolerance, indicated by a gold tolerance band.

Some manufacturers also identify the resistor *type* with a particular body colour. For example, a cream body usually means a carbon film resistor, while



light green or light blue generally means a metal film resistor.

A resistor with a brown body sometimes means the resistor is a 1/2 watt resistor, even though it is the size of a 1/4 watt resistor. However if in doubt, consult the manufacturers' data, as there is no real standardisation for body colour.

Preferred values

To standardise on resistor values, manufacturers agreed many years ago on the *preferred value* range. The most common range is the 10% preferred

PREFERRED VALUES FOR RESISTORS

5% range	10% range
1	1
1.1	
1.2	1.2
1.3	
1.5	1.5
1.6	
1.8	1.8
2	
2.2	2.2
2.4	
2.7	2.7
3	
3.3	3.3
3.6	
3.9	3.9
4.3	
4.7	4.7
5.1	
5.6	5.6
6.2	
6.8	6.8
7.5	
8.2	8.2
9.1	
10	10

DECADES:

0.01 to 0.1
0.1 to 1
1 to 10
10 to 100;
100 to 1000
1000 to 10,000
10,000 to 100,000
100,000 to 1,000,000
1,000,000 to 10,000,000

Fig.6: The above list of resistor values are those normally sold by most parts suppliers. The table lists the values in each of the nine decades, giving 108 values in the 10% range and 216 in the 5% range. The 5% range is not as readily available as the 10% range.

values, and many hobby suppliers stock these nominal values only.

The values in the range (see Fig.6) are calculated on the basis that the resistance value could be anywhere from 10% lower to 10% higher than the marked value. For example a 100 ohm, 10% resistor could have a value between 90 and 110 ohms. A 120 ohm, 10% resistor will be between 108 ohms to 132 ohms.

Notice how the highest acceptable value of the 100 ohm, 10% resistor overlaps the lowest value of a 120 ohm, 10% resistor. If a 110 ohm resistance value is required, you have the choice of selecting it by measurement from either a range of 100 ohm or 120 ohm, 10% resistors.

However manufacturing techniques for resistors have improved significantly since the introduction of the 10% preferred range of values, and these days most resistors have a tolerance of 5%. Thus a 110 ohm resistor is now outside the tolerance of either a 100 ohm or a 120 ohm 5% resistance value, making the 5% tolerance range necessary.

Normally the 10% range of values is adequate anyway and as shown later, a 110 ohm resistor, or any value for that matter, can be made by combining resistors. Some component suppliers stock the 5% range which, as shown in Fig.6, includes a 110 ohm value.

The table of Fig.6 also lists the *decades* available. A decade is the range of values between 10 raised to a certain power, and the next higher or lower power to which 10 is raised. An example is the decade between 10^2 (= 100) and 10^3 (= 1000). There are nine decades catered for, which gives a total of 108 resistor values available in the 10% preferred range.

Value multipliers

A characteristic of electronics is the range of numerical values that need to be accommodated. For example it is not uncommon to have resistor values of up to 10,000,000 ohms and currents as low as 0.000000001 amps. Because of the range of values, *multipliers* are used to make them easier to express.

Multipliers are a feature of the metric system and most people are familiar with some of these – such as the *kilo*, *micro* and *milli* multipliers. Most readers know, for example that 60kph means 60,000 metres per hour, where the letter 'k' is an alternative way of saying 1000.

In electronics there are a number of multipliers commonly used, shown listed in the table of Fig.7. Each letter, Greek or otherwise, represents 10 raised to a particular power, giving a convenient way of expressing a large or small value. For example, an 8.2 million ohm resistor (8,200,000) becomes an 8.2M ohm resistor, where 'M' (short for mega or meg) represents 10^6 (or one million), replacing six decimal places in the value. To convert the value from megohms back to ohms, the value (8.2) is multiplied by 10^6, meaning the decimal place is moved six places to the right.

A current of 0.005 amps is generally expressed as *five milliamps*, written as 5mA. Here the letter 'm' (note the lower case) means multiply the number (5) by 10^{-3} (or 0.001) to express the value in amperes. That is, move the decimal place three places to the left.

Put another way, the letter 'm' also means *divide* the number (5) by 1000, as 10 raised to a negative power gives a value equal to the reciprocal of 10 raised to the same positive power.

The examples in Fig.7 should be studied so that you become familiar with multipliers, as they are used extensively in electronics.

MULTIPLIERS USED IN ELECTRONICS

NAME	LETTER	MULTIPLIER VALUE
giga	G	$\times 10^9$ (= x1,000,000,000)
mega	M	$\times 10^6$ (= x1,000,000)
kilo	k	$\times 10^3$ (= x1000)
milli	m	$\times 10^{-3}$ (= x0.001) or divide by 1000
micro	u	$\times 10^{-6}$ (= x0.000001) or divide by 1,000,000
nano	n	$\times 10^{-9}$ (= x0.000000001) or divide by 10^9
pico	p	$\times 10^{-12}$ (= x0.000000000001) or divide by 10^{12}

Examples:

4.7kV = 4.7×10^3 = 4700 volts

3.45uA = 3.45×10^{-6} = 0.00000345 amps

345uA = 345×10^{-6} = 0.000345 amps

270pF = 27×10^{-12} = 0.0000000027 farads

2.2M ohm = 2.2×10^6 = 2,200,000 ohm

75nA = 75×10^{-9} = 0.000000075 amps

Note:

volts divided by kilohms = milliamps
volts divided by megohms = microamps
kilohms times milliamps = volts
megohms times microamps = volts

Fig.7: Multipliers are used to avoid writing lots of zeroes in large or small electrical values. Study the examples to see how a value is expressed with a multiplier.

Combining resistors

Sometimes it is necessary to combine resistors to give a value not otherwise

Resistors in series: $R_T = R_1 + R_2 + R_3 + \ldots$

Resistors in parallel: $$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$$

or: $$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

or for two resistors: $$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

or for N resistors of the same value (R) in parallel:

$$R_T = \frac{R}{N}$$

Fig.8: These equations show how to calculate the total resistance of (top) series connected resistors and (next) parallel connected resistors.

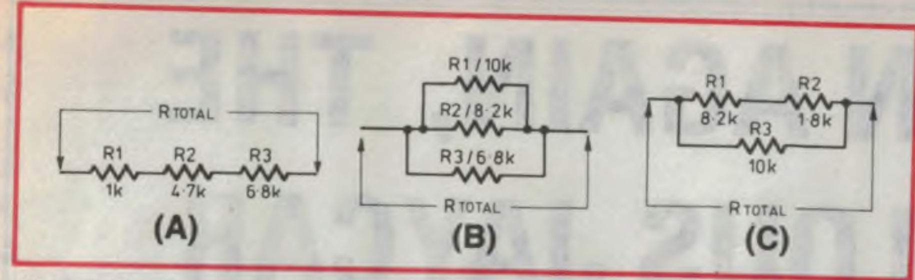


Fig.9: (a) Series connected resistors, with a total resistance of 12.5k ohms. (b) Parallel connected resistors giving a total resistance (always less than the smallest resistor value) of 2.71k. (c) A series-parallel network that gives a combined resistance of 5k ohms.

obtainable. Also by combining resistors, the power dissipation can be shared. For example, two 1/2-watt resistors can be combined to give a one watt resistor.

There are two fundamental ways of combining resistors: in *series* or in *parallel*. Sometimes a network of resistors might involve both types of combinations, giving a series-parallel circuit.

The table shown in Fig.8 lists the equations used to calculate the total resistance for both the series and the parallel circuits. Fig.9 shows some circuit examples. The equation to find the total resistance of a number of series connected resistors is the easiest – simply add each of the values, as shown in Fig.9(a).

Calculating the total resistance for parallel connected resistors is a little more difficult. There are a number of ways of doing this, as shown by the four equations in Fig.8. The first two equations are *general* equations, and unless the values are easy, a calculator is probably required. The next two equations can only be used in certain circumstances. If there are two resistors in the combination, the *product* divided by the *sum* of their values gives the total resistance. Alternatively, if all the resistors have the same value, divide the individual value by the number of resistors.

A golden rule for parallel resistors is *the total resistance is always less than the smallest value*. For series connected resistors, the total resistance will always be larger than the largest single value. A series-parallel circuit is shown in Fig.9(c), in which R3 is connected in parallel with the series combination of R1 and R2. You might like to see if you can figure out the total resistance of this circuit, before you read the answer in the caption.

Summary

Resistance is quite a topic, as this chapter has shown. As we progress, more circuits using resistors will be explained giving further examples of how they are used. Obviously, the number of possible ways of connecting resistors is virtually limitless, and a formal training course in electronics would spend time applying Ohm's law to calculate currents and voltages in resistive circuits.

There are other considerations as well, but the content of this chapter should allow you to understand at least the basics of resistors and resistive networks.

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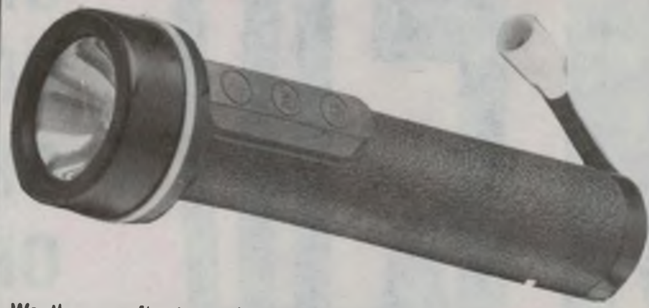

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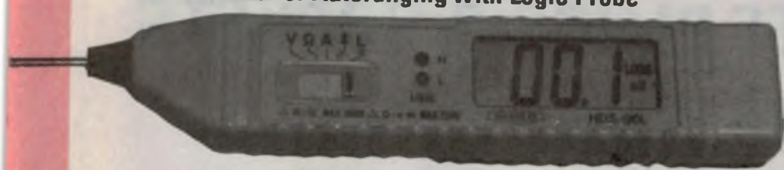

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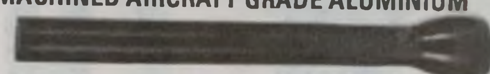

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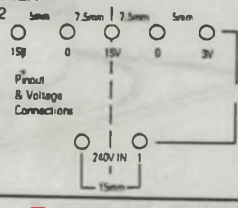

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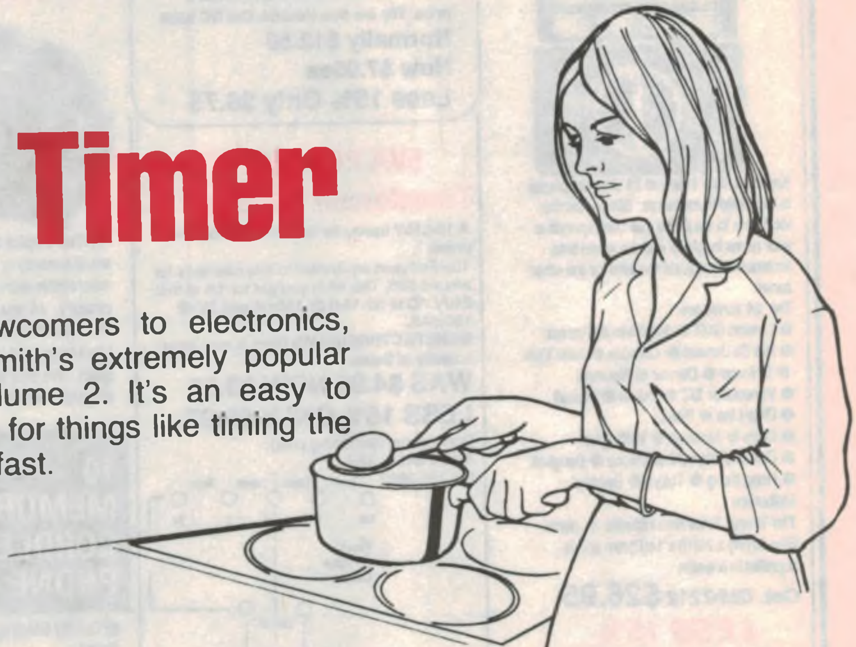
Dick Smith 'Fun Way Into Electronics' Project:

A Simple Universal Timer



Here's a great little project for newcomers to electronics, adapted by permission from Dick Smith's extremely popular book *Fun Way Into Electronics*, Volume 2. It's an easy to build timer circuit, which can be used for things like timing the cooking of your boiled eggs for breakfast.

In the past, electronic replacements for kitchen gadgets haven't proved popular, because of complexity of operation. This simple timer circuit should solve that problem.

Of course, it can time more than eggs, with a range of a few seconds to around 15 minutes. And you can use it to turn a device on for a given time, then off again, if you wish (instead of the other way around as with the buzzer).

Using it is simple. First turn on the power switch, and it beeps at you (just to show the battery is OK and all is well). Dial the time wanted, and press the 'time' button. The sound ceases, and will not occur again until the selected time has expired. It will continue to sound until you turn it off. It's that simple!

If you wish, the circuit can be reduced to single-button operation by using a 'double pole' switch (one action turns the circuit on and triggers the timing function). While this reduces the number of switches required, it also eliminates the self-checking function of the beeper sounding when the first switch is turned on, as above. (See 'what to do next' for more details).

How it works

This circuit uses a 555 timer integrated circuit. Here, however, the IC is not connected to oscillate, but to time one period only.

The 555 timer works by sensing voltage levels, and acting when certain levels are reached. These levels are called 'threshold voltages', and different pins sense different thresholds. For example, if the voltage at pin 2 *falls* below 1/3 of the supply voltage, the IC turns on. It doesn't matter if the voltage rises again, or falls again: once the threshold is reached and the IC turns on, pin 1 is virtually disconnected.

Conversely, if the voltage at pin 6 *rises* above 2/3 of the supply voltage, the IC will turn off. Once again, this pin does not have any further function until the IC is turned back on again.

We make use of both of these 'thresholds' in this circuit. As you can see, pin 2 is normally held at the positive supply voltage by R1. When the push button is

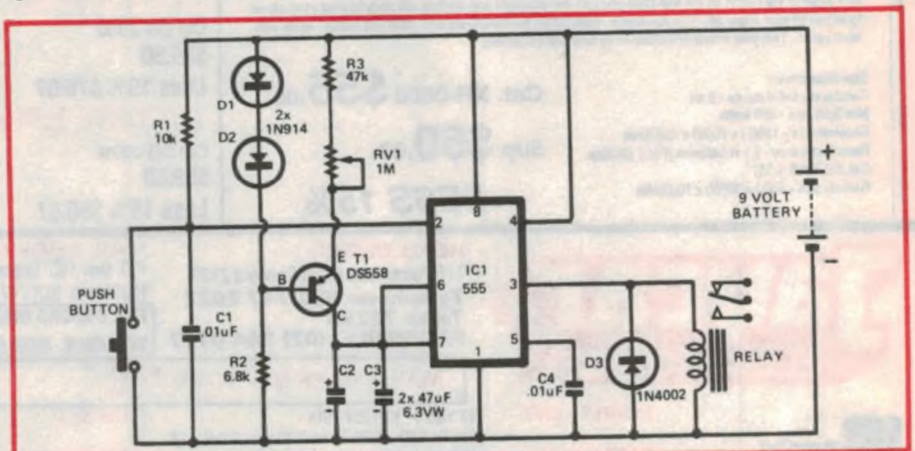


Fig.1: The circuit diagram for the timer. The relay contacts can be used to switch devices either on or off for the timed period, simply by using either the 'normally open' or 'normally closed' contacts.

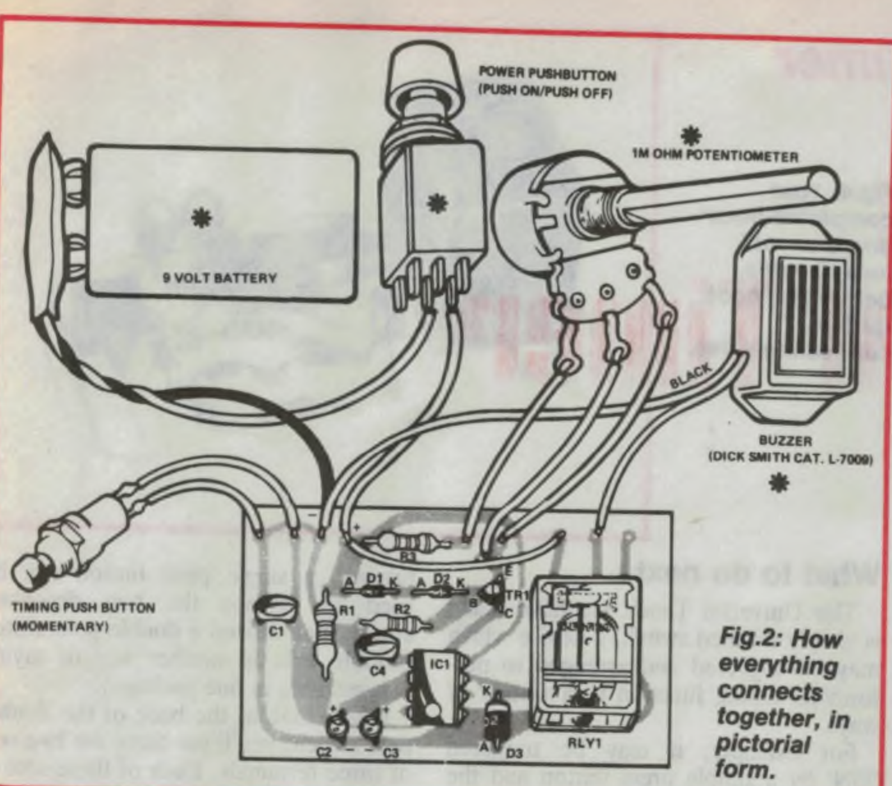


Fig.2: How everything connects together, in pictorial form.

pressed, pin 2 is taken down to the negative supply, obviously passing its theshold on the way. The IC then turns on; current flows from pin 3 through the relay, pulling it in.

Until the IC turned on, pin 7 was connected to the negative supply via internal circuitry in the IC. Once it conducts, this connection is removed.

D1, D2, R3, RV1 and T1 form what is known as a 'constant current source'. A known, and very stable, amount of current is able to flow through TR1 and charge C2 and C3 (being in parallel, they are effectively one capacitor). The charging current is dependent on the setting of VR1.

As C2 and C3 charge, the voltage across them rises. After a time, this voltage reaches the pin 6 theshold – and the IC turns off. Pin 3 stops supplying current to the relay, which opens. The timing period is thus over.

D3 is connected across the relay to prevent damage to the IC. As the relay drops out, the collapsing magnetic field induces a 'voltage spike' across the relay. This could, in theory, be high enough to damage the IC, so D3 short circuits this voltage and prevents any damage occuring.

Putting it together

To help you in building this project, the steps are itemised. We suggest you tick them as they're completed.

1. If you have purchased a kit (Dick Smith Cat. K-2624 or similar), check off the components against the parts list to make sure they are all there and are the correct types and values.
2. If you have not purchased a kit you will need to obtain the components listed and either make a printed circuit board using the component position diagram as a guide, or use a piece of perforated or tracked board.
3. Mount the components as shown in the component position drawing. Place and solder the resistors and capacitors first, being extra careful to mount the 47uF capacitors the right way around as they are polarised. In this case, the leads marked '+' go on the inside, nearest the transistor. Check that all components are 'dressed' or positioned neatly before soldering them in.
4. RV1 and the relay can now be placed in position and soldered. Both of these components will only fit one way easily, so if you are having trouble the pins may be bent or you may be trying to put it in the wrong way.
5. Great care must be taken when placing the three diodes D1, D2 and D3, firstly to ensure that you have the correct diode and then, that you have it the correct way around. D1 and D2 are 1N914 diodes – the smaller glassy looking ones with a black band at one end – while D3 is a 1N4002 diode, the larger black one with a silver band. Mount D1 and D2 as shown, with the black bands both towards the transistor, and D3 with its silver band inwards.
6. Mount the transistor in the correct place with its flat side towards the relay.
   Double check that it is in the correct position and with the right polarity by noting that the centre pin (base) is joined to the banded end of D2 by the PCB track, while the emitter goes to RV1. The collector goes to pins 6 and 7 of IC1 and the positive ends of C3 and C4, as is shown in the circuit diagram and the component position drawing. Solder it in, using a heatsink clip to prevent damage by overheating.

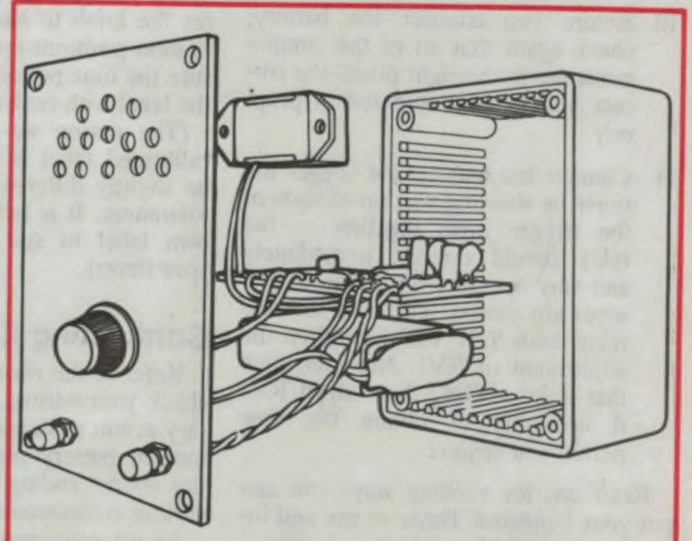


Fig.3: This is how the complete kitchen timer fits into a small Zippy box. The buzzer is simply switched on and off by the relay contacts.

Simple Universal Timer

7. Now to IC1, the 555 timer integrated circuit. Perhaps this is the first IC you have ever soldered in, but don't panic! It is not really difficult provided you are careful and follow these steps: insert the integrated circuit into the holes on the PCB until the little shoulders on the pins prevent it from going further; make sure it is the right way around, by noting that pin 1 (the one marked with the circle indented into the top of the IC) is in the corner nearest D3 and that it goes to the track leading to the negative side of the battery; then turn the board over and carefully solder each of the pins to the pads, making sure you don't run solder between the pads. While it is important not to overheat the integrated circuit, it is just as important to apply sufficient heat to obtain a correctly soldered joint. Inspect the connections to make sure you've soldered them all without shorting out any of the pads and that's it. Easy, wasn't it?
8. Solder on the battery snap wires, again taking care to see that you have the correct polarity – red (positive) to the large pad forming the junction of R1, D1 and R3, and black to the long negative track that connects with C1, C3 and C4 as well as other components.
9. Connect whatever type of triggering means you desire (see 'What to do Next') to the pads shown in the drawing with just two wires connected.
10. Before you connect the battery, check again that all of the components are in the right place, the correct polarity and soldered in properly.
11. Connect the battery and trigger the timer by shorting the bared ends of the trigger wires together – the relay should operate immediately and stay operated when the trigger wires are parted. The time that the relay holds 'ON' will depend on the adjustment of RV1. Note the time that it stays 'ON', then adjust RV1 if necessary to obtain the time period you require.

Read on, for exciting ways you can put your Universal Timer to use and inventive ways of triggering it.

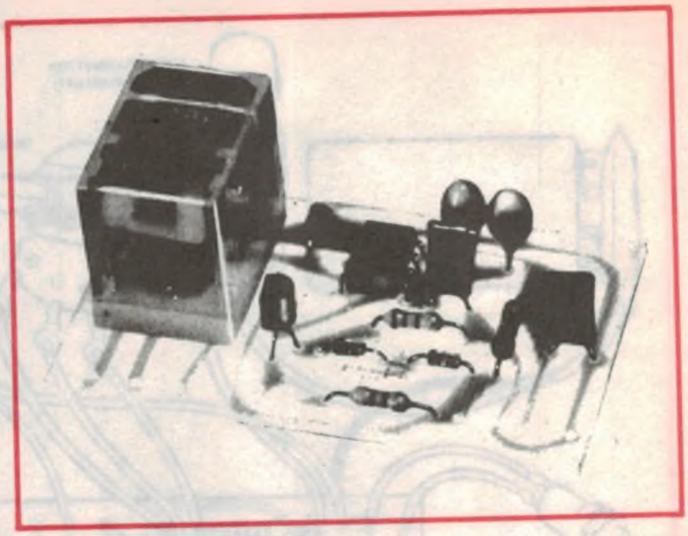


Fig.4: Your completed timer board should look like this, before you hook up the connecting wires.

What to do next

The Universal Timer you have made is simply a timed switch, a device which may be triggered and arranged to perform its timing function in a variety of ways.

For example, it may be triggered 'ON' by a simple press button and the relay contacts wired to switch either 'ON' or 'OFF', to sound a warning (you could connect it to the siren described in this book) or to stop a process.

Fig.3 is an exploded view of the Universal Timer used as a kitchen timer, as shown in the drawing at the start of this project.

As you can see from the drawing, this is done by the addition of two small pushbuttons (DSE Cat. S-1102 and S-1205), a small buzzer (DSE Cat.L-7009 is ideal) and a 1M ohm potentiometer (DSE Cat. R-1813), wired into the circuit as described and all placed in a Zippy box (DSE Cat. H-2753).

Use the label artwork supplied to give your timer a really professional look. When you have it set up and operating, set the knob to each of the white calibration positions on the label, and measure the time period with a watch. Mark the label with each time measured.

(The reason we cannot print a precalibrated label is that each timer will be slightly different due to component tolerances. It is better to calibrate your own label to suit the components in your timer).

Connecting it up

Refer to the wiring diagram to double check your wiring, connect the momentary action push button, the power push button, battery snap and buzzer. Note the colour coding of the wires to the various components.

As we mentioned at the start of this project, a single push button can be used to replace the two described above. You'll need a double pole switch (double pole is another way of saying two switches in one package).

If you look at the back of the double pole switch, you'll see there are two sets of three terminals. Each of these sets of

PARTS LIST

Resistors:

R1	10k ohms
R2	6.8k ohms
R3	47k ohms
RV1	1M ohm potentiometer

Capacitors;

C1	10nF polyester
C2,C3	47uF 6.3 volt tantalum electrolytics
C4	10nF polyester

Semiconductor:

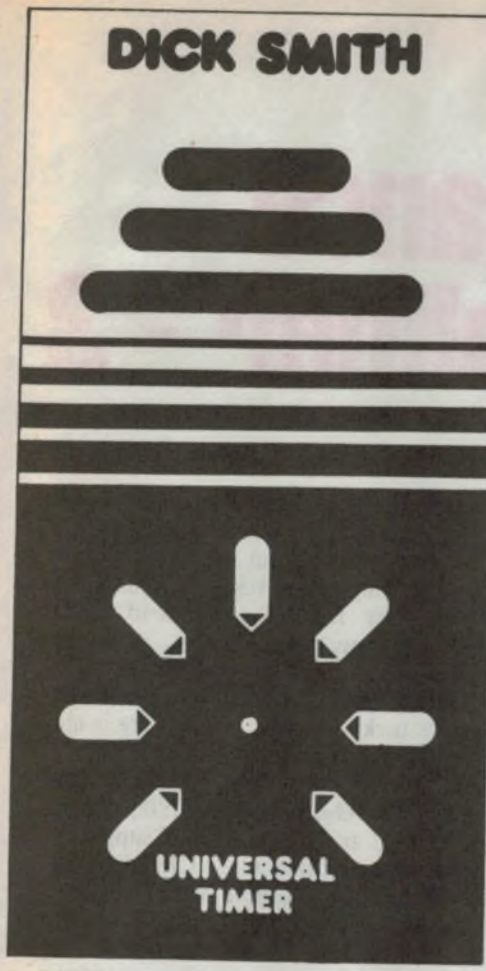
TR1	DS558 or similar PNP transistor
D1,D2	1N914 silicon diodes
D3	1N4001 or 1N4002 silicon diode
IC1	555 timer integrated circuit

Miscellaneous:

PB1	Momentary action push button switch
Rly	1 miniature relay with 9V coil, single change over contacts

Battery snap, solder, hook-up wire

You will also require a 9V battery (not normally supplied with a kit) or some other DC supply, and a suitable mounting board or printed circuit board of correct design. The Dick Smith Funway K-2624 Universal Timer kit contains the correct PCB.



The front panel, actual size. A coloured version appears in DSE's 'Fun Way into Electronics', Volume 2.

terminals is treated as a separate switch, and is wired just as the two separate switches above.

The 1 megohm potentiometer shown replaces the trimpot supplied in the kit. They are electrically equivalent, but the larger variable pot is more convenient to use. The three leads on the large pot replace the three leads on the trimpot: they connect in the same order (i.e., left to left, centre to centre and right to right).

Mount all of the components in the zippy box as shown in Fig.3. You might like to add a knob – the one shown is DSE Cat. H-3762, but almost any knob will do.

If you want to use the timer regularly, you won't want to be buying batteries all the time. Fitting a 3.5mm socket as shown in Fig.5, will enable you to use a plug-pack adaptor such as the DSE Cat M-9295 versatile battery eliminator or something similar.

