1st BIRTHDAY ISSUE!

AUSTRALIA'S TOP ELECTRONICS JOURNAL JULY 1986 $3.30 NZ$4.50

The AUSTRALIAN ELECTRONICS Monthly

excitement electronics

Fixed CAPACITORS
Uses & Abuses

8-digit, 1 GHz counter

Tilbrook's latest power amp.

Computer decoder for weather satellite pics

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- Philips Aust.-made stereo TV
- 50 MHz Philips CRO
- Racal 1200/1200 modem
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- Emtronics Scanner

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The Australian Electronics Monthly

WELL, WHAT DO YOU KNOW? It's our first birthday! To celebrate, we're giving away the presents! Inside the magazine you'll find a series of contests with some fabulous prizes to win, donated by some of the 'big names' on the electronics scene. Like Philips, Racal, Dick Smith Electronics and Emtronics. And they're no dinky 'toy' prizes, either. No matter what you're interest — be it computers, communications, electronics experimentation (R&D if you like!), or relaxing in front of the TV! — there's a prize that should take your fancy. You may enter as many or as few of the contests as you wish, as many or as few times as you wish. Everyone gets a chance at every prize!

Our first issue featured a project from well-known author/designer extraordinaire, Tom Moffat — the Listening Post, which has become a legend in our short lifetime. To kick off Volume 2, we thought it timely to publish another of Tom's efforts — a Satellite FAX Decoder. It's a sort-of-Listening Post for weather satellites that allows you to decode and print the pictures continuously transmitted by the series of polar-orbiting weather satellites on the 136-138 MHz band.

Also in our first issue, we featured a 'universal' 60/100 watt MOSFET audio power amp module by David Tilbrook. It has become something of a 'benchmark' project, used in a wide variety of applications ranging from homebuilt hi-fi amps to PA systems. This issue, we present construction details of David's latest MOSFET power amp module which will shortly be employed in our 'ultra-fidelity' stereo power amp, companion to the ultra-fidelity preamp published late last year and now well-established as the 'new standard' project audio preamp.

For the cherry on top of the birthday cake's icing, we present our first annual index, painstakingly compiled by my wife, Val. If you didn't get every issue, now you can see what you missed out on!

Our first year has certainly been an eventful one. I'd like to take this opportunity to sincerely thank all those who've given their support, assistance, co-operation and encouragement. Especially readers — a happy birthday to you all!

Roger

Roger Harrison
Editor

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The capacitor clan! Photo courtesy IRH Components. Design and production, Angelika Koop.

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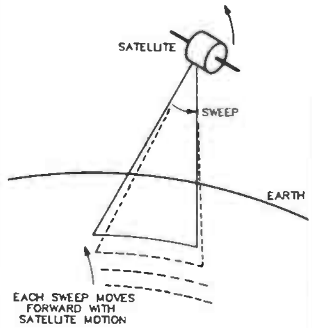

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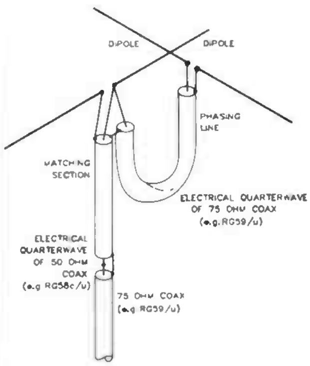


CONSUMER ELECTRONICS

FEATURE

NEWS & GENERAL

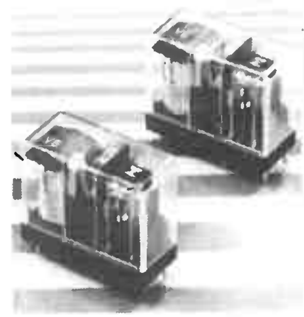
BIRTHDAY CONTESTS

Win some great prizes

NEXT MONTH!

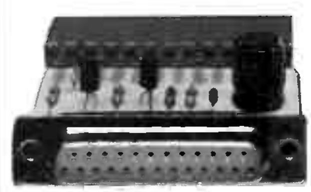
A DC PROTECTOR FOR AMPS & SPEAKERS

Designed to team with the 6000 MOSFET amp module, but usable with any power amp, this project prevents dc fault conditions or excessive clipping from exterminating amps and speakers alike.



RELAYS — THE RUNDOWN

Wide application and new technology keep these versatile components going. This major feature takes a look at relay technology, discusses the various types and examines the practices and pitfalls involved in their application. Bound to become a 'reference'



C64/VIC MODEM COUPLER — SIMPLE SERIAL CARD

Here's a cheap, simple serial interface for Commodore VIC-20 and '64 owners — just the thing for driving modems, etc! It plugs into the user port and derives power from the computer — no external supply needed. Build it in a jiffy!

THE LISTENING POST ON THE BBC-B COMPUTER

Andrew Boon VK7AW Shows how to interface our most popular project to the BBC-B computer to decode and print Morse, radioteletype (RTTY) and radio facsimile (FAX) pictures.

While these articles are currently being prepared for publication, unforseen circumstances may affect the final contents of the issue.

Great prizes to win in our

1ST BIRTHDAY CONTESTS!

It's our birthday and *we're* giving away the presents!

Enter any or all of our five Birthday Contests offering these fabulous prizes:

Philips 54 cm Stereo Colour TV!
Philips new 50 MHz CRO, Model PM3050!
DSE Multitech PC System 1 plus Racal 1200/1200 Modem!
Regency HX1000 VHF/UHF Handheld Scanner, from Emtronics.
Ersa MS1500 Temperature-Controlled Soldering Station, from Meltec.

RULES

You may enter each of the five contests as many times as you wish, but you must use a separate entry form for each entry and include a month and page number cut from the bottom of the relevant contest page. You must put your name and address on each entry form and sign it where indicated. That is, photocopies are acceptable but an original month/page number from a copy of this month's magazine must accompany each entry form.

The contest is open to all persons normally resident in Australia or New Zealand, with the exception of members and families of the staff of Australian Electronics Monthly, the printers, Offset Alpine, and/or associated companies.

Contestants must enter their names and addresses where indicated on each form. Photostats or clearly written copies will be accepted, but if sending copies you must cut out and include with each entry an original page number and month cut from the bottom of the page of the contest. This contest series is invalid in states where local laws prohibit entries. Entrants must sign the declaration, accompanying each contest, that they have read the above rules and agree to abide by their conditions.

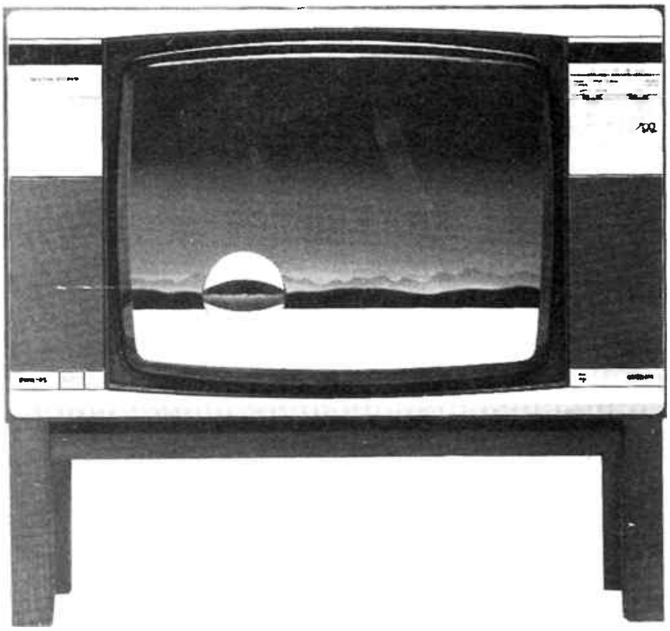
The winning entry will be drawn by the Editor, whose decision is final; no correspondence will be entered into regarding the decision.

Winners will be notified by telegram the day the result is declared and the winner's name and contest results published in the next possible issue of the magazine.

Send your entries to: **AEM 1st Birthday Contests**
PO Box 289
Wahroonga 2076 NSW

Entry coupons with each contest

1ST BIRTHDAY CONTEST No. 1.



Win this fabulous Philips 54 cm colour stereo TV model CH285.

This TV receiver offers VHF and UHF reception incorporating a 'search' feature that finds the TV Signals for you, which can then be stored withthe press of a button. It comes with a full-function remote control and includes a 'Teletext Option' permitting the fitting of a Teletext decoder when required. The picture tube is a 90 degree deflection type with black matrix and pigmented phosphor, featuring quick-start in-line guns. Circuitry features automatic degaussing, automatic vertical and horizontal hold and automatic fine tuning plus interference suppression from cars and other electrical sources. Sound output is 2 x 10 watts RMS driving two 203 x 76 mm speakers. The set has been designed to complement the natural style decor of the Australian home, with attractive woodgrain vinyl and screw-in timber legs and rail. Philips offer a 12 mth free parts and labour warranty and 24 mths free picture tube warranty.

Prize kindly donated by Philips Consumer Products, a division of Philips Industries Ltd.

All you have to do is answer the following questions and then tell us in 30 words or less what you think are the most attractive features of the prize.

1ST BIRTHDAY CONTEST No. 1.

Q1: Three men were instrumental in the development of television with stereo sound. An Englishman devised the electronic line-scanned, 25 frames/second system of 'electric vision' using cathode ray tubes, which he published in 1908. A Russian-born US citizen patented the 'iconoscope' TV camera in 1923. Another Englishman, instrumental in putting to air the first public TV Broadcasts from London's Alexandra Palace, patented circuitry fundamental to the development of both television transmission and reception as well as stereo sound. What are their names?

....

....

....

Q2: The first stereo/dual-sound channel TV set was designed and manufactured in Australia by Philips and launched on the market soon after the Minister for Communications announced the introduction of dual-sound channel television bradcasting. Name the month and year of that announcement.

....

Q3: name the model number of that Philips TV.

....

Q4: Philips' promotional theme for their stereo TVs revolves around one word. Use your head now! What is it?

....

Now tell us, on a separate piece of paper, what you think are the most attractive features of the prize.

Name ....

Address ....

.... Postcode ......

I have read the rules of the contest and agree to abide by their conditions.

Signed ....

NEWS REVIEW

Second AUSSAT delayed by Ariane rocket crash

The launch of Australia's second AUSSAT satellite, which was due on August 12, will be delayed by as long as two months owing to the crash of a European Space Agency's Araine-2 rocket on May 31 last.

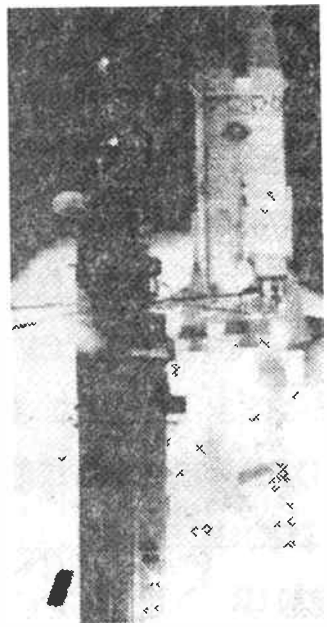
The Araine-2 in question was carrying a telecommunications satellite. Some 4.5 minutes after blast-off, the third stage completely failed to ignite, plunging the rocket into the Atlantic from an altitude of nearly 200 km.

The European Space Agency (ESA) launch centre is located at Kourou in French Guiana, on the north-east coast of South America.

This latest crash is the fourth in a series of some 18 launches. Last September, Arianespace suffered a major disaster when technicians had to blow up an Ariane-3, which was carrying two satellites at the time, following a problem with its stage three motor. The disaster was witnessed by French President Miterrard.

Such problems have 'rocketed' insurance charges for satellites in recent years, causing some companies to back away from covering the risky periods of launch sequences. Over US$200 million was lost on four separate US satellite launch failures last year, and the cost of the January 29 Shuttle disaster this year has yet to be counted. Some US$168 million was paid out by insurers on the Ariane launch failure alone last September.

If the Russians can do better, then they look well-placed to pick up some 'commercial' satellite business from the west.



Graziers grab GBs

The George Brown Group, comprising George Brown Sydney, Melbourne, Canberra, Newcastle and Protronics Adelaide and Perth, has been purchased by the G.B.S. Falkiner Group. The Falkiner group, with an asset backing in excess of $20 million, includes the famous Haddon Rig Merino Stud Property, an outstanding performer in the Australian Wool Industry since 1882.

The success of Falkiners is attributed to diversification, adaption of innovative management and agressive marketing. These practices will be employed in The George Brown Group to maintain its leading position within the electronic and electrical component distribution industry in Australia, Falkiners say.

Chairman, Mr. George Falkiner said, "This diversification allows access to an industry which is countercyclic to the agricultural business, has some exposure to hi-tech industries, has exceptional growth potential and has a strong customer base.

The new George Brown Board of Directors consists of: Mr. George Falkiner (Chairman Falkiner Group), Mr. Peter McLachlan (Director Falkiner Group), Mr. Bob Hardy (George Brown Group Chairman), Mr. Bob Ford (George Brown Electrical Sales Director), Mr. Ron Whyte (George Brown Electronics Sales Director), and Mr. Bob Crabbe (Protronics Managing Director).

Telescope to probe sex life of the stars

A new radio telescope being constructed in Hawaii will allow scientists to probe the dense regions of interstellar gas which are the 'breeding ground' of stars. It is to be named the James Clerk Maxwell Telescope (JCMT) in honour of the Scottish scientist's contribution to physics.

Maxwell was born in Edinburg in 1831 and educated at the city's university. He later became the first Cavendish Professor of Physics at Cambridge University.

His contributions to physics spanned the whole of the discipline but his key contributions involved the theory of electromagnetism and the kenetic theory of gases. In the latter field, he discovered the velocity distribution of atoms and molecules in gas, known as the Maxwell Velocity Distribution.

Of greater relevance to astronomy, he discovered the laws of electromagnetism through a brilliant piece of mathematical physics. In making these discoveries, he showed that light is a form of electromagnetic radiation.

The new telescope being built at the Mauna Kea observatory in Hawaii under an arrangement with the University of Hawaii will, when fully commissioned in 1987, open up the last of the wavebands still to be explored by ground-based telescopes — the millimetre and submillimetre wavebands.

The facility will be the world's largest submillimetre wave telescope. The project is being jointly funded by the British Science and Engineering Research Council (SERC) and the Netherlands Organisation for the Advancement of Pure Research (ZWO).

These wavebands are expected to give ground-based astronomers an insight into the processes going on inside the dense regions of interstellar gas, the breeding ground of stars. These areas are opaque to optical radiation but transparent at infrared and millimetre wavelength. By probing them with the JCMT, astronomers hope to gain a better understanding of the ways stars form.

Arlec founder retires

Industry identity David K. Anderson, the founder of Arlec Pty Ltd, retired on 18 April last after leading the company for some 40 years since he founded it as a one-man operation in suburban Melbourne.

Since that time, the company has grown to an international group with around 500 employees engaged in the manufacture and marketing of a wide range of electrical products sold to industry and via retail throughout Australia and in twenty other countries.