Darkroom timer

To adapt the Universal Timer for darkroom use, set it up exactly the same as for a kitchen timer, with one exception: change R3 to 4.7k. This lowers the minimum time to around 4 seconds: much more useful in the darkroom. Of course, your calibration will now be for a much shorter time range.

Instead of the buzzer, you might like to use a red LED for darkroom use (this doesn't have to be turned off immediately – it isn't annoying!) If you use a LED, connect as per the buzzer, but place a 470 ohm resistor in series with the LED to protect it. Connected in this way, the LED will come on at the end of the timed period. If you wish to reverse the sequence, simply connect the LED to the 'NO' (normally open) contacts of the relay.

Perhaps you would like to have the timer automatically turn your enlarger on and off. Easy! But there is a snag: the relay probably won't be able to handle the current drawn by the enlarger bulb, so you may have to use a power relay in series with the PCB relay.

Of course, there is nothing to stop you doing both of the above: a LED and a controlled enlarger. Even better, you could connect the enlarger relay to the 'NO' contacts and the LED to the 'NC' contacts, so the LED shows when the enlarger is off. There are a large number of variations possible: see what you can work out.

Other uses

Because it is so small and versatile, the Universal Timer can be built into a whole range of equipment that operates on a timed cycle. Building security lights, alarm delays, etc. – see how many uses you can find for a timing circuit like this one!

If you wish to operate the timer with a device having a different supply voltage, don't worry if the voltage is in the range of, say 6 to 15 volts. The circuit will operate happily over this range. If the voltage is outside this range, it would be best to revert back to the battery or plug-pack supply giving around 9 volts.

Other triggering methods

There are many other ways of triggering the timer, and you might like to try some of them. All that is necessary is some means of shorting C1 (that is, connecting its top connection to the negative supply). Any of the projects in this book which operate a relay could be used to do this (the light activated switch, sound activated switch, touch switch, etc).

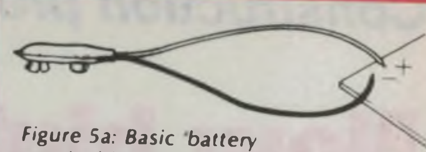


Figure 5a: Basic 'battery snap' wiring without switch. The black lead in all cases is negative.

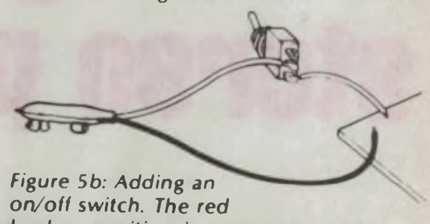


Figure 5b: Adding an on/off switch. The red lead, or positive, is broken by the switch. Note the centre and one of the outside switch terminals are used.

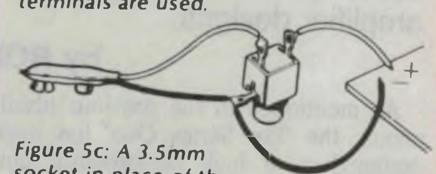


Figure 5c: A 3.5mm socket in place of the switch. The socket automatically cuts off the battery if wired in the way shown.

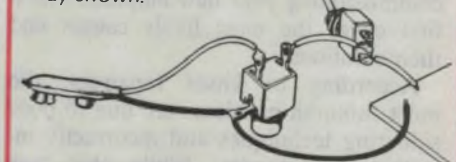


Figure 5d: The battery snap with both an external power socket and on/off switch. The switch interrupts either battery or plug-pack.

Fig.5: How to add an on-off switch and a socket for a plug-pack battery eliminator, shown in pictorial form to make it easy.

You could use the delay in conjunction with one of these other circuits. For example how about the light or sound activated switch operating boom gates on a model railway, with the time delay keeping the gates closed until well after the last carriage has passed?

There are many things you will find around you that could trigger the delay.

Note: This project description has been adapted from Dick Smith's Funway into Electronics', Volume 2, by kind permission of Dick Smith Electronics. Now in its 20th printing, this book is an excellent introduction to practical electronics project building. It is available at all DSE outlets (B-2605), and contains many other interesting and educational projects.

New high performance stereo power amplifier - 3

In this third and final article on the Playmaster Pro Series One, we'll talk about troubleshooting the circuit and pass on some general faultfinding hints which apply to most current amplifier designs.

by ROB EVANS

As mentioned in the previous instalments, the 'Pro Series One' has been designed as a high performance unit that is both easy to build and simple to get going. However in the unhappy event that you do have any trouble commissioning your new amplifier, we'll first cover the most likely causes and their solutions.

According to kitset repairers, the most common problems are due to poor soldering techniques and incorrectly installed components. While this may seem rather obvious, many failures can be avoided by carefully checking the PCB and wiring *before* power is applied to the unit. However impatience gets the better of us all at some time, and we dive in regardless.

In the Pro Series One, the most likely results of a fault condition during the initial tests are either that the 10 ohm resistors added temporarily in the supply rails during initial setting-up will burn out, the 100 ohm supply decoupling resistors (R23 and R24) will fail, or the amp will exhibit a large DC offset at its output. Of course other symptoms are quite possible, but most construction-orientated problems will produce one or more of these effects.

In any event, the first step is to carefully check the PCB for dry joints, solder bridges between the tracks and incorrectly placed (or wrongly polarised) components. If you find and correct the fault, try the amp again, bearing in mind that the previous condition may have damaged components – for example electrolytic capacitors don't like reverse polarities, or forward voltages higher than their rated figure.

If the component positions and solder joints pass inspection, some deductive reasoning may be required. Assuming for the moment that only the 10 ohm resistors have failed, the output stage is most likely source of the overload since all of the driving stages are isolated by resistors R23 and R24. Use a multimeter to test for a possible short between the MOSFETs and the chassis. If a short is detected, progressively remove the MOSFET mounting bolts until the fault disappears – then you've found the culprit.

Rather than a simple short circuit, the overload may be due to an excessive bias voltage applied between the MOSFET's gates, due to a faulty connection or an open circuit in RV1. To double check, temporarily connect the junction of R14 and R15 to the junction of R16 and R17 – this will bypass the bias circuit, and should set the MOSFET's drain to source current to a very low level.

Of course, the overload may be due to a MOSFET failure – however this is most unlikely, since compared to bipolar devices, the MOSFETs are extremely rugged. Nevertheless, if you suspect one of the complementary pairs, it may be removed and the amp retested with only one pair in place for that channel.

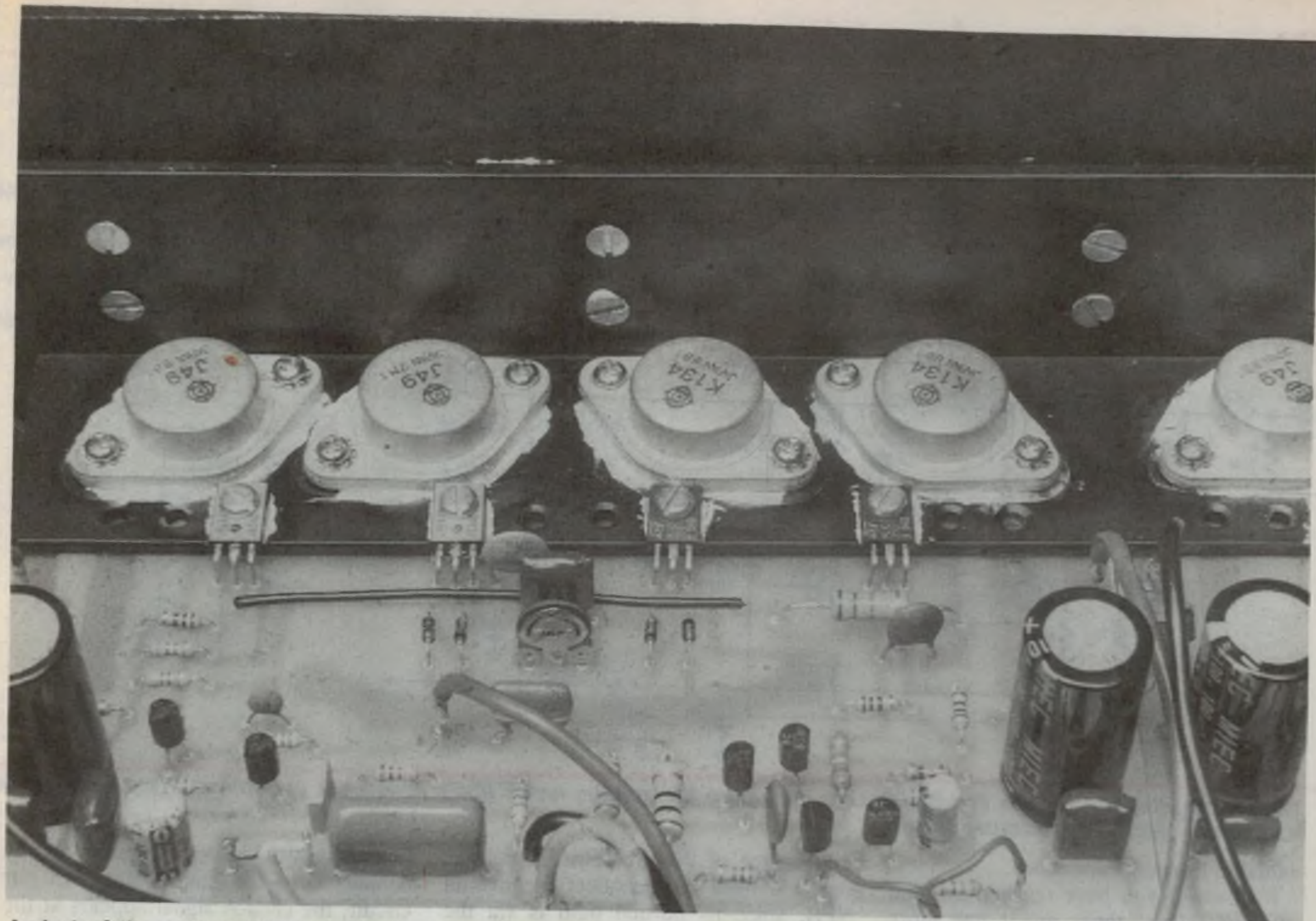
If the amplifier is suffering from supersonic oscillations, chances are that the 10 ohm resistors will take a moment to fail. This should give you sufficient time to check the output with an oscilloscope or a rectifying detector probe (see *EA* May 1987, page 66: 'Feedback on Playmaster 60/60'). Note that the overload indicating LED in the new Pro Series One should illuminate in the presence of oscillations, as the amplifier's negative feedback (NFB) attempts to correct the output signal. So persistent blowing of the resistors, plus a telltale glow from the overload LEDs (without any input signal), would be strong evidence of oscillation.

While this type of problem can be quite tricky to solve, chances are it may be traced to an incorrect value (or faulty connection) of C6, C8 and C9 to C12. Also check the input filter components R2 and C2, the 0.1uF supply bypassing capacitors C13, C15, C17 and C18, and the position of the 0V and speaker negative leads on the PCB.

Don't attempt to cure the problem by adding extra compensation capacitors around the circuit. While this may be an apparent solution in some circumstances, it will invariably compromise the amplifier's distortion figures, or lead to other forms of instability. However if no other remedy can be found, try increasing the values of C8 and C10 to 27pF and 560pF respectively.

Just as the 10 ohm resistors protect the output stage, the 100 ohm resistors R23 and R24 will tend to protect the driver stages, as well as forming supply filters in conjunction with C14 and C16 respectively. If these resistors rapidly fail, suspect the polarity and condition of C14 and C16, or some other form of direct overload in the driving stages. Also, if C13 and C15 are of the low-cost 'greencap' variety, they may have broken down to a short circuit due to heat build-up from a prolonged soldering job.

The problem may also be a gross overload in the driving circuitry itself, due to incorrectly placed or orientated components. If things visually appear correct, a simple continuity check between each transistor's collector/emitter and collector/base junctions may quickly reveal a faulty device – with a high voltage power supply, transistors tend to fail in a catastrophic manner when



A shot of the output stage of our new amplifier. When checking voltage levels around the flat-pack driver transistors, take particular care not to short their legs together with the test probe(s).

the junctions simply punch through.

If we now assume that the fault condition is rather less dramatic than smoking resistors, such as an excessive offset voltage at the output, the procedure is a little more defined.

The circuit diagram includes voltage readings taken from the prototype during static conditions – that is, with no signal source or load connected. A significant variation from these readings may indicate the area of concern. However this can be a little misleading, since the amplifier's feedback loop will try to correct the error, generating voltage shifts through the entire circuit.

In practice, a moderate offset at the output (say a few volts), would indicate a problem around the input differential pair Q3 and Q4. Also, double check the values of R1 and R2.

Other circuit faults will cause the amp's output to latch up to the positive or negative supply rail. In this case, you can logically trace through the circuit, following the action (or lack of action) of the NFB.

If the output is latched up to (say) the positive rail, we can expect Q4 to be biased OFF via R12. This should unbalance the collector voltages of Q3 and Q4, causing slightly more voltage drop across R6 and less across R7. In a similar manner, this should unbalance the differential pair of Q5 and Q6, forcing the collector voltage of Q6 to fall, thereby correcting the output error. Clearly, this chain of events must be broken at some point – the 'break' indicates the area of the faulty component.

In more serious circumstances, a fault condition may cause the mains fuse to blow. If the 10 ohm resistors are still intact, then it's most likely that the fault is within the power supply itself. The first place to check is the connections of the filter capacitors and bridge rectifier – bear in mind that these components may be irrepairably damaged if wired incorrectly.

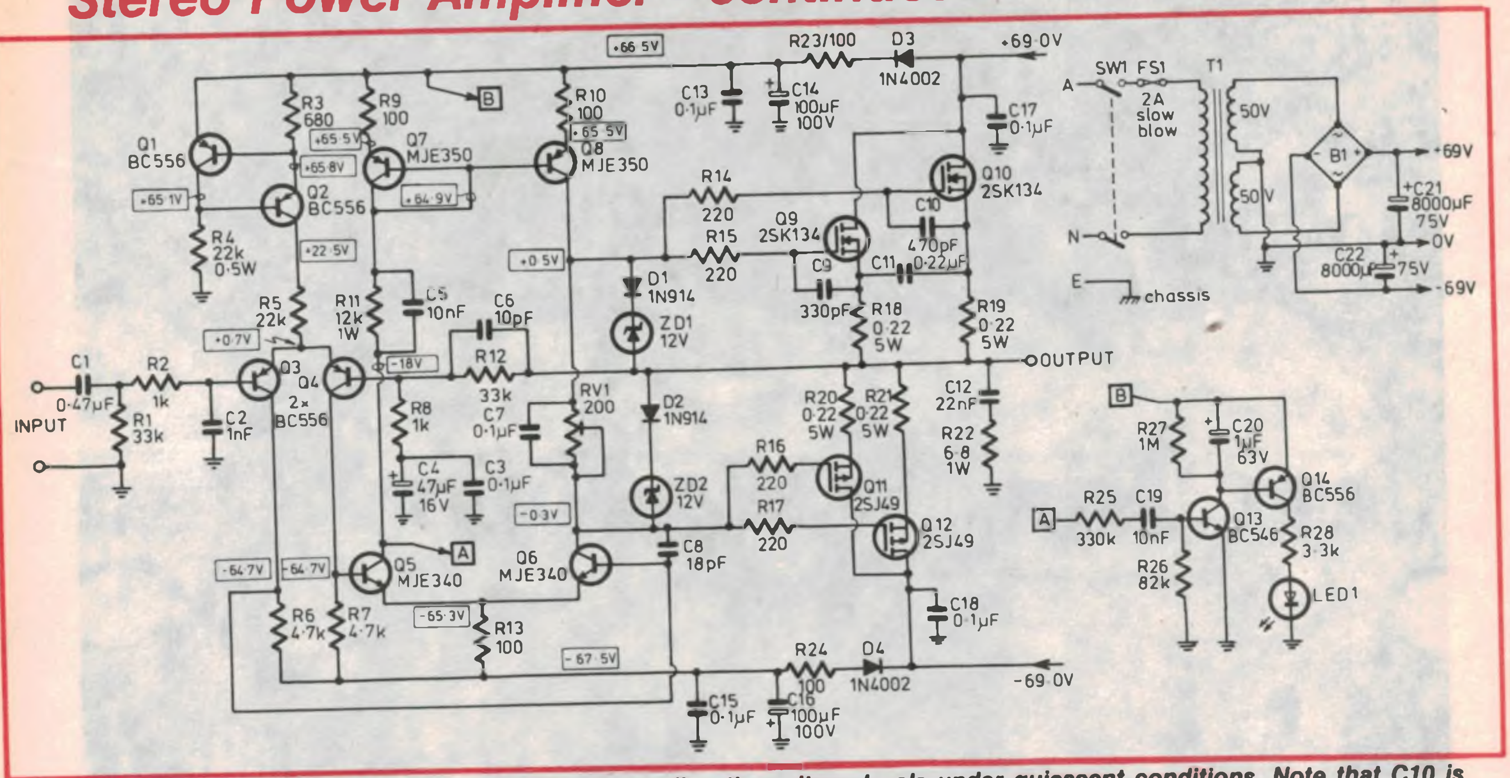
If all appears well, discharge the filter capacitors (say with a 100 ohm resistor), and check the path between each supply rail and 0V with a multimeter. For this test, make sure that the voltage which appears at the meter's probes (in the 'resistance' mode) matches the supply rail's polarity – digital multimeters tend to have the red coloured probe supplying a positive voltage, whereas the same lead has a negative potential on analog units.

The reading should start from a very low figure, and slowly rise to a high value. A permanently low figure will indicate a faulty capacitor or a short within the bridge rectifier, assuming that the associated wiring is correct. However, if the reading settles at even a few hundred ohms, the filter capacitor may be viewed with some suspicion.

General faultfinding

When faultfinding is required, try to sit back for a moment and make a few intuitive judgments of the conditions under which the circuit failed. If you've digested the above information and have a clear understanding of how the circuit works, a little careful reasoning should guide you to the right area. It's a waste of time and money to immediately start changing all of the semiconductors – you may or may not fix the problem, and you will certainly miss a

Stereo Power Amplifier - continued



The circuit diagram for the Pro Series One, including the voltage levels under quiescent conditions. Note that C10 is 470pF, not 390pF as previously shown.

valuable learning experience.

If however you have reached the end of your tether, there are a few more drastic steps you might like to try. These require some temporary modifications to the circuit, and are applicable to most contemporary power amp designs.

As mentioned above, an amplifier's NFB tends to spread the effect of a fault condition through the entire circuit. If for example, an amp is producing a badly distorted signal when running into a load, the NFB will force the driving circuits to generate large error signals – this is quite misleading when the various waveforms are monitored with an oscilloscope.

In this case, the AC NFB may be removed by shorting out the dividing resistor in the NFB network – for our circuit, this would be R8. Although some amplifiers may become unstable in this condition, it will normally provide far more realistic waveforms for the independent analysis of each stage. Naturally, the circuit's gain and overall distortion will increase by a considerable amount, due to the lack of NFB.

In other circumstances you may wish to test an amplifier with the output transistors removed or disconnected. This helps to verify that the remaining stages are functioning correctly, or conversely, that the driving circuitry is the sole source of the problem. Of course, you will need to reconnect the overall NFB, since its normal path is via the output transistors.

This may be done in a couple of different ways. In the Pro Series One circuit for example, simply install a forward biased diode between the collector of Q8 and the output, and again between the output and the collector of Q6. Or simpler still, simply short out ZD1 and ZD2, which connects D1 and D2 to complete the NFB path as required.

If the amplifier you're troubleshooting has bipolar output devices in the familiar complementary symmetry arrangement, each 'half' is generally formed around a number of transistors connected in a Darlington configuration. Each of these stages has an input (base of first transistor) to output (emitters of power transistors) static voltage drop of around 1.5 volts – this should be roughly matched by the substituting diodes.

A common LED is an ideal device for this purpose, since it has an appropriate forward voltage drop, and will give a visual indication of the biasing voltage that is normally applied to the output stage. However, if you are not concerned about the amplifier's biasing conditions and are more interested in its dynamic performance, the class-A output of the driving stage may be directly connected to the main output. In our circuit, the class-A signal appears at the collector of Q6.

Bear in mind that if the above tests are to be realistic, the class-A stage should be loaded as if it were driving the output devices. For example, if a bipolar output stage has a current gain of say 400, and the amplifier can deliver 100 watts into 4 ohms, we can roughly calculate a substitute load.

This output power corresponds to an output current of 5 amps (RMS), and a voltage swing of 20 volts (RMS). Therefore the class-A stage must be able to deliver 12.5mA (5/400) at a swing of around 20 volts, or in effect, drive a load resistor of about 1600 ohms (20/0.0125).

The load presented by a MOSFET output stage is quite different on the other hand, since at low frequencies the gate to source junction appears as a very high impedance. Essentially, this appears as an open circuit to the collector of Q6, and a substitute load is quite unnecessary.

While the above method will help to solve some of the more curly problems, and even save the lives of a few output devices, there are many occasions where it's impractical to carry out such temporary modifications. A typical sad scenario is when the output transistors have failed (for whatever reason), and the replacement devices immediately self-destruct when power is reapplied. Unfortunately, it may not have been possible to protect the devices with the ubiquitous 10 ohm resistors, and the odds were against you.

Nevertheless, there is a time honoured protection device (which may be built from a few simple parts from your junk box) that may prevent this kind of disaster.

This device uses the characteristics of a simple 240V lamp to control the mains power into a piece of equipment. To wire it up, you'll need a mains plug, a mains line socket, a lampholder and a length of mains cable.

Strip the shielding from the cable, and connect the terminals of a lamp holder in *series* with the active lead as it passes from the plug to the socket – wire the earth and neutral leads as normal. *Make sure the earth lead is wired to the correct terminals, and that there is no exposed connections or wiring.*

When this device is supplying power to an amplifier for example, there should only be a few volts dropped across the lamp filament (if the bulb has an appropriate power rating), until an overload occurs. At this point, the filament's resistance will increase dramatically and drop a much higher voltage, which in turn limits the current and prevents the amplifier from drawing an excessive amount of power. As a bonus, the lamp is then illuminated, which indicates that an overload has occurred.

The lamp filament will also restrict the current surge which normally occurs when power is first applied to an amplifier, due to the initial charging action of the power supply's filter capacitors. This in turn causes the voltage on the supply rails to rise quite slowly, giving the components a better chance of survival in a faulty circuit.

The actual power of the lamp can be chosen to suit the device under test. Only a few volts should be lost across the filament when the circuit is in its normal idling condition (an amplifier must not be connected to a load) – start with a 60 watt lamp, and increase the power rating as required.

So while faultfinding audio amplifiers with NFB can be rather tricky, a sound understanding of the circuit principles, a little clear thinking and a few tricks up your sleeve should lead you down the right path. Generally, the amount of trouble that you experience with a home-built amplifier often depends on the amount of trouble that's gone into its construction. EA

50 and 25 years ago..

"Electronics Australia" is one of the longest running technical publications in the world. We started as "Wireless Weekly" in August 1922 and became "Radio and Hobbies in Australia" in April 1939. The title was changed to "Radio, Television and Hobbies" in February 1955 and finally, to "Electronics Australia" in April 1965. Below we feature some items from past issues.

February 1940

New Miniature Valves: The advent of 1.4-volt battery valves has made it possible to produce portable sets which are both efficient and economical in operation. With the intention of making possible further reduction in the weight and size of these receivers, the RCA manufacturing company in the USA has developed four 'miniature' all glass tubes which are highly efficient in operation from a 45-volt B supply.

The new tubes include a converter (1R5), radio frequency pentode (1T4), diode-audio frequency pentode (1S5) and power output pentode (1S4). The diameter of the tubes is slightly under three-quarters of an inch, and the overall length is less than 2-1/8 inches. No base has been used, but instead .040" wires from the seal serve as pin connections for the socket. The exhaust tube is located at the top of the bulb.

We would point out that these valves are most unlikely to be imported into Australia, as their advantages here appear to be limited.

40cm Waves for Plane Beacons: A new system for instrument landing of aircraft, using 40 centimetre waves, has been developed by collaboration between the US Civil Aeronautics Authority and the Massachusetts Institute of Technology. The system makes use of nearly all of the modern developments in the field of micro-wave research, and was recently demonstrated to CAA officials at the East Boston airport.

The transmitting equipment operates on a frequency of approximately 700mc. At such high frequencies, beams may be formed by radiating the energy from horn structures of convenient dimensions. Two such horns were used in the demonstrations, each fed from a separate transmitter. The horns are wooden structures, about 26 feet deep and 10 by 2-1/2 feet at the mouth. They are lined with copper sheeting.

February 1965

Microwave Power Transmission: Two demonstrations at the Spenser Laboratory of Raytheon, at Burlington, Massachusetts have provided the first glimpses of what some engineers believe may develop into a major new technology – the transportation of energy by microwave beam.

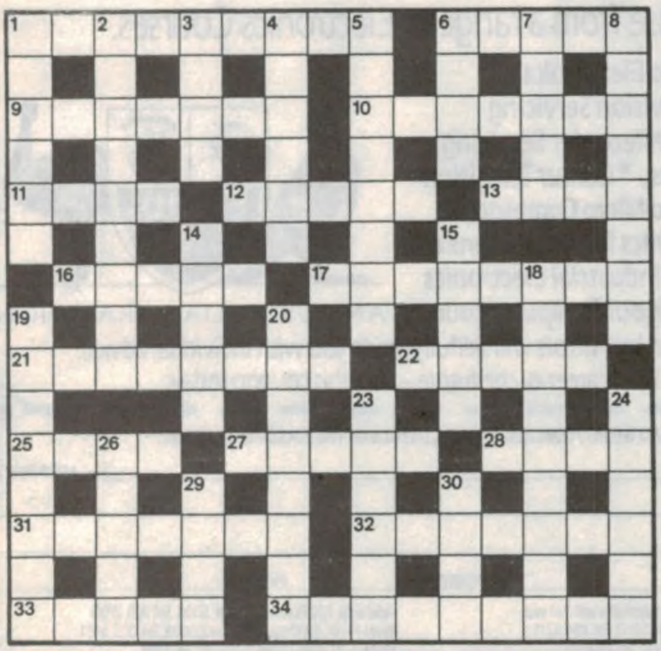
In May 1963, a demonstration showed 102 watts of 3,450Mc energy successfully received over a distance of 20 feet. More recently, on October 28, 1964, a model six-foot helicopter was powered by microwave energy and climbed vertically up a guide wire to a height of 50 feet, using only 5kW of generated power.

Clearly as a technology it is still in its infancy. But the baby has now made a few hesitant steps. Who would dare to speculate on what may be achieved in maturity?