In 1963, an associated company, Soanar Electronics Pty Ltd, was established as a distributor of electronic components which, today, is a major force in its field.

Arlec has its head office and factories in Melbourne and 'substantial' offices and warehouses throughout Australia plus factories in Hong Kong.

Mr Anderson, who was chairman of both Arlec and Soanar, has been succeeded by Mr George Soanes, the founder of Soanar Electronics. Mr Graeme Nicholson and Mr Joe Telfer remain as Managing Directors of Arlec and Soanar respectively.

Modern fixed capacitors

— what the textbooks never told you.

Part 1

Les Ferdinand

It is very easy to take capacitors for granted. Being passive components, you rarely need to study any sort of data book to check characteristics - after all, they're printed on the body, aren't they? But, the situation is not as simple as it first appears. Here's a comprehensive look at modern fixed capacitors, covering all the major types, with details on their characteristics, advantages, disadvantages and applications.

THERE IS A LOT more to a capacitor than first meets the eye. Unfortunately, one often finds this out in unexpected and sometimes unpleasant ways. One source of major problems is the confusion that arises from the profusion of capacitor types available. The reason so many capacitor types exist is basically quite simple — no one type can fulfill all the requirements of a 'perfect' capacitor.

A perfect capacitor will have an infinite resistance to dc, it will have no high frequency losses and will not alter its capacitance with temperature variation. In effect, none of its characteristics will alter when it's subjected to variations in environmental factors or applied electrical conditions. A few modern capacitors will meet some of these requirements; unfortunately, none are perfect.

Fundamental characteristics

We shall now deal with characteristics that are applicable to all capacitors. The various characteristics can be more or less important at given times and under differing circumstances.

The main characteristic of a capacitor is its ability to store charge. The amount of charge that a capacitor will hold is proportional to the applied voltage and the capacitance. The charge built up in a capacitor is an electrostatic charge. This can be put in the form of an equation:

$$Q = C.V$$

where, Q = the quantity of electricity (the charge) in Coulombs,

C = capacitance in Farads, and

V = the applied voltage.

The energy stored in placing a charge on a capacitor is given by:

$$W = \tfrac{1}{2}(Q.E)$$

$$= \tfrac{1}{2}(C.V^2)$$

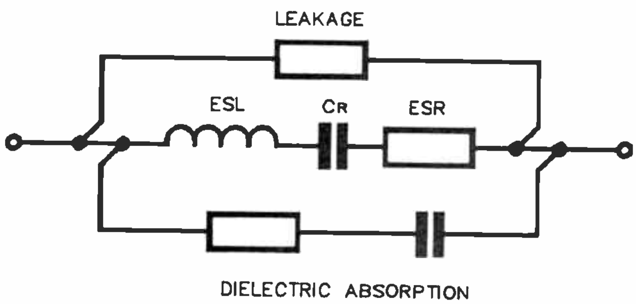
$$= Q^2/2C$$

▶

All capacitors exhibit 'faults' owing to their construction and the materials employed. These may be summarised as follows:

Leakage (L)
Effective Series Resistance (ESR)
Effective Series Inductance (ESL)
Dielectric Absorption (DA)
Dielectric Constant (Er)
Dielectric Loss (DL)
Dissipation Factor or Tangent of Loss Angle (tan δ)
Temperature Coefficient; Tempco (TC)

"Equivalent circuit" or "model" of a 'real' capacitor.



Leakage is the direct current that flows through a capacitor when its rated dc voltage is applied. Leakage is a good method of rating the quality of a capacitor. It is usually measured at 20 degrees Celsius for most capacitor types.

Effective Series Resistance is the total resistance within a capacitor which consumes some power. ESR includes the leads, plates and in electrolytic capacitors, the electrolyte. ESR contributes to the self-heating within a capacitor and varies with frequency and temperature. A capacitor's ESR can be calculated from:

$$ESR = \frac{\tan \delta}{w \cdot C}$$

$$\text{or } ESR = \frac{\tan \delta}{2.\pi.f.C} \quad \text{(Ohms)} \quad \begin{array}{l} f \text{ in Hz} \\ C \text{ in Farad} \end{array}$$

Effective Series Inductance is the inherent inductance in a capacitor, including the leads. The construction of a capacitor affects its ESL. Mica, ceramic and some electrolytic capacitors for example, have a lower ESL than plastic film/foil types. ESR and ESL are significant factors in the high frequency performance of capacitors. Capacitors used in microwave applications have no leads at all, simply a tinned 'termination band' at each end to reduce the ESL. They are generally known as'chip' capacitors.

Dielectric Absorption is a characteristic of dielectrics which determines the length of time a capacitor takes to deliver the total amount of its stored energy. DA is also known as Dielectric Hysteresis. It can be determined by measuring the voltage across an already-charged capacitor after it has been shorted for an interval of between two and 10 seconds. DA can be represented, or 'modelled', as an RC network (where R is a very high resistance) in parallel with the main capacitor. The DA of a capacitor can have an effect on low frequency signals passed through it. DA is measured by charging a capacitor with a set voltage for a specific period of time (greater than one minute), shorting it for a period of one to 10 seconds, then allowing it to recover for a fixed period of time (one min. to 10 mins). The ratio of the final-to-initial voltage gives the value of dielectric absorption.

Dielectric Constant is defined as the ratio of the capacitance of a capacitor with the given dielectric to that of the same capacitor with air for its dielectric. It's also known as Permittivity. The value varies with frequency, some dielectrics showing greater variation than others, effectively reducing the capacitance at increasing frequencies.

Dielectric loss is a hysteresis effect within the dielectric. Power is dissipated by the dielectric as the friction of its molecules opposes the molecular motion produced by an applied ac field. It is the cause of most of the loss in plastic film capacitors at high frequencies as dielectrics do not change polarity without losses.

Dissipation Factor can be defined as the ratio of energy lost in a capacitor's dielectric to the energy stored per cycle. It's a measure of the deviation of the capacitor from an ideal capacitor. Dissipation factor can also be expressed as the ratio of the permittivity of the dielectric to its conductivity. It is a parameter which depends on temperature and frequency, usually increasing with increasing frequency or increased capacitance.

$$D = \frac{\text{energy in} - \text{energy out}}{\text{energy out}}$$

Dissipation factor is usually given as a percentage e.g: 0.05 DF = 5%.

Temperature Coefficient is the average rate of capacitance change with respect to temperature, over a specified temperature range, and is normally expressed in parts per million per Kelvin (absolute scale) degree or per Celsius degree. Normally it is referred to a reference value of capacitance at 25 +/- 10 degrees C

The above is a brief description on capacitor faults. In reality they are far more complex than this summary indicates and warrant an article all their own.

Categories

Capacitors are characterised and recognised by the category of the dielectric employed. There are some ten identifiable categories; here they are, listed alphabetically:

Air
Ceramic (porcelain)
Electrolytic
Glass
Mica
Paper
Plastic
Polymer
Tantalum
Vacuum

Of this list, the most widely used capacitors in electronics fall into just five of the categories: ceramic, electrolytic, paper, plastic and tantalum.

Air and vacuum dielectric fixed capacitors are quite specialised, often used in high voltage applications. Mica capacitors, once widely used, have been largely supplanted by plastic and ceramic types, while glass capacitors are now quite rare for much the same reason. Polymer capacitors are very new, but look like supplanting tantalums in some applications in the future, but their current high cost does not justify their widespread use as yet.

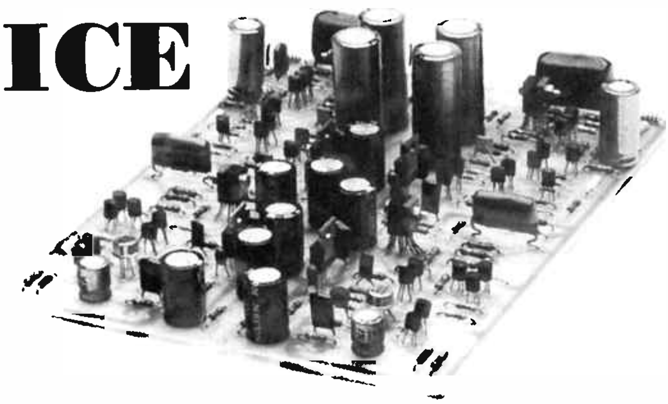
I'll deal with electrolytics and tantalums firstly, for that seems a good place to start.

The electrolytic

The electrolytic capacitor has gained an exceptional position among the numerous types of capacitor types due to their low price and high capacitance values in a component of small physical volume.

Electrolytic capacitors depend on a convenient property of the oxides of certain metals and that is they act as a non-conductor in one direction only. This property can be ex- ▶

AEM KIT CONSTRUCTION SERVICE



You'd like to have the AEM6000 audio system but feel you haven't the expertise to build it or simply don't have the time?

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Under the supervision of the designer, David Tilbrook, your kit can be built, tested and a comprehensive set of measured specifications supplied. What you will get is a custom-built, top-line audio system, professionally handmade and ready to use.

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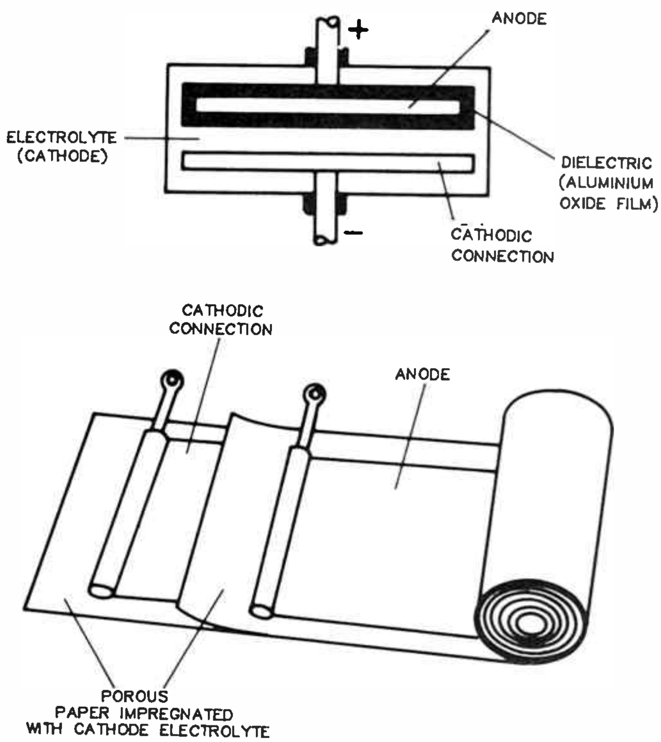
ploited to form a dielectric on a metal film or plate. Aluminium and tantalum are the two metals primarily employed. A thin film of oxide is electrolytically deposited on a thin foil of the metal. The thinness of the oxide film and its high dielectric constant results in a high capacitance per unit volume.

The electrolytic capacitor consists of two electrically conducting layers with a dielectric in between. The main difference between electrolytic capacitors and other types is the conductive liquid forming one electrode, instead of the normally used metal layer.

Aluminium electrolytic capacitors are manufactured by the foil winding method. The first step is the forming of a layer of aluminium dioxide by electro chemical processing. The thickness of this layer is proportional to the forming voltage. This process is called anodic oxidation.

For safety reasons the forming voltage is higher than the peak voltage of the capacitor. The thickness of the dioxide layer is approximately 1.2 NM/volt

The foil used in the manufacture of aluminium is usually etched, this process increases the effective surface area by



General principle of the electrolytic capacitor and typical construction.

15 to 300 times giving a resultant increase in capacitance for a given case size.

The negative electrode is a liquid eloctrolyte impregnated in paper. This paper also acts as a spacer between the positive foil carry the dielectric layer and the negative foil.

This "sandwich" is ruled into a winding impregnated with electrolyte (the positive lead welded on, the negative lead is usually connected to the case) encapsulated in an aluminium case and sealed.

Owing to a let-down on delivery of the manuscript for this feature, we have had to hold over the bulk of the article until next issue.

Sony release a CD 'Walkman'

From the company that brought you the 'Walkman' portable cassette player, and the innovators that produced the world's smallest portable compact disc player, comes the Sony D50-MKII, an even further miniaturized CD player incorporating newly-designed anti-rolling mechanism and penlight battery operation that can be used virtually anywhere, like the Walkman.

Dubbed the 'Discman', it has all the features of the original D50 unit with automatic music sensor, two-speed search function and versatile music repeat, plus added features. You can now hear up to 16 selections in any order you like with the 'random music sensor', or if you are tired of your tunes in the same order, you can use the new 'shuffle play' feature.

The Discman is 40% smaller and 15% lighter than the previous model and measures 125.9 mm square and a slim 27 mm in thickness.

The unit comes equipped with a super-thin rechargeable battery pack that snaps securely to the player, giving 4½ hours playback on a single charge, Sony says. An ac charger pack is supplied.

An optional battery unit can be obtained which replaces the rechargeable battery pack and takes eight AA penlight batteries — for those extended periods away from a suitable power source, e.g: camping, picnics, etc.

An ac adaptor and connection cord are supplied to instantly connect to any home sound system, from a component hi-fi to a radio/cassette recorder.

Other features include a safety function which automatically shuts off the power when the lid is open or when there is no disc inside the player, feather-touch operation controls, headphone volume control and auto power-off function to prevent unnecessary battery wear.

Further information from **Garry Beauchamp Sony, Australia) Pty Ltd, 33-39 Talavera Road, North Ryde 2113 NSW. (02) 887 6666.**

Sharp car audio from Dick Smith

Sharp has granted Dick Smith Electronics nationwide exclusive distribution rights to the company's new line of car audio components and DSE aim to take on the current market leaders.

Each of the new Sharp range of components is competitively priced, according to DSE, starting with the $349 RG-375G(BK) radio/cassette which offers three-band reception, Dolby-B noise reduction and a five-band graphic equaliser.

Next in the line-up is the RG-700AM stereo AM/FM-cassette deck with Dolby-B noise reduction and digital display for just $399.

The top of the line is Sharp's RG-675G which combines AM/FM tuner, five-band graphic, digital dial and an infra-red remote control which gives total deck operation, even from the back seat — all for $599.

A range of car speaker units is also offered. Full details from your nearest DSE store or from **PO Box 321, North Ryde 2113 NSW. (02) 888 3200.**

Tannoy speakers now here

A selected range of speakers from the British company Tannoy, led by two models which are making their worldwide debut, are now available in Australia.

Australian distributor Regent Audio, the Consumer Products Division of Broadcast & Communications Ltd (BCL), announced that this range represents Tannoy speakers which are well known in the professional recording world for their high quality sound reproduction.