EA CROSSWORD

ACROSS

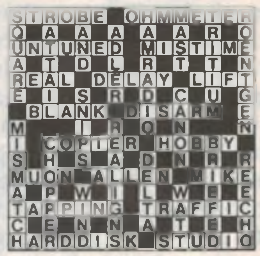
1. Public radio transmission. (9)
6. Not current. (5)
9. Channel selectors. (1,1,5)
10. Furniture for hi-fi equipment. (7)
11. A multi-pin coupling, the ---- connector. (4)
12. British scientist noted for theories of cosmogony. (5)
13. Colour in test pattern. (4)
16. Portion of e/m spectrum. (5)
17. Underwater explorer. (8)
21. Name of angle between planes. (8)
22. Trimmer used for circuitry correction. (5)
25. Planet having first soft landing in 1971. (4)
27. Seat used at workbench. (5)
28. Hyperbolic function. (4)
31. Locators for shorts. (7)
32. Radio operator. (7)
33. Proportional factor in transformer specification. (5)
34. Reduce intensity of an electrical parameter. (9)



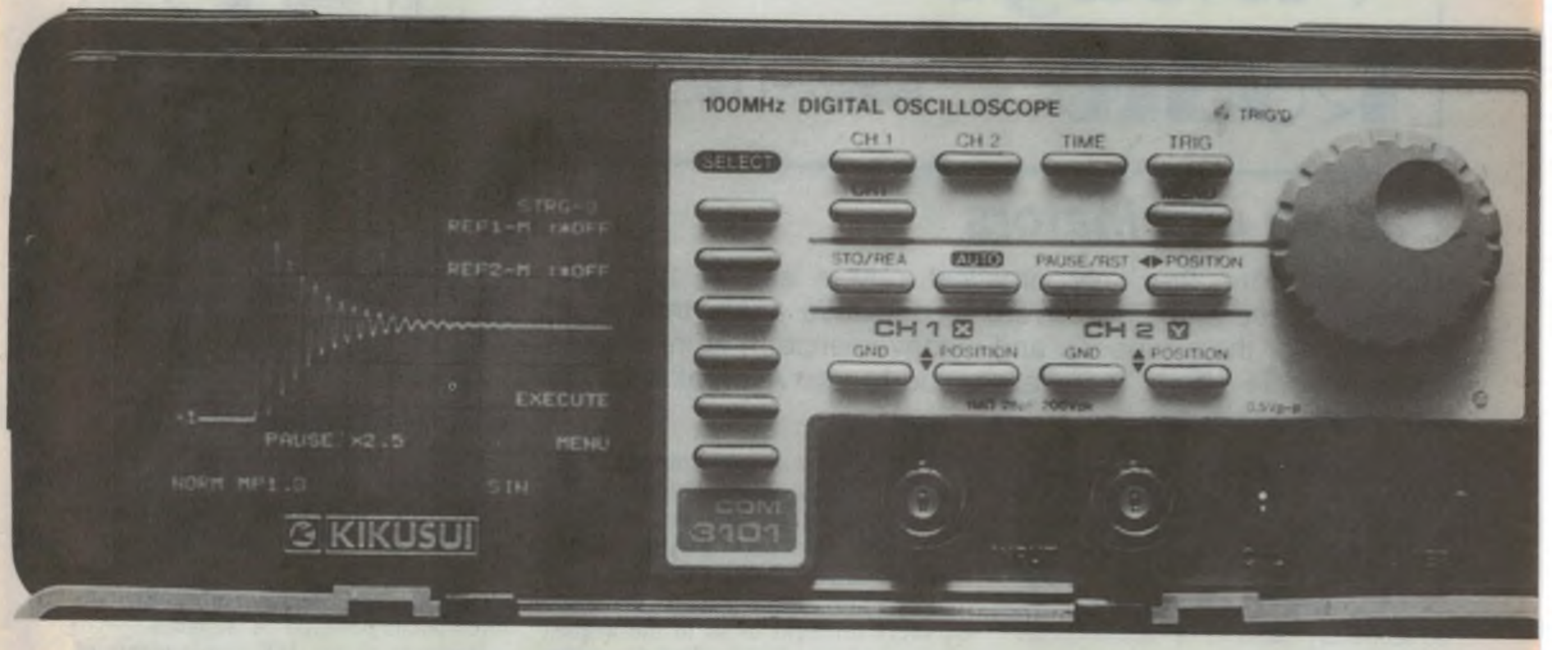
DOWN

1. Magnetic domains form ---- patterns. (6)
2. Instrument that records oscillations. (9)
3. Small mass unit in imperial system. (4)
4. Respond to telephone ring. (6)
5. Major brand of hi-fi equipment. (8)
6. Copies on to tape. (4)
7. Retail network in electronics. (5)
8. Set off a charge. (8)
14. Device using Schottky barrier. (5)
15. Defect. (5)
18. Prominent spiral galaxy. (9)
19. Rain gauge. (8)
20. Decimal part of a logarithm. (8)
23. Semiconductor impurity. (6)
24. Property of a proton. (6)
26. Respond to a stimulus. (5)
29. Thermometric fixed point. (4)
30. Term with decibel as unit. (4)

JANUARY SOLUTION



Auto-Ranging DSO with On-Screen Cursors, DVM, Counter, Battery Pack . . .



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FEATURES	COM 3101	COM 3051
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Bandwidth	100MHz	50MHz
Channels	2	2
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Max Sweep Speed	2ns/DIV	10ns/DIV
Delayed Sweep	YES	YES
Digital Storage		
Repetitive BW	100MHz	50MHz
Single shot BW	8MHz	8MHz
Functions Envelope, Averaging, Arithmetic etc		
Options		
Battery Pack	50 mins	50 mins
GP-IB	Available	Available

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The real mode and storage mode waveforms are displayed on the COM-3000's high intensity and high resolution CRT. The parameters and cursor measured value, as well as the values measured by the DVM and frequency counter in the real mode are all displayed on the screen.

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For more information on the COM-3000 Series contact **Emona Instruments,** 86 Parramatta Rd, Camperdown, 2050 or call **(02) 519 3933**.

EMONA
'THE TECHNOLOGY HOUSE'

Vintage Radio

by PETER LANKSHEAR

Battery eliminators

Batteries were the only practical power source for early receivers, and with the advent of domestic radio, they were criticised for their expense and inconvenience. It is interesting to look at the efforts that were made to use AC mains power as an alternative source.

Three quite different types of battery were required to power the early valve receivers. The 'A' supplies needed to heat the valve filaments were generally 6 volts or less, but with current demands often in excess of an ampere, so secondary batteries or 'accumulators' were often necessary.

In contrast, the high tension (HT) or 'B' supply needed for the valve plates typically only needed to provide only 20mA of current, but at considerably higher voltage: from 45 to above 100 volts. Although small capacity lead-acid batteries were sometimes used, high tension supplies were generally made up of batteries of dry cells.

Very early receivers didn't use 'C' batteries to provide grid bias, and in later years, bias voltages were often obtained automatically from the 'B' supply. But when separate bias supplies were used, the virtually zero current requirements meant that 'C' batteries could use small dry cells – which lasted as long as their shelf lives. They were relatively inexpensive, and the biggest problem was that their voltages remained constant while those of their companion 'B' batteries fell with use.

One solution was to dispense with the 'C' battery and derive bias from the voltage developed across a resistor in the HT return (negative) lead.

Accumulators unpopular

In professional communications and marine installations, the cost of batteries was of little consequence, and there were trained operators to look after charging and maintenance requirements of accumulators.

However, with domestic radios, the situation was different. The popular American 201A valves had filaments rated at 5 volts at 0.25 amperes each, although somewhat lower consumption European types became available with 4.0V, 6.0V and later 2.0V filaments. Filament batteries, with capacities of up to 100 ampere-hours had to be carted off every fortnight or so to the nearest garage, radio or bicycle shop for charging, leaving the radio out of action. To provide a second battery to cover this period was an additional and considerable cost, leading one enterprising British firm to run a 'swap a battery' charging and delivery service.

To cater for radios in areas without charging facilities, the American '99, '-11 and '-12 valves were developed. These could be operated from a battery of heavy duty dry cells, as could the Philips 'A' series and their equivalents from Europe; but it was an expensive exercise. RCA's recommendation for a filament battery for their Radiola 28 receiver equipped with '99 type valves was a series-parallel group of 12 'No.6' dry cells – which would be priced today at upwards of $10 – each!

Little wonder then, that in the mid 1920's there was intensive research into the development of AC heated valves and mains powered HT supplies. And for existing receivers, a thriving market developed for mains powered 'battery eliminators'.

Battery eliminators

Low consumption directly-heated valves were very sensitive to any filament supply hum. Initially, as capacitors of only a few microfarads were available, considerable difficulties were experienced in producing adequately filtered mains powered 'A' supplies.

However as the HT requirements of battery receivers rarely exceeded 30mA, tolerable hum filtering was possible with modest filter chokes and paper capacitors, and 'B' and 'C' battery eliminators soon appeared – although compared with batteries in good condition, their performances left a bit to be desired.

Basically a B-C battery eliminator consisted of a transformer, rectifier, filtering system and voltage dropping resistors. The biggest problem was regulation of the intermediate voltages (needed for screen grids, etc), which were derived through resistors. Getting the right tappings often involved a bit of experimentation.

A notable 1925 development by RCA to cope with the regulation problem was the first gaseous voltage regulator, the 90 volt UX-874, an analog of the modern solid state zener diode.

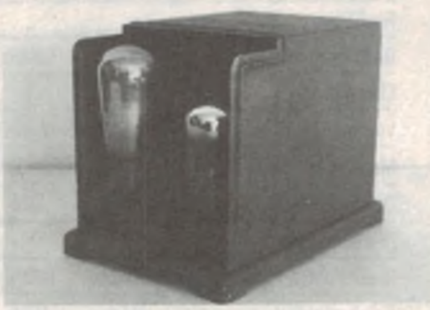


Fig.1: The Philips 3003 'B' and 'C' battery eliminator, shown here with the valve cover removed.

Fig.2: The companion Philips 1017 trickle charger for 'A' batteries, with its tiny mercury-vapour rectifier.

Several rectifiers

A variety of rectifier types was used, including the familiar high vacuum diode. Other types used included copper oxide, copper sulphide, cold and hot cathode gaseous, and electrolytic rectifiers – used in bridge, biphase and half wave configurations.

High vacuum double diodes for 'B' eliminators became available during 1925. The Westinghouse type UV-196 was unusual in having a single anode and two filaments! As described in our August 1988 column, its more conventional companion the RCA UV-213 was later upgraded to become the best known rectifier valve of all time – the 80.

Raytheon's series of cold cathode helium-filled rectifiers was popular. Although having the advantage of requiring no heating current, gaseous rectifiers needed a minimum 'striking' voltage for reliable starting.

Copper oxide and copper sulphide rectifier stacks were early examples of semiconductor diodes. As each segment was limited to about 10 volts, these rectifiers were most frequently used for low voltage applications and were used for battery chargers until recent times.

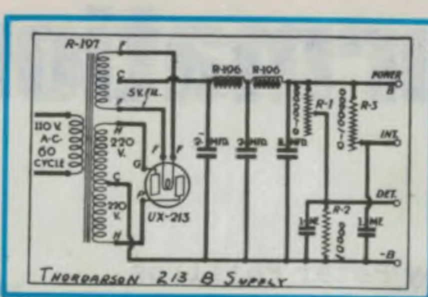
Hot cathode mercury vapour and argon filled rectifiers were also popular for battery chargers.

Electrolytic rectifiers

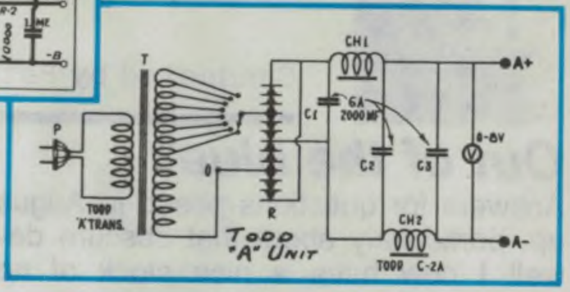
A somewhat bizarre rectifier, known irreverently as the 'slop jar', the electrolytic rectifier or Noden valve consisted of a glass container containing an electrolyte and a pair of electrodes. The cathode was pure aluminium or tantalum, but the anode could be iron, carbon or lead. Borax, sodium bicarbonate, sodium phosphate, ammonium borate and ammonium phosphate were some of the chemicals used for the electrolyte. Each cell could handle up to 50 volts and electrodes were rated at about 40mA per square inch. A typical rectifier for a 'B' eliminator was a compact group of eight quite small jars.

Electrolytic rectifiers could be home made, and for some years the ARRL Amateur Handbooks gave full instructions for their manufacture. An HT supply for a transmitter needed an array of jars that could be rather messy, untidy and potentially lethal!

Mercifully, electrolytic rectifiers eventually disappeared, but they left us with an invaluable legacy – none other than the electrolytic capacitor. Today, electronics technology as we know it would not be possible without the electrolytic capacitor in its various forms.



Left: An example of the classic biphase or full-wave rectifier 'B' supply, using a UX-213 dual-diode valve rectifier. Note also the twin filter inductors or 'chokes'.



The circuit for the American 'Balkite' AB 6-135 eliminator, which used half-wave electrolytic rectifiers for both 'A' and 'B' supplies.

Replacing A batteries

The advent of the electrolytic capacitor meant that sufficient capacitance for filtering filament supplies became available, but initially it was necessary to continue the use of filament batteries. Some compromise was provided by home battery charging.

It was possible in areas with DC power mains to connect a secondary battery in series with some of the household lamps, and have the charging done more or less free. A safer method when AC mains were available was to use a trickle charger, such as the Philips 1017 Rectifier Unit illustrated in Fig.2.

Often, hum and noise were sufficient to prevent the charger being used while the radio was in operation. The radio, battery eliminator, charger and filament battery could be interconnected so that when the radio was not in use, the battery was charging. Turning the radio on by means of the circular knob on the top of the Philips 1017 charger switched the mains over to the B-C battery eliminator and connected the filaments to the A battery.

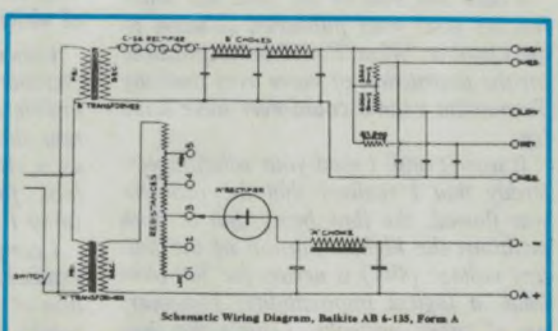
So when the radio was off, the 1017 trickle charged the A battery, but when the radio was on (with HT supplied by the eliminator), the 1017 went off, with the valve filaments running on the charge which had been stored in the A battery.

Some fully mains operated receivers were made which actually ran the valve filaments from the HT supply. Type '99 valves with their 60mA filaments connected in series were well within the capabilities of HT rectifiers and filtering systems, but some receivers actually lit 250mA UX-201A filaments from the HT supply, using a BA Raytheon gaseous rectifier rated at 350mA. One can only guess at the receiver hum level, with 4uF filter capacitors!

The system of heating series connected filaments from the HT supply was resurrected 25 years later, with portable Mains/Battery radios using the 1.4 volt/50mA valves.

About the time that successful 'A' eliminators became available, mains powered valves had appeared and the demand for eliminators declined, causing some manufacturers to switch to making receivers. This happened in America with the Majestic and Philco companies, and in Holland with Philips. All three went from eliminator manufacture to become giants in the radio industry.

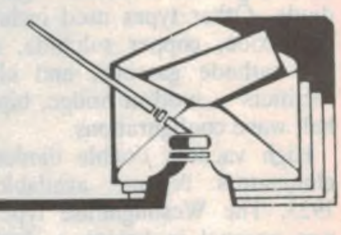
The high cost and inconvenience of providing batteries for valve receivers is still a problem today, but modern technology has simplified the design of battery eliminators. Next month we will describe the construction of a 'universal' mains power supply for running battery operated valve receivers.



Right: 'A' eliminators only became practical with the development of electrolytic capacitors. This one used a copper-oxide bridge rectifier.

Information centre

Conducted by Peter Phillips



Out of the blue?

Answers for questions posed in August 1989 are still turning up, particularly about that obscure device, the blue LED. As well I now have a nice stock of new questions to pose, resulting from the debacle due to a mistake in the What?? question posed in October. As one contributor put it, 'here's my revenge...'

Printing lead times are a phenomenon of magazine publishing that often confuses readers. For example, if a question is posed in this issue, reader responses won't appear until May. The impression therefore may be that we are ignoring your replies, when in fact we are acting as fast as the lead times allow. The classic example of this concerns the What?? problem posed on page 158 of the October 1989 issue – the question that could only be solved if one assumed negative resistor values. (Will regular readers ever forget?)

Although I just caught the January issue in time to print the news that the problem was incorrectly posed, it isn't until now that I can fully address the extent of interest the problem aroused. I've lost count of the number of letters I received advising me that either the problem was wrong, or the solution was wrong. By now every correspondent should have received a reply thanking them, apologising, grovelling etc. I blew it, and a personal reply to each letter was the least I could do.

And out of the ashes comes the Phoenix, in the form of more teaser type questions, mainly supplied by the writers of the above letters. ('Great!' I thinks to meself, wondering mischievously if I should include a few more printing errors.) Relax, it was a genuine mistake that I hope won't be repeated.

In deference to these contributors, I'll start this month with a quick overview of the correspondence concerning the mistake, as it seems most readers were not only understanding, but even glad of the opportunity to figure it all out. Phew!

October's What??

As the letters poured in, I started a number of files categorising them into those who picked the mistake (the majority), those who thought the solution wrong and those who were plainly upset. The following letter indicates how some readers (very much the minority though) reacted to the error.

After spending several hours on the problem (Oct.'89) I was shattered. What at first appeared a reasonably straightforward problem had me tearing my hair out. Finally, in an act of desperation, I started changing the figures around and got a solution that worked. The voltage drop across the parallel combination of R1 and the 500 ohm resistor should be 14V and the drop across R2 should be 35V. The drawing is wrong!

The reason, of course, is a printing error. However it tends to make one wonder what other printing errors exist. I use your magazine to help keep me up to date with the latest developments. Please don't degrade your otherwise good magazine by tolerating sloppy production. (D.S., Willetton WA)

Most contributors were a little less upset, and a little more understanding. Here's an example:

I dare say that by the time this letter reaches you, your published solution to the October 'What??' will be responsible for the destruction of more trees than the Tasmanian vandal could ever have hope for.

It wasn't until I read your solution yesterday that I realised that the problem was flawed, the flaw being that in both positions the highest portion of the battery voltage (49V) is across the 500 ohm load, a logical impossibility. However, we all make misteaks. (That's the supplied spelling by the way! Ed.) Perhaps you should have kept it for next April's edition.

In the meantime keep up the good work, I enjoy the challenges. (J.G., Moama NSW).

In fact, most letters were fairly complimentary and very good natured, the last thing I expected I have to admit. For example, one correspondent (D.B., Mt Waverley Vic) suggested (tongue firmly in cheek) that the problem and the solution were mutually exclusive: *'The circuit is that of an oscillator, with its negative resistance values!'*. However, D.B. wants more teasers, as, he writes, these exercise the mind, while gardening and household maintenance keep the muscles in tune.

A lot of writers proved that the values for the unknown resistors should be –250 ohm for R1 and –200 ohm for R2. However, they all had reservations...

Either I'm getting too old and there is something I didn't see in the question, or the person responsible for the question is a maniac or – just possibly – there is an error in the circuit. (A.F., Balwyn Vic). and...

Your solution printed in November to the problem posed in October is incorrect. The correct answers are – 250 ohm for R1 and R2 equals -200 ohm. (Proof included).

I trust you find this information useful. By the way, if the diagrams in the October issue were misprinted and your solution is correct, I will be most upset! (I.B., Little Mountain Qld)

I'll leave this topic on a high note with the following letter, the sentiments of which give me hope to carry on:

Concerning the 'What??' question in October, no wonder your relative was unable to solve the problem! But please note that my comments are not intended as a criticism of your column, which I look forward to reading every month (after I read Jim's editorial of course...).

I congratulate you on your initiative in expanding what was a fairly dreary section of the magazine. Keep up the good work! (P.S., Carlingford NSW)

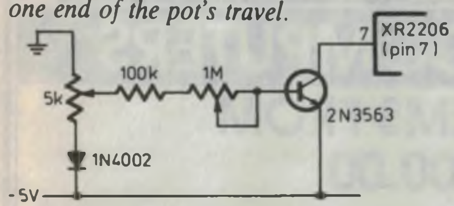
Function generator

The next letter offers a modification to the function generator published in *EA* in April 1982. The writer believes the unit is great, but rather awkward when it comes to adjusting the frequency. His suggested modification is simple, and apparently effective:

The function generator with digital readout described in April 1982 and refined in subsequent errata notes is a classic piece of clever design, resulting in a genuinely useful product. It is still available as a kit from Dick Smith (K-3520) or Jaycar (KA-1428).

However the frequency setting controls on this device are rather clumsy, as all the control is concentrated up one end of the control pot, requiring an additional 'fine tuning' control. The reason for this problem is simple, and the cure easy.

The frequency of an XR2206, the IC that produces the waveforms in the function generator, depends on a fixed capacitor (selected by a switch) and the value of the current flowing out of pin 7. The original circuit has a variable resistance between pin 7 and the –5V supply, giving a hyperbolic relationship between frequency and resistance. That is, halving the resistance doubles the frequency, quarter the resistance quadruples the frequency, and so on. The result is that the greatest changes in frequency occur at one end of the pot's travel.



The circuit of Fig.1 fixes this problem, by producing a current flowing from pin 7 of the XR2206 that is now directly proportional to the rotation of the 5k linear pot. Both pots shown in Fig.1 are already mounted on the panel, so only three additional components are needed for this modification.

The silicon diode is used to produce a 0.6V voltage drop, to avoid a dead area at the low frequency end of the scale. The 2N3563 was selected as it has a low gain, minimising effects of gain variation due to temperature changes. The 100k resistor sets an upper limit on frequency and protects the transistor from excess base current. The 1M pot is used to set the range limits and the 5k pot is used to adjust the frequency.

I had to cut two tracks on the PCB to incorporate these modifications, although later versions may not require this. The final result gives very good frequency control. (M.M., Wembley Downs WA).

Blue LEDs

At last some information has surfaced on blue LEDs, in response to a reader request I also printed in that fateful October '89 issue. All the letters say much the same thing: they're expensive and they're made by Siemens – although one correspondent states Sanyo make this device as well. This correspondent even included a colour picture, captioned 'Sanyo introduce blue LEDs' which shows an array of LEDs that look more white than blue. Here's that letter first:

There are two current manufacturers of blue LEDs that I know of. One is Siemens, who have been producing and selling these devices for about four years. Due to its large chip size on relatively costly Silicon Carbide (used also for making grinding wheels!), it is an expensive device. In quantity it sells for $A20 each. Bought singly, they sell for around $40 and are available from Promark or Reserve Electronics, both based in Sydney.

The second manufacturer is Sanyo. The Siemens LED is rather a disappointment when operating. It's a pale, rather dull light blue colour – not the bright, low cost device one might expect. I hope this helps you. (R.G., St Clair NSW).

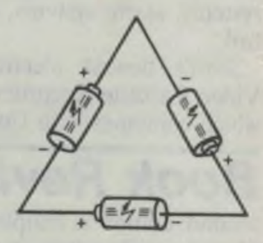
Another correspondent sent details including the price one pays for these in England. Again the device referred to is made by Siemens, and after converting the English price to Aussie currency, a single blue LED would cost you $53. For this you get a 5mm, type LB5410 Siemens device that gives light output at a wavelength of 480nm, requiring 20mA of current at a forward voltage drop guaranteed to be less than 8V. My thanks to J.A. from Salisbury, Qld for supplying this information.

A third correspondent, (C.J., Victoria) is more complimentary about the performance, but agrees with J.A. that the price is around $54. The device referred to has a slightly different type number, an LDB5410.

But the last word is from Siemens themselves, who supplied a list of distributors and technical details. The type number is the same as that referred to by C.J., the LDB5410, which seems to differ from the LB5410 type in that 25mA at a forward voltage of 4V is required to light it. The applications listed in the data sheet include spectroscopy, calibration and light sources in medical equipment. Siemens are represented in most capital cities, and the list of distributors includes George Brown (Hilton, SA and Spring Hill, Qld), Promark (Nunawading, Vic. and Artarmon, Sydney), Reserve Electronics (Sydney and East Perth) and several other suppliers around Australia.

So blue LEDs are, it would seem, readily available. Pity about the cost, but then blue lights, particularly the flashing ones with a siren attached, do tend to be expensive!

What??



This month's question is from a contributor who wishes to remain anonymous.

The question is: if three ordinary 1.5V carbon-zinc torch batteries are connected in series, each with an internal resistance of 30 ohms, as shown in Fig.2, determine the current flowing in the circuit and the voltage drop across each battery.

Answer to last month's What??

The answer to last month's What?? is (approximately) 25 ohms. Here's the solution, using 'reasonable approximations' as the question asked. Looking back into the output terminals, the emitter resistor R3 is clearly in parallel with them. However, any impedance between the base and ground is also effectively in parallel with the output terminals, except this impedance needs to be divided by the AC current gain (hfe) of the transistor. The resistors Rs (impedance of the signal source) and the bias resistors R1 and R2 are all a part of this impedance, giving a parallel combination of 2.5k. When divided by the AC current gain of the transistor (100), a value of 25 ohms is obtained. The parallel combination of 1k and 25 ohms is near enough to 25 ohms anyway, giving the final answer.

NOTES & ERRATA

Musolight (September 1989): Capacitor C18 (470uF/35V) is not shown on the circuit diagram, and is connected between the cathode of D7 to ground. However it is shown on the component overlay diagram. The value of C4 (10uF) is not shown on the circuit diagram. The value of C2 is incorrectly shown as 4.7uF; it should be 4.7nF. The value of R5 is not clearly shown and is a 4.7k resistor. The parts list should be amended to read: 7 x 47k and 8 x 10k.

Learn Electronics

Continued from page 17

memory organisation, flow charting, input, output, interfacing etc.

Industrial electronics is also taught, as factory production relies heavily on electronic control and processing in applications such as air conditioning, fuel systems, alarm systems, and power control.

Stott's newest electronics course is Video Cassette Recorder Fundamentals, which combines with Colour and Monochrome television servicing subjects. This course gives clear instruction in the fundamentals of television servicing and VCR operation, maintenance and repair. It is suitable for the home handyman, TV repairman or complete beginner. An instructional videotape is included with the study materials.

Further information can be obtained by contacting Stott's Correspondence College, Stott House, 140 Flinders Street, Melbourne 3000 or phone (03) 654 6211.

Book Reviews

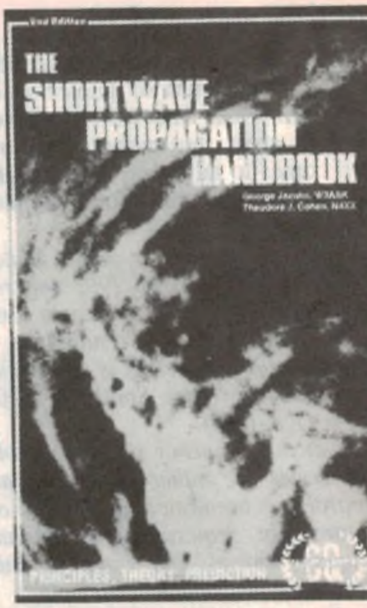
Continued from page 75

second edition a couple of years later. However it hasn't been readily available in Australia until fairly recently, and it's something of a classic – hence this attention.

HF propagation has the reputation of being more of a black art than a science, and I for one suspect that's still pretty true. However at the same time, over the last 50 years or so there *has* been amassed quite a deal of solid knowledge about at least the major factors which determine propagation at these frequencies. And this compact, reasonably priced little volume is generally regarded as a sound, readable introduction to the subject.

As well as being very active radio amateurs, both authors are well-qualified and experienced professionals working in the communications field. They produced the first edition of this book by adapting various articles on HF propagation that had been published in *CQ* magazine, with the idea of collecting together all of the basic material on principles, theory and prediction of propagation. For the second edition they then further revised and updated this material.

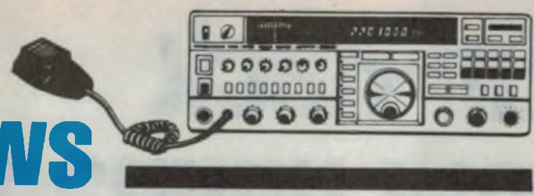
The text is friendly and accessible, with enough theory to satisfy those of a more analytical bent, but without things becoming so heavy as to discourage the



reader who just wants to get a good 'feel' for the basics. This should make it of value not just to radio amateurs, but to students and people working in HF communications areas as well.

The review copy came from Stewart Electronic Components, of 44 Stafford Street, Huntingdale 3166 (PO Box 281, Oakleigh 3166), which can supply it by mail order for the price quoted. (J.R.)

Amateur Radio News



Little growth in Oz amateur radio

Statistics released recently by the DoTC show that the number of amateur radio licensees in Australia grew by only 0.5% from 1988 to 1989.

On 1st October 1988, there were 18,026 licences on issue, whereas the corresponding figure for 30th September 1989 was 18,120 – only 94 more.

Novice numbers decreased by 67, while full AOCP licensees increased by 166. Victoria had the largest increase overall (up by 99, to 5022), but NSW still has the highest total with 5274 – although this is down by 135.

Many amateur radio organisations in other countries are also concerned by lack of growth in the hobby.

WIA now has 'no-AR' membership

Following a great deal of debate regarding membership fee rises proposed for this year, the WIA has apparently decided to make available a new grade of membership carrying a lower fee. The new 'X' grade offers all of the normal benefits of membership, except for receiving the WIA's official journal *Amateur Radio*.

Annual fees for X grade membership in VK6 is only $30, with VK2 charging $33. Corresponding fees in VK7 are $38 and in VK1, VK3, VK4 and VK5/8, $39.

Pensioners and students can still receive full 'with-AR' membership at reduced rates, which are in most cases about $12-15 above the new X-grade fees.

Gosford Field Day – reminder

Readers are reminded that the Central Coast Amateur Radio Club's very popular Annual Field Day is on this month, on Sunday 18th at the Gosford Showgrounds.

The field day will include seminars, trade displays, disposal stands and a flea market. Tea, coffee and biscuits will be available between 8am and 3pm, with take-away food also on sale. There is plenty of off-street parking.

For further information phone (043) 92 2244, after hours only.

Phone patch now approved

According to the WIA's NSW Division newsletter, amateur automatic phone patch operation is now approved. That is, calls can now be placed by the originating party. However both commercial and home-made equipment must still be isolated from Telecom's network via an approved line isolation unit (LIU).

Printed circuit boards and isolation transformers for the LIU published in *Amateur Radio* some time ago are available from the NSW divisional office, 109 Wigram Street, Parramatta 2124 – phone (02) 689 2417.

Taken at the NSW Microwave Field Day reported last month, this shot shows the informal opening ceremony for the new 23cm repeater. Left to right: Julie Kentwell VK2XBR, Chris Ayres (Dick Smith Electronics), Bob Clark VK2YOD and Roger Henley VK2ZIG (NSW Division President).