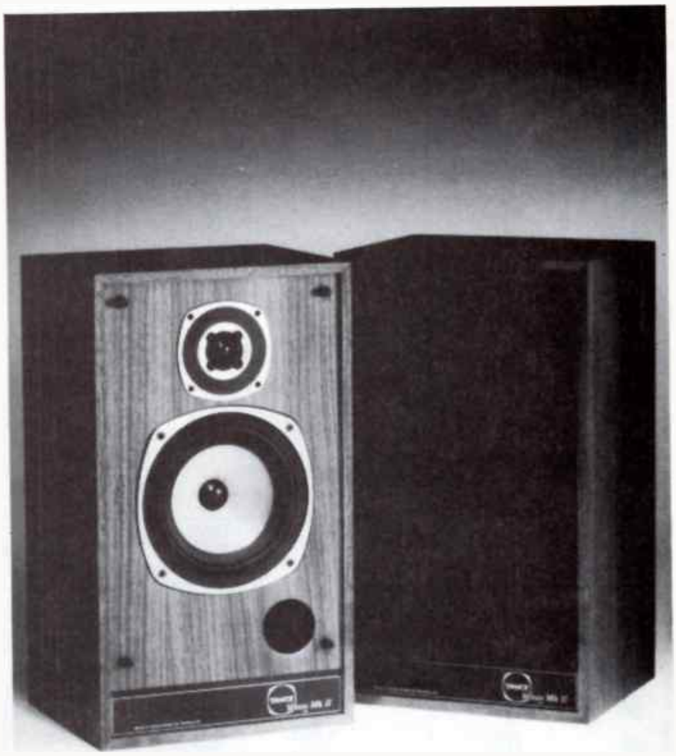
The six models being launched range from $399 for their 'Titan', to $1199 for both the Venus Mk II and the newly introduced D-200. Other models, ranging up to $11 000 can be ordered upon request.

The DC-200 is making its debut along with Model DC-100, and Australia is one of the first countries where these dual-concentric speakers are being launched.

Tannoy is well known as the developer as many new technologies, including dual-concentric loudspeakers. This involves the unique concept of mounting the tweeter and woofer-midrange drive units on the same axis, one cone behind the centre of the other.

Tannoy's dual-concentric speakers employ circuitry that aligns the apparent HF and LF sources at one point along their common axis. The result, Tannoy claim, is a single point source loudspeaker that eliminates unnatural time delays and provides the smooth, consistent intensity of sound necessary to create a precise stereo image.

For further information contact **Margot Pickering, Regent Audio, 16 Suakin St, Pymble 2073 NSW. (02) 449 5666.**



Welcome to the 1986 PERTH Electronics Show

Make your plans to attend Today!

It's the most important Electrical and Electronic Event in 1986.

P.E.S., the most complete Consumer Electronics Show in Australia. You'll be able to view and preview the latest in home and car audio, home and portable video, personal computer hardware and software, personal electronics, photographic, satellite earth stations, home and kitchen appliances, white goods, brown goods and much, much more.
With over 200 companies represented, it's an ideal time to plan your Christmas buying!

SPECIAL AIRFARE & ACCOMMODATION ARRANGEMENTS

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Exclusive Trade and Media Only Day Wednesday, July, 30th

- Opening Ceremony and luncheon 11.30am to 1.15pm.
- Trade admitted from 1.30pm until 8pm. By invitation or by suitable identification. Free admission to bona fide members of the industry and media, aged 18 years and over.

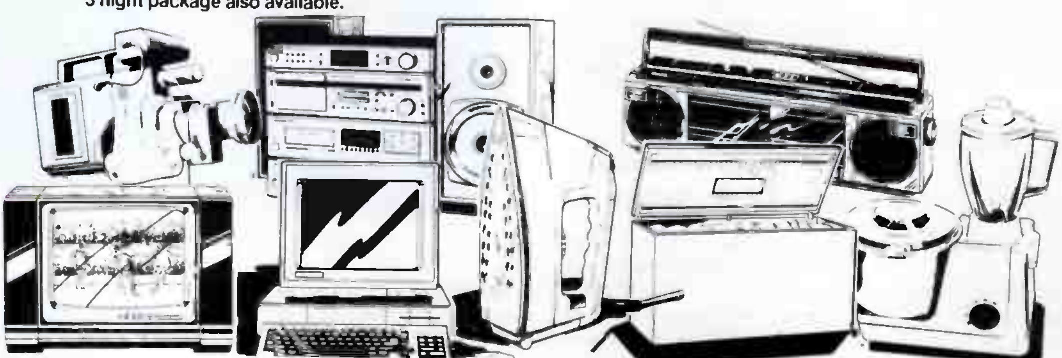
PUBLIC ENTRY. Thursday, July 31st — Sunday, August 3rd.

TRADE CONFERENCES AND SEMINARS MEETING ROOMS.

This year's seminars will cover a wider range of topics — full programme to be published later.
Separate meeting and conference areas are also available on request.

LOCAL RETAILER INVOLVEMENT

W.A. retailers will be encouraged to mount electronic show window displays. Starter kits will be issued, free of charge, upon request from exhibitors, who can then distribute to their retailers.



All bookings and enquiries must be made through the offices of Jebsens Travel P/L.
4th Floor, 231 Miller Street,
North Sydney, NSW 2060
Telex 70284 JEBRED. Telephone (02) 922 4300

For further information on the Perth Electronic Show contact The Manager, Chris Gulland.
Perth Electronic Show
PO Box 745
West Perth 6005
Telex 92952. Telephone (09) 382 3122

Perth Show — the industry girds its loins for battle

Following a severe slump in sales this past year in virtually all sectors of the consumer electronics market, it seems the industry is preparing the way to battle back the ground lost.

Some industry observers say consumers have been unsettled by the series of price hikes made necessary by the fall of our dollar with respect to most currencies, particularly against the Yen.

Despite something of a shakeout in the video market over the year, the Consumer Electronics Suppliers Association report strong, though unspectacular growth, forecasting a market penetration of 56% by the end of 1986. Over half a million VCRs, valued at $445 million, were sold in Australia over 1985-86.

CESA's Television and Video Products Group Chairman, Mike O'Neill (from AWA-Mitsubishi) said, "The steady increase in the popularity and sales of VCRs is paralleled by a growing stability in annual television sales."

In an interview, he told us that camcorders and the new hi-fi video machines have stimulated extra sales. The growth in hi-fi video machines is expected to contribute some 85,000 unit sales this coming year, he said. Such machines are sold primarily to consumers updating from a much older machine and to audio enthusiasts to whom the video function is secondary. O'Neill thinks this will create spin-off sales of audio systems.

At this year's Perth Show, though, it seems the real battle will be between the 8 mm and VHS-C formats. Sony is set to launch at least one new model, while JVC fires salvos from an ever-strengthening position. We expect them to make great play of the 'why change format' argument to win points. Could be interesting.

On the audio side, CD remains the darling of the marketplace, with continued growth and a steady release of new models from existing makers as well as the odd new name. Sony made much of their D-50 portable at last year's show, also introducing a CD 'ghettoblaster'. Philips joined battle with them, also releasing a portable and ghettoblaster. A flurry of new CD equipment releases is expected this year, aimed at new niches in the market — if any can be found.

The aftermarket CD accessories are beginning to appear in quantity, riding on the back of the CD boom, providing a little cream for retailers where competition is tough and margins slim.

With the demands of the digital sound era, we can expect to see great activity among the loudspeaker purveyors this year. Never a firm to stand still for long, if at all, B&W has developed a new means of controlling loudspeaker enclosures using an internal matrix of high density particle board.

The matrix 'cells' are filled with acoustic foam and the bass driver virtually 'sees' an almost truly anechoic chamber, B&W claim. Appropriately, they've dubbed their new digital monitors 'Matrix'.

Geoff Mathews of Convoy, who distribute B&W here, told us they hoped to demonstrate B&W's new Matrix speakers at the show.

Scan Audio, who've been successfully marketing the AEM6000-series speakers this past year, will have new Scan-Speak and Dynaudio products to show, along with the AEM speakers.

Satellite TV made a strong showing at last year's show, with AUSSAT TVRO gear heavily promoted — AWA-Thorn leading the field. But this year, the TV set might get the gong as a rash of digital TVs with all sorts of 'high-tech' features have been released overseas and we should expect to see some preview product here.

According to the organisers, bookings for this year's show are up once again, for the eighth year in succession. Last year they introduced a series of trade seminars, which had great impact. This year, seminars on CD will be delivered by Ian Withers from Philips Australia and Hideki Ishii from Kenwood, Japan, while Sony's Michael Hart will talk on 8 mm video.

ANNOUNCEMENT

Shortly, we will be making major changes to *Australian Electronics Monthly.*

In the past, electronics magazines in Australia have promised 'bigger/brighter/better' things to come, but have never quite matched the performance with the promise.

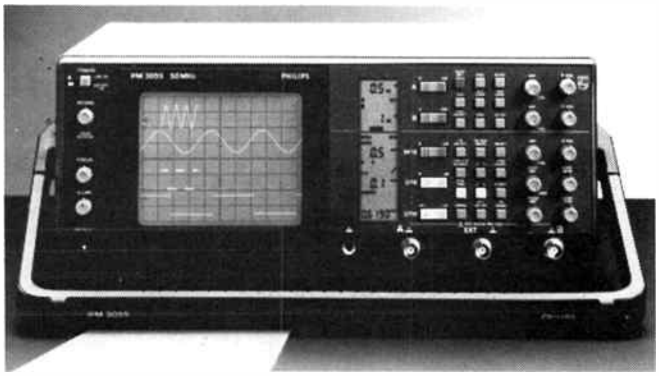
But not us.

For starters, we are going to significantly expand our project content — like *double*, would you believe?

Interested? Like to find out more?

STAY TUNED. SAME TIME, THIS MAGAZINE, NEXT MONTH

Philips take radical steps in new 50 MHz CRO range



Philips' new family of 50 MHz oscilloscopes use the latest instrument technology to combine a big step forward in features and ease of operation with a dramatically reduced price level, the company claims.

Most striking external feature of the PM 3050 family oscilloscopes is the all-new front panel concept. Designed to simplify and rationalize operation, this panel design incorporates a liquid crystal display to indicate menus, insturment status and settings, up/down rocker controls instead of traditional rotary switches, and multifunction softkeys to reduce the overall number of controls on the front panel.

The front panel operates in the same sequence as reading a book: from left to right, and from top to bottom. All control operations take place under microprocessor control.

An 'autoset' key, already an established feature of Philips' high-frequency oscilloscopes, is also incorporated. This automatically optimizes oscilloscope settings for amplitude, timebase and triggering to bring any connected signal in range. The signal then appears on the display without the need for the normal time-consuming manual settings.

The 8 x 10 cm CRT features a parrallax-free graticule with variable illumination. Vertical sensitivity is variable between 2 mV/div. to 10 V/div. With worst-case rise time of >10 ns/div. Timebase speeds range from 50 ns to 0.5 s.

Philips has adopted a completely new manufacturing approach for the new range. The chassis is a single injection moulding made of an engineering-grade plastic material, and incorporating all the required provisions for mounting internal units and options. This technique saves assembly time and costs, and provides a very sturdy and rigid unit, Philips claim. All major components of the oscilloscopes are modular, to allow fast field service and replacement.

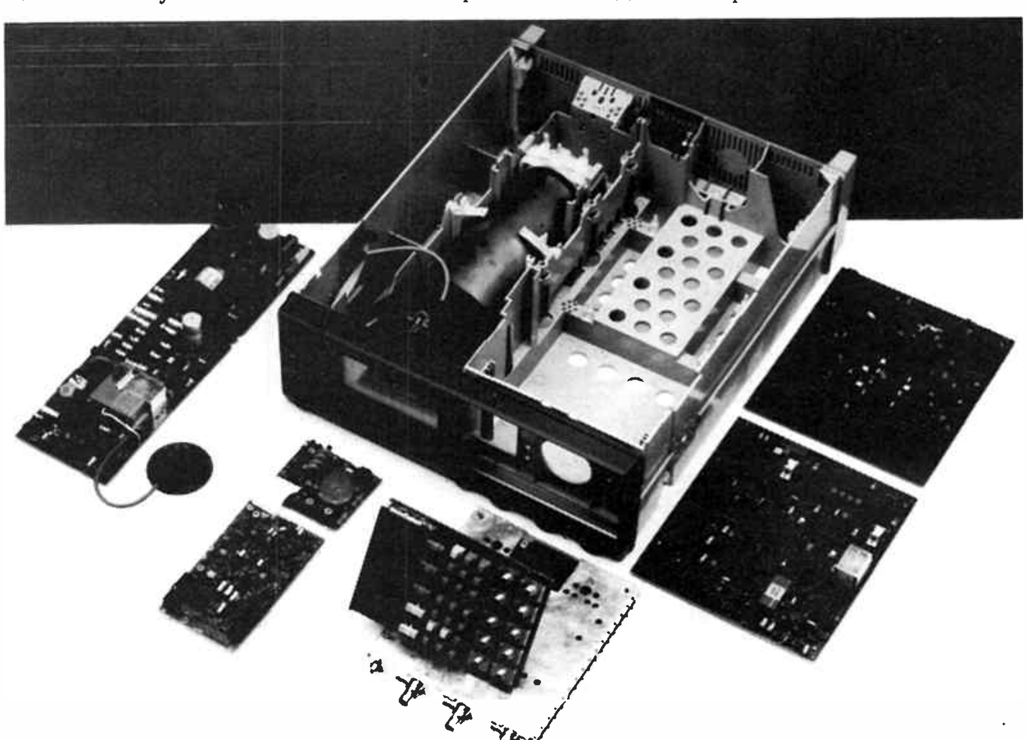
The basic PM 3050 is the starting point for a complete family of oscilloscopes, comprising a wide selection of variants and options to meet a very broad range of user requirements.

The oscilloscope itself is available with single- and dual-timebases, and in regular and rack-mounting versions. A special transportable model for field use will be added to the range later.

A significant option is a separate, external IEEE interface box which can be connected whenever required. As well as enabling operation in automated system environments, this option allows for automatic calibration using an external computerised system.

A built-in automatic checking routine provides a sequence of tests to exercise all major scope functions, with standard on-screen displays to indicate correct performance.

With this new family of 50 MHz CROs, Philips aim to win a big share of the 50 MHz scopes market.



Fairchild extends FAST line with 15 ns PLAs

Fairchild Semiconductor has added Programmable Logic Arrays to its FAST (Fairchild Advanced Schottky TTL) logic family with a series of vertical fuse devices featuring propagation delay times as fast as 15 nanoseconds and 50 MHz clock frequency.

Called FASTPLA, the series is designed to extend the popular FAST standard logic family and is fully compatible with industry standard medium 20-pin PAL(R) devices, according to Art Swift, Product Planning Manager.

Four device types are immediately available, with 13 additional devices planned for introduction by the end of 1986. "These devices are the first of an extended family of programmable products that eventually ▶

will include new architecture and alternative technologies such as ECL," Swift said.

The series includes programmable output polarity so designs can be configured for active high or active low output versions. Power-up reset and tristate devices are also featured. At power-on, outputs remain in the high impedance state until dc power supply conditions are met. Maximum supply current for the new devices is 180 milliamps.

Using a combination of FAST Standard Logic and FASTPLA, instead of Low-Power Schottky TTL, can reduce circuit complexity, signals required and parts count, and can eliminate a wait state in microprocessor-based systems, according to Swift.