Original Zip-Rack system now upgraded

Dick Smith Electronics is now distributing the Zip-Rack range of international standard 19″ rack kits for electronic equipment, fully designed and manufactured in Australia. The new Zip-Rack '420 Series' incorporates a number of improvements over the original and similar designs, and is also available in a wider range of sizes.

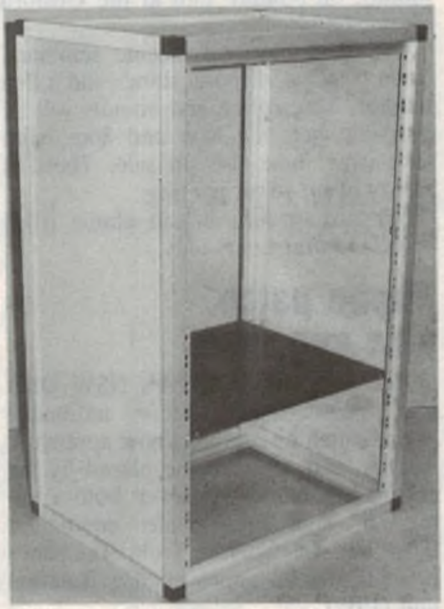
The Zip-Rack system was developed in Melbourne about six years ago, by John Ewenson. An industrial electronics design draftsman, Mr Ewenson saw the need for an Australian-made 19″ rack system that would compete against costly imports.

The original development work took place in the time-honoured birthplace of great technological innovations: his home garage. After much experimentation, he came up with a system based on a specially-designed custom designed aluminium extrusion, which could be cut and assembled together easily using moulded corner connectors, to form strong and attractive racks of virtually any desired standard size.

Design work was finalised in 1984, and Comalco commissioned to produce an extrusion die and production metal. A punching tool was also designed and made, to comply with the international standard for rack mounting flanges. Zip-Rack was born, and has proved to be very successful. So successful, in fact, that before long similar products appeared on the market.

Needless to say, however, John Ewenson didn't sit on his laurels. His operation soon outgrew the family garage, and moved to a small factory in Bayswater. It's now called Autotron Australia, with Mr Ewenson as MD. And the firm has now developed its new 'Series 420' Zip-Rack system, which incorporates a number of worthwhile improvements over both his original system and many of the similar systems as well.

For example the extrusion now provides a heavier-gauge mounting flange, to provide greater strength where it's needed. The moulded plastic corner connectors have also been redesigned, with a chamfered edge in place of the original relatively sharp outside corner. A new clip-in steel tray has also been



designed, to support equipment not originally designed for standard rack mounting. And finally the Series 420 range provides a selection of six different standard sizes, somewhat greater than previously available.

Like the original Zip-Racks, the new Series 420 racks are supplied as 'knock-down' kits, which assemble to produce racks with total panel heights of 6, 12, 18, 24, 30 and 40 international rack units. All kits assemble with a standard depth of 420mm, with an overall width of 540mm.

Each kit consists of 12 lengths of the special hollow section extrusion, which are interlocked using eight heavy duty moulded black plastic corner connectors. All parts are deburred and ready to assemble, with no screws, nuts or washers required. The frame extrusions have a satin anodised finish, giving a very professional appearance.

Although this press-fit assembly technique provides a self-aligning, rigid frame, the final rack can be further strengthened if desired by drilling and rivetting overlapping flanges at each corner. In fact one of the flanges is provided with a small central groove, to assist in centring the drill for this purpose.

The flanges are accurately punched to comply with international standards for 19″ racks. Included in each rack kit are four rubber buffer feet, to protect the bench or floor surface.

Also included with each kit are simple assembly instructions, and well as reference information on the international 19″ rack system.

To mount equipment in the completed rack, each kit includes a 36-piece fastener pack. This includes 12 M6 machine screws, 12 matching M6 cage nuts for the rack flanges, and 12 M6 nylon dress washers to protect the equipment front panels. The screws also have a Phillips head rather than conventional straight slot, to assist in keeping the screwdriver from slipping out and possibly scratching one of the equipment front panels.

The fastener pack is sufficient to mount three pieces of equipment – more than is provided by some competing rack kits. However for mounting additional items, further 36-piece packs and 100-piece bulk packs are available as optional extras.

Other optional accessories include sheet steel cover sets, providing side and top covers to suit each of the six standard rack sizes. There is also that newly-developed clip-in steel tray, to mount non-rack mounting equipment. The cover panels have a light beige texture finish, while the tray is in black.

In short, the new 420 Series Zip-Rack is better than ever, and provides a very attractive and cost-effective way to house a wide variety of professional electronic equipment and systems.

The 420 Series range is being distributed exclusively throughout Australia and New Zealand by Dick Smith Electronics, at prices ranging from $129.00 for the 6U model to $259.00 for the 40U model. DSE now also carries a range of standard rack mounting equipment cases, to complement the Zip-Rack frames. (J.R.)

Standard equipment racks

The following basic reference information on the internationally used 19-inch equipment rack system is adapted from a data sheet produced by John Ewenson, of Autotron Australia.

'19-inch rack practice' has been around for 50 years or more – hence ye olde '19-inch' bit, in these days of metric measurement. The system concept provides for the orderly integration of a wide variety of system modules, into a single standardised and cost/space efficient format.

The system is recognised by virtually all nations as the international standard in most fields of electronics – and nowadays, that means almost everywhere.

The 19-inch system starts with two critical dimensions, both relating to the panel size that mounts across the front of the rack. That is, the front panels for the individual modules. The critical dimensions are:

(a) Panel width, which must be 482.6mm (19″), and cannot be changed.

(b) Panel height, which must only be in integral multiples of 44.45mm (1.75″) – known as *one rack unit*, abbreviated to 1U or 1RU.

So you can have a panel height of 1U, 2U, 3U, 4U and so on. Panels of half-unit or other fractions of a rack unit are not allowed.

All other relevant dimensions for both rack and equipment modules are shown in the diagrams.

The rack frame vertical mounting flanges are punched to accommodate 1U modules over the full height.

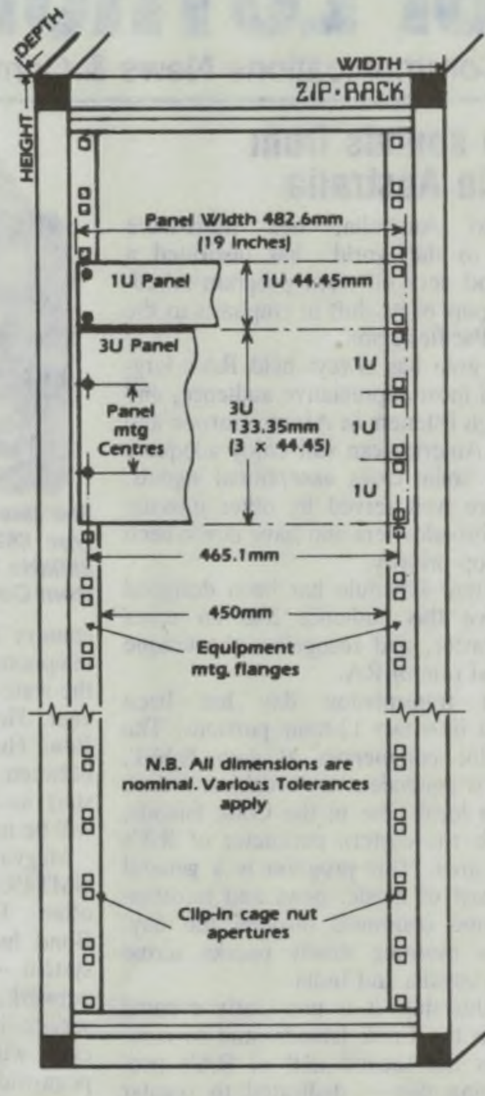
Panels and equipment are mounted to the rack flanges using M6 Philips-head screws. Clip-in M6 cage nuts are fitted to the rear of the panel mounting flanges of the rack.

Also of importance is the placement of the mounting holes on the equipment module panels. The horizontal spacing between the holes at each side of the panel must be 465.1mm, while the vertical spacing on each side should vary with the panel height as shown in Table 1. Conforming to this international standard ensures a good fit, optimum use of rack space and a professional appearance when all panels and equipment are mounted.

When you are looking at racks, the professional product will be identified by the number of rack units it can accommodate – e.g., 12U, 18U and so on. Similarly when you are investigating cases, panels or equipment for rack mounting, these should also be identified firstly by their height in rack units (refer Table 1) and also of course by their depth of case.

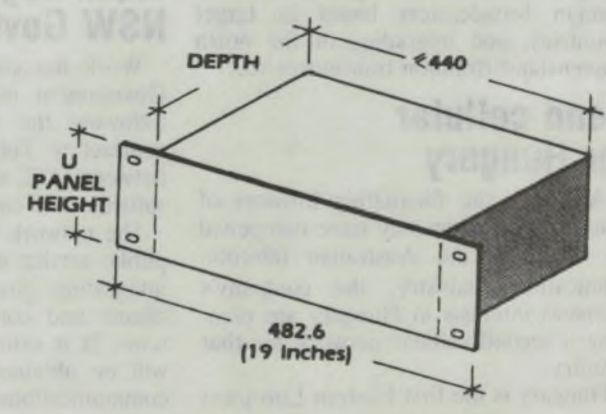
PANEL SIZE	PANEL HEIGHT mm	PANEL MTG CENTRES mm
1U	44.0	31.8
2U	88.1	76.2
3U	132.5	57.1
4U	177.0	101.6
5U	221.5	146.1
6U	265.9	190.5

TABLE 1: Panel Dimensions



19 inch Rack Fundamentals

Needless to say, the rack frame needs to be deep enough to accommodate the equipment modules, without being excessively deep (which would restrict access). Allowance for rear-mounted connectors may have to be considered, as does the bench or floor space occupied by the complete rack of equipment.



Rack Mounting (Equipment) Case

SPECTRUM

Communications News & Comment

Conducted by DAVID FLYNN

New sounds from Radio Australia

Radio Australia, our short-wave 'voice to the world', has instituted a new and very different program schedule as part of its shift in emphasis to the Asian/Pacific region.

This area has always held RA's largest and most appreciative audience, and although listeners in Africa, Europe and North America can still enjoy adequate and in some cases exceptional signals, they are well served by other international broadcasters and have never been RA's top priority.

The new schedule has been designed to serve this audience like no other broadcaster, and recognises the unique regional role of RA.

Each transmission day has been divided into two 12-hour portions. The first slot commences at 4am EAST, which is equivalent to 'breakfast radio', at 7am local time in the Cook Islands, towards the eastern perimeter of RA's target area. This program is a general broadcast of music, news and information, and continues through the day, and as morning slowly breaks across Fiji, Australia and India.

By this time it is now early evening back in the Cook Islands, and so commences the second half of RA's programming day – dedicated to regular programs and features at this convenient listening time. Once again, these programs are beamed to local audiences as night marches west.

Other measures being considered to increase RA's penetration into the area include the possibility of establishing relay or 'time-share' agreements with foreign broadcasters based in target countries, and upgrading of the north Queensland Brandon transmitter site.

Bond cellular for Hungary

Although the fluctuating fortunes of Bond Corporation may have dampened its hopes in the Australian telecommunications industry, the company's overseas interests in Hungary are planning a second cellular network for that country.

Hungary is the first Eastern European country to introduce a cellular mobile telephone service, to be established by the state-owned Magyar Posta early this year. However the rival network from Bond Hungaria Telecom, a co-operative between Bond and local players, will start around the same time, and both will be incompatible.

Magyar Posta will use the 450MHz NMT450 standard, popular in many other European countries, whereas Bond has chosen the 900MHz AMPS system – the same as used in its Chile network. This will be the only AMPS service in Europe, however, and may clash with plans to develop the European-wide digital CMTS on the same frequencies.

This service is expected to commence operation in the UK by mid next year, spreading across the continent to include some 9 million subscribers (from a population reach of 300 million) by the end of the decade.

The latest family of land/mobile HF transceivers from Australian firm Codan, type 8528, offers 2-24MHz transmitter coverage and a receiver tuning from 250kHz to 30MHz, with 400 programmable memory channels. Further details from Codan, (02) 971 2233.

Work begins on NSW Govt network

Work has commenced on the NSW Government communications network, following the award of the lucrative contract to Telepower, a joint venture between OTC and the Computer Power software and consultancy group.

The network will link numerous state public service offices throughout NSW, integrating government facilities with clients and computer information systems. It is estimated that large savings will be obtained by establishing direct communications between offices, thus bypassing Telecom.

Similar systems have previously been established in other states, using dedicated links to provide voice, fax, telex and data communications between individual users or on a group basis.

The Telepower bid marks another successful foray by OTC into the commercial field, and has been supported by some 16 NSW-based electronic information and computer companies who have since joined Telepower.

Upgrade kit for scanner

Owners of the popular Realistic PRO-2004 desktop scanner will be intrigued by an 'upgrade' kit produced by Sydney scanner specialists Proscan.

The kit increases the PRO-2004 memory capacity to 400 channels (from a previous 300), enables a useful 30kHz step on the 800MHz cellular band, increases scan speed and improves the mute action.

Included with the kit are all necessary components and full instructions, which claim the modifications are very simple and can be carried out by almost anyone who knows how to use a soldering iron. The kit also comes with a replacement overlay for the PRO-2004 keypad, which reflects the increased channel capacity and the additional channels in each 'bank'.

The kit costs $9.95, including postage and handling, and is available from Proscan, PO Box Q365, QVB, Sydney 2000. Trade enquiries are welcome.

Simple 12V/30V DC-DC converter

Here's an easy-to-build low power converter which operates from 12V DC and produces 30V DC. It's been designed to allow the November 1989 FM Transmitter to operate from a single 12V supply – but has many other potential uses.

Some of the readers wishing to construct our 2m FM Transmitter (*EA* November 1989) have expressed a desire to operate the unit in a vehicle. The problem is the 30V supply that the circuit requires, in addition to the main 12V supply.

This simple 12 to 30V converter will make it possible to operate the whole transmitter from a 12V battery. Because of the low power involved, a diode-type voltage multiplier is used.

IC1 is a 555 timer operated in astable mode, with the frequency set to 100kHz by R1, R2 and C1. The square wave output at pin 3 is applied to three multiplier stages via C4 to C6.

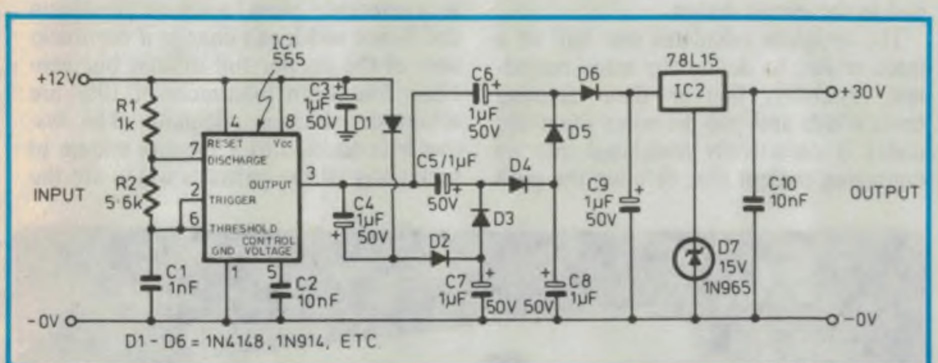
To understand the multiplying action, let's have a look at the first stage, formed by C4, D1, D2 and C7. Diode D1 stops the squarewave signal after C4 from going below 12V. The whole squarewave will therefore 'sit on top' of the 12V supply. During the positive peaks of this signal, D2 becomes forward biased, charging C7 up to this level.

With a typical peak-to-peak signal amplitude of 10V and allowing for the voltage drop over two diodes, C7 will therefore have a DC voltage of about 21V across it. The following stages add to this voltage in a similar fashion.

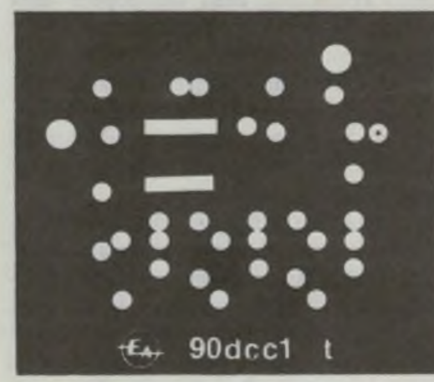
A voltage in the order of 38V is finally reached across C9. This voltage varies considerably according to the supply voltage and the regulator IC2 with zener diode D7 is therefore added to keep the output at a constant 30V.

PCB artwork for a double-sided board is included. The top copper layer acts as a ground plane and may help to suppress output spikes. However you can also make a single-sided board, as the ground connections are also provided on the track side. Place the components according to the layout diagram.

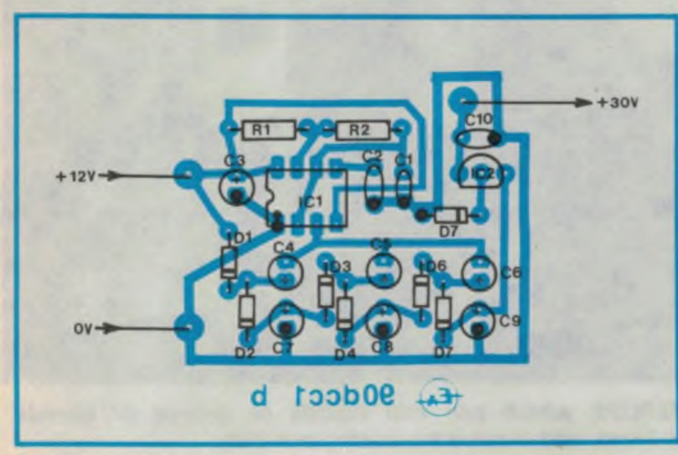
The power output available from the unit depends on the input voltage. With an 11V supply the unit can deliver 13mA, increasing to 28mA at 12V and 43mA at 13V. With only 3mA required by the 2m transmitter, the converter will work satisfactorily over a wide input voltage range. (D.deL.)



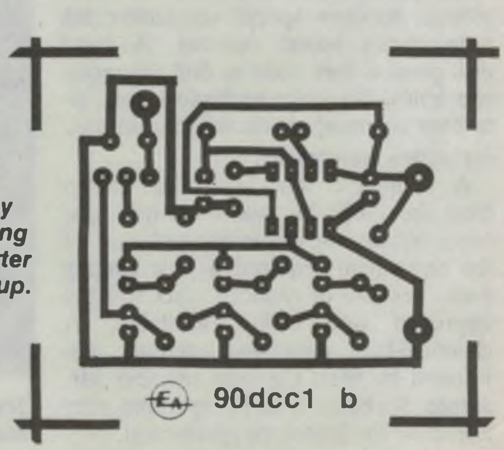
The circuit for the converter, which uses a 555 chopper driving a diode voltage multiplier – very simple and straightforward.



Above and below: Upper and lower patterns for the converter PCB, shown actual size.



Left: The overlay diagram, showing how the converter board is wired up.



Making prototype PCB's without chemicals

With the increased concern for the environment, any alternative to the conventional chemical etching of PC boards is welcome. BoardMaker, a PC-driven engraving machine introduced in this article, makes prototype and small scale production of PCBs not only environmentally safe, but also significantly cheaper and faster.

by WINIFRED VINCENT

The most common way of producing printed circuit boards is by etching away unwanted copper, using chemical etchants. This involves making a CAD design, then a photographic negative which is placed on the photoresist covered board laminate and exposed to ultra-violet (UV) radiation. After the UV illumination, first the exposed photo resist and then the copper film underneath it are dissolved away by etching, to leave the desired tracks.

This technique involves a darkroom, various washing and cleaning tanks, venting equipment and special storage facilities for acids and relatively toxic wastes.

For making prototype boards, running a facility like this is expensive and most of the time PCB making is contracted to an outside facility, which means a time delay of days or even weeks. Moreover the integrity of a research and development project is placed in the hands of an outside supplier, and therefore total control at this critical stage of a project is lost.

Another method uses a modified X-Y plotter, to draw special conductive ink onto circuit board material. A small drill press is then used to drill the requisite holes. To make multiple layers, alternate layers of conductive and insulating pastes are applied.

A technique that has been known from the 1960's but was for a time ignored, because of the initial high cost of the equipment required is now coming back, because of reduced costs and the improved line widths available. A chemical-free engraving method, developed by West German engineer Mr. Jurgen Seebach, it is being found very attractive for prototype production.

Instant Board Circuits of California is making and marketing this system, called BoardMaker, which can be interfaced to all IBM-PC based PCB CAD systems.

A plot file with Gerber industrial standard database format is read by the PC using special software programs. These read the plotfile and define the coordinates of the design (pads, corners and intersections of traces), then calculate an *outline* around each trace and pad in the circuit design.

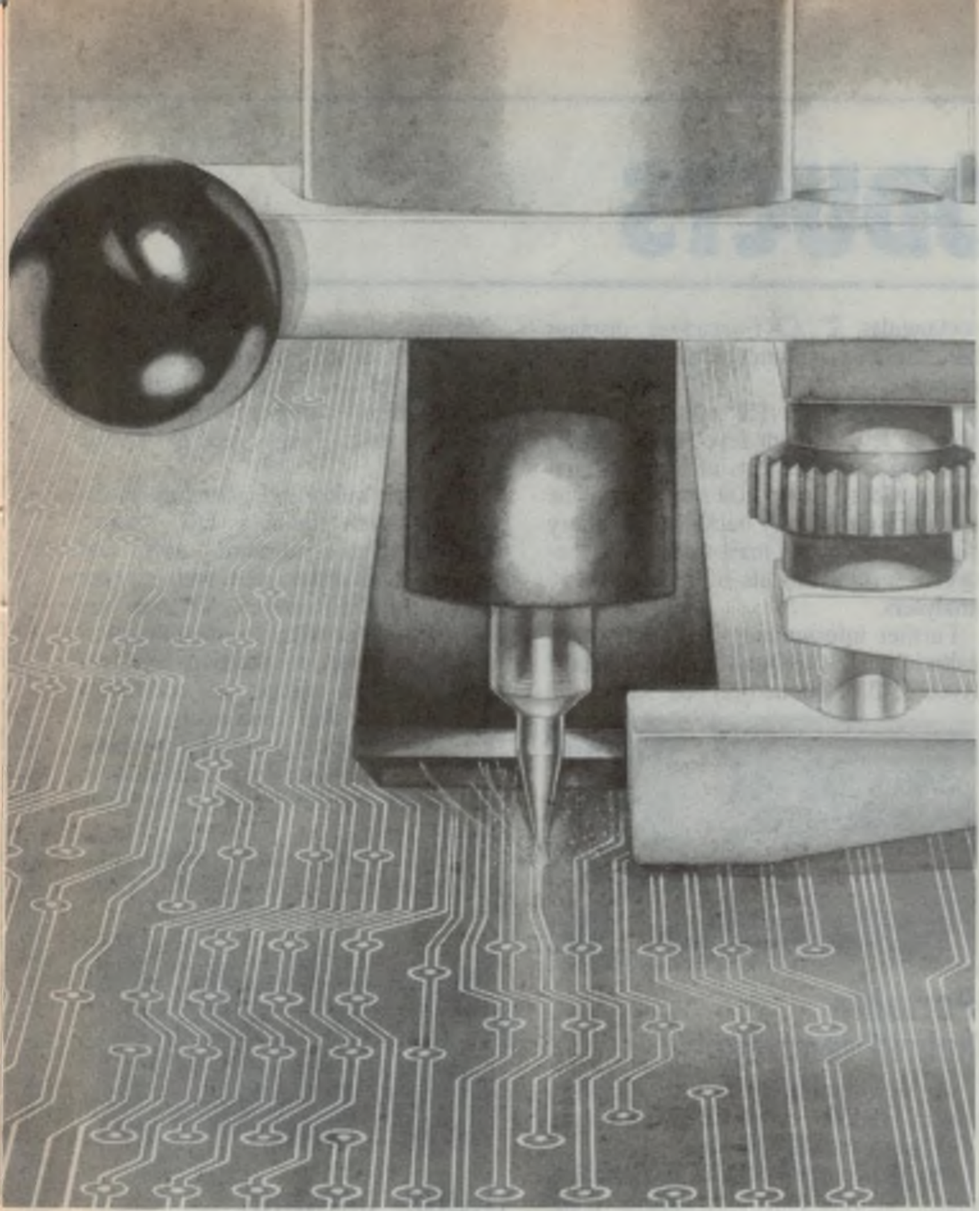
The program calculates one half of a trace width, to define the trace boundary. Thereby, Gerber data defining trace width and pad-diameter (aperture code) is successfully translated into an engraving control file, defining the path of a milling tool in engraving away a groove to produce each conductor line and pad. After all the calculations have been completed, a new file is created, which can be saved on a floppy diskette and taken to the engraving system. When a blank laminated board is placed inside the system and the cover closed and started, engraving is done as shown in the picture.

The milling-cutter tools have a sword-shaped tip. Cylindrical milling tools at such diameters are not readily available and tend to have shorter operating life.

A mechanical reference system that views the circuit board's top surface as a zero point determines how far the sword-shaped bit presses into the material. The deeper the bit mills, the wider the insulation channel produced.

Since the circuit board surface is used as a reference point, a set cutting depth and hence width can change if the thickness of the copper foil differs; but generally line-width tolerances of 10% are achieved, which is adequate. The system is connected to a vacuum system to suck away all the particles which are the

The BoardMaker 912PLUS, which can mill boards or groups of boards measuring up to 23 x 30cm, and is rated for continuous duty.



The milling cutter removes a thin strip of copper all around each PCB trace, isolating it from the remaining copper laminate.

by-products of engraving.

Using this technique, a two sided 100mm x 165mm board with 20 IC's takes approximately 2.5 hours to produce, including the drilling. A 50mm x 70mm board with medium density will take only about 15 minutes.

As can be seen, in contrast with the chemical etching process more copper will be left on the circuit board, to provide an added ground plane. However chemical processing is often subjective and is notorious for its variability, due to the degradation of chemicals. Whereas the engraver has greatly reduced setup costs and time delays, and doesn't require much skill to operate it. Of course here also one will have to look out for such things as wearing of tools, etc.

PCB line widths in the range 0.003" to 0.005" are attainable by this engraving method. Double sided board production is also possible, and to connect the top circuit layer to the bottom, either wire links are used with soldering on both sides, or a thin wall eyelet is used in the holes, and then spot welded. The inserts or eyelets are easily wetted and promote interior and exterior capillary action, to facilitate solder flow from one side to the other, if desired.

However, the system can also be used with a conventional throughplate system. After completion of the drilling phase the board is metallised and plated, and then put back on the engraving machine to be engraved. To assure registration of the board, it is held in place by registration pins.

To accomplish this, reference holes are drilled and pins are pressed in to the holes for alignment in conjunction with a vyce mounted on the machine. Once the board is locked down in reference position for second side machining, the machine head must be positioned directly over a designated hole so that the tool spindle axis and the center of the hole are precisely aligned.

Even though the IBC engraving system is favoured for prototype making, it can also be used to make conventional film negatives for production runs of coventional chemically etched boards. The idea is to make a prototype board, test it and correct it. Then perhaps make one more again, testing it also. When the final design is proven satisfactory, a normal Gerber plot file can be used to make artwork with rubylith film. This saves the cost of using a photoplotter.

The other major use for these machines is making face plates from coloured laminate plastic sheets, or aluminium panels. This will again be suited for prototype or small run applications only.

BoardMakers mill isolating tracks, drill different hole diameters and route any special cutouts or board shapes into standard PCB board material. Different kinds of tools are used for film cutting, milling, drilling and routing. The only special skill required for the operation of the machine is the ability to change a drill.

BoardMaker 912 and 912PLUS handle boards up to 9" x 12", whereas the BoardMaker 2222 handles boards up to 22" x 22". The latter two have higher speed (3.6cm/sec) and better resolution. The B2222 also has dual head assembly option, enabling two 10" x 22" circuit boards to be made simultaneously.

BoardMaker 2222 is well-suited for high density surface mount applications, due to its capability of small hole drilling, whereas Boardmaker 912 is suited for low density SMT boards.

The B912PLUS with associated software and tools currently sells for US$8995. The manufacturer can quote on any of the other systems.

The system is easy to install. All that is involved is connecting the parallel interface cable to a parallel port of the personal computer, booting the IBC software package and connecting the vacuum.

Some of the well known US users of BoardMaker are: AT&T Bell Labs, General Electric, Hewlett Packard, IBM, Los Alamos Labs and major universities.

For further information, contact Instant Board Circuits, 20A Pamaron Way, Novato, CA 94949 or phone (415) 883 1717.

NEW PRODUCTS

Security system shock sensor

Murata Manufacturing has released the PKS series shock sensor, intended for security systems, where mechanical shock or vibration is to be sensored.

The PKS series can be set on desks, filing cabinets, doors, windows or automobiles; the sensor will transform any mechanical shock or vibration into an electrical output.

The electrical specifications are, sensitivity of 40mVp/1G (25°C, 10Hz-1kHz) with capacitance of 10nF (25°C/1kHz) and a temperature range of -20°C to +60°C.