For more information, contact **Fairchild Australia Pty Ltd, 366 Whitehorse Road, Nunawading, 3131 Vic. (03) 877 5444.**

Surface-mount HP Schottky diodes

A new series of Schottky diodes from Hewlett-Packard, HSMS-2800/2810/2820, is designed for analogue and digital application requiring devices in the SOT-23 surface-mount package.

These new components come in two single- and three dual-diode pin configurations, designed expressly to be electrically equivalent to HP's existing family of glass-packaged Schottkys diodes, 5082-2800/10/35. This will aid current users of HP devices to convert to surface-mount manufacturing technology.

Typical applications of these diodes include mixing, detecting, switching, gating, sampling and wave shaping. For further information, contact **VSI Electronics (Aust) Pty Ltd, 16 Dickson Avenue, Artarmon 2064 NSW. (02) 439 8622.**

After Chernobyl, you need this . . .

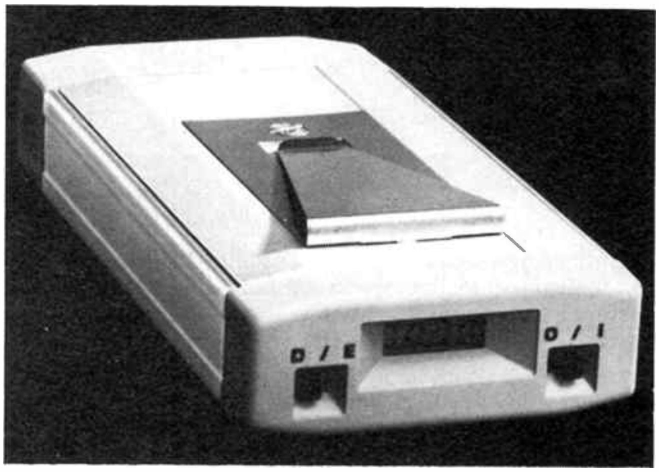
Philips' PW4514 Pocket Radiation Monitor is a compact, battery-operated unit for personal use that detects gamma and x-ray radiation, computing exposure rates ranging from 0.1 to 999 milli-Rontgens/hour and accumulated dosages ranging from 0.1 to 999.9 mrad.

It incorporates a 4-digit liquid crystal display with 4.8 mm high characters viewed through a recessed 'window' in the end of the case. An audible alarm is incorporated to warn of the radiation exposure in excess of a preset level.

The PW4514 employs an end-window Geiger-Muller tube, mounted in the end opposite the display, and is powered from four pen-light or equivalent rechargeable cells. It measures 153 x 78 x 28 mm and weighs 235 grams without the batteries.

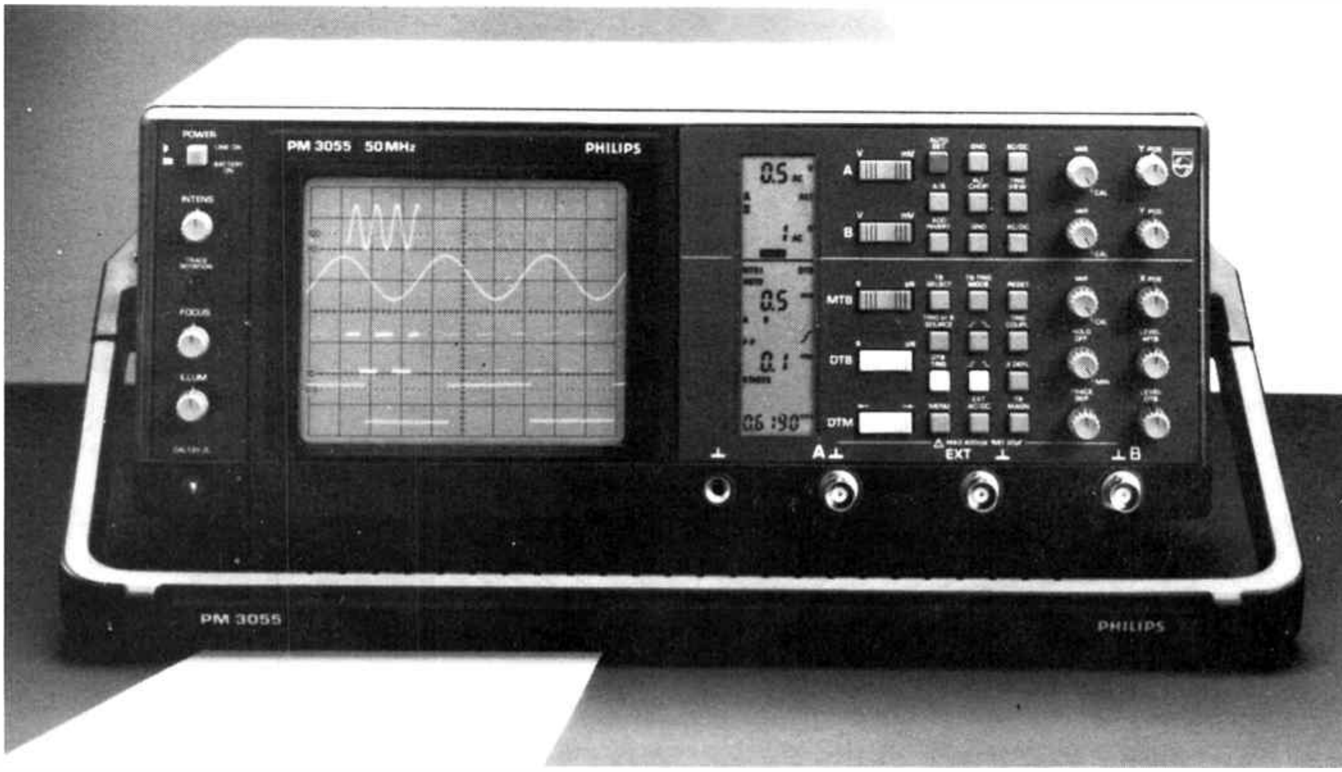
Looks like just the thing to take on your next European business trip or South Pacific holiday (while the Russians are in trouble, we needn't let the French off, either!)

Full details are available from **Philips Scientific, 25-27 Paul St, North Ryde NSW 2138 NSW. (02) 888 8222.**



1ST BIRTHDAY CONTEST No. 2.

Win this new generation Philips microprocessor-controlled 50 MHz dual-trace CRO, model PM3050.



Here's a fabulous opportunity to own one of the world's most sophisticated 50 MHz dual-trace CROs featuring an all-new concept in front panel design. It incorporates a liquid crystal display to indicate instrument status and settings, up/down rocker controls instead of the traditional rotary switches, and multi-function 'softkeys' to reduce the overall number of controls. And you operate it as you would read a book: from left to right, and from top to bottom. An 'autoset' key automatically optimises settings for trace amplitude, plus timebase speed and triggering, to bring any connected signal in range and provide a usable display without the usual time-consuming manual settings.

The 8 × 10 cm CRT features a parallax-free graticule with variable illumination. Vertical sensitivity is variable betwen 2 mV/div. to 10 V/div. Timebase speeds range from a fast 50 ns to a slow 0.5 s. The chassis comprises a single injection moulding of engineering-grade plastic material, providing a very sturdy instrument. All major component assemblies are modular to allow fast field service or replacement.

Prize kindly donated by Philips Scientific & Industrial, PO Box 119, North Ryde 2113 NSW.

1ST BIRTHDAY CONTEST No. 2.

Q1: Who first described ". . . a method for the demonstration and study of currents varying with time", and in what year?

. . . .

Q2: The earliest attempt at constructing a linear sawtooth timebase is attributed to R. St. G. Anson in 1924 who employed a neon tube, but it suffered from slow sweep times and poor linearity. The development of the 'hard valve' timebase six years later paved the way for rapid development of the modern oscilloscope. Who developed it?

. . . .

Q3: In the PM3050 specifications, what is the worst-case rise time of the vertical amplifiers?

. . . .

Q4: The addition of a 'significant option' to the PM3050 permits operation in an automated system, including automated calibration. What is this option?

. . . .

Now tell us, in 30 words or less, on a separate sheet of paper, what features of the PM3050 most attract you (and we haven't listed them all here!).

Name . . . .

Address . . . .

. . . . **Postcode** . . . .

I have read the rules of the contest and agree to abide by their conditions.

Signed: . . . .

*The Contest Rules are set out on page 6 of this issue.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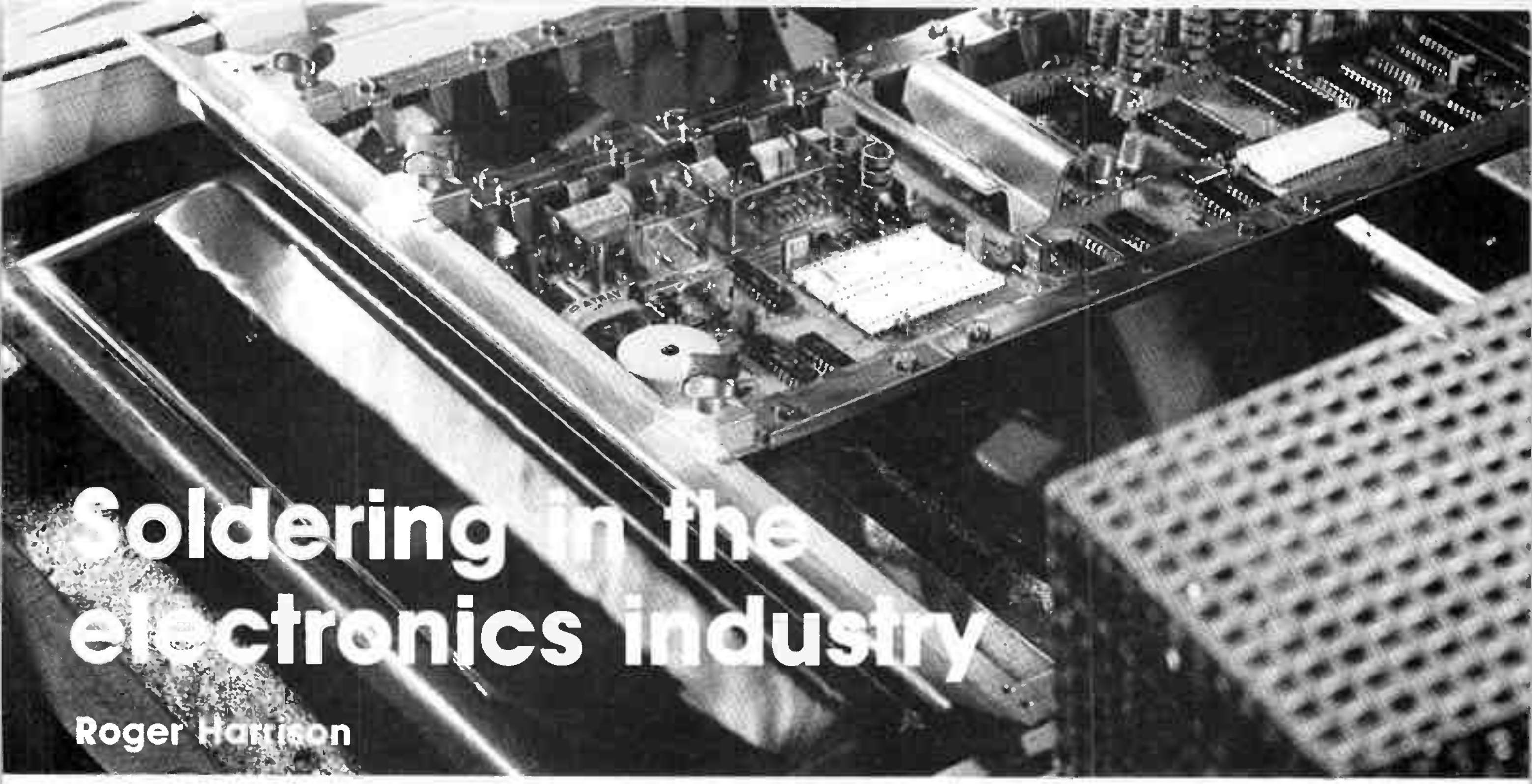


Soldering in the electronics industry

Roger Harrison

Soldering is fundamental to electronics, be it 'on the kitchen table', on the R&D lab. bench or in the factory production line. Methods employed in the industry range from the familiar hand soldering through automated or semi-automated processes. Here's an overview of the technology and techniques employed within the electronics industry today.

SOLDER PROVIDES a means of making inter-metallic contact and a mechanical bond between component connections and circuit wiring in electronic equipment. Soldered joints have been employed in electronic assembly since the 1920s. Almost everybody involved in electronics takes solder and soldering pretty well 'for granted'. It was the rise of the broadcast industry between the two world wars that gave the impetus to manufacturing of electronic (then 'radio') equipment on a large scale. The development of the electrically-heated soldering iron, claimed by the West German firm Ersa who first applied for a patent in 1921, fuelled the tremendous growth of electronic manufacturing and hand soldering irons became the tool that introduced a mini industrial revolution within the then-declining industrial revolution.

The development of printed circuit (or 'printed wiring') boards by Eisler in the U.K. in 1943 brought a measure of automation to electronic equipment assembly as they did away with the linking of components by point-to-point wiring, producing the interconnections in their final form with a single fabrication step.

In 1949, Danko and Abramson of the US Army Signal Corps developed 'dip soldering', which permitted automated soldering of componentry on printed circuit boards. These two developments paved the way for a second revolution in electronics manufacture, laying the foundations of today's industry which now influences almost every facet of our life and work.

Hand soldering, however, still occupies an important niche in the electronics industry, alongside the automated methods now widely employed, so let us examine 'first things first'.

Hand soldering

Soldering components and/or wiring by hand is still very much a necessary operation in a wide variety of circumstances. Electrically-heated irons predominate, though some gas-heated irons are employed in certain situations. Examples include use with sensitive circuitry in-situ where charge leakage from the iron's power supply may cause damage (battey-operated irons are also used for this) or the joining or repair of cables and connectors in the field where a current supply is not available and prolonged use precludes employing a battery powered iron.

Hand soldering is widely used in developmental work, limited-run production assembly, production testing and fault repair ('re-working'), servicing and maintenance. Continuous-heat and 'quick-heat' irons once predominated, but temperature-controlled irons are making rapid inroads in all areas.

Temperature-controlled irons offer significant advantages, providing rapid initial heat-up, better heat transfer to the joint, markedly decreased possibility of damage to fragile components and improved tip life. A wide variety are made and marketed, ranging from relatively simple mains-powered fixed temperature types to microprocessor controlled, temperature variable types featuring digital tip temperature display. Many have interchangeable tips to suit varying applications.

When the iron tip is first applied to a joint, heat is conducted away by the parts of the joint and the tip temperature tends to drop. In irons without tip temperature control, the tip is normally run at such a temperature that this drop does not allow the tip temperature to fall nearthe solder's plastic temperature range below 190 degrees C with the range of joint heat capacities normally encountered.

But this often means the tip temperature is too high for fine joints, with the constant risk of overheating and damaging components. Too much heat capacity, or too high a tip temperature, may result in damage to the components being joined. It will almost certainly render fluxing from flux-cored solder ineffective as the flux will be largely vaporised before ▶

it gets a chance to do its job of boiling-off oxides from the joint materials.

Conversely, with uncontrolled irons the tip may have insufficient heat capacity for some joints and will be unable to raise the joint's temperature sufficiently for soldering, thus possibly creating an unreliable 'cold' joint. These problems are readily solved through the use of a temperature-controlled iron.

Several techniques are employed to control the tip temperature. One of the simplest adopted, and widely used in Weller irons made by the Cooper Tools Group, exploits the 'Curie point temperature' of a magnet to turn the power on and off to the heating element. Figure 1 shows the general arrangement. The permanent magnet is attracted to the rear of the tip, closing the switch. Power is applied to the element which heats the tip. When the tip temperature reaches the Curie point of the magnet, the magnet loses its magnetism and the spring opens the switch. The tip then cools and, when the temperature drops below the Curie point, the cycle is repeated.

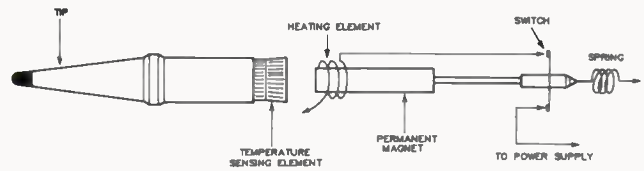


Figure 1. The 'Curie point temperature' iron tip temperature control system, widely employed in Weller temperature-controlled irons.

Tips are made to operate at different Curie temperatures and replaceable tips permit simple selection of the required tip temperature.

Naturally, there is some hysteresis in this system and the tip temperature 'cycles' over a small temperature range. Some applications require closer control of the tip temperature and electronic techniques are employed to sense tip temperature and control current to the iron heating element.

'Zero-crossing' power control is now widely employed to control heating element current.

SOLDER AND FLUXES IN ELECTRONICS

Solder is an alloy of tin and lead that melts at a temperature well below the melting point of either metal alone. A continuous intimate contact between the parts of a joint is created by the mechanical interlocking of the solder with the irregular texture of the metallic surfaces being joined.

Solder commonly employed in electronics comprises 60% tin and 40% lead and is known therefore as "60/40" solder. It melts at 188 degrees Celsius and is 'plastic' down to about 183 degrees C. As copper is absorbed by solder during the soldering process, from the metals being joined and especially from the iron tip, a widely-used solder alloy comprises 60% tin, 38% lead and 2% copper. Some solders contain a small percentage of silver, for use with plated conductors. A typical formulation comprises 62% tin, 36% lead and 2% silver. Low-temperature solders, specially formulated for servicing or re-work applications, are made with a melting point as low as 145 degrees C. Typically, such solder will comprise 50% tin, 33% lead and 17% cadmium.

Solder for automatic soldering machines is generally straight 60/40 solder or 60/38 with 2% copper.

Oxidation on the parts being joined, which prevents contact by the solder, is first removed with a 'flux'. This is usually composed of organic resin, made from the sap of pine trees, plus added 'activators' which decompose at soldering temperatures, releasing an acid that dissolves the oxides. Solder for hand soldering usually comes in 'wire' form, containing one or more 'cores' of flux. When applied to a heated joint, the flux melts ahead of the solder to do its preparation job on the joint parts. At soldering temperatures, the flux 'de-activates', preventing corrosion from residues.

In automated soldering, liquid flux is usually applied to the pc board being worked immediately before the soldering operation by means of a spray, a wave or by foaming.

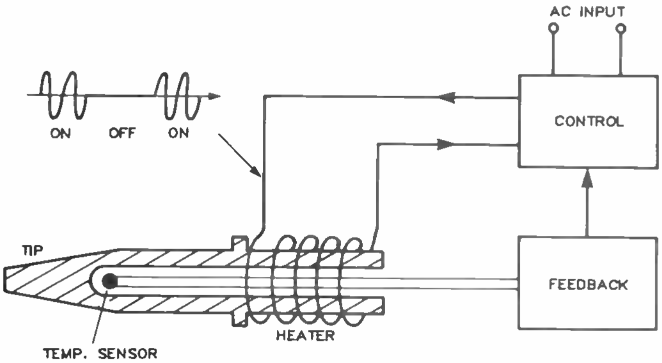


Figure 2. The 'zero-crossing' power control method employed to provide infinitely variable control of iron tip temperature without the spikes generated by other switch systems.

Figure 2 illustrates a commonly used technique. The tip temperature sensor, usually a thermistor or thermocouple, is coupled to a feedback circuit which provides a signal to the power control circuit. This will switch the power on for a given number of cycles and off for a given number of cycles to provide the required power to the iron's heater to maintain the tip at temperature. The control circuit only switches power on or off to the heater where the ac cycle passes through zero.

This technique provides close control of tip temperature and has the advantage that it does not generate any switching transients. Such transients, which are produced by switch-type temperature control techniques which can turn on or off at any part of the mains cycle, can be coupled by the iron into components being worked on. Some sensitive semiconductor devices employing MOS or FET construction technologies may be damaged by such transients under some circumstances.

Electronic temperature control of the tip will better maintain the tip within the required solder wetting temperature range, between 245 and 270 degrees C, during use. When the tip is applied to a joint of substantial heat capacity, the tip temperature will naturally drop, but the immediate and measured response of an electronic control system speeds tip temperature recovery time. This makes for more consistent joints, with repeatable results. In addition, the 'idling' temperature of the tip, typically as high as 500 degrees C for constant-power irons and around 380-420 degrees C for 'fixed temperature' irons, can be maintained much lower than in non-electronic control methods, as much as 50 degrees lower according to Royel. This reduces tip oxidation and wear, even with plated tips, reducing the frequency of replacement.

Figure 3 shows the construction of one type of temperature controlled iron, made by Royel. To maximise the rate of heat replacement into the tip, the thermal gradient between the heating element and the tip must be minimised. Royel employ a nickel ferrule to ensure metal-to-metal contact the length of the tip's shank.

Circuitry protection

As briefly mentioned earlier, there is a requirement to heed precautions necessary with semiconductors sensitive to damage by voltage or current transients. Voltage 'spikes' of quite low energy and voltage, induced via the iron tip applied to a joint in a circuit, even though the equipment is not powered-up, can destroy delicate MOS or FET input gates.

Likewise, 'leakage' of current from the iron's heater power supply, be it low voltage or the mains, can cause damage to sensitive semiconductors. Isolation of the iron's heater supply — by means of a well-insulated transformer secondary ▶

Scope recently released two closely-related versions of this locally-designed 60 W soldering station, one with floating earth. Both allow tip temperature selection from 200-470 degrees C, employing zero-crossing heater control.

— reduces the problem, but introduces another. With the iron tip and barrel effectively isolated, and with the use of plastic handles and cable sheaths, static charges can be readily built-up or transferred to the iron. An operator carrying a static charge will transfer charge to the iron which can then be conducted to the circuitry being worked on via the iron barrel and tip. Zappo! Write off a few semiconductors.

A number of measures are employed to eliminate this problem. The iron barrel and tip may be earthed 'remotely' via the supply and the mains — but that's not wholly reliable as it's totally dependent on effective mains wiring in the workplace. Some manufacturers provide a means of connecting a 'leakage resistance' between the tool and the operator via a high resistance bonding strap that attaches around the operator's wrist and connects to the iron barrel. This ensures any static charges are equalised and dissipated before any damage can be done.

Currents induced in the mains earth can create problems, too. Earthing the iron barrel and tip via a 'local' earth strap to the comon line of the circuit being worked on can obviate this problem, as well as the static discharge problem. Many manufacturers make provision for this in their soldering stations.

'En-masse' soldering

The soldering of hundreds of joints en-masse in a single operation has obvious manufacturing advantages. En-masse soldering of components mounted ('stuffed' is the industry terminology) on printed circuit boards was devised by Danko and Abramson of the US Army Signal Corpos in 1949 with their 'dip' soldering technique. The name is apt. The boards were literally dipped in a 'pot' of molten solder after being fluxed on the track side. Later, a conveyor system was devised to drag the track side of the boards across the top of a solder pot, providing more automation of the procedure. Hence the term, drag soldering.

In 1956, Strauss and Barnes of Fry's Metal Foundries in the UK developed the "flowsoldering" technique in which loaded pc boards are passed across a stationary 'wave' of molten solder, created by pumping it through a rectangular nozzle. It is now more widely known as wave soldering.

More recently, a variety of techniques have been devised to meet special needs, particularly with the introduction of surface-mounted devices (SMD). 'Re-flow' soldering is a technique becoming widely used. Solder is applied as a paste to the required areas, the components placed in position and the whole assembly heated in a chamber by means of gas flames, infrared radiant heat or a hot vapour.

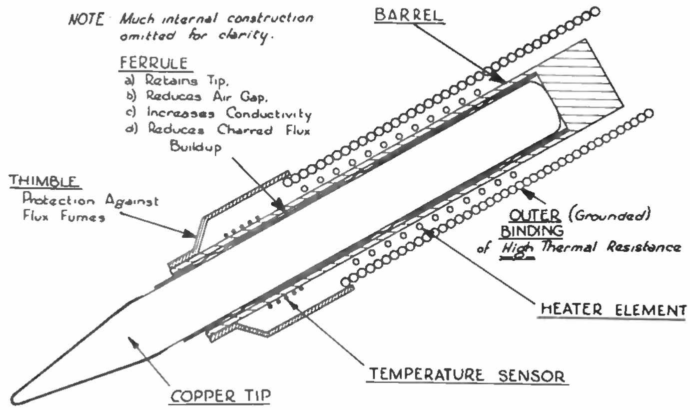


Figure 3. Cutaway view of the construction of a soldering tip which is employed in an electronic temperature control system. The sensor may be nickel or platinum. (Courtesy of Royel International Ltd).

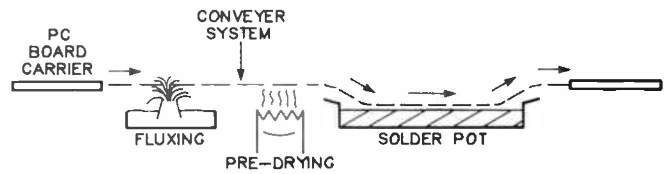
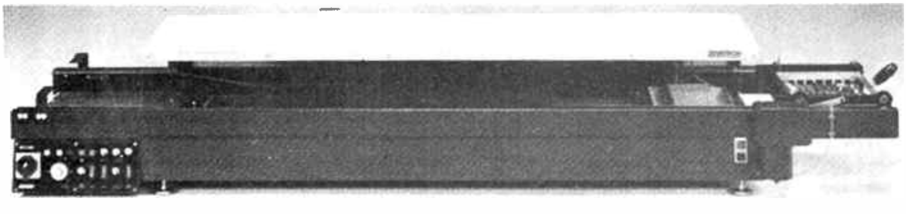


Figure 4. The drag soldering system.

Drag soldering

Modern drag soldering machines employ a three-stage process. Figure 4 illustrates. The stuffed boards are loaded on a carrier which passes them over a fluxing unit. This may ▶

Ersa's MS8000 soldering station, distributed by Meltec, features zero-crossing heater control, continuously variable temperature selection (with LCD readout) from 150 to 400 degrees C and easily exchanged bits. 'Potential equalisation' protection is provided.



This Zevatron bench-mounted unit is typical of small drag-soldering machines. Zevatron machines are distributed here by Alfatron.

apply the flux by means of a spray, by foaming or a continuous wave, all maintained by a continuous pump. It seems the favoured method these days is foam fluxing as it allows fine regulation of the flux deposit by controlling the amount of air in the foam. The conveyor then passes the boards over a pre-drying unit which heats the board to around 80 degrees C or so. This generally comprises an infra-red heater which evaporates the alcohol flux solvent and pre-heats the board, reducing thremal shock when it comes to soldering. The boards then pass through the solder bath, spending some two to four seconds in the bath depending on individual requirements.

As you would expect, the solder surface will oxidise and a 'dross' will form. This has to be swept away prior to passing a board through the bath and this is usually performed with a 'paddle' dragged periodically across the surface or immediately ahead of each board as it passes through.

Soldering time can be determined by varying the conveyor speed or the length of the drag through the bath. The solder in the bath is generally maintained at a temperature of around 240-250 degrees C. The angle at which the boards enter and leave the bath controls the formation of solder bridges between closely-spaced pads, as well as 'icicles' (pointed solder projections) on the soldered joints.

Drag soldering machines used in the industry range from bench mounted units costing several thousands of dollars, up to complete plants with microprocessor controlled operation and costing hundreds of thousands of dollars. The smaller machines are well within the financial reach of small electronics businesses and are even found in part-time 'sideline' businesses operated by one or two people.

They are largely used with boards employing leaded components where soldering is required on only one side.

Wave soldering

Wave soldering employs, fundamentally, a two-stage process, as can be seen in Figure 5. The stuffed printed circuit board is conveyed along a, usually inclined, linear track. It first

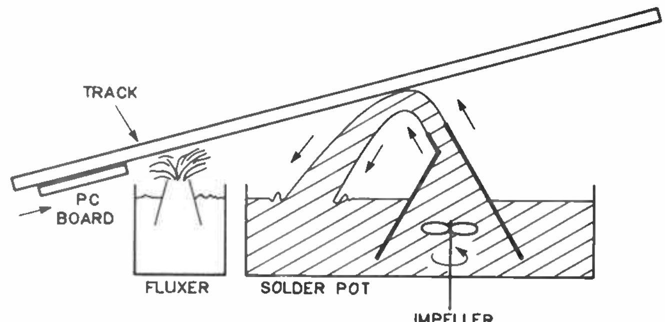
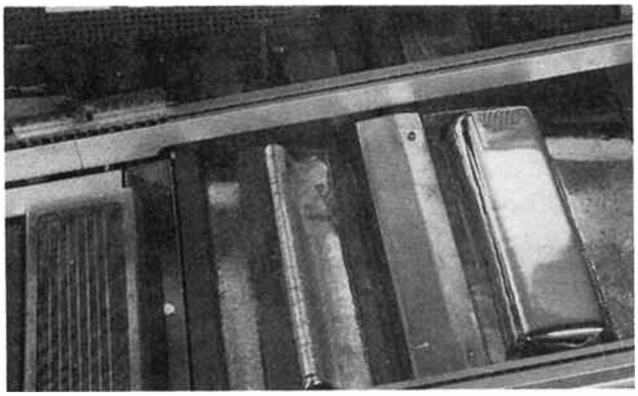


Figure 5. The wave soldering process.

▶

passes over a fluxer which, as in the drag soldering system, may apply the flux by a spray, foaming or a wave. From there it passes through the wave of molten solder, only the track side making contact with the solder. A pre-drying stage may be included, between the fluxer and solder pot, making it a three-stage process.

The wave of molten solder is created by pumping it up through a nozzle by means of an impeller immersed in the solder bath. The wave can take a variety of forms, as Figure 6 illustrates. This shows both single- and double-wave systems. With single-wave systems, the wave flow opposes the direction of movement of the pc board. With double-wave systems, waves flow in both directions. Each has its own advantages in particular circumstances, which I shall discuss shortly.