With a low profile height of only 4.5mm and diameter of 24mm, the PKS is easily mounted.

For further information contact IRH Components, 32 Parramatta Road, Lidcombe 2141 or phone (02) 648 5455.

Scalar analysers

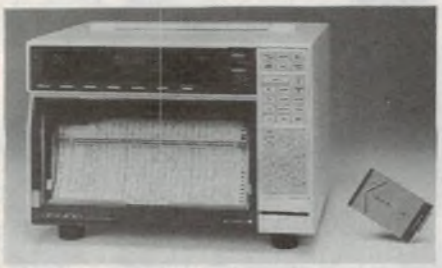
The Leader 6000 and 6030 are designed for the real-time display of high frequency device propagation characteristics.

Frequency range for the 6000 is from 100kHz to 50MHz, and the 6030 from 10MHz to 300MHz. A selectable level method is used, enabling high accuracy measurement of true value, without the influence of harmonics from the signal source. Parameter settings can be made quickly by numeric keyboard input or by a rotary encoder and digital selector.

A high intensity, high performance rectangular 7" CRT readout displays measurement parameters as well as the response.

The 6000/6030's RF output is available at a maximum level of +13dBm, enabling measurements of high attenuation devices. Up to 100 settings can be stored in the battery backed-up memory and data can be mass-transferred between several models of the 6000/6030 analysers.

Further information from AWA Distribution, 112-118 Talavera Road, North Ryde 2113 or phone (02) 888 9000.



Portable hybrid recorder

A new portable hybrid recorder, model HR1300, has been added to the Yokagawa recorder line-up.

The new portable hybrid recorder has many versatile functions, such as high-speed scanning of 20 points/sec and high-speed recording of 50 points/sec. Each channel can be programmed to print in a choice of 10 colours and it is very easy to operate.

The HR1300's compact and lightweight design makes it convenient for use anywhere, and the optional DC power source of 10 to 32 volts expands its portability into all fields where 240 volts AC is not available.

Panel programming is user-friendly and the IC memory card can be used to store and recall programs.

Further information from Parameters, 25-27 Paul Street North, North Ryde 2113 or phone (02) 888 8777.

Precision motion controls

Newport Corporation offers a complete range of devices for precision motion control, encompassing both manual and motorised positioners designed for a wide variety of applications.

Manual adjustment screws include a unique differential micrometer with fine resolution of 0.07 microns. Other adjusters offer submicron positioning sensitivity over ranges up to several inches.

Newport's motorised actuators incorporate smooth running DC motors, which avoid the vibration, noise and heat problems associated with stepper motors and PZT drives. Versions are available with or without integral optical encoders to provide position feedback information. A range of controllers allow for flexible powerful control. These include programmable, sophisticated PC-bus systems, in addition to inexpensive and intuitive joystick-driven models.

For further information, contact Spectra-Physics, 2-4 Jesmond Road, Croydon 3136 or phone (03) 723 6600.

Digital channel access monitor

The Bradley Interceptor I-264 is designed specifically for the CCITT environment, and provides powerful monitoring and channel access capability to help isolate network problems. The I-264 can monitor two 2048k bits/s circuits simultaneously, as well as drop and insert one or more 64k bits/s time slots of the high speed carrier. The Interceptor has a variety of status indicators, provides receive frequency measurements and displays the received byte for the selected channel. In addition, the I-264 allows access to signalling channels for modification, monitoring, etc.

The Menu Select button allows selection from 8 menus. The two-line 20 character display provides the ability to configure the instrument, displays test and error results and lists the internally generated insert signals.

The Interceptor is housed in a rugged aluminium case, designed to tightly seal the front panel when closed. The flexibility of the menu, combined with the software modules' easy access, readily accommodates the addition of future interfaces.

The Interceptor is available from Vicom offices throughout Australia and New Zealand.

For further information phone (03) 690 9399.

Humidity temperature meter

The new Australian made TPS model LC83 is a lightweight, portable meter with liquid crystal display for ease of reading, even in direct sunlight. The precision, thin-film capacitance sensor is used for measuring humidity. A silicon sensor is used for temperature measurement. Both sensors give a fast, accurate response. The LC83 is suitable for use in any application where an accurate measurement of relative humidity and/or temperature is required.

Some of the many applications for which the LC83 is suitable include cinemas, greenhouses, air conditioning, nurseries, and monitoring of environmental conditions in the workplace. The latter is becoming a frequent requirement in many offices and factories.

Further details from TPS, 4 Jamberoo Street, Springwood 4127 or phone (07) 290 0400.

15MHz dual trace battery scope

Black Star has released its UK designed and manufactured model 1502 miniature, dual trace, battery or mains operated oscilloscope with a range of functions normally found only in full-size oscilloscopes.

15MHz bandwidth, comprehensive features and very compact size, combine to make the 1502 a low-cost, versatile instrument for use in the field or on the workbench.

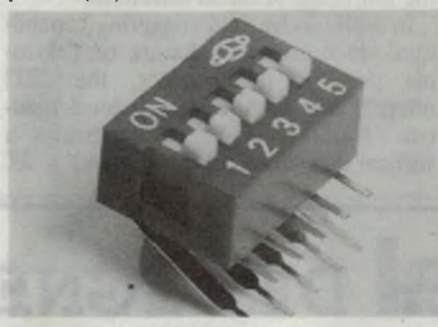
The vertical amplifiers have a –3dB bandwidth of DC to 15MHz and a risetime of 23ns. The 23 calibrated input steps provide deflection factors of 10mV/div to 50V/div. Display modes include CH1, CH2 (normal or invert), alternate, chopped and add. The timebase provides sweep times from 0.5s to 0.1us in a 1-2-5 sequence. Full triggering facilities are provided.

Operation is from mains voltage or internal rechargeable batteries.

The 1502 comes complete with 2 x probes (x1/x10), instruction manual and Australian approved mains lead.

Options available include a viewing hood, carrying case, high voltage probes, RF probes and current probes.

For further details, contact Obiat, 129 Queen Street, Beaconsfield 2015 or phone (02) 698 4776.



Right-angle DIP switch

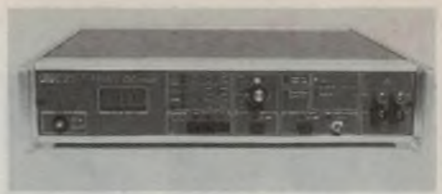
The DA series right angle dip switch manufactured by Diptronics Manufacturing, offers a mechanical life of 10,000 operations min. per switch; an electrical life of 5000 operations min. per switch (50mA, 24V DC); an operational force of 400g +/– 200g; a non-switching rating of 100mA at 50V DC and a switching rating of 50mA at 24V DC.

The normally open SPST contact system offers low contact resistance, high reliability and self-cleaning action.

For further information contact Adilam Electronics, Suite 7, 145 Parker Street, Templestowe 3106 or phone (03)846 2511.

Digital micro-ohmmeter

The Valhalla 4300B digital micro-ohmmeter is suitable for measuring the very low resistances encountered in the windings of heavy duty motors, generators and transformers, with other applications existing in the area of contact resistance and component measuring



and sorting. Tech-Rentals now have this newly released product on their rental inventory and available for hire.

The unit measures from 2 milli-ohms to 20k in five ranges, with a resolution of 100 nano-ohms, and values are displayed on a high contrast 4-1/2 digit LCD display. Basic accuracy is .03% +/– 2 digits. The 4300B also provides six user-selectable test currents, varying from 100 micro-amps to 10 amps, and three voltage sensitivity settings (20mV, 200mV and 2V).

For further information, contact Tech-Rentals offices in Melbourne (03) 879 2266; Sydney (02) 736 2066; Brisbane (07) 875 1077; Perth (09) 470 3644; and Canberra (062) 57 4983.

Logic analysers

Hewlett-Packard has introduced two low-priced HP1650 series logic analysers that have the combined capabilities of a state-and-timing logic analyser and a digitising oscilloscope.

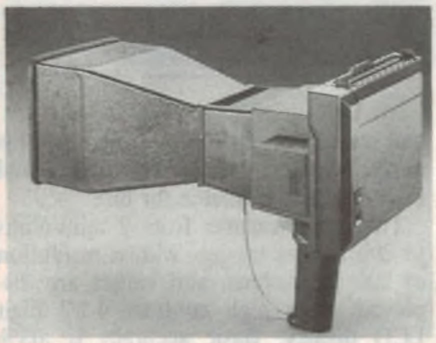
By combining capabilities in a single instrument, users have wide-channel-count and functional-test capabilities of logic analysers, as well as the voltage-resolution and parametric-test capabilities of an oscilloscope.

All HP1650 series logic analysers have complex-state triggering that filters out unnecessary data and lists only the desired states. The analysers have a simplified, user interface that can be accessed through the front-panel keyboard and knob.

A built in disc drive stores instrument setups and measurement data for later evaluation or retrieval. A single keystroke transfers the current display to a printer or plotter, and provides report-quality documentation.

Further information from Hewlett-Packard Australia, 31-41 Joseph Street, Blackburn 3130 or phone (03) 895 2644.

New Products



Direct screen cameras

New direct screen cameras from Polaroid turn information displayed on a TV monitor, CRT display, oscilloscope and other instruments into colour or black-and-white hard copy self-developing photographs.

The three cameras in the range, the DS-39, DS-31 and DS-34 are lightweight, portable hand-held recording systems producing high quality hard copy in minutes. The cameras feature interchangeable snap-on hoods, to suit a variety of host screens and operators need no training or darkroom experience to produce long lasting records in the office, laboratory, workstation, quality control centre, design bench or medical facility.

Further information from Polaroid Australia, Unit 3, 31 Waterloo Road, North Ryde 2113 or phone (02) 887 2333.

100MS/s, 100MHz portable DSO

The new Tektronix 2232 portable analog/digital storage oscilloscope (DSO) uses custom digital acquisition ICs to attain 100MS/sec sampling and 100MHz bandwidth. The 2232's proprietary detection capability allows for glitch capture as narrow as 10ns at all sweep speeds, including dual channel operation.

The 2232 supplies extensive ease-of-use features such as onscreen readout of scale factors and cursor measurements of voltage and time. A new user interface incorporates CRT bezel buttons to access saved reference waveforms and the full range of menu selections.

In addition to solid triggering capabilities which are the hallmark of Tektronix portable oscilloscopes, the 2232 offers a new feature: trigger-level readout. The new scope also provides a vertical resolution of 8 bits and a 4K record length for exceptional accuracy.

For further information please contact Tektronix Australia, 80 Waterloo Road, North Ryde 2113 or phone (02) 888 7066.

40MHz dual trace scope

The Hitachi V-422 oscilloscope is a light and compact design with a large 6" rectangular internal graticule CRT with 12kV accelerating potential, fitted with autofocus and scale illumination.

There are many extra features such as the DC offset function which allows quick DC level readings without having to change input coupling ranges, voltage and frequency reading outputs for highly accurate digital measurements. Alternate magnify allows simultaneous observation of standard and x10 swept waveforms.

The oscilloscope has a vertical sensitivity of 1mv/div to 1V/div on x5 magnifier, with an accuracy of 3% and a risetime of 8.8ns. The timebase ranges are 0.2us/div to 0.2s/div with x10 magnifier giving 20ns/div.

For further information contact IRH Components, 32 Parramatta Road, Lidcombe 2141 or phone (02) 648 5455.

100MHz, 96ch logic analyser

Philips T&M's new PM3655 Logic Analyser combines no loss of performance – no matter which features are used – with PC functionality.

User-configurable up to 96 channels in any combination of state and timing modes, the PM3655 provides full 100MHz data acquisition rates on all channels with no trade-off in the number of channels used versus clock rates. It also offers glitch capture at 5ns on all 96 channels, and with no loss of speed or memory.

Economically priced for a fully configured system, the PM3655 incorporates two buses. A high-speed instrumentation bus supports the logic analyser functions, while a standard PC-XT bus affords the user the familiar interface and open architecture of standard PC technology. This design uses ECL technology, and unlike those currently using MOS technology, ensures that all logic analyser functions are available at the same time.

For further information contact Philips Test & Measurement, 25-27 Paul Street, North Ryde 2113 or phone (02) 888 8222.

New DIP switch series

Just released by Augat Alcoswitch are two new series of DIP switches. The DPU series, which is supplied with factory applied tape seal for process compatibility, features the piano style actuator. The DPT series offers a flush type actuator which prevents accidental actuation.

Both series provide firm detent with audible tactile response that assures the operator that the switch has been made, and both feature gold plated contacts and solder plated terminals to extend shelf life and enhance solderability.

Available in 4, 6, 8 and 10 positions, both series are housed in a conventional profile package, constructed in process compatible, high temperature plastics.

Further information from Augat, 21/26 Wattle Road, Brookvale 2100 or phone (02) 905 0533.

70W DC-DC converter

Interpoint has added the MFW series to its line of high performance DC-DC converters. This series consists of single, dual and triple output 3.5, 5, 12, and 15 volt models delivering up to 70 watts of power.

The input voltage range of 19 to 40V DC (28V DC nominal) makes them ideal for military/aerospace applications.

All models feature hermetically sealed metal packages measuring 1.77" x 3.08" x 0.55" (excluding flanges). This results in a power density of over 23 watts/in^3.

Additional features include full input/output isolation, internal filtering, short circuit protection, external synchronisation capability and an inhibit function. Environmental screening referencing MIL-STD-883C methods is offered as an option and custom screening to customer SCD's is also available.

For further information contact M.B & K.J. Davidson, 17 Roberna Street, Moorabbin 3189 or phone (03) 555 7277.

Low cost keypads

The Component Product Division of IEE announced the newest addition to the rapidly growing line of cost effective Thriftswitch keyboards. The series 2575 keyboards feature front panel mounting, black ABS bezels and double-shot molded keys (white with black legends are standard).

Three popular output configurations are standard, which include single pole/-common bus, X-Y matrix and 2 of 7.

Like all the Thriftswitch products, the 2575 series provides electrostatic shielding as a standard feature. The conductive rubber contacts are rated 5mA at 12V DC, with a maximum resistance of 200 ohms. The highly reliable key and switch mechanism offers a contact and legend life of over 1,000,000 switch actuations under normal operation.

For further information, contact M.B & K.J Davidson, 17 Roberna Street, Moorabbin 3189 or phone (03) 555 7277.

'POSTcard' diagnostic board for PC's

Designed to fit into a spare expansion slot of any IBM or compatible PC, this sophisticated test card from Award Software will check most major functions and components of the machine – even in its most basic system configuration.

When a hardware or firmware problem causes the total failure of a PC, there is often very little to indicate what went wrong. In many cases, you may be greeted by a blank or frozen screen, no apparent response from the keyboard, and a similar result after re-booting the system. To have any chance of correcting the fault, you really need more data on the nature of the failure.

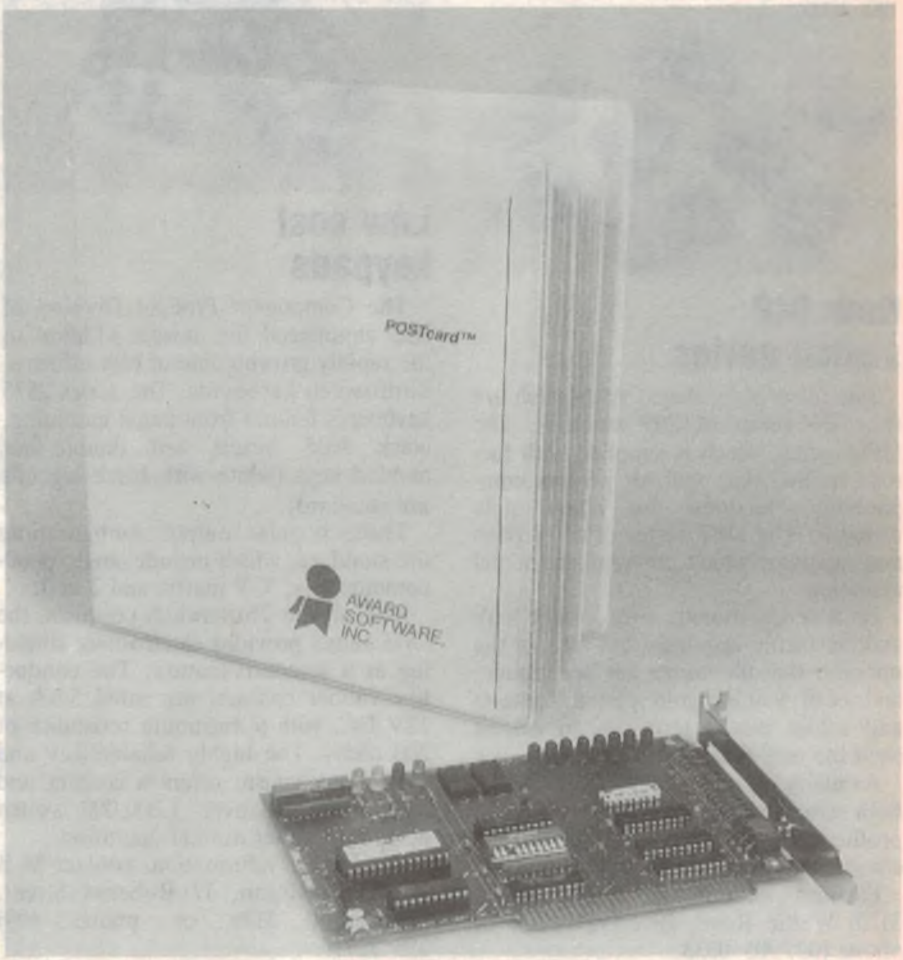
The usual method of gathering such information is to perform a detailed and sequential analysis of the system bus with some form of logic analyser. This enables the repairer to find the point at where the system locks up during the booting process – and hopefully, the device or function at fault. However this is not as simple as it sounds, since to accurately assess the state of the bus and the system, a very intimate knowledge of the computer's workings (down to the bit level) is required.

Fortunately, the system's BIOS ROM not only controls the computer's internal communications and booting (or initialising) procedure, but performs a comprehensive series of system checks as part of its start-up routine. So if these checks can be monitored, the fault may be traced by detecting which particular test has failed. This checking scheme is known as the Power On Self Test (POST) routine, and is a standard BIOS feature of all IBM-based machines.

The familiar memory test that appears on the screen during a system boot-up is an example of one of the many POST functions. Another example may be seen by booting a system with the keyboard connector unplugged, where the POST system will cause a 'KEYBOARD ERROR' (or similar) message to be displayed on the screen. *Don't* try this if you have a hard disk and no master RESET switch, since without an active keyboard, the drive cannot be parked, so that the power can be shut down to reset the computer. The keyboard will not function if it is connected *after* the system is active, since it is initialised during the boot procedure.

While the system will generally respond to a POST error, only a small number of the tests will cause a meaningful message to be sent to the screen. These are general statements, and simply indicate the broad area of trouble – and of course, even this limited information is totally lost if the screen is inactive. In this case, the POST facility may indicate a faulty or incorrectly configured video adaptor card by a series of coded beeps from the built-in speaker.

So the information at hand in a near-total failure is quite limited. As you would expect, normal diagnostic software is of no use in this situation, since an operating system (in our case MS-DOS) must be loaded before it will run.



```
POSTcard Diagnostic ROM
Version 2.0  07/18/89 13:19
COPYRIGHT (c) 1988 Award Software Inc.
----  Configuration Report  ----
CPU type                :    V20
CPU clock frequency     :   9.7 MHz
Math Coprocessor        :  Not Installed
Base Memory Size        :     640Kb
Extended Memory Size    :       0Kb

Number of Floppy Drives   :  2
Number of SCSI Drives     :  0
Number of Hard Disks      :  1
Number of Parallel Ports  :  1
Number of Serial Ports    :  1

   Primary Display - Color
Secondary Display - Not present
ROM module at   D100   length - 28 Kb

Press  <ESC>  to exit Diagnostic.
```

```
          Diagnostic Menu 2.0

 Press          For
 -----          -----
   f1      Base Memory Test
   f2      Video Tests
   f3      Fixed Disk Tests
   f4      Floppy Disk Tests
   f5      Serial Port Tests
   f6      Parallel Port Tests
   f7      Keyboard Test
   f8      Math Coprocessor Test
   f9      Extended Memory Test
```

A reproduction of POSTcard's system report and main diagnostics menu, as displayed on the computer's screen.

Award's POSTcard

The diagnostic advantages of the 'POSTal' codes has been enhanced in the more recent BIOS versions from Award Software, and other major BIOS manufacturers. Part of this improvement is in the accessibility to the actual POST codes, where the number of each test is sent to a particular port address as it is performed. The PC/XT Award BIOS version 3.0 and greater, and the AT 286/386 Award BIOS version 3.02 and greater support this new facility, with the data available at a port address of 80 hex.

The most basic function of the Award POSTcard is to monitor and display the information appearing at this, or any other user selectable port. Note however, that the POSTcard will only display the POSTal codes in a machine equipped with the *most recent* BIOS versions, as detailed above. In practice, the address to be monitored is set by a ten position DIP switch, and the data is simultaneously displayed on three separate LED arrays.

The first display is a two-digit hexadecimal readout mounted flush with the surface of the PCB, which provides a decoded hex version of the data at the selected port. The two remaining displays are identical, and each composed of a row of eight individual LEDs – these monitor the data lines D0 to D7 and provide a direct binary version of the information.

Each binary display is mounted on a different section of the PCB to allow for different viewing angles, with one LED strip at the top of the board (opposite the connector), and the other 8-LED array protruding through the metal mounting bracket. This should allow access to a readout in the most awkward physical arrangements, as the POSTcard can be used in virtually any IBM-based machine – including laptop computers, which invariably suffer from a crowded expansion slot.

Four more LEDs are positioned at the top of the POSTcard to monitor the computer's power supply rails – that is, one each for +12V, –12V, +5V and –5V. These are quite essential in a faultfinding situation, since the supply rails must be present for any meaningful analysis of the system or the POSTal codes.

It's past this level that the more elaborate and interesting functions of the POSTcard come into play. These advanced functions are controlled by the card's own 32k ROM chip, which runs a number of preset programs as selected by an associated 10-position DIP switch. In effect, this is the card's own system BIOS, which allows it to perform the test routines in an independent manner.

This is perhaps the biggest advantage of the POSTcard as a diagnostic tool, since it allows the computer system to be analysed *without* loading an operating system. Of course, it's quite likely that a faulty machine is unable to run the operating system anyway.

The first function of the POSTcard's own program is the POST looping facility. This causes a master reset at the end of the POST routine, forcing the system's BIOS to continuously cycle through its initialisation procedure. This in turn allows extended testing for reliability checks, and a controlled environment for troubleshooting intermittent faults.

If the forced loop is too clumsy, an alternate conditional loop may be selected by the function DIP switches. Here, the system pauses briefly to allow the user to exit the function by pressing any key on the keyboard. However many XT/PC configurations will not allow this process, since the keyboard is initialised by the BIOS at a later stage than the POST routine – when the POSTcard interrogates the keyboard, it finds no response.

When this facility operates normally, the POSTcard program will leave the POST loop tests and move onto its Comprehensive Diagnostics function. Alternatively, the function DIP switches may be set so that the program bypasses any POST manipulation, and moves directly to its Comprehensive Diagnostics routine.

Diagnostics

The Comprehensive Diagnostics section of the POSTcard's program operates like a similar, software based diagnostics program – except that it is controlled by the card's internal ROM. In practice, the computer's screen is used to display a report of the system configuration, and a menu-driven diagnostics function table (see the associated diagram of the screen arrangement).

The memory test menu engages a number of checking techniques for the system memory, including standard data checks and a DRAM refresh test. Virtually the whole memory may be tested, since the POSTcard's ROM based program only needs a small stack area for running-data storage. Also, the tests may be locked into a continuous loop for extended testing.

By comparison, the video tests are quite spectacular. The screen displays various patterns during the alignment, linearity and character generation tests, with the program automatically adjusting to the current display format (mono or colour). The video RAM is tested in a similar manner to the main memory checks, and may also be locked into a continuous loop function. Not surprisingly, the video memory tests cause some rather dramatic action on the screen.

The fixed disk (that is, hard disk) checks apply to '286 and '386 machines only, and perform non-destructive data tests on both standard and SCSI-style drives. Also, both matching controller cards are checked for errors.

Similarly, the basic floppy drive tests are non-destructive, and apply to the popular drive formats. However, in this case the PC/XT machines are covered, and the tests feature an alignment submenu which engages an extensive set of function tests for the various floppy drives.

These checks require an appropriate 'Digital Diagnostics Diskette', which

POSTcard – diagnostic card for PC's

was not included with our sample POSTcard. Nevertheless, the tests look extremely thorough, and check the spindle speed (special disk not required), disk centring, radial alignment, azimuth alignment, index reference and stepper motor hysteresis. Also included is a 'seek track' facility, which allows you to move the drive head to any specified track for head alignment purposes.

The parallel and serial port tests check the handshaking, controller functions, looping ability and interrupt response of all active external ports. A 'loop-back' plug is required for most tests, and the appropriate connections for the common types of plugs (DB9 and DB25) are detailed in the POSTcard manual.

The last few tests cover the keyboard, math coprocessor and extended memory. When the keyboard test function is activated, the screen will continuously display the hex scan code for the last key pressed. The math coprocessor test simply checks for the presence and function of the extra chip, while the extended memory test examines the additional memory in a similar manner to the main (base) memory tests mentioned above.

When you leave the Comprehensive Diagnostics or POST looping functions, the system will attempt to boot the operating system in the usual manner. Once the system is operating normally, the POSTcard will play a passive role and simply monitor the data at the selected port address. This monitoring ability is quite useful for checking the activity at other port addresses, which may be occupied by a troublesome peripheral for example.

Using POSTcard

While the obvious use for Award's POSTcard is in a maintenance or service context, it clearly lends itself to the design and development field. The independence of the card's POST test routine means that a system may be analysed in almost any stage of development – right down to just a system board and power supply. In a manufacturing situation the card could be locked into one of its loop functions for extended 'burn-in' testing, or other forms of soak testing (components, firmware etc).

The POSTcard itself is very easy to install and use. It's a 'short' length card measuring 100mm x 162mm, with the LED arrays positioned around the perimeter, and the centre space occupied by the system ROM, two PALs, two DIP selector switches and a handful of logic chips. A Non Maskable Interrupt (NMI) switch is included, and is positioned to protrude through the board's rear mounting bracket, for user access. Software using the NMI vector may need to be triggered or reset by the switch, while in normal circumstances, its action would be interpreted as a system RAM parity error.

Using the POSTcard as a diagnostic tool turns into quite a learning exercise. While LED displays become a fruitful window into the system's BIOS and bus status, you can easily become lost in the bits and bytes of its general activity. It's when a system has one of those nasty intermittent faults, or appears completely dead that the POSTcard presents a direct and unique solution.

To this end, the card's manual (POSTmanual?) provides a detailed listing of the POSTal codes for an appropriate BIOS ROM – presumably, an Award BIOS version 3.0 or greater. In reality, the codes are simply the number of each test in the POST routine. Included in each code listing is its equivalent binary, hex and decimal number, and a brief description of the test performed. For example, the familiar memory check is listed as POSTal code (test) number 1F hex, and is described as 'Test Base Memory – 64K to Top of Memory'.

The manual itself is very thorough and clearly written, with a minimum use of jargon. It provides a step by step guide to installing the POSTcard, and setting the two DIP switches for its various options. Also included is a large number of operating hints and examples, and detailed description of each of the Comprehensive Diagnostic tests.

So all in all, Award's POSTcard is an easy to use and versatile diagnostic board. While it may not be a high priority on the shopping list of the average computer user, it would be a logical choice for anyone involved in the design, manufacture or servicing of IBM-based computer products. And the price? Well, at $802.06 (including tax) it's hardly small-change, but in terms of testing time and convenience, it may well prove to be a sound investment.

For further information on the POSTcard and other Award Software products, write to (via the POSTman!) Energy Control International, 26 Boron St, Sumner Park, QLD 4074, or phone (07) 376 2955. (R.E.)