Inside view of a wave soldering machine. This is a double-wave unit. The pre-heat section may be seen on the left, followed in the centre by the first wave, with the larger second wave to the right. (Ersa photograph, courtesy of Meltec).

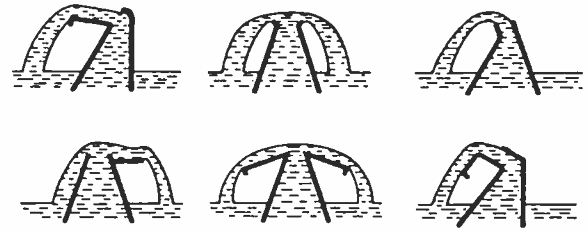


Figure 6. Showing various solder wave formations employed in wave soldering machines.

Wave soldering is particularly suited to soldering of double-sided, through-hole plated boards and boards incorporating surface-mount devices. The track which the board follows is tilted to allow the venting of gases produces during the soldering process, particularly from the flux employed.

In wave-soldering SMD boards, the SM devices are first glued in position, on the track side of the board. The board is passed through the wave, component side down. Where components may 'shadow' one another from the solder flow, and in densely-populated boards, double-wave systems ensure proper soldering of SM devices.

To reduce or eliminate solder icicles and bridging between closely-spaced SM component terminals or track pads, some manufacturers employ a double-wave system with the first wave contacted being a deep, turbulent wave claimed to ensure good wetting, and the following one a smooth, gently flowing laminar wave which removes excess solder and ensures proper joint formation.

Where pre-drying (or pre-heating) is employed, the board temperature is raised to about 70-90 degrees C before passing to the solder wave. Apart from aiding the flux action, this pre-heats the board, reducing thremal shock during the soldering process which may cause minute cracks in fine joints. The pre-dry/heat process may be done with fan-blown hot ▶

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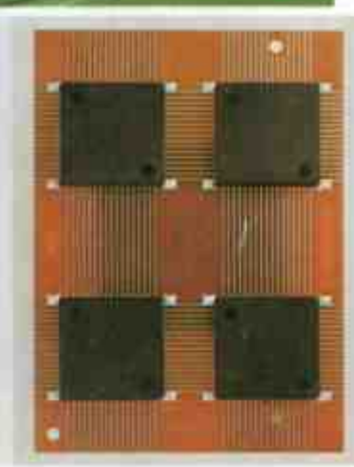

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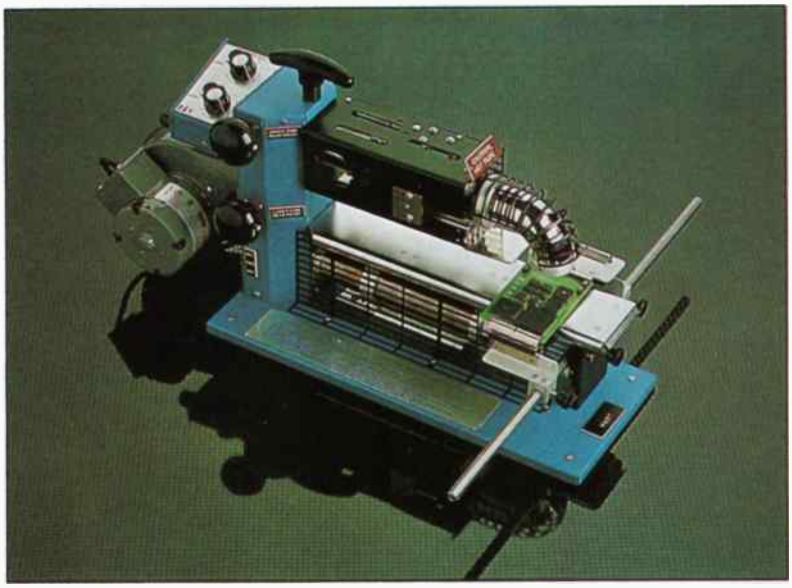
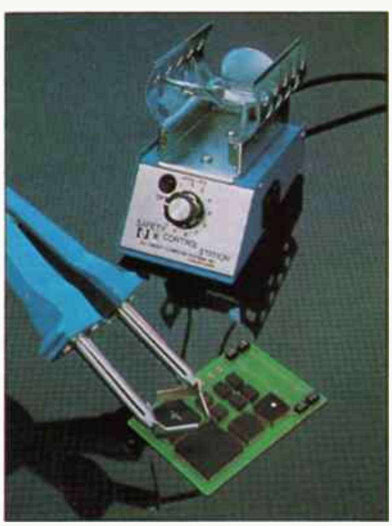


HART200 Series

Nu-Concept Systems, Inc. is the dominate supplier of equipment to the industry for surface mount removal and reattachment. Nu-Concept's principal product is the HART system (Hot Air Repair Terminal) which enables users to remove and reattach components to circuit boards. Temperature indicators assure the circuit board and components remain under 400°F during rework. The "HART" system works equally well on Dual-In-Line, Gate Array Technology and Surface Mount Prototyping.

HART200A (Hot Air Repair Terminal) is one of a family of quality products made by Nu-Concept Systems, Inc. which include. . .



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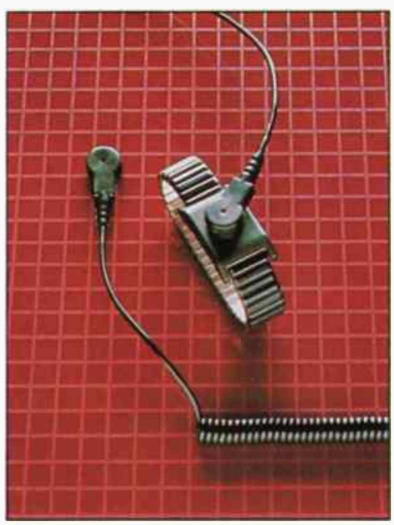

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Figure 7. The re-flow soldering process. (Courtesy Siemens).

air, electrically heated radiation plates, direct infrared radiation or a combination.

As mentioned earlier, foam, spray and wave fluxers may be employed. Each method has its advantages and disadvantages. The foam fluxer is non-critical to setup and operate and is widely used. It ensures good flux wetting in through-hole plated boards, but cannot be used with all types of flux. In continuous use applications, where the board-holding frames become warm, contact with the frame causes the foam wave to collapse, rendering the fluxing process ineffective.

Spray fluxing is suited to most fluxes and confines the flux to the underside of the board. The amount of flux applied can be apportioned much better than with the other methods. It is not suited to through-hole plated boards.

Wave fluxing can be used with any flux type and is unaffected by warm soldering frames. It provides good wetting with through-hole plated boards but applies rather more flux than the other methods.

Wave soldering machines, like drag soldering machines, range from small bench-mounted units costing several thousands of dollars, up to automated plants sold for hundreds of thousands of dollars. The smaller units are often seen in many small to medium sized electronics manufacturing businesses these days.

Infra-red re-flow soldering

'Re-flow' soldering is a technique specifically employed on boards using SM devices. A solder paste is screen-printed, stencilled or injected onto the board component pads. The components are then placed in position and held by the sticky solder paste. The assembled board is then heated to soldering temperature, 're-flowing' the solder which bonds the component terminals to the copper track pads.

The board is then passed through either a vertical or horizontal 'oven' in which large area, low intensity radiation panels generate a gentle, uniform heat. Heat absorption is not sensitive to the colour of the components and 'shadowing' by larged components is not a problem.

It is usual to pre-heat the boards for about one minute at around 90 degrees C, then raise the temperature over the following minute to soldering heat, followed by rapid cooling. peak temperatures during the soldering phase may be as high as 350-400 degrees C.

Infra-red re-flow soldering machines are generally very compact and can be fitted as a module in an automated assembly line.

Vapour phase soldering

This technique was developed in the USA and UK during the early '70s. It is particularly suited to soldering all-SMD boards, particularly where both sides of a multilayer board may be populated with components as the whole board may be soldered in single operation.

Re-flow soldering is employed in this technique, too. The solder paste is applied to the component terminal pads on the board first, then the components placed in position, held by the paste. The assembled board is then lowered into a tank constructed as shown in Figure 8.

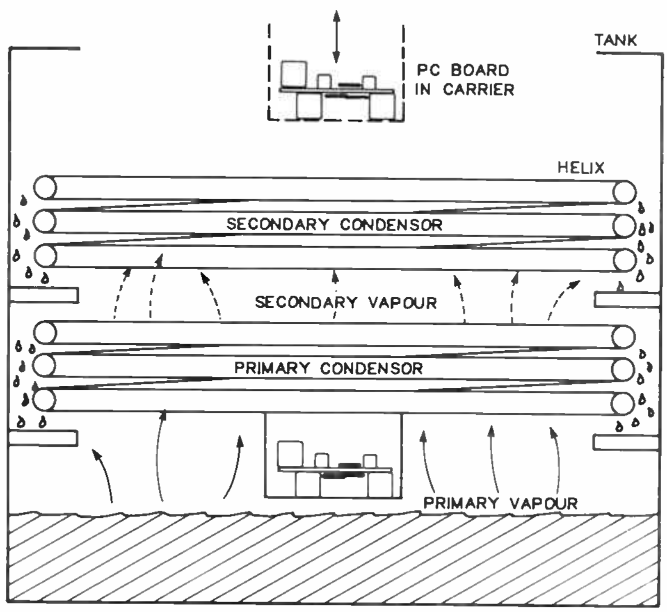
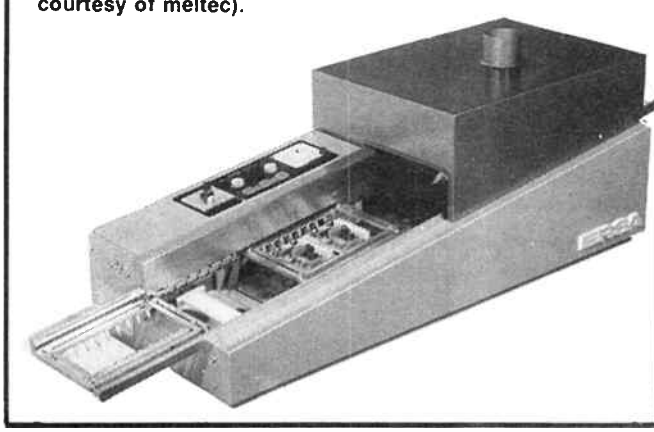


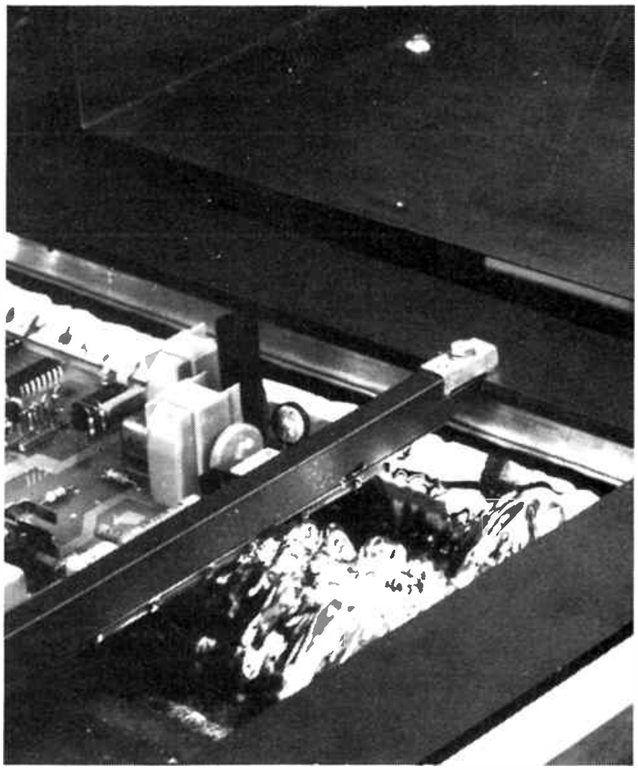
Figure 8. The vapour phase soldering process.

In the bottom of this tank is a liquid that boils at a temperature of around 210-220 degrees C. This liquid, the 'primary fluid', is a *perfluoropolyether* (PFPE) which exhibits such useful properties as: non-flammable, chemically inert, low volatility, low surface tension, oxidation resistance and good viscosity. PFPEs are available from several chemical companies under proprietary names such as 'Galden' (from the Moltedison Co.) and FC70 or FC71 (from 3M).

Two condensor helixes are mounted in the tank, one above the other, through which is passed a cooling liquid. The primary fluid is heated to produce a saturated vapour, the 'primary vapour'. This rises, and is cooled when it passes the primary condensor, some of the fluid condensing on the helix, to be passed back to the heated pool at the bottom of the tank. The secondary condensor cools the remaining ▶

A typical bench-mounted wave soldering machine. (Ersa, courtesy of meltec).





Showing a pc board passing over a turbulent wave in a wave soldering machine. Turbulent waves are said to improve solder wetting. A smooth wave follows, to complete the soldering process. (Zevatron picture, courtesy of Alfatron).

vapour, the 'secondary vapour' which is now at a much lower temperature, condensing the fluid which is passed back to the tank bottom also.

The assembled pc board is lowered on a basket, first into the secondary vapour zone where it is preheated, and then into the primary vapour zone which is at a temperature of around 220 degrees C. The hot vapour condenses onto the board, heat flowing from the fluid to the solder paste and component terminals, 're-flowing' the solder. The hot vapour is able to penetrate throughout the board and components, in even the most inaccessible places. This ensures uniform results, regardless of component density or layout. There is no excessive solder to cause bridging and the re-flowed solder bonds over the entire contact area.

The cooler secondary vapour confines the hot primary vapour, preventing it from boiling away too rapidly (PFPE is expensive!) and serving as a pre-heat zone.

As the boiling point of PFPEs can be readily defined and controlled, actual soldering temperatures can be acurately determined, virtually eliminating the chances of overheating.

Vapour phase re-flow soldering is a more expensive technique than drag, wave or infra-red re-flow soldering but comes into its own where the other methods fail, particularly where high component density SM boards are employed. The processing temperature can be held lower than that for infra-red because potential energy is stored in the latent heat of vapourization; the maximum temperature is that of the primary fluid. This can be very important when dealing with heat sensitive materials. Within the system there is an oxygen-free inert atmosphere which virtually eliminates oxidation during the soldering process. Thus, only small amounts of mild resin flux are required, greatly simplifying post-soldering cleaning of flux residues.

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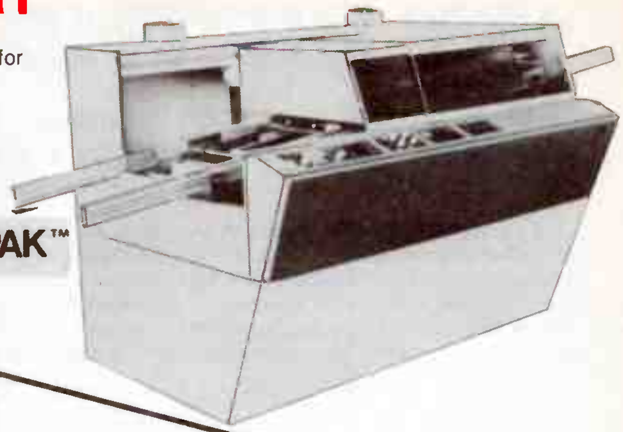

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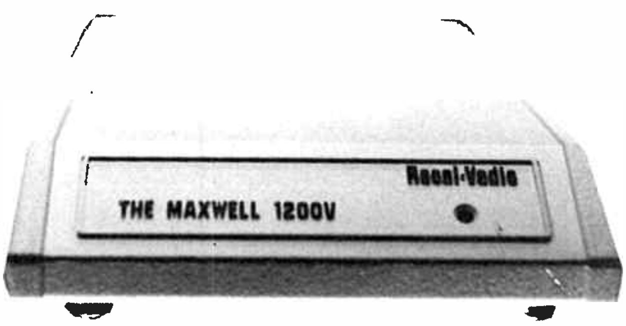
1ST BIRTHDAY CONTEST No. 3.

Win a Multitech 'Popular 500' System 1 from Dick Smith Electronics and a Racal-Vadic Maxwell Modem Model 1200V, full duplex 1200 baud modem.

Here's a fantastic opportunity to win a top-flight PC-compatible computer system from Australia's best-known electronics retailer, together with a high speed data communications modem from one of the world's leaders in data communications. Just answer these intriguing questions and write us a short essay on what you find most attractive about the prize package.



The Multitech System 1 prize kindly donated by Dick Smith Electronics, PO Box 321, North Ryde 2113 NSW. The Racal-Vadic Maxwell 1200V modem prize kindly supplied by Racal Electronics, Talavera Rd, North Ryde 2113 NSW.

The Multitech System 1 from DSE features a single 5.25" 360K disk drive, 256K RAM, multifunction card and colour video card with RGB output and 640 x 200 (mono) and 320 x 200 (four colour) pixel graphics resolution (monitor not included). The 84-key QWERTY keyboard features 10 function keys and a numeric keypad.

The Racal-Vadic Maxwell 1200V modem is a Hayes-compatible fully professional modem offering reliable high speed full duplex communications at 1200 baud over the switched telephone network. It's housed in a convenient small package that fits neatly under your 'phone.

1ST BIRTHDAY CONTEST No. 3.

Q1: A famous 19th century poet and the "princess of parallellograms" were closely associated. What were their names?

. . . .

Q2: What on earth has Q1 got to do with computing?

. . . .

. . . .

Q3: The word 'modem' is a contraction of two other words. Name them.

. . . .

Q4: Which disk operating system, and which version, is supplied with the System 1 Multitech?

. . . .

Q5: Racal modems intended for use on the public switched telephone network conform to a communications standard set down an international committee in which they are an active participant. Give the full title of that body.

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Now, on a separate sheet of paper, tell us in 30 words or less what you find most attractive about the prize package.

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**The Contest Rules are set out on page 6 of this issue.*

Microbee plug their '16-bit product hole'

Microbee Systems has released its first 16-bit personal computer, 'filling the hole' in their product line-up between the 8-bit Z80-based Premium Series and the upcoming 32-bit 68000-based Gamma. It's an IBM-compatible portable, made by Mitac, one of Taiwan's largest computer equipment manufacturers.

The launch came as a surprise, as it is radical in terms of Microbee's established 'Australian-made' policy, for one, and moves them into a much larger, and hotly contested, market niche than that which they already occupy with their existing products.

Microbee System's Chairman, Owen Hill, explained that the move was a strategic one, aimed at establishing links with the personal computer industry mainstream which has a 16-bit IBM-based machine architecture running PC/MS-DOS as its foundation. This strategy, he says, is entirely in keeping with their earlier decision to license and supply CP/M from Digital Research with disk-based Microbees.

The Microbee/Mitac is a little unusual as IBM compatibles go. For one, it sports a high degree of IBM compatibility using a BIOS licensed from the US-based Phoenix Software Associates, claimed to provide the closest software compatibility with the real thing. Secondly, it's a compact, portable design measuring a mere 340 x 420 x 70 mm, and weighing just 4.9 kg. You can choose to use either a standard monitor or an optional 80 x 25 liquid crystal display (to be released later this year).

The processor is an 80C88, the CMOS version of the 8088, running at 4.77 MHz. It comes with 256K of RAM as standard, expandable to 640K on-board.

Other features include a 5.25 inch disk drive in the side of the unit, a carrying handle, and a compact, 'IBM-type' keyboard. Input/output ports are IBM standard, both in how they are accessed by DOS and their gender. Two serial ports provide standard RS-232 I/O, it has a standard Centronics printer port and a mouse or joystick port. A battery-backed real-time clock and calendar is included.

The hardware also includes what is, effectively, an IBM Enhanced Graphics Card giving RGB colour video output. An expansion box will be available later this year, providing three full-length, IBM-compatible expansion slots. This box plugs into the side of the unit and has room for a further full-height hard disk or two half-height drives, or a half-height drive and a streaming-tape drive for back-up purposes.

Sales and service for the Microbee/Mitac will be through Microbee Technology Centres, in each state, except Tasmania, who will be stocking a range of standard MS-DOS software packages for it. These will be offered at competitive prices as has always been the company's policy, Microbee claim. Further details from your local Microbee Technology Centre.

— Jamye Harrison

CAD software advance announced

The development of a complete set of software tools for the computer aided design of electronic sub-systems from printed circuit board to custom Very Large Scale Integrated (VLSI) circuits potentially enables the Australian electronics industry to be at the forefront of the custom silicon chip revolution, according to the Minister for Industry, Technology & Commerce, Senator Button.

The development has been the result of a Government-funded Public Interest Project, involving the Department of Industry, Technology and Commerce in co-operation with the Joint Microelectronics Research Centre and Technisearch Ltd.

The software is substantially technology independent and targeted at companies requiring the capacity to design electronic sub-systems in printed circuit boards, hybrid, gate array, standard cell, or full custom chips.

Driving the AEM4504 low-cost speech synthesiser with your Commodore 64

Frank Rees
27 King St, Boort, Vic. 3537

Here's the hardware hookup and some simple software details to get this project 'talking' with your Commodore 64.

WITH SUCH A LOW PRICE advertised on kits for this project, published in the February '86 issue, it's at last economical for 'do-it-yourselfers' to explore speech synthesis with a Commodore 64. Interfacing it to the computer is simplicity itself, as the accompanying hookup diagram shows (also see Table 1, page 44, Feb. '86 issue). You can use a 'DIP-header' at the speech synth end, running light hookup wires between it and a 24-pin edge connector which plugs into the C64's User Port. Suitable edge connectors can be hard to come by, but Geoff Wood Electronics in Sydney can help out hard up hackers here.

The ALD input of the SPO256A-AL2 speech chip can be driven directly from the C64's interface, thus rendering IC3, R5 and C11 unnecessary. Note that the cable running between the User Port and the speech synth may be one or two metres long. Anything longer than that is asking for problems.

The project may be powered separately, or perhaps from pin 2 of the C64 User Port, where you'll find a ready source of +5 Vdc.

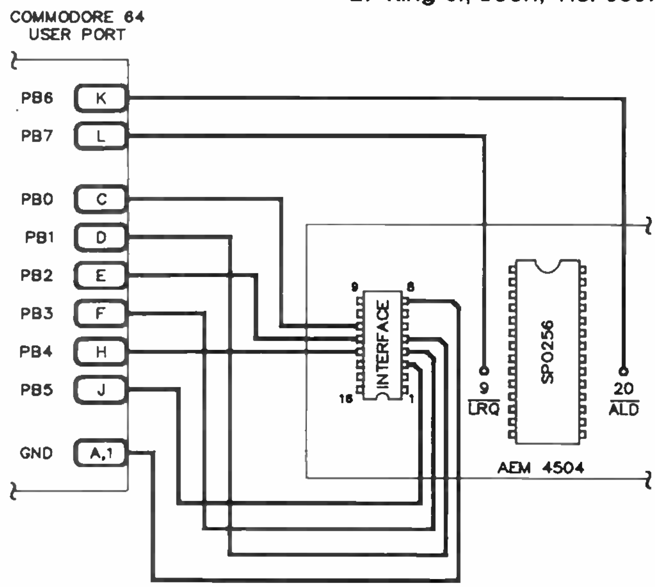
Plug the project into the User Port, with the computer turned off. Power-up and then try loading and running the accompanying BASIC program, "Sound Off" (NOTE: P here equals 56577).

```
            "SOUND OFF"
 10 POKE P,255
 20 POKE P+2127:"BIT7 IN,OTHERS OUT"
 30 FOR X=0TO63
 40 WAIT P,128,128
 50 POKE P,X
 60 POKE P,X+64
 70 NEXT X
 80 WAIT P,128,128
 90 POKE P,0
100 POKE P,64
110 END
```

This program will exercise the synthesiser's vocals.

You have a number of software options for driving the unit. Without a printer interface attached to the C64 User Port, you can direct an LPRINT statement to the User Port with a program along the lines detailed in this column in the February '86 issue (p. 71). The initialise routine should set up the C64's PIA at DD01 (56577) and the ASCII-to-Baudot conversion routine would be replaced with a machine language version of lines 40 to 60 in the Sound Off program. The same channel could provide a serial output to the '4505 text-to-speech project using a variation of the routine now used to output Baudot through pin C of the User Port.

Driving the '4504 with the interface shown here simply requires the use of POKEs. The POKE address (P) is 56577. Handshaking between the C64 and the '4504 is via the ALD and LRQ lines which are hooked up to the C64's bit 6 (PB6) and bit 7 (PB7), respectively. The first two lines of the Sound Off program initializes the SPO256A-AL2. Once that's accomplished, you just POKE numbers to the port by using a "POKE P, n", where 'n' is the required allophone address as per Table 6, the Allophone Address Table, in the SPO256A-AL2 data sheet on p. 95 of the February '86 issue. Here are a few relevant examples:



POKE P, 255
POKE P+2, 127

This sets up LRQ for IN, readies speech data for output and sets the ALD line for output.

POKE P, 5 — speaks "OY", sets ALD low.
POKE P, 69 — sets ALD high

This is your first allophone — "OY", as in "boy". You can insert a pause of the required length with the following:

POKE P, 0
POKE P, 64

This gives a 10 ms pause and sets ALD high.

I'm writing a phrase dictionary along the lines of Mark Bishop's, 'cleaning up' a few of the pronounciations along the way. I'll submit it for publication in due course. Meanwhile, this'll get your '64 talking, cheap. (Note: interface connections to the Commodore VIC-20 User Port are identical, as can be seen from Table 1, p. 44 Feb. issue. However, the POKE address given here may well be different for the VIC-20, but it's worth trying. — Ed.)

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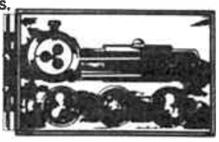

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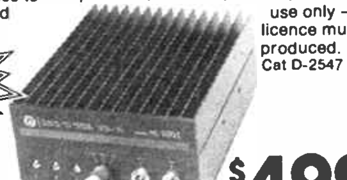

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A software-driven super modem project

Part 4

Chris and Dan Darling - design
Roy Hill - articles

This article concludes the description of the project with a discussion of its overall operation.

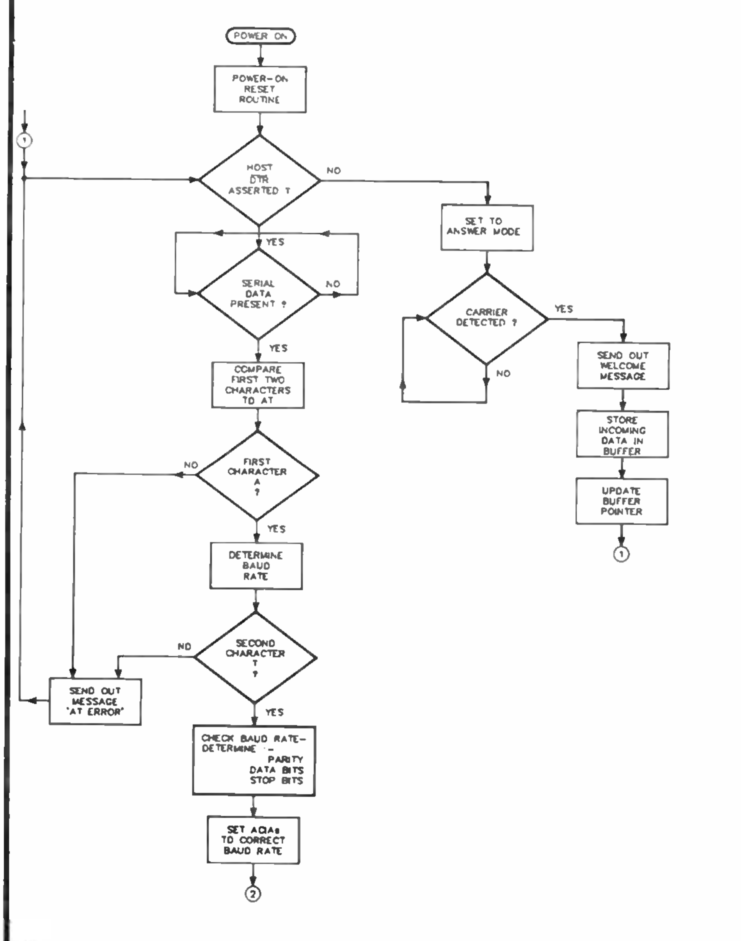
THE FOLLOWING DISCUSSION of the operation of the Super Modem is not intended to be an in-depth analysis of the circuit's operation. It is intended to provide an overview of the manner in which the unit communicates with the host and remote terminals/computers and which particular ICs are responsible for any action taken. You should keep the block diagram (Part 1, p.72 April issue) and (Part 2, May issue, pp.48-49) on hand while reading this. A complete overview of the manner in which the Super Modem powers-up, selects its default settings and commences a communications session is shown in the Flowchart of Figure 1.

When the Super Modem first fires up after the power is applied, the reset vector stored in eprom directs the processor to a set of routines which initialise the PIAs and ACIAs, check on the RAM buffer pointer (to allow for battery backup), initialise the modem chip and then examine the DTR line from the host computer. If this line is not asserted, the Super Modem defaults to the ANSWER MODE and waits for a remote terminal/computer's carrier to arrive (See Figure 1).

If the DTR line is asserted by the host computer, the Super Modem defaults to the COMMAND MODE and sits waiting for serial data to appear on Pin 17 of IC9 (the 6821 PIA — this device is essentially used for control of ICs other than the modem chip). This pin (17) is directly coupled to a serial input (Pin 3 of IC17 — the 1489 line receiver) as well as Pin 2 of IC12 (the host ACIA). When the CPU (IC10) detects a serial data stream on this pin, it checks the bit pattern against a mask stored in the EPROM. The first character checked should have a bit pattern corresponding to the capital letter 'A'. If the CPU matches this bit pattern (an error tolerance is built into the testing routine), the CPU uses the letter to determine the sending baud rate of the Host terminal/computer. The CPU then waits for the second letter and matches this against the bit mask for the capital letter 'T'. If the pattern matches, the CPU confirms the host baud rate and then determines the number of stop bits and data bits and the nature of the parity (if any). If a further command follows the letters 'AT', the CPU then by-passes the PIA and switches in IC12 (the host ACIA) to parse (separate into its component parts) the remainder of the command line to the CPU.