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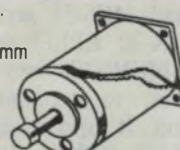

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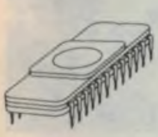

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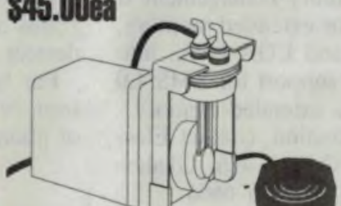

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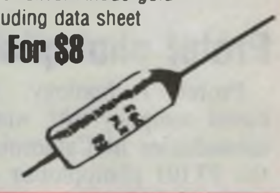

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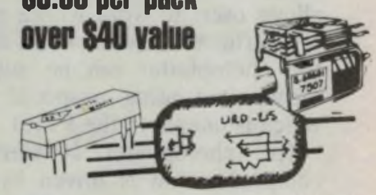

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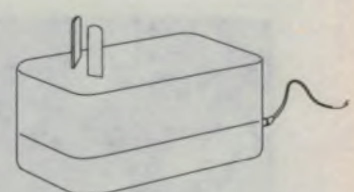

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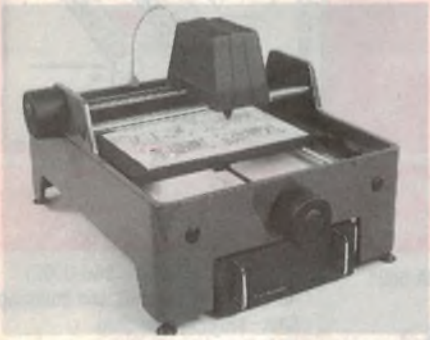


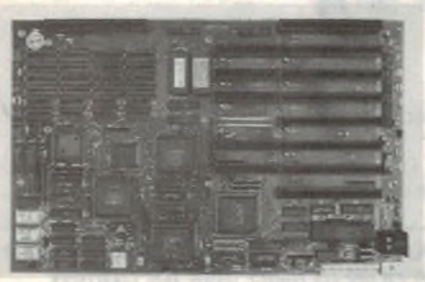
Protel photoplotter

Protel Technology, an Australian based company with wholly owned US subisidiaries in California, has released the PT101 photoplotter onto the international market.

The photoplotter incorporates custom-designed, low-cost aperture wheels. These are enclosed in a special housing which makes them easy to change. This allows users to work with a wide range of apertures. When a wheel is changed, the photoplotter can be automatically recalibrated using a special technique which is unique to the PT101.

The photoplotter is Gerber-format compatible and is driven by any low-cost IBM compatible XT computer which runs the user-friendly Protel software.

For further information contact Protel Technology, GPO Box 204, Hobart 7001 or phone (002) 73 0100.



20MHz 80386SX motherboard

Electronic Solutions has just released its 20MHz 80386SX motherboard. The motherboard is a state-of-the-art design, providing the flexibility and speed of the 386 chip at an affordable price.

The bus speed is also adjustable to 8MHz (for older AT standard cards) but can be switched to 12MHz for those running newer cards which can cope with faster bus speeds. Electronic Solutions has a complete range of these 'fast cards,' from disk controllers to video to I/O. They greatly increase throughput for disk and video based operations.

The card caters for up to 2MB of memory on the motherboard. The use of sophisticated page interleave memory access enables the board to work at zero wait states, even with inexpensive 100ns RAM. Further memory upgrade is kept at high speed by using a 'Fast Memory Extended Memory Card' providing up to 300% improvement in speed over conventional AT bus memory cards.

Sophisticated memory management is available catering for extended memory, mapping of ROM and EGA BIOS into fast shadow RAM, support for EMS 4.0 and disk caching via extended memory.

For further information, contact Electronic Solutions, PO Box 426, Gladesville 2111 or phone (02) 906 6666.

Universal flash programmer

The PKW-1100 flash programmer offers a new level of hardware performance for efficient and reliable programming at high speeds.

It combines programmable pin drivers and customised firmware with 8MHz processing to eliminate overhead and ensure support for the fastest programming algorithms.

PKW-1100 interrogates devices for unique manufacturer and identifier codes. These codes are then used to select the correct device type and programming algorithm.

The PKW-1100's versatile base architecture adapts easily to handle a wide range of programming requirements. The standard adaptor RX-1 supports EPROMs and EEPROMs in 24, 28, 32 and 40 pin DIP packages. Microcontroller adaptor RX-2 supports the popular MCS-48 and MCS-51 series microcontrollers. RX-30 EPLD adaptor transforms the PKW-1100 into a cost effective solution to programmable logic development. It supports all popular 20, 24 and 28-pin EPLDs from all major manufacturers.

Adaptor RX-3 offers support for the newest family of bipolar compatible CMOS PROMs, whereas the RX40 multiset adaptor transforms the PKW-1100 into a high speed gang/set programmer that simultaneously programs up to four EPROM or EEPROM devices.

For further information, contact Alfatron, 5/14 Jersey Road, Bayswater 3153 or phone (03) 720 5411.

Infra-red connection between buildings

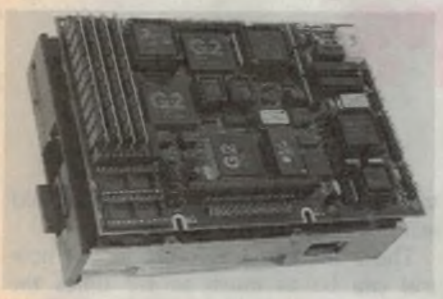
An economical and reliable system for linking Apple MacIntosh computers on AppleTalk Local Area Networks (LANs) in different buildings has been developed by a Melbourne-based company, Dataplex.

The new system is centred on a high speed infra-red optical data link. Called the DPX-725 AppleTalk LAN Extender, the system can connect AppleTalk LANs to different physical locations within line-of-sight into one continuous network.

Installation of the LAN Extender involves mounting an infra-red transmitter/receiver head unit on the rooftops of the buildings. The rooftop units are then cabled to a base unit in each building, with the AppleTalk cable being plugged into each base unit.

Dataplex has also developed a fibre-optic modem for extending AppleTalk networks in electrically noisy or secure environments.

For further information, contact Dataplex, PO Box 541, Lilydale 3140 or telephone (03) 735 3333.



Little Board 286 now runs at 16MHz

In a move to broaden the embedded applications for its family of PC/AT compatible single board systems, Ampro Computers has announced two enhancements to its Little Board/286 line. The Little Board/286 is now available in a higher performance, 16MHz version, and can now support higher capacity memory modules for on-board RAM expansion of up to 4MB. The higher performance version will maintain the same tiny (5.75") form factor, which is virtually unaffected by the support for higher capacity RAM modules.

For further information, contact Current Solutions, 12A Church Street, Bayswater 3153 or phone (03) 720 3977.

Stationary mouse

The Trackman 'Stationary Mouse' is claimed to to feature a new, comfortable shape; a small, thumb-operated ball for controlling cursor motion; three buttons for selection; and a hardware default resolution of 300 dots per inch.

Serial and bus versions for IBM PC, XT, AT, PS/2 and compatible systems are available through dealer channels at a suggested retail price of $250 for the serial version and $265 for bus.

Because Trackman is stationary, it takes up little desk space and can be used in a variety of situations, such as a keyboard drawer, which are not suitable for a mouse. It requires no wrist or arm movement and conforms naturally to the hand. Its default hardware resolution level of 300dpi is adjustable between 50 and 19,000dpi through software.

Further information from BJE Enterprises, Unit 12, 124 Rowe Street, Eastwood 2122 or phone (02) 858 5611.

IEEE 488 bus analyser

Analyser488 is a 488-based test system which includes several capabilities not found in previous analysers. The new analyser operates in several modes to allow easy monitoring and analysis of IEEE 488 bus systems.

Although Analyser488 is a standalone bench-top device with a keypad and display, its RS-232 port allows it to be operated from any computer or terminal with a serial port. Included is Analyst488, a companion software package for the IBM PC, PS/2 and compatible computers that provides complete control of the analyser through intuitive pull-down menus and pop-up windows.

Unlike primitive switch box analysers, Analyser488 displays bus operations in several formats, including message mode, which translates bus commands into understandable mnemonic bus messages. As a PC analyser, all of the analysis and capture features are available from the PC keyboard or mouse. Data can be displayed in three different formats and in multiple windows for comparison and scanning.

For further information, contact Scientific Devices, 2 Jacks Road, South Oakleigh 3167 or phone (03) 579 3622.

High performance joysticks

The Magic 909 range of joysticks for IBM PC/XT/AT/386 and compatibles are ruggedly constructed to withstand the rigours of enthusiastic playing, and for hasty cramming into executive desks.

They feature easy fingertip control of the very important 'fire' button (that's the one on the top).

The stick is very convenient as far as movement is concerned, having trim adjustments on both axes. This enables the joystick to be perfectly adjusted for cursor position with all appropriate games software. Automatic spring return means the stick goes to centre position when let go. There are also separate switches 0 and 1 at front.

For further information, contact Electronic Solutions, Box 426, Gladesville 2111 or phone (02) 906 6666.

New PLC program

Procon Technology has recently released version 2.0 of its highly successful programmable logic control (PLC) program for the IBM-PC and compatibles. Used in conjunction with any PC-IO-XX interface board, this program provides a relay ladder logic style of programming that's easy to understand. The user-friendly editor allows program changes to be made with ease and the on-screen debug facility simplifies the testing of programs.

Due to the limited I/O capability, this version is best suited for small control applications and for educational and training purposes. The specifications are: 8 external inputs, 8 external outputs, 64 internal control relays, 8 timers (0.1 seconds up to 24 hours), 8 counters (counts from 1 to 99,999) and a 1000 program step capability.

For further information contact Procon Technology, PO Box 43, Essendon 3040 or phone (03) 336 4956.

Reducing the safety hazard of switchers

What's that – those ubiquitous switch-mode power supplies a safety hazard? Yes, according to this article from the USA, they have a major problem that has hitherto gone unrecognised. But luckily there's a solution at hand, in the form of a new device called the PowerMiser.

Right now there is a very real danger present in literally thousands of business facilities and engineering laboratories, throughout both the USA and many other developed countries. It causes severe harmonic distortion in building wiring, overloading the neutral to the point where the wiring can burn, and transformers explode.

The culprit: switching-mode regulated power supplies, those small, highly efficient and cost-effective devices used to power everything from personal computers to copying machines, in today's modern offices and laboratories. And the very thing that makes them so beneficial can be a major safety hazard that has thus far gone virtually unnoticed.

Almost every piece of electronic equipment produced today uses 'off line switchers' to rectify and filter incoming AC line current to produce a working voltage in the 250 to 300V DC range. The voltage is then electronically chopped at high frequency, and again rectified and filtered to produce the low voltage – high current outputs required by the equipment they power.

It is inherent in the design of these supplies that they draw current from the AC line *only* during the peaks of the voltage sine wave. This is because the charge maintained on the input filter capacitors places a back bias on the input rectifiers, and they cannot conduct until the sine wave voltage exceeds the bias voltage. Current is then drawn from the AC line in short, very high peaks.

As a result, switching power supplies have a very poor power factor. Depending on the impedance of the AC line, it will average from 0.5 to 0.75, with 0.65 being typical.

This poor power factor is not due to phase angle displacement of the voltage and current wave forms. In fact, the waveforms are almost exactly *in phase*; but the current waveform has high peaks and is *rich in harmonics*.

Standard 'averaging' current meters will indicate significantly less current than is actually flowing, since they measure true RMS current *only when the current is sinusoidal*.

An AC power analyser will reveal however, that the total harmonic current present can equal or exceed the primary current! In fact, the third harmonic alone can be as much as 85% of the primary current. These harmonic currents do no useful work, but are responsible for the heating of wiring and transformers.

Balancing phase loads in a 208V/120V three-phase system will *normally* reduce neutral current to zero. *(Editor: The same applies to our 415V/240V system).* But with harmonic distortion induced by the switching power supply, the third harmonic (and multiples of the third) will be *in phase with one another and will not cancel in the neutral.*

These harmonic currents in the neutral can be as much as 1.7 times the phase current. If the neutral and phase conductors are the same size, the heating in the neutral conductor will be roughly three times the heating in the phase conductors. Failure of building wiring may result.

Further upstream, the third and multiples of the third harmonic will circulate in the delta connected wirings of the three-phase delta-wye transformer, but not appear in the input line current to the transformer. The kVA input to the transformer will be less than the kVA output. If the transformer is not sized to handle the output kVA, including the circulating kVA, failure may again result.

The solution

The place to attack this problem is at its source – the switching mode power supply. A device is now available which will eliminate the hazardous harmonic line currents induced by switchers by changing the current *pulse* into a modified sine wave.

The PowerMiser, developed and patented by HC Power Inc., provides a

TABLE 1: Effect of Power Factor Correction

WITH NO CORRECTION

LOAD (W)	V-RMS	A-RMS	P.F.	A-RMS FUNDAMENTAL	2ND	3RD	5TH	7TH	9TH	11TH	13TH
1000	115.64	18.35	0.651	12.389	.105 .8%	10.48 84%	7.3 59%	3.85 31%	1.18 9.5%	.877 7%	1.12 9%

WITH POWER MISER PMAX-111 POWER FACTOR CORRECTOR

LOAD (W)	V-RMS	A-RMS	P.F.	A-RMS FUNDAMENTAL	2ND	3RD	5TH	7TH	9TH	11TH	13TH
1000	117.96	12.1	0.987	11.99	.02 0%	.94 7.8%	1.2 10%	.654 5.5%	.08 0.6%	.38 3.2%	.18 1.5%

NOTE: All readings taken with Voltech Model PM-1000 AC Power Analyzer and HC Power series HC10 Power Supply with 1000 watt electronic load.

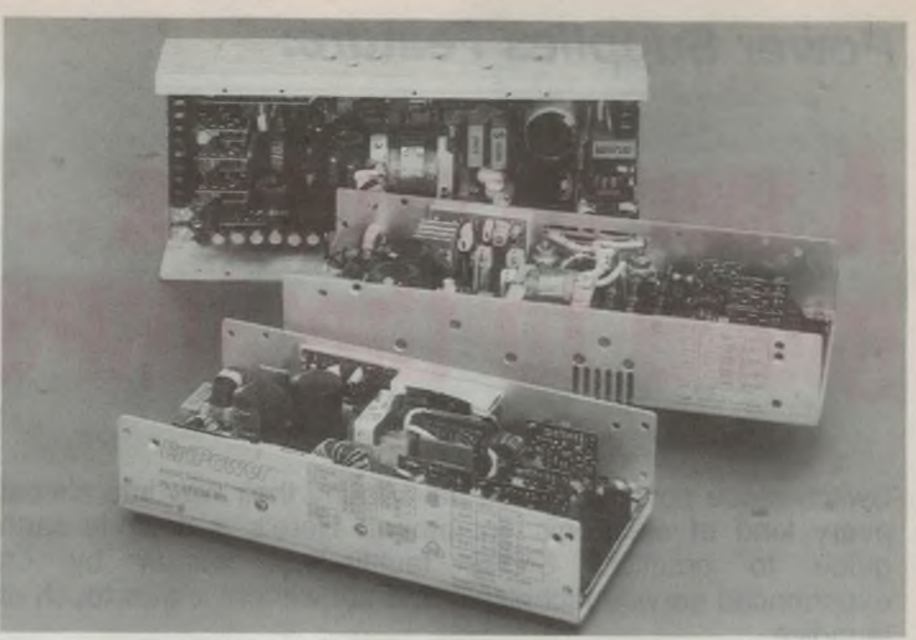
H256364

power factor of 0.98. Equally important, its conversion efficiency is 98%. This results in an *effective* PF of 0.96, which is superior to any other system currently available.

Harmonic currents are greatly reduced by the PowerMiser, and the heating effect on wiring and transformers is brought under control. Its effect on AC line current (the original reason for its development) is equally dramatic. AC input current is reduced by at least 30% (see Table 1). It enables a 1000 watt supply to be operated from a standard 115V AC 15A outlet without exceeding the 12A limit imposed by Underwriters' Laboratories regulations.

The design of this new power factor corrector is scaleable, and PowerMiser units are currently available for power range of 250 to 500 watts, 500 to 1000 watts, 1000 to 1500 watts, 1500 to 2000 watts, and 2000 to 4000 watts. This power rating is based on the output power rating of the power supply.

The PowerMiser may be installed anywhere between the AC input and the power supply, so it can be used in existing systems and facilities. More than one supply may be driven by a single PowerMiser. For instance, a number of small computers and peripherals may be driven by a single unit. Operation below the specified minimum power level will simply result in a slightly degraded power factor, and will not affect the safe operation of the power supply.



These new PLY series open-frame switchers from Ericsson Components in Sweden are undoubtedly no more prone to generate line harmonics than any others. We've simply used them to illustrate the story...

Further information on the PowerMiser series of power factor correction units is available from the Australian representative for HC Power, Dewar Electronics of 32-34 Taylors Road, Croydon 3136 (PO Box 49, Ringwood East 3135) or phone (03) 725 3333.

Power Supplies Feature:

A serviceman's guide to the SMPS

Switch-mode power supplies have found their way into almost every kind of electronic equipment. Here's a down-to-earth guide to practical SMPS faultfinding, written by an experienced service technician and not without a wee touch of jaundice...

by J.L. ELKHORNE

Anyone who's ever been involved with computer or electronic equipment can be pretty sure that these days, underneath the bonnet lies a switchmode power supply. The ubiquitous SMPS could best be described as a circuit designed by an accountant.

Iron and copper are expensive in our modern world, so some bright spark had the idea of doing away with the massive stepdown transformer found in linear power supplies. To be sure, this cuts production costs – and weight, too.

Unfortunately, the manufacturer's savings are the user's woe. Probably 50 to 60% of equipment failures can be attributed to a SMPS that simply 'died', of its own accord. Despite overvoltage and overcurrent protection schemes, the critical components are often under-specified, or overly susceptible to mains transients.

I worked for a curious fellow for a short time this year who wasn't your typical workshop supervisor. "What's this 'SMPS failure'?" he asked, on reading a job sheet concerning a computer terminal I'd inspected.

After I'd gently explained the term, he sniffed, "Well, you should write things like that out. No one would know what you were on about."

Even the apprentice understood those dread letters, however, and said so. And anyone in the TV service business has probably seen more switch-modes than he wanted to.

The SMPS implementation can take a number of forms, and each designer seems to delight in using obscure parts. The SMPS is essentially a pretty simple circuit, however. Check out the block diagram in Fig.1.

AC mains power enters the board, probably through a simple low-pass filter. This helps prevent the chopper frequency from getting back into the mains wiring.

The 240 volt AC (nominal) is applied directly to a bridge rectifier. After filtering, its DC output drives the chopper circuit, which might operate at something like 40kHz.

So, we have a large voltage, a small current, and a high operating frequency – feeding into a small and relatively cheap transformer for isolation. On the other side of the transformer is a fairly standard low-voltage rectifier and filter system, except that because of the high frequency the filter capacitors can have smaller values than for a linear supply.

Some form of feedback, also isolated between the secondary output(s) and the base of the chopper transistor on the primary side, is used to maintain the output voltage regulation.

The monitoring circuitry will often be a very complex (and rare) IC. The feedback might be via an optocoupler, or even another really tiny transformer.

Our outputs will likely be +5V, +12V, and possibly a –12V feed, also. Some scheme of overvoltage protection is further added – this could be a crowbar circuit.

The feedback alters the duty cycle and switching frequency of the chopper transistor, to maintain regulation.

When trouble strikes

When something does go wrong, the majority of the time it will be one – or more – of four or five components on the primary side of the transformer.

There will almost always be a fuse in the primary circuit. Check it first, anyway, but the chances of it being blown are very slim.

The input rectifier bridge might have lost one or more diodes; this can be determined with the simple, old-fashioned meter test. Next, the chopper transistor and probably the components associated with its base circuit should be

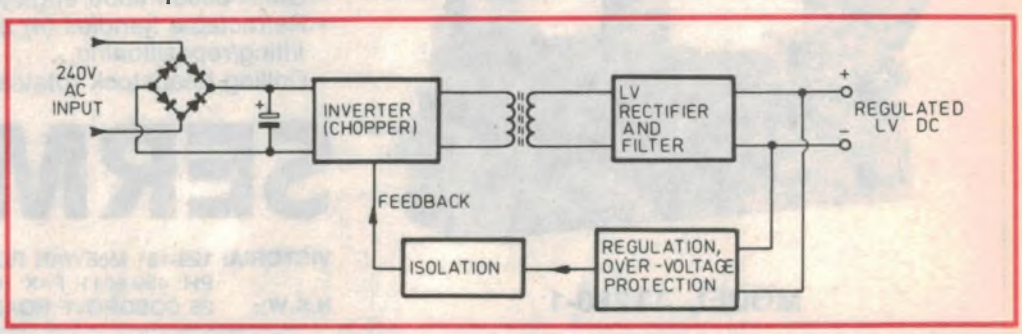


***Fig.1:** The basic arrangement used in most switch-mode supplies. The incoming 240V is directly rectified and used to power an inverter, operating typically at around 40kHz. This allows the use of a smaller transformer.*

metered. You will probably find a signal diode and small resistor.

Some of the SMPS's use a small signal transistor as part of the feedback network. When the chopper goes, so does its little friend.

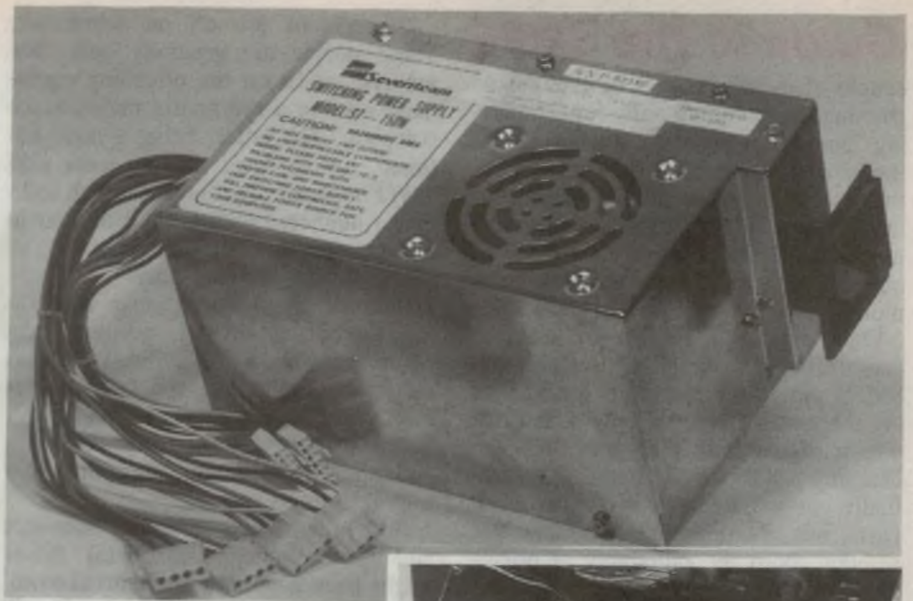
Less common on the primary side, but not unknown, are filter capacitors shorted or leaky – or even gone open circuit. Some of these parts are fussy about the high ripple factor, and the average bog-standard electrolytic will *not* survive!

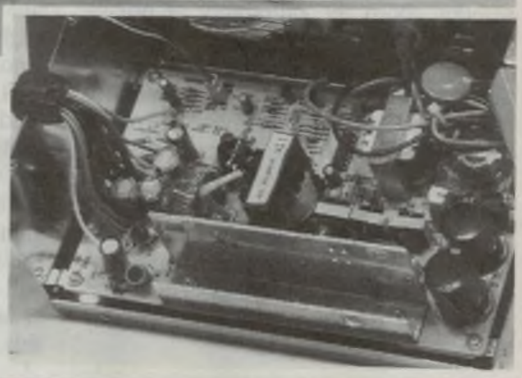
The best approach is to replace any and all of the suspect items in the primary circuit, hook the supply up to a static dummy load, and power it up. A variac, if available, is well worthwhile in doing this. Otherwise, you'll have to perform the 'smoke test', and I trust you're not nervous about sudden, loud noises!

Philosophy

A basic knowledge of theory, though, is not much help when the would-be fixer cannot source the right replacement components, or has to discover a really snarly fault.

Probably two-thirds of the supply failures will be found to be one (or more) of four components, as mentioned. A





Outside and inside views of a typical small switch-mode supply, of the type used in many personal computers. Note the relatively small stepdown transformer, with the input bridge and filter capacitors at the far right.

Guide to the SMPS

couple of meter readings or even 'shotgunning' the common parts (i.e., replacing 'em all, regardless) will overcome the simple problems. The other one-third will surely fall in the difficult-to-impossible category – and a replacement supply will be the most efficient answer, in terms of time and sometimes money.

One company I worked for last year was bringing complete replacement SMPS units into Australia for $23.00. At the same time, the only source for one particular switching transistor was charging $28.00 for the beast! We eventually got a better deal on replacement parts, but situations like this make one wonder about the rationality of pricing in Australia.

Even more unreasonable is the cost to the end user. A simple video monitor failure can be more expensive to repair than to replace. Take this case: a small businessman in rural Victoria has bought a computer system from the local office-supply company. Shortly after the 90-day warranty expires, so does the monitor. Customer calls dealer who – of course – does not employ any service personnel(!).

Dealer fobs job off on distributor. These people are generally only 'box movers', and turn the offending equipment over to a third-party maintenance company. The latter, being a multi-national, has to cover internal costs with TWO markups. The hapless bench technician lumbered with a piece of gear in these circumstances tries the easy fix, as time is always of the essence.

Chances are the serviceman is working without schematics, adequate test equipment, or spare parts. When his magic wand fails, his supervisor grizzles and reluctantly orders a changeover board, from yet another company which specialises in profiting from the poor high-tech infrastructure.

Both the SMPS chopper transistor *and* the monitor's horizontal driver might have gone into zener breakdown. And it's entirely possible both will still look like transistors in a simple meter-reading exercise –– even if you're using a sophisticated digital meter.

Yes, Virginia, the 'professionals' still do it the way they did back in 1947. A gain test, however, will normally prove the transistor is faulty – the beta (h_{FE}) will be quite low. Few companies ever seem able to justify test equipment even this simple, though.

The situation really gets thorny if it's an EHT fault that caused the SMPS to roll over and die in the first place. If you can't adequately test the horizontal transistor and arbitrarily replace it, you might be changing a $40 component for no valid reason.

On the other hand if you *don't* change it first, it might break down under applied voltage – and take out the SMPS again. It's not at all uncommon for the expensive circuitry to protect the 50-cent fuse...

Circuits designed in the US seem particularly at risk. Over there, they use a 110-volt mains, and their approach to a 'universal' power supply is to design for compatibility with 220 volts, 'for the rest of the world'. Tsk, tsk.

The already low line capability is exacerbated in areas of Australia where the mains can exceed 260V on a regular basis. Furthermore, the difference between the 60-hertz mains power 'over there' and the 50Hz we know and love(?) can contribute further to breakdown problems.

By now, you're probably yearning for the good old days of simple, brute-force linear supplies – inefficient though they may be. So are a lot of service technicians, I can assure you.

Choosing a bench DC power supply

For experimental and development work, as well as servicing, one or more regulated general-purpose 'bench' power supplies are generally essential. Here's a quick rundown on the factors you should consider when choosing this type of supply.

by JIM ROWE

There's an old electronics adage which says that you can't have too many bench power supplies. That's generally because no matter how many you have already, Murphy's Law often has a way of ensuring that you need *one more* source of independantly adjustable voltage or current, to check out some aspect of performance.

It's because of this that most electronics labs and workshops gradually seem to collect all kinds of bench supplies: old ones, new ones, big ones, small ones, some that provide high voltage at low current and others that provide low voltage at high current. There are often some supplies with constant-voltage output, others with constant-current output and perhaps others which can provide either or both.

Similarly some may have meters to monitor voltage and current; others may have digital readouts, while still others may have neither. Then again, some supplies may provide a single fixed or adjustable DC output, while others may provide multiple outputs which are either fixed, independantly adjustable or perhaps tied together to 'track' one another in master-slave fashion.

Of course, a commercial lab or workshop can often justify the cost of having a great many different kinds of bench supply, especially if it is part of a large firm or organisation and doing important development, quality control or maintenance work. Some special kinds of supply may be almost essential for working on specific jobs, and hence their purchase can be written off against the projects concerned. Afterwards they can then become available for other jobs, as part of the general lab facilities.

But it can be much harder for the independant service technician, design engineer or hobbyist to justify, or even afford more than a couple of bench supplies, especially when they're starting out to build up a lab. That's generally when it becomes necessary to choose just one or two supplies, which are likely to meet most of your needs – at least for the foreseeable future.

This article is intended to help in making that choice.

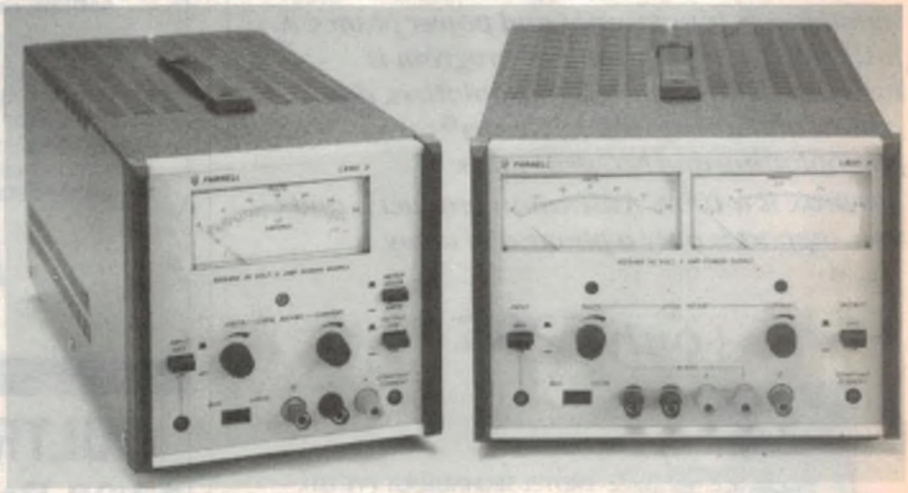
Analysing needs

First of all, it's a good idea to sit down and carefully try to analyse exactly what kind of a bench supply or supplies you need. This can save a lot of avoidable expense later on.

An important factor is the kind of the circuitry you'll be working on. For example, are you mainly likely to be working with analog, or digital circuitry? Generally analog circuitry tends to call for a larger number of separate supplies than most digital circuits.

Some digital systems need little more than a husky supply capable of delivering a fixed 5V DC at a reasonable number of amps, although some of the more sophisticated digital systems may also require multiple supplies to serve different kinds of logic circuit (e.g., ECL as well as TTL or CMOS), or to provide a drive source for DACs, ADCs, or op amps involved in analog signal processing circuitry.

On the other hand, analog circuits and systems may well require two, three, or sometimes even more separate and independantly adjustable supplies, to allow detailed analysis of their opera-



The 'LB' series of bench supplies from UK maker Farnell Instruments, offering 0-30V output at either 2A or 4A, single or dual meters, automatic CV/CI changeover and an integral IEEE488 interface for remote programming. (Courtesy Elmeasco Instruments)

The 'PAR' series of supplies from Kikusui in Japan offer four voltage/current ranges (to 80V), separate digital displays for both voltage and current, automatic CV/CI changeover and optional IEEE488 interface. (Courtesy Emona Instruments)

tion. This kind of circuit may also require at least two supplies that are tied together, so that they can be adjusted up and down with a single knob.

An example is analog circuitry with op amps running from balanced positive and negative rails, with the midpoint grounded. Here a dual-polarity tracking supply allows both rails to be varied together, to check the influence of power line voltage changes on circuit operation.

Another factor to consider is the kind of work you're doing, on the equipment concerned. If you're mainly involved in servicing and maintenance, this will generally require fewer supplies than if you're doing circuit development or experimental work.

For example a service workshop working mainly with mobile two-way radio equipment and other gear that is normally installed in cars may only need one or more fixed-output and relatively simple DC supplies producing 13.8V DC, with a suitably high current capability. There may not even be any need for monitoring the supply voltage – just a means of checking the current drawn by the equipment under service, to make sure it's within the design limits.

On the other hand, a circuit designer working on a new design may need many more supplies, to allow them to vary the voltage or current in specific parts of the circuit while keeping the conditions constant in many other parts, to check how tolerant the design is to variations in supply voltage, stage gain and component values. And to ensure that the designer can monitor and record all conditions, as well as spotting signs of potential trouble, all of the supplies are likely to require full metering.

Another consideration is the power level at which you're going to work. If you're mainly going to be working on low-level audio signal processing equipment, for example, there'll be no need to worry about bench supplies capable of delivering tens of amps. But almost certainly you *will* be very interested in getting a supply or supplies with very low AC ripple on the output, to minimise the injection of hum into your sensitive circuits.

On the other hand, a design engineer working on industrial power control equipment probably won't be worried by a few millivolts of ripple on the output, but may well need a supply that can deliver pulses of many amps, without any noticeable 'sag' in its output voltage regulation.

A designer working on high-power hifi audio amplifiers might need both – a supply that can provide relatively high voltage and current, with good voltage regulation as well as very low AC ripple in the output.

So the kind of equipment you'll be working on, as well as the kind of work you'll be doing, can have a big influence on the kind of performance and facilities you'll be looking for in your supplies. That's why it can pay to analyse your needs in advance, before studying the kinds of bench supply that are available.

Remember, though, that just as with most other kinds of equipment, the kind of performance and facilities provided by a bench supply tend to be proportional to price. The highest-priced supplies at the top end of the range will tend to provide many more features and facilities than those further down the range; in that sense they're more 'general purpose', and more suitable for almost *anyone's* needs than the cheaper units.

The only trouble is, you may not be able to afford or at least justify their much higher price tag, to get this greater flexibility. That's when it can be an advantage to have worked out your needs and priorities in advance, so that you can find a supply or supplies that are affordable, while sacrificing only those of your needs that are 'nice but not absolutely essential'.

If your budget is limited (join the club!), it's often better to go for a couple of low-to-medium priced supplies, perhaps with somewhat complementary facilities, rather than a single highly-priced supply that's 'all singing, all dancing'. This may well give you greater flexibility, and a larger number of separately adjustable outputs.

Mind you, bench power supplies do tend to be the 'work horses' of any lab or workshop, used day-in and day-out for many years. In other words, they tend to be more of a long-term investment than many other types of bench equipment.

Bearing this in mind, it's probably a good idea to stretch your budget just a little when buying one, if you can. This may allow you to get one with an extra output, more facilities or with additional current capability, better regulation or lower AC ripple.

The odds are that later on, you'll be grateful that you did this. Your needs are bound to grow, and those extra capabilities and facilities might well obviate – or at least delay – the need to buy an additional supply.

Basic facilities

Now let's look at the basic facilities provided by a typical bench-type power supply, and the measures used to judge its performance.

Like the dedicated power supplies found in many pieces of electronic equipment, a bench power supply is essentially a system for taking the incoming 240V AC mains power and converting it into DC power which is in most cases at a rather lower voltage, to suit the needs of electronic circuitry. Typically it may provide either fixed or variable voltages, up to say 20 or 30 volts, or occasionally up to 60V or more.

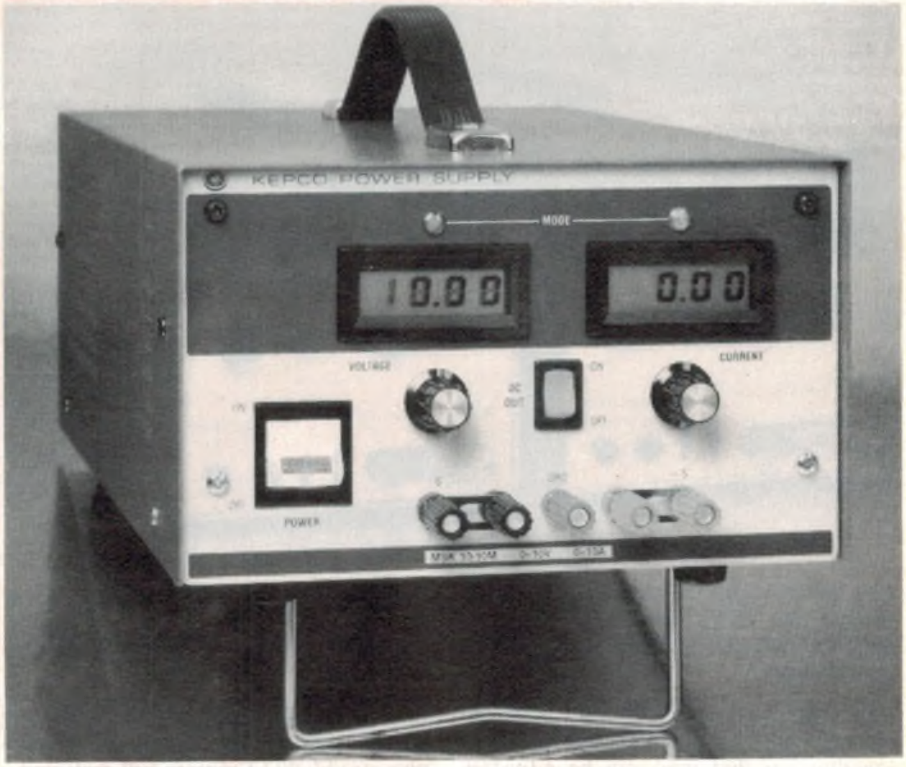
Bench supplies

In most cases, the supply consists of a step-down power transformer, followed by a rectifier and filter system to convert the resulting low-voltage AC into DC. This is generally followed by a *control and regulation* circuit, to allow the raw and unregulated DC from the filter to be set to the desired voltage level, and maintained accurately at that level despite changes in mains voltage, load current or both. The regulation circuitry also tends to provide additional filtering, to reduce any AC ripple on the DC to a very low level.

The type of supply just described is a basic 'linear' type, which is the type still most often used for general bench supplies. However for high power supplies in particular the 'switch-mode' type of supply may also be used, where the 240V mains is rectified directly and used to operate a high-power oscillator or chopping switch, operating at relatively high frequency. This allows the use of a rather smaller power transformer and filter capacitors, for the same power level. As before the low-voltage AC from the transformer secondary winding(s) is rectified and filtered, then fed to a control/regulation circuit – which in this case may also control the duty cycle of the power oscillator, to achieve higher efficiency.

The switch-mode type of power supply (SMPS) tends to be smaller and less heavy than the linear type, for a given power level. It also tends to be more efficient than the linear type, and hence runs cooler because less power is lost as heat. However at the same time it also tends to be less 'clean', producing higher levels of spurious output than the linear type as a result of its high internal levels of high-frequency AC.

Often it's also less easy to adjust the output voltage of an SMPS over as wide a range as with a linear supply, without running into 'complications'.



Made in the USA, the Kepco MSK 10-10M supply provides 0-10V at up to 10A, with dual digital displays for voltage and current. A preview switch allows setting up before the load is connected. Note the separate sensing terminals. (Courtesy Elmeasco Instruments)

Kikusui's PAK-A/AM range of high performance switch-mode supplies is available in both bench models (left) with digital display, and modular models (right) for building into systems. Models have 350W, 700W and 1kW ratings. (Courtesy Emona Instruments)

So on the whole, most bench supplies of the adjustable variety tend to be of the linear type, while the SMPS kind are used for high powered fixed-output supplies for digital circuitry, etc. But this doesn't mean that there aren't some excellent fully-adjustable and very 'clean' SMPS bench supplies around – there are. You just have to be a little more careful, to make sure you're getting one.

Output adjustment

The majority of general-purpose bench supplies *are* designed to allow their output voltage to be adjusted, of course, as this makes them more flexible and increases their potential applications.

Some supplies are continuously adjustable over a wide range: say from 0V to 20V, or from 1V to 30V. Others may allow adjustment over the same overall range, but only in separate segments such as 1V – 4V, 4V – 6V, 6V – 9V and so on. Still others may only allow variation up or down from a nominal voltage level or levels, by a designated percentage range – e.g., a nominal voltage of 5V with a range of +/–15%, or a nominal voltage of 13.8V and a range of +/–10%.

How the supply allows you to achieve

this adjustment can vary, too. Some may provide a conventional rotary pot, while others may provide a multi-position switch – either alone, or together with a pot for fine adjustment. These are the two main systems used with low- and medium-priced bench supplies, and they each have advantages and shortcomings.

A rotary pot allows smooth and continuous adjustment of the output voltage, and also allows you to set the voltage to an exact figure anywhere in the range. This can be quite important, in many applications.

On the other hand if you only want to set the output to a relatively small number of fixed and discrete output levels, and select these quickly, the switch system can be more convenient – assuming the voltage levels provided by the switch are those you want, of course.

Programmability

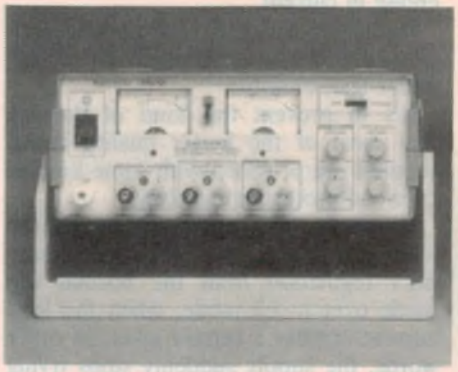
Some of the more expensive bench supplies allow *remote digital programming* of the output voltage, from a computer or controller, via an interface bus such as the IEEE-488. This simply means that the supply can be made to produce a different output voltage simply by feeding a new command to it from the computer. The same models may also allow you to 'punch up' a new output voltage manually, via an input keyboard on the front panel.

This approach can be a distinct advantage for automated testing, where the computer can vary voltages via the supply and monitor the test circuit's response via various measuring instruments. The ability to change rapidly from one accurately set output voltage level to another also makes this kind of supply well suited for testing a circuit's transient response – i.e., its ability to cope with sudden changes.

Metering

The simpler bench supplies which use switch selection of the output voltage may not even provide an output voltage meter, relying on the supply's regulation characteristic to maintain the voltages at the marked levels. Those which provide a rotary pot for adjustment do normally provide a meter, tending to make them a little more expensive.

Of course it's desirable in any case for a bench supply to provide a meter to monitor the *current* drawn by your load circuit. With some of the lower-cost supplies this is the same meter that is used to monitor output voltage, with a switch used to select either voltage or current indication.



Part of the TM250 range of low-cost instruments, the Tektronix CPS250 triple output supply provides two 0-20V/500mA outputs and a fixed 5V/2A output, all independant, with dual meters. (Courtesy Tektronix)

This kind of 'shared' metering system can be quite satisfactory for many applications, as often you don't need to monitor the output voltage after setting it to the desired value. The meter can thus be switched to read load current, without any real sacrifice. And of course a single shared meter or digital display tends to cost less than two separate-function meters or displays.

There are a certain number of applications, however, where it's really quite a nuisance to have to switch the meter back and forth, in order to read first output voltage and then current. So if your budget can stretch to a model with dual metering or displays, go for it.

How about the choice between conventional 'analog' or moving-coil meters, and digital displays? Many manufacturers of bench supplies provide both – not generally in the same supply, but in the form of alternative versions of each model.

There are minor differences between the two approaches. A conventional analog meter tends to make it easier to follow trends and cyclical variations – such as the current drawn by an amplifier output stage as it warms up, or that drawn by an RF stage handling a modulated signal.

On the other hand, a digital display tends to make it easier to set the output voltage or current to a particular level, and reset it later to the same level.

Which of these facilities is of greater value to you is largely a matter of personal preference, and again the kind of work you'll be doing.

Nowadays there may not be much difference between the two approaches, in terms of price. Although analog metering tends to be simpler and involves fewer components, the meters themselves are hand-made and are steadily becoming more expensive. Digital metering circuits are more complex, with more components required, but

The 'PAD-L' and 'PAD-LP' series of supplies from Kikusui have both bench and floor models, with outputs ranging from 0-8V/20A to 0-500V/2A and 0-1kV/200mA. All provide very high reliability. (Courtesy Emona Instruments)

Bench supplies

those components are now generally all produced and assembled using automatic machinery.

So currently, the costs tend to balance out, with the analog approach tending to become more expensive and the digital approach tending to become cheaper, as time passes.

CV, CI modes

The basic mode of operation for most bench-type power supplies is *constant-voltage* or 'CV' operation. That is, when you set the supply's output voltage to a certain level, it tends to remain constant at that level, despite variations in the incoming mains voltage and the current drawn by the load circuit. In other words, the supply's regulating circuit operates in constant-voltage regulating mode.

Note we're not talking here about *fixed-voltage* bench supplies – although these too will generally be operating in CV mode, as it happens. We're talking about the behaviour of the supply's regulating circuitry, in response to mains voltage and loading changes.

In CV mode, the action of the regulating circuit is to maintain the output voltage constant – either at the single nominal voltage, in the case of a fixed voltage supply, or at whatever voltage you've selected in the case of an adjustable supply.

An alternative regulating mode is *constant current* or 'CI' operation, where the supply will attempt to maintain not its output voltage, but the current drawn by the load.

What's the point of this? At first sight, it may be hard to understand why you'd want a supply to do this, instead of the intuitively more logical CV operation. And in fact there are not all that many applications where you want the supply to be operating in CI mode all the time, to the exclusion of CV mode.

More importantly, though, the idea of having a CI mode of operation available on a bench supply is for protection against damage due to overloads.

Overload protection

Whether you're using a bench power supply in a development lab or a servicing workshop, there's always a risk of overloads occurring. Components can fail, wires can touch accidentally, transistors can 'run away' thermally, and so on. All of these events tend to cause an unexpected and potentially damaging increase in current.

Damaging to what? Quite possibly, to *either* the bench supply itself, the circuit under test, or *both*.

It's to prevent this kind of damage that most of the better quality bench supplies are provided with some kind of overload protection circuitry.

Generally, this protection takes the form of a circuit which changes the supply's regulation from the normal CV mode over to CI mode, when the load current reaches a certain level. In other words, the supply suddenly stops trying to keep the output voltage constant, and swings over to limiting the output current which can be drawn – 'damage control mode', if you like.

With low-end supplies, this protective mode changeover may occur at a fixed current level, designed purely to protect the bench supply itself from damage. However the maximum current level that the supply can safely deliver might well be far higher than the level which can cause damage to the components in the circuit under test, so this kind of supply might not offer much protection to your test circuit.

Because of this, the better bench supplies provide for adjustment of the current level at which the supply changes from CV to CI operation. This allows the maximum current to be set to a level which will not interfere with normal circuit operation (where the supply operates in CV mode), while still protecting your test circuit in the event of an overload (which causes it to swing into CI mode).

This type of bench supply will thus tend to have two main controls: one to adjust the output voltage in normal CV operation, and the other to adjust the maximum current which can be drawn in CI 'overload' mode.

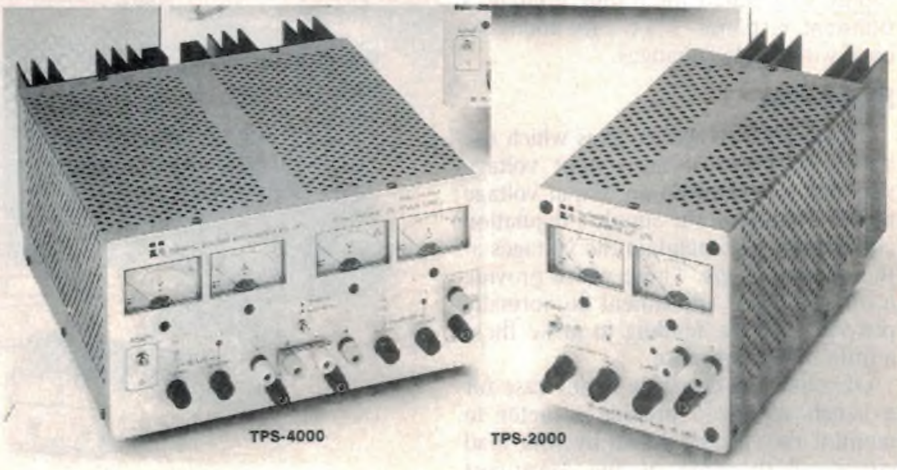
Instead of entering a constant current mode for overload protection, some supplies have a 'fold-back' current limiting mode. This doesn't just limit the current to a maximum value, but actually 'winds it back' to a level rather lower than the level at which the overload protection circuitry is set to trip.

While this kind of facility can provide additional protection for both the supply itself and your circuit, it can also cause complications with some types of test circuit. In fact in some circumstances, low-frequency oscillations can be produced with this kind of overload protection. So on the whole, the CI type of current limiting is generally more suitable for most applications of bench supplies.

Specifications

When you're checking out the specifications of bench power supplies, probably the first things to look for are the voltage and current capability. There's no point in looking further into the specs, unless the supply concerned will produce the voltages you need, and is capable of supplying enough current. As noted earlier, these figures will depend upon the kind of equipment you're going to be working with, and the kind of work you're doing.

Incidentally, it's a good idea to be a little conservative in selecting the voltage and current rating of a supply. Make sure that you get a supply that is capable of delivering *more* than you're likely to want, if possible, because in most cases you cannot safely connect bench supplies in series or parallel, in order to get higher voltage or current



The TPS 2000 and TPS 4000 series supplies from Topward in Taiwan offer single (right) or triple (left) outputs, separate meters for voltage and current, master/slave operation for dual supplies, CV/CI operation and outputs to 60V/3A. (Courtesy Elmeasco Instruments)

capability.

Although many supplies are protected against catastrophic damage caused by reverse voltage, this still doesn't mean that they can be safely connected in series, to produce a higher voltage. Similarly connecting supplies in parallel, in order to boost the current capability, is generally asking for BIG trouble.

Supplies that are capable of being connected safely in series or parallel in this way are generally very expensive. Generally you'll find it preferable to use a single supply, with voltage and current ratings sufficient for the job.

Regulation

Next, you'll probably be particularly interested in the output voltage *regulation* performance of the supply, when it's operating in normal CV mode. This is usually specified in terms of two separate components: the regulation against changes in mains input voltage, known as *line regulation*, and the regulation against changes in load current, known as *load regulation*.

Line regulation is usually quoted in terms of the maximum output voltage change, in percent, for a certain change in AC line voltage (typically +/-10%, or +/-24V for a nominal 240V AC input). A typical figure might be given as say 0.01%, meaning that when the supply is set to produce an output of say 10V, its output will not vary by any more than +/-10mV (0.01% of 10V) when the incoming AC mains voltage varies within the range from 216 – 264V (240V +/-10%).

Load regulation can be quoted in the same way, in terms of the maximum output voltage change – again in percent – for a certain change in output current. Normally this will be for a change from zero load current (i.e., no load) to full rated load. So again, if a supply has a quoted load regulation of say .01%, and a rated output of say 2A, this means that when set for an output of say 20V, its output voltage will not vary by more than +/-20mV (20V +/-0.01%) between no load and a full load current of 2A.

An alternative, or additional way of specifying load regulation is to quote it not as a percentage changed, but in terms of the supply's effective *output resistance*. This is visualising the supply as a Thevenin DC source – a perfect generator in series with a built-in loss resistance.

Needless to say, the smaller the effective series resistance, the less the output voltage drops with load current. So a typical supply might have an output

The compact PS 5004 programmable precision supply module from Tektronix is part of that firm's TM 5000 modular instrument system. It provides 0-20V at up to 300mA, with full IEEE488 compatibility. (Courtesy Tektronix)

resistance of say 5 milliohms – implying that its output voltage will drop by 5mV for each amp of load current.

With some of the more 'professional' bench supplies, the output characteristic may be specified not in terms of effective resistance, but more generally as an *impedance*. This is merely taking into account any inductive or capacitive *reactance* that may be present at the supply output terminals, as well as the regulation resistance.

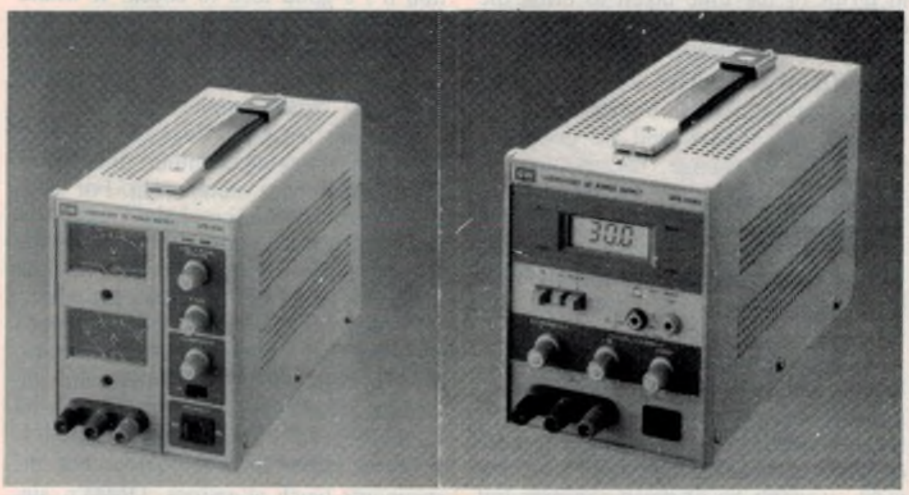
In many cases this will be of rather academic interest, as the leads used to connect the supply to the test circuit may well have more inductance than that present within the supply itself. In any case, it's usual to connect at least a small bypass capacitance across the supply rails of the test circuit, to prevent supply and lead inductance from causing any problems.

Note that some of the more expensive bench supplies have separate terminals for the actual outputs of the supply, and the sensing inputs of the internal regulation circuitry. Normally these terminals are bridged together, using metal straps, so that the supply senses and regulates the voltage precisely at its own output terminals. However if desired, the straps can be removed and separate wires run from each pair of terminals to the load circuit.

This allows the supply's regulator to sense the voltage right at the load itself, and maintain that load voltage constant despite any voltage drops introduced by the connection leads. A nice feature, but not one that most of us are likely to use all that often...

Like the voltage regulation in CV mode, a supply's current regulation in CI mode may also be specified, as a percentage. This is generally less important than the voltage regulation, but can be relevant if you're actually likely to use the supply as a constant-current source for circuit testing (as opposed to merely relying on the CI mode for overload protection).

As well as quoting the basic regulation performance, the specification for a bench supply may also give figures for



Goodwill's type GPR supplies are made in Taiwan and offer a choice of dual analog meters or switched digital display, outputs from 0-18V/3A to 0-60V/1A, CV/CI operation and excellent regulation. (Courtesy Emona Instruments)

the *AC ripple and noise* level present on the output. This is usually quoted for full output voltage and rated maximum output current, and given as a peak-to-peak or RMS voltage – e.g., 4mV p-p or 0.5mV RMS. Note that there may well not be any simple 'form factor' relationship between the two.

The regulation in CV mode may also have an associated *temperature coefficient* specified, showing how much (or how little) the output may drift as a result of ambient temperature change and/or temperature rise in the supply itself. Whether this will be of any great importance for you will depend on the kind of work you're likely to be doing.

For multiple-output supplies in which two or more of the outputs are arranged to 'track', in a master/slave manner, a further parameter which will probably be specified is the *tracking error*. This is simply the maximum amount by which the 'slave' output will differ from the 'master' output, due to both regulation circuit errors and differential loading.

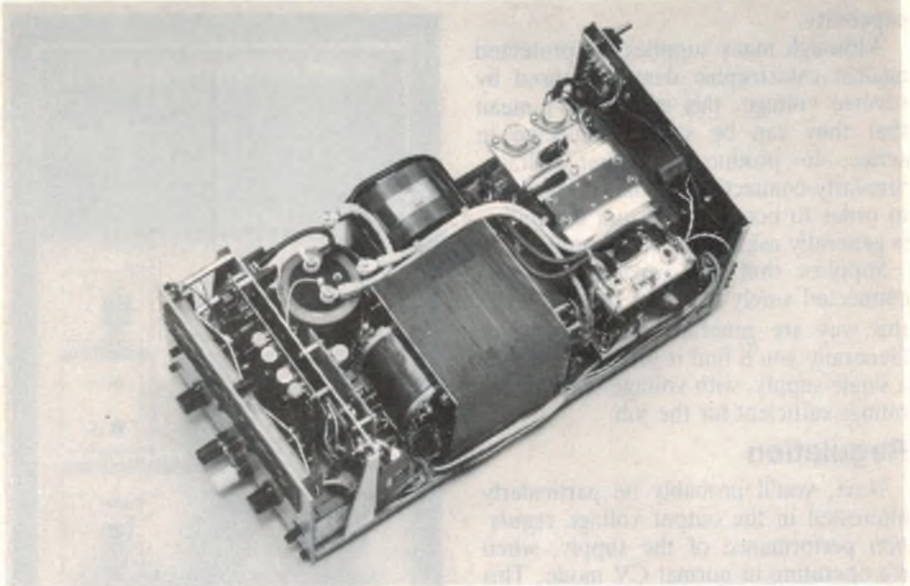
In most cases the tracking error is shown as a percentage of output voltage – e.g., +/–0.2%. There may also be a small additional *absolute* error figure, such as +/–5mV, to allow for fixed offsets in the internal circuitry.

A final parameter often quoted in bench supply specifications is *transient response*. This is a measure of the speed with which the supply's regulation circuitry responds to changes in load conditions. Like all feedback and control systems, this generally tends to take a finite time to correct the output voltage level when the load current suddenly changes, either up or down.

Often the transient response is quoted in terms of the time taken to bring the output voltage back to within say 100mV of its original value, when the output current is either increased from zero to full rated load, or vice-versa.

Frequently figures will be given for both kinds of change, because the response time may well be different. It may well take longer for the voltage to recover after a sudden *drop* in current than after a sudden *rise*, for example, because reservoir/filter capacitors may need to be discharged.

Whether the transient response of a bench supply will be of great importance to you will again depend upon the kind of work you'll be doing. For a lot of general development and servicing work, it won't be of much concern; but just occasionally it can be important to have a supply that responds quickly.



Inside one of the smaller Kikusui 'PAD-L' supplies, showing its rugged construction. An inductor-input filter is used to reduce capacitor ripple current and line input current harmonics. (Courtesy Emona Instruments)

Safety

A point to bear in mind, especially when choosing a bench supply at the lower-priced end of the market, is electrical safety.

Naturally enough, a bench supply in particular needs to observe all of the usual safety requirements, because its output is directly accessible to contact by the user – you! – via the circuit or equipment under test.

All of the bench supplies sold by reputable firms will have been submitted for safety 'type approval' by the relevant authorities, and this will be shown by a suitable sticker on the rear panel. However not all of those at the economy end of the market may be in this category, so for your own protection it's a good idea to check. It would be false economy to risk your life for the sake of saving a few dollars, surely.

At this stage it might be worth noting that most bench supplies have the DC output rails basically 'floating', but with provision to connect either polarity to mains earth via a metal strap. For safety, in case of an internal short circuit in the supply, it's a good idea to leave this earthing strap connected – to one side of the output or the other, as you wish.

In some cases it probably won't matter which side of the output is earthed, as the test circuit will otherwise be floating. However if you're going to be hooking up the circuit to other supplies, or more importantly to various test instruments (such as scopes, DMM's, signal generators and so on), you'll have to be more careful. Many of these other instruments will have one side of their inputs or outputs earthed, so you could end up with an effective short across the supply output.

Sometimes the only way to avoid this sort of problem will be to temporarily remove the supply's earthing strap altogether, and rely on one of the other instruments to provide the safety earth. This may also be necessary at times when you're working with sensitive audio circuitry, to avoid hum loops.

Finally, there's the matter of mains voltage rating. Some of the cheaper imported bench supplies are designed to operate not from a nominal 240V, as found in most areas of Australia, but from 220V. They may also use a power transformer designed for operation on a 60Hz supply, instead of our 50Hz supply.

Often this can mean that the transformer will overheat rather noticeably, when operated on 240V/50Hz for more than a short period. Not very desirable in a bench power supply, which tends to be used for many hours at a time!

In view of this possibility it's a good idea to check the fine print in the specification for a bench supply, to make sure that it's rated for continuous use on 240V (or at least 230V) and 50Hz. All of the better quality units will be, but it's better to make sure.

I hope the information given in this article helps you in choosing the right bench power supply for your needs. My thanks to the suppliers who provided information to help me in writing it, and the pictures of representative supplies shown in the illustrations.

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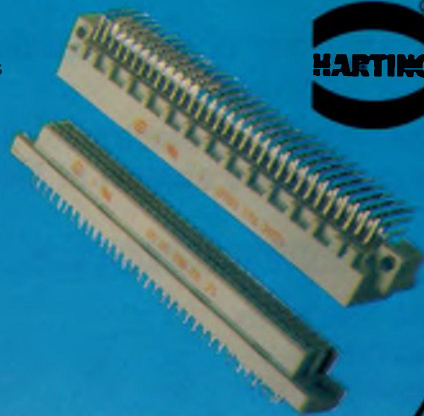

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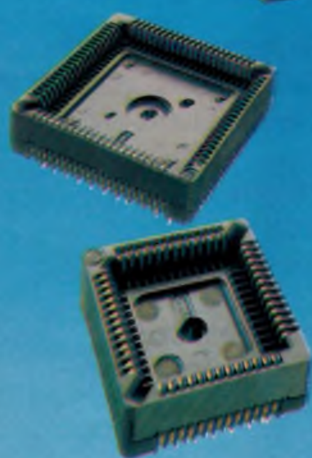

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Test Equipment Review:

H-P's new E2377A handheld DMM

The E2377A is one of a trio of new handheld digital multimeters just released by Hewlett-Packard. It offers a basic DC accuracy of 0.3%, a data hold facility and the ability to measure temperature with an external K-type thermocouple probe – all in a compact and sturdy gasketed polycarbonate case.

Although many people nowadays associate the name Hewlett-Packard with computers, the company is of course world renowned in the electronics industry for its measuring instruments. In fact that's where it started, with Bill Hewlett and Dave Packard building high-quality audio oscillators in a Palo Alto garage. They were so successful that the company soon became a major force in test and measuring equipment.

Right from the start, H-P could be described as 'engineer driven', with the emphasis on innovation and performance rather than low price. And as the years have passed, this has been the continuing H-P tradition – which is of course very appropriate for a firm addressing professional markets.

Now and again they came out with what we might call 'consumer' level products, although still with a discernable bias towards the professional user. They were among the first to produce pocket calculators, for example, and were very successful in this area. When the price of basic calculators fell, with the entry of Asian manufacturers, H-P quickly moved up into the 'scientific and professional' part of the market, where they soon became a market leader.

When LSI chips first made it possible to produce a truly compact DMM, I seem to recall that H-P produced the first 'DMM in a probe' for servicing. A neat little unit it was, too.

But by and large, during the last 10 years or so they've moved more and more away from the low-priced end of the market, specialising in the kind of high performance test equipment and measuring systems for which they've become so highly regarded.

Of course, one thing that we've learned over the years is not to take Hewlett-Packard for granted. Every so often they come up with something unexpected, and that's just what happened a couple of months ago when they announced the release of a new trio of relatively low-cost handheld DMMs.

The lowest-priced of the three is the E2373A, a basic 3200-count unit with 0.7% DC accuracy, which sells for only $173 tax free. There's also the top of the range E2378A, which is electrically identical to the E2377A we're reviewing here, but comes in a specially ruggedised and water-resistant case. This sells for $332 tax free.

The mid-range E2377A is a 3200-count meter, like its less expensive brother, but it offers double the basic DC accuracy: 0.3%. It also offers twice the AC accuracy, with 1% compared with 2%, plus double the AC bandwidth: 1kHz instead of 500Hz. Further 'extra features' include the Data Hold function, the Temperature function (with a suitable thermocouple probe), and a separate fuse on the 10A current ranges.

As with the other two models, the E2377A provides an analog 'bar graph' display in addition to the 3-1/2 digit numerical display. The overall length of the analog scale is 42mm, and it is divided into 32 divisions – giving a useful resolution for viewing trends.

The actual digital numerals are around 12mm high, and this plus the high contrast of the LCD panel used ensures that the display is highly readable.

Like the other two models, the E2377A provides five DC voltage ranges with full scale readings of 300mV, 3V, 30V, 300V and 1000V. Accuracy on the two lowest ranges is 0.3%, widening to 0.4% on the three highest ranges. Input resistance is higher than 1000M on the lowest range, 11M on the next and 10M for the three highest ranges.

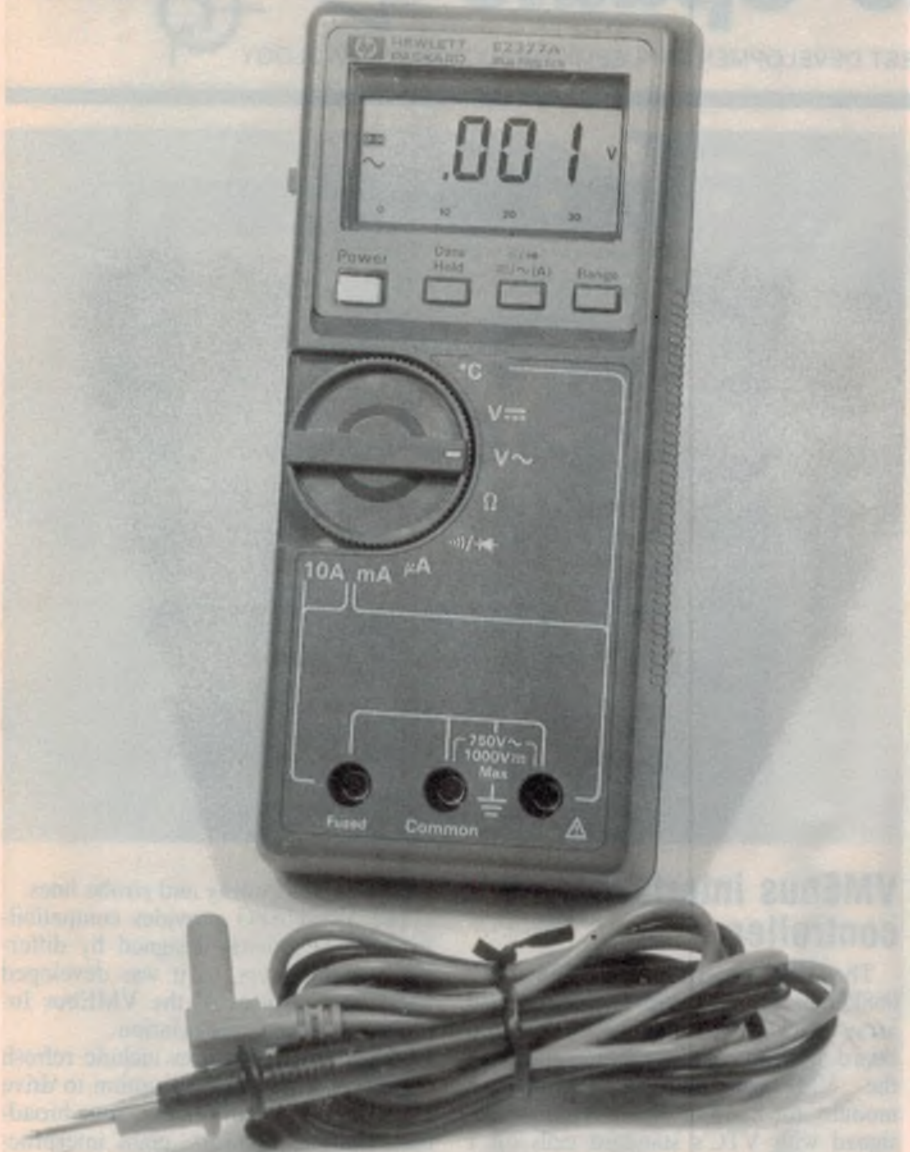
There are four AC voltage ranges, with full scale readings of 3V, 30V, 300V and 750V. Accuracy on all four ranges is 1% + 3 counts, from 40Hz to 500Hz, while from 500Hz to 1kHz it widens to 2% + 5 counts on the three highest ranges, and is unspecified on the lowest range. Input impedance on all four ranges is 1M in parallel with 50pF or less.

There are five current ranges for both DC and AC, with full scale readings of 300uA, 3mA, 30mA, 300mA and 10A. DC accuracy is 1% + 2 counts on the three lowest ranges, widening to 1.5% + 2 counts on the two highest ranges. For all five AC ranges the accuracy is 2% + 5 counts, from 40Hz to 1kHz.

For resistance measurement there are six ranges, with full scale readings of 300 ohms, 3k, 30k, 300k, 3M and 30M. Basic accuracy is 0.7% + 1 count on the four centre ranges, widening to 0.7% + 2 counts on the lowest range and 2% + 2 count on the highest range. Open circuit voltage is less than 1.3V, and the highest test current is 700uA (on the lowest range).

Quite separately from the resistance ranges *per se* are a 'Continuity Check' range and 'Diode Test' range, which share the same position of the main function switch. Toggling between the two functions is performed via one of the pushbuttons under the display.

The continuity range is effectively another resistance range with an FSR of 300 ohms, but in addition there is a small 'beeper' which sounds for resist-



ances of less than about 20 ohms. Maximum test current is again 700uA, with open circuit voltage less than 1.3V.

The alternative diode test range reads effectively from 0 – 2V, to allow clear indication of forward voltage drop. Rated accuracy is 3% + 2 counts, with a maximum open-circuit voltage of less than 3.3V and a test current of 600uA for a diode drop of 0.6V.

When used with a suitable K-type thermocouple probe, the temperature range reads from –20 to 700°C, with a resolution of 1°C and an accuracy of 2% + 2 counts (not counting sensor error). H-P makes two suitable probes available, one for measuring surface temperature (E2301A) and the other airflow temperature (E2302A). Both require the use of a Thermocouple Probe Adaptor (E2303A).

Inside the case

Having seen inside quite a lot of the current crop of DMMs, we couldn't resist looking inside the E2377A as well – for comparison. All of the components and circuitry are mounted on a single PCB, including the batteries and control switches. The front-panel pushbuttons are actually tipped at the back with conductive polymer, which bridges between plated PCB contacts when each button is pressed.

Virtually all of the active functions appear to be provided by a single LSI chip, mounted down near the input jacks. Apart from this there are only a couple of discrete active devices visible.

All in all, the unit seemed to be very soundly designed and solidly made – just what you'd expect from H-P.

Incidentally, the sample unit was clearly marked 'Made in Japan'. Presumably it is made by Yokogawa-Hewlett-Packard, H-P's Japanese affiliate.

How it went

In use, we found the H-P E2377A a very well-behaved little meter. Its display is very clean and readable, and the readings relatively free from the excessive 'bobble' found with many instruments.

The auto-ranging facility works well, consistently settling for a range that provides the highest resolution – although you can over-ride it using the Range button, if you wish. Similarly the Data Hold facility works smoothly. One of the things we liked here is the dual Hold buttons, one on the front and the other on the left-hand side – where you can press it conveniently with your left thumb.

Its performance checked out very well, against our reference instruments and resistances. On DC voltage it seemed to be well within the rated 0.3% – in fact probably nearer half that figure. We also got a similar figure (0.15% overall) for DC current measurements – again well within the specs.

For resistance measurements we got figures generally within 0.3%, compared with the spec figure of 0.7%. The only exception was down at around 20 ohms, where the error rose to 0.94% overall (including bobble) – but this is still inside the full spec figure of (0.7% + 2 counts).

For AC voltage the specified accuracy is 1% + 3 counts, up to 500Hz, and 2% + 5 counts up to 1kHz. We got figures that were certainly inside this range, being typically around 0.7% up to 500Hz and 1.7% up to 1kHz. These are again overall error figures, including bobble. The error did begin to rise fairly smartly above 1kHz, though.

Summarising, then, we found the H-P E2377A a very nice little meter indeed: sturdy, convenient to use, easy to read and with better than average accuracy. Judging by the construction and backed by the H-P reputation, it should also prove very reliable. For the quoted price of $297.00 plus tax it seems good value for money.

Further information is available from Hewlett-Packard Australia, 31-41 Joseph Street, Blackburn 3130 or phone (008) 033 821. Melbourne callers should phone 895 2555. (J.R.)

Solid State Update

KEEPING YOU INFORMED ON THE LATEST DEVELOPMENTS IN SEMICONDUCTOR TECHNOLOGY

Image processor for laser printers

National Semiconductor's new NS32GX32 32-bit imaging system processor is being used by ALPS America in a powerful new laser beam printer. The chip allows the printer to maintain a 20 page-per-minute output rate in a multi-user environment, even when printing complex graphics.

The ALPS LPX2020 printer is fully compatible with Hewlett-Packard's LaserJet Series II printer, and can be upgraded to emulate Adobe's PostScript Page Description Language. Many options are available, including a 20-megabyte disk drive, a 1000-sheet offset stacker and up to 8 megabytes of memory.

The processor features large on-chip instruction and data caches, and a clock frequency of up to 30MHz for high performance. Graphics processing is supported through multiple cost-effective floating point solutions.

The NS32GX32's optimising compilers and powerful instruction set produce highly compact code, which reduce memory size requirements.

For further information, contact your nearest National Semiconductor distributor.

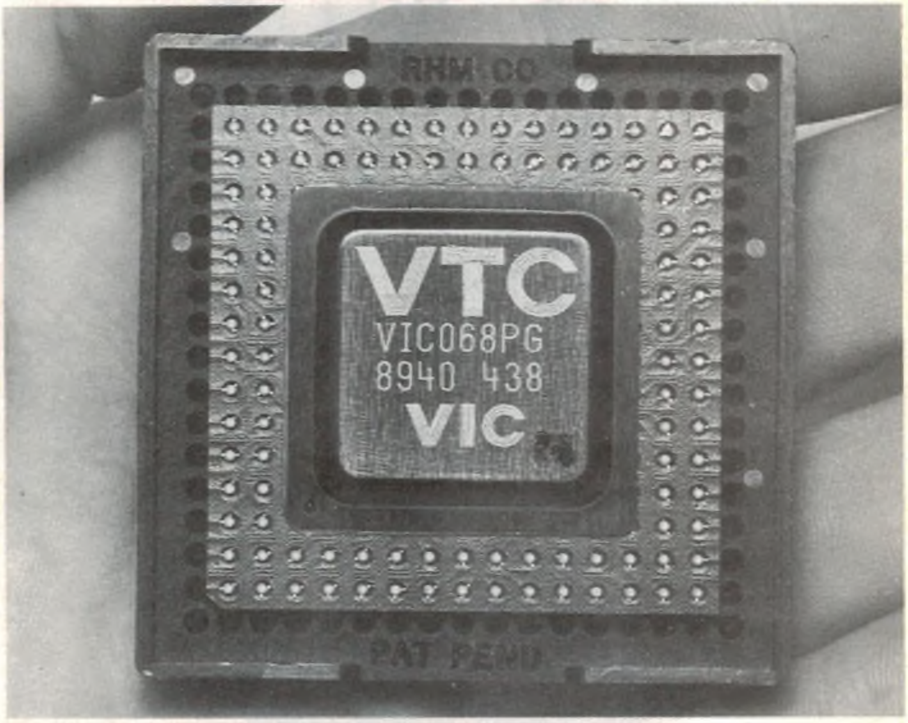
Fast SRAMs at high densities

National Semiconductor has introduced Static Random Access Memories (SRAMs) which establish a record in speed and density for memory products. These SRAMs, manufactured using an advanced semiconductor process called BiCMOS, store up to 256K bits each and operate at access times as low as 10ns.

BiCMOS combines the benefits of the speed of bipolar processes with the low power advantages of CMOS processes, thus producing high speed and low power memory products.

The new SRAMs are available in 16Kx4 and 64Kx4 configurations. Other SRAMs of this size are half as fast as the new memories, which operate at 10ns and 12ns respectively.

For further information, contact your nearest National Semiconductor distributor.



VMEbus interface controller

The VME interface controller VIC-068PG is a single chip in 144-pin grid array package to minimise cost and board area, to maximise performance of the VMEbus interface master/slave module, for 8, 16 or 32 bit systems. Designed with VTC's standard cells on 1 micron CMOS process, it provides all VMEbus system controller functions and many other features to simplify interface development.

CMOS high drive buffers provide direct connection to the address and data lines, to the arbitration, interrupt, address modifier, utility and strobe lines.

The VIC-068PG provides compatibility between boards designed by different manufacturers, as it was developed under the auspices of the VMEbus International Trade Association.

Miscellaneous features include refresh option for local DRAM, option to drive DTACK high upon release, four broadcast location monitors, eight interprocessor communication registers, TAS/CAS/CAS2 instruction support for the 68020 microprocess.

For further information contact Dynamic Component Sales, 6-17 Heatherdale Road, Ringwood 3134 or phone (03) 873 4755.

Tone/pulse dialler ICs

A range of new telecommunications ICs released by Winbond Electronics expands the function and performance available from basic telephone handsets.

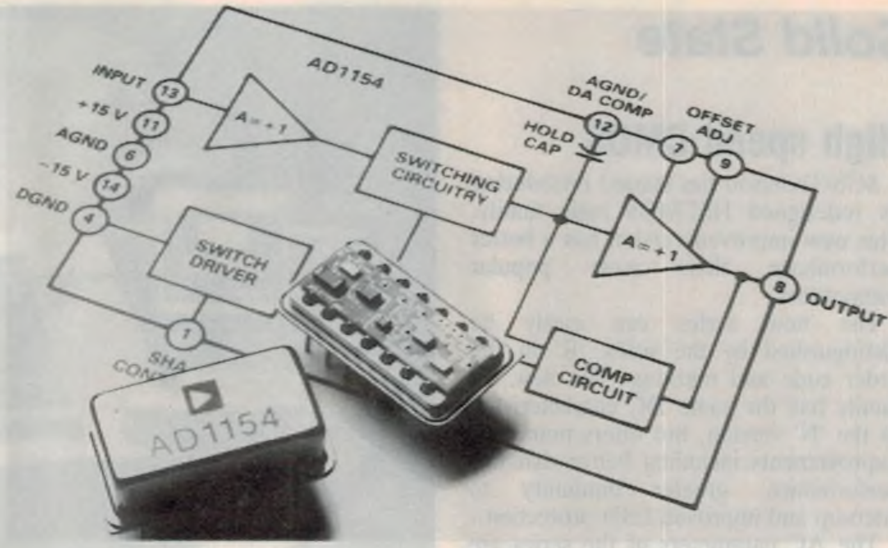
Each model in the series has been developed to provide mask option capability as well as pin compatibility with different country standards in communications ICs. This can lead to low cost manufacturing techniques using a common printed circuit board.

The diallers have a number of memory options and are tone/pulse switchable, with last number redial and save memory. They perform either DTMF or pulse dialling by selecting the mode pin or P/T key.

Future models will not only contain expanded memory functions but also LCD driver capability from a single IC.

For further information contact Priority Electronics, Suite 7, 23/25 Melrose Street, Sandringham 3191 or phone (03)521 0266.

Low cost linear 16-bit SHA



Analog Devices' AD1154 sample-and-hold amplifier (SHA) maintains 16-bit accuracy in high-resolution data acquisition systems for 40% less than the cost of competitive versions. The AD1154 can therefore be used to upgrade the performance of 14-bit systems without increasing system cost. Complete with an internal hold capacitor and proprietary error-compensation circuitry, the SHA's guaranteed maximum nonlinearities in hold and sample modes is +/-0.00076% and +/-0.003%, respectively (B grade).

While providing critical precision with 16-bit analog-to-digital converters, the AD1154's speed performance is comparable to existing 14-bit SHAs. A 3.5us typical (5us maximum) acquisition time to +/-0.00076% of 20V, 150ps aperture uncertainty, and 80ns aperture delay make the AD1154 convenient for high-speed data acquisition and strobed measurement systems. In addition, its 10V/us slew rate and guaranteed 120kHz minimum full-power bandwidth provide the range needed in peak-detection circuits.

For further information, contact Avisun, Unit 9, 1 Short Street, Chatswood 2067 or phone (02) 417 8777.

High speed 4-Megabit DRAMs

Australian-controlled semiconductor firm Ramtron has completed the design of two high speed 4-megabit Dynamic Random Access Memories (DRAMs), which are organized as 4Mx1b and 1Mx4b with maximum access time of 50ns. In addition to traditional DRAM applications, 4-Mb DRAM market growth is expected to driven by new applications such as digital television, facsimile machines, and solid state replacements for magnetic disks used in computer systems.

Ramtron's products include the non-volatile Ferroelectric Random Access Memory (FRAM), and it was recently awarded a US Patent titled 'Self-Restoring Ferroelectric Memory'. This new patent is Ramtron's 16th international patent covering ferroelectric technology.

For further information, contact Ramtron Australia, 1st Floor, 30 Carrington Street, Sydney 2000 or phone (02) 262 1933.

Octal CMOS DAC

Precision Monolithics has introduced the DAC-8800, the first octal 8-bit CMOS DAC in the industry to offer serial input and dual polarity output.

Consisting of eight independently addressable DACs, the DAC-8800 offers three-wire serial input interfacing. This feature, combined with the small 20-pin package, saves valuable PC board space.

The DAC-8800 has the unique ability to set up either unipolar or bipolar output voltage ranges for each set of four DACs, as determined by the user supplied reference inputs. TTL compatibility is maintained over a wide supply range from single +5V to a total of +20V.

For further information, contact VSI Electronics, 16 Dickson Avenue, Artarmon 2064 or phone (02) 439 8622.

ASIC design kits

Gateway Design Automation and VLSI Technology have introduced two ASIC design kits that allow users of Gateway's Verilog-XL logic simulator to simulate designs for implementation in VLSI's gate array and standard cell families.

The design kits include Verilog-XL simulation model libraries for VLSI's VGT200 and VGT300 gate array and VSC120 and VSC300 standard cell products, a delay calculator, and test vector interface programmes.

For further information, contact Energy Control International, 26 Boron Street, Sumner Park 4074 or phone (07) 376 2955.

'Adaptive' power MOSFET driver

Siliconix has released a new Si9910 'adaptive' power MOSFET driver.

This single-channel, non-inverting driver adapts to the power MOSFET's operating conditions, thus providing protection for the MOSFET while optimising gate drive when needed. This eliminates the need for designing motor drives for worst-case conditions or for adding external devices to guarantee safe operation.

The Si9910, which can be used as either a low-side or high-side driver, includes a low-impedance, emitter-follower output and a Schmidt trigger input. Its on-board protection circuitry protects the MOSFET against excess dv/dt and di/dt, undervoltages, and overcurrent conditions by monitoring the operating conditions through feedback loops and altering the drive output. CMOS inputs allow logic-level control of either high-power MOSFETs or IGBTs.

The Si9910 is designed to drive a broad range of power MOSFETs in the motor control applications from DC up to 220V AC. It will simplify the implementation of special features such as speed and position control functions.

End products that will benefit from this adaptive design include major appliances, fans and blowers, industrial controllers, avionics, automobiles and hand power tools.

For further information contact Anitech, 241/255 Brown Road, Noble Park 3174 or phone (03) 795 5111.

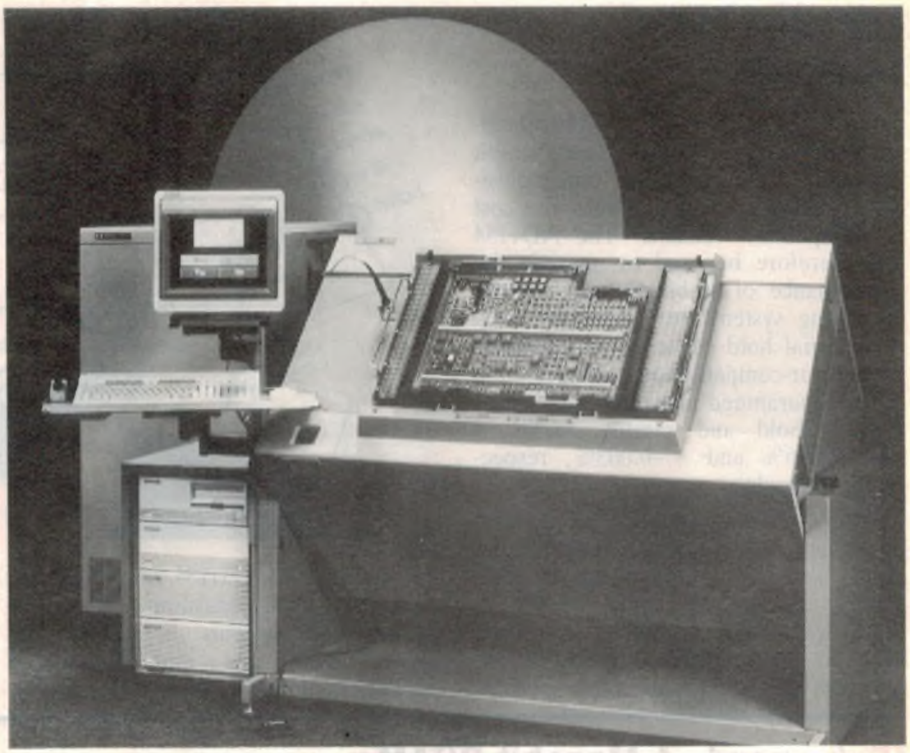
High speed CMOS

SGS-Thomson has started introducing its redesigned HSCMOS logic family. This new improved version has a better performance than most popular competitors.

The new series can easily be distinguished by the suffix 'R' in the order code and marking. The new 'R' family has the same DC characteristics as the 'N' version, but offers numerous improvements including better dynamic performance, greater immunity to latch-up and improved ESD protection.

The AC parameters of the series are 2(30% faster than the current 'N' series. This has been obtained by reducing the channel length; reducing the gate oxide thickness; and using new layout rules to reduce stray capacitances.

Further details from Promark Electronics, 104 Reserve Road, (cnr. Whiting Street), Artarmon 2064 or phone (02)439 6477.



Hewlett-Packard's new HP 3070 combinational-board-test system, which can carry out fully integrated digital and analog functional tests on wired PC boards with up to 2592 circuit nodes.

1-10W DC/DC converters

LP Series is a complete family of low power 1-10 watt, low noise, fully regulated DC/DC converters. The series consists of over fifty different models, offering a variety of input output combinations to meet the requirements of most analog and TTL/CMOS circuits.

Standard features include input filtering to minimize reflected input current, and output current limiting short-circuit protection. Input/output isolation is between 300V DC for some models and 500V DC for others.

The CMOS 5V operation and low power consumption lends this part to portable and low power operation.

All units operate at 20kHz minimum frequency, attaining efficiences as high as 65%, and reducing output ripple and noise. Output voltage accuracy is contained with +/-1.0%.

For additional information contact your local Elmeasco Instruments office or phone Sydney (02)736 2888, Melbourne (03)879 2322, Adelaide (08)344 9000, Brisbane (07)875 1444 or Perth (09)470 1855.

VLSI chips for 80286, 80386 systems

VLSI Technology has introduced two very high-integration CMOS chip sets for use in the design of PC/AT-compatible based systems.

The two-chip VL82C286 is intended for use in 80286 and 80386SX microprocessor-based system designs at clock speeds of 25MHz and below, while the three-chip VL82C386 is intended for the newer 80386 systems operating at clock speeds of 33MHz and below.

The VL82C286 PC/AT-compatible two-chip set consists of:

- VL82C320 system controller/data buffer (160-pin quad flatpack).
- VL82C331 ISA (Industry-Standard Architecture) bus controller (160-pin quad flatpack).

The VL82C386 PC/AT-compatible three-chip set consists of:

- VL82C330 system controller (128-pin quad flatpack).
- VL82C331 ISA bus controller (160-pin quad flatpack).
- VL82C332 data buffer (128-pin quad flatpack).

Further information from Energy Control International, 26 Boron Street, Sumner Park 4074 or phone (07) 376 2955.

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