The reason that the CPU switches from the PIA to the ACIA for handling the remaining command string is to allow the modem to receive simultaneous data from both host and remote terminals/computers, both possibly at different baud rates. This reception can be carried out semi-automatically by the ACIAs and this frees the CPU to oversee other important tasks. The CPU stores the incoming command line in the RAM buffer, until it either detects a <CR>, or until the RAM space allocated to the input buffer is exhausted. If at any stage

SUPERMODEM OPERATIONAL FLOWCHART

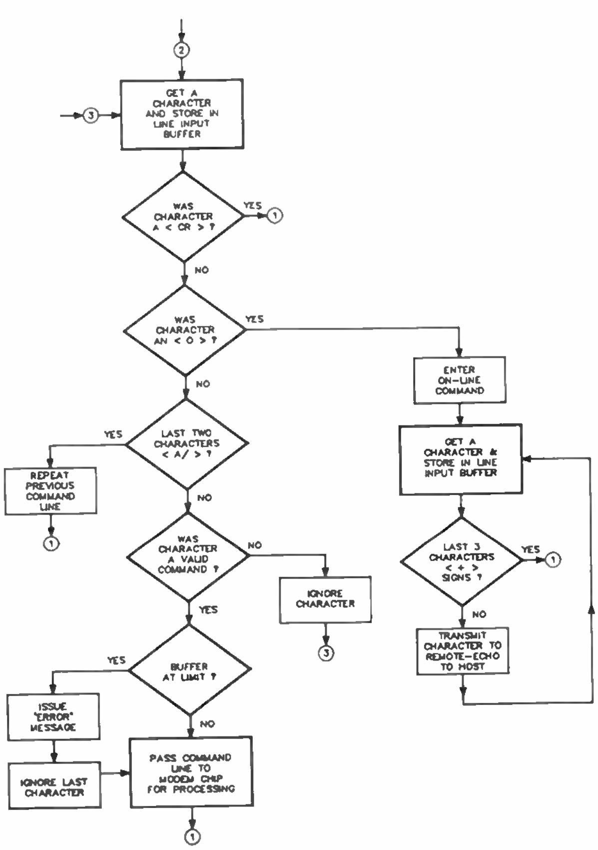


during the input of the command line the CPU detects an 'O' command or an 'A' command, then the appropriate action will be taken immediately (refer to the Command Set Summary, Table 1, Part 3, pp. 94-95, June issue).

Setting the ACIA clock speeds

Each of the two ACIAs (ICs 11 and 12) require two separate clocks. These allow each ACIA to handle different transmit and receive baud rates. This is the main reason for the choice of the 6850 ACIA over other similar chips which do not allow for separate clocks. The primary frequency is provided by the 4.9152 MHz crystal and the output from this oscillator is buffered (and inverted) by IC7 (a 74LS04). The buffered clock is then fed into a two-stage flip-flop (IC8, a 74LS74) and from there to the CMOS divider chip (IC6, a 4060 divider). The output pins of the 4060 are again inverted/buffered (CMOS devices are not known for their ability to drive large numbers of gates) and the buffered outputs are fed directly to the input pins 1, 2, 3, 4, 14 and 15) of the four multiplexers (ICs 1-4, all 74LS151s). Two multiplexers are required for each of the two ACIAs; ICs 1 and 3 (respectively) are used to control the transmit/receive of the remote ACIA, and ICs 2 and 4 (respectively) are used to control the transmit/receive of the host ACIA. The required baud rate is selected by one of the ports on IC9 (the PIA) and the selected baud rate is applied to the appropriate pin on the ACIA. Note that the multiplexers are always selected and generating all possible baud rates. This does not present any conflict because the output of the multiplexers is only present on a single pin of the ACIAs and the appropriate ACIA selection is controlled by the output port of the 6821 (IC9). For example, pins 2, 3 and 4 of IC9 select the receive clock on the host ACIA by enabling pins 9, 10 and 11 of IC4. This selects the required clock speed to give the selected baud rate.

Pins 6, 7 and 8 of IC9 select the receive rate from the remote ACIA by way of IC3, pins 10, 11 and 12 select the transmit rate to the host by way of IC2, and pins 14, 15 and 16 select the transmit rate to the remote by way of ICI. There is no other destination for any of the clocks.



Control of the modem chip

The remaining PIA (IC13) is used almost exclusively for modem control functions. Port A of this device is used to select the Mode Control pins of the 7910/7911, according to the following table:

Continued p. 45 ▶

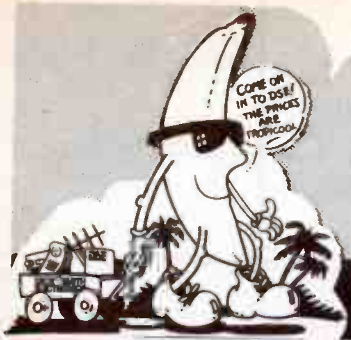
PIA PIN NUMBER/SETTING

6	5	4	3	2	PROTOCOL
0	0	0	0	0	Bell 103 Originate 300 bps full duplex
0	0	0	0	1	Bell 103 Answer 300 bps full duplex
0	0	0	1	0	Bell 202 1200 bps full duplex
0	0	0	1	1	Bell 202 with equaliser 1200 bps half duplex
0	0	1	0	0	CCITT V.21 Originate 300 bps full duplex
0	0	1	0	1	CCITT V.21 Answer 300 bps full duplex
0	0	1	1	0	CCITT V.23 Mode 2 1200 bps half duplex
0	0	1	1	1	CCITT V.23 Mode 2 equaliser 1200 bps half duplex
0	1	0	0	0	CCITT V.23 Mode 1 600 bps half duplex
0	1	0	0	1	
0	1	0	1	0	Reserved
0	1	0	1	1	
0	1	1	0	0	
0	1	1	0	1	
0	1	1	1	0	
0	1	1	1	1	
1	0	0	0	0	Bell 103 Originate loopback
1	0	0	0	1	Bell 103 Answer loopback
1	0	0	1	0	Bell 202 main loopback
1	0	0	1	1	Bell 202 with equaliser loopback
1	0	1	0	0	CCITT V.21 Originate loopback
1	0	1	0	1	CCITT V.21 Answer loopback
1	0	1	1	0	CCITT V.23 Mode 2 main loopback
1	0	1	1	1	CCITT V.23 Mode 2 with equaliser loopback
1	1	0	0	0	CCITT V.23 Mode 1 main loopback
1	1	0	0	1	CCITT V.23 BACK loopback
1	1	0	1	0	
1	1	0	1	1	Reserved
1	1	1	0	0	
1	1	1	0	1	
1	1	1	1	0	
1	1	1	1	1	
21	20	19	18	17	

MODEM PIN NUMBER

TABLE 1

A complete summary of the functions of each of these modem pins, together with a complete description of the 7910 chip, can be found in the November 1985 issue of this magazine.



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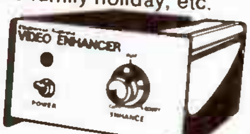

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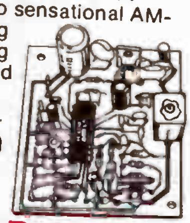

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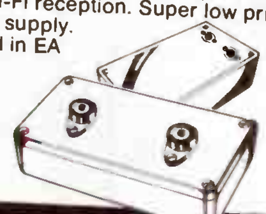

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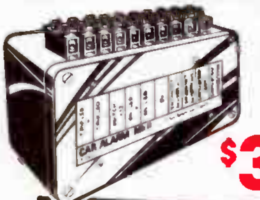

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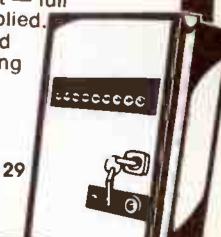

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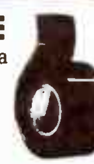

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From p. 41

Secondary Modem Control pins

The remaining control pins of the modem, together with a brief description of their function are included in Table 2 here:

PIA PIN NUMBER (IC13)	MODEM PIN NUMBER	FUNCTION
7	28	Transmit data on the back channel
8	12	RTS Request to Send
9	11	BRTS Back Request to Send
13		CTS — enables the Data Send from the Host (if supported by the Host package/computer)
14	16	DTR to Remote — Used to switch modem to voice mode — Disables 7910
15		IBM Ring on RS232 (via Pin 13 on 1488 line driver
16		Speaker On/Off — toggles the base of Q1 — low base = On, high base = Off.
17		Pulse Dial Control — This pin controls the Telecom type Pulse Dial via Q4 and the relay DTR TO Host — This is used to sense if the Host is alive and well — if not, the SUPER MODEM defaults to the ANSWER mode. NOTE: These two control lines are vital for the Back Channel modes of operation
IC9 Pin 13	IC17 Pin 6	

TABLE 2

System reset

The reset for the system is provided by the ubiquitous 555 timer chip operating in the one-shot mode. The required time delay is generated by the combination of R6 and C25 which produce a pulse duration of approximately 1.5 seconds. The output pulse is inverted by one gate on IC7 (a 74LS04) and the resulting low pulse is applied to pin 37 of IC10 (the 6809), pin 34 of ICs 9 and 13 (the 6821s) and to pin 3 of IC21 (the modem chip). The latter line is not really required, due to the fact that the entire set of modem, registers and control lines is set by the software routines stored in EPROM. This generates a complete Reset of *ALL* control lines and registers, with the sole exception of the pointer to the RAM buffer (we really don't want to destroy the data in the buffer, do we?)

Well, that wraps it up. Have fun on line with your Super Modem.

STOP PRESS

Owing to numerous requests received, two alterations have been made to the software supplied with the AEM 4610 Super Modem.

1. The default to auto-answer section of the software has been deferred to the next software/hardware update. This particular feature of the modem would have found most use in one-way bulletin boards and those persons operating bulletin boards have asked for:
2. The software now contains incoming baud rate sense. This is used to allow the Super Modem to determine the incoming baud rate of a calling terminal/modem. Up till this time, PAMS operators have either had to dedicate multiple ports for their bulletin board (one for each possible input baud rate), or depend upon their communnications software to perform a search of the incoming baud rate. The Super Modem auto baud rate sense now eliminates both of these requirements.

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Experimental 'code-to-speech' synthesiser

Part 2

Rowan Deppeler – design
Roger Harrison – article

This article concludes the description of the project and gives details on using the unit within an IBM PC or PC-compatible computer, along with a small 'demo' program.

THE PC BOARD edge connector enables the unit to plug directly into a vacant 'I/O channel' slot in your IBM PC or PC-compatible. The unit derives power from the PC's +5 V supply available on the I/O channel pins. Note that C27, a 10μ tantalum, provides a bypass for the incoming supply close to the edge connector. If you plan to use the project exclusively with your PC, the four rectifier diodes (D2-D5), the three-terminal regulator, IC14 (and its heatsink), and capacitors C21 and C22 may be omitted. You won't need the pc-mount screw terminal blocks either. You will need to solder in place ICs 1, 2 and 3 if you haven't already done so. Sockets may be used if you wish.

The I/O SELECT link must be set to the IBM position, linking pin 11 of IC5 to pin 3 of IC3 and pin 9 of IC11. Set the u-v-w jumpers for IC4 for parallel input. Set the z jumper to whichever delimiter option you wish. The loudspeaker may be mounted in any convenient position in your computer's system box, or even externally. Alternatively, a 50 mm diameter speaker could be mounted to the rear (non-component) side of the pc board with a generous glob of Silastic or similar silicone compound, making sure the speaker frame does not come in contact with the tracks.

The accompanying demonstration program illustrates how to use the project. The board 'resides' at address 208 (hex). Its RESET address is 209H. Resetting, or initialisation, is best effected by sending ten pulses to the board. The CTS256A-AL2 signals its BUSY status via bit 7 of the PC I/O channel data bus (D7 — pin A2).

Table 2 details all the IBM slot pin assignments employed here, while Figure 3 shows the edge connector arrangement on the pc board.

Enter and check the program, debugging any errors. Save a working copy. With the 4505 board plugged in, run the program. The program will initialise the board, which utters "OK." Now, type in a short sentence after the prompt "Please enter string:" appears. Your project should then articulate what you typed in. If the project doesn't behave as expected, look for unsoldered pins or dry joints around ICs 1, 2 and 3.

Continued p. 52 ▶

IBM DEMONSTRATION PROGRAM

```
10 ' Initialise speech board
20 FOR I = 1 TO 10:OUT 521,0:NEXT 'Output data not required
30 'Buzz off to main routine
40 GOTO 140
50 ' Output routine for address &h208
60 IF INP(520) = 255 THEN 60    'Busy status bit 7 high
70 OUT 520,CX:RETURN            'Output character to board
80 'Output a string c$ to the speech board
90 FOR I = 1 TO LEN(C$)
100 CX = ASC(MID$(C$,I,I+1))    'Split string into characters
110 GOSUB 50
120 NEXT
130 RETURN
140 'Main input routine
150 PRINT"Please enter string : ";
160 C$="":INPUT C$
170 IF C$="" THEN END
180 C$=C$+" ":GOSUB 80           'Add <space> as a delimiter
190 GOTO 140
```

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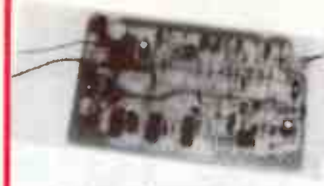

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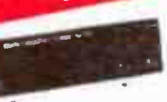

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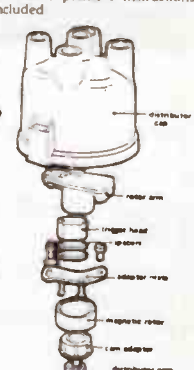

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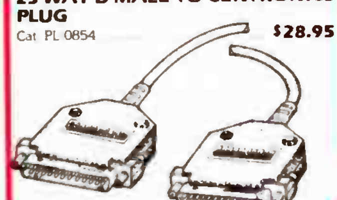

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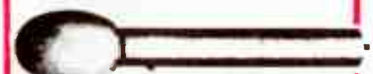

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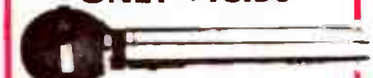

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From p. 49

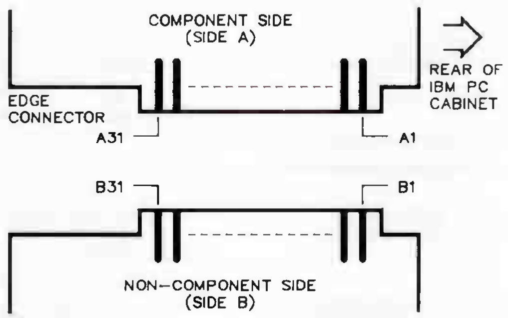

Figure 3. The pc board's edge connector pinout. This suits the IBM bus, enabling the project to plug into an available slot on the motherboard.

APPLICATION SUGGESTIONS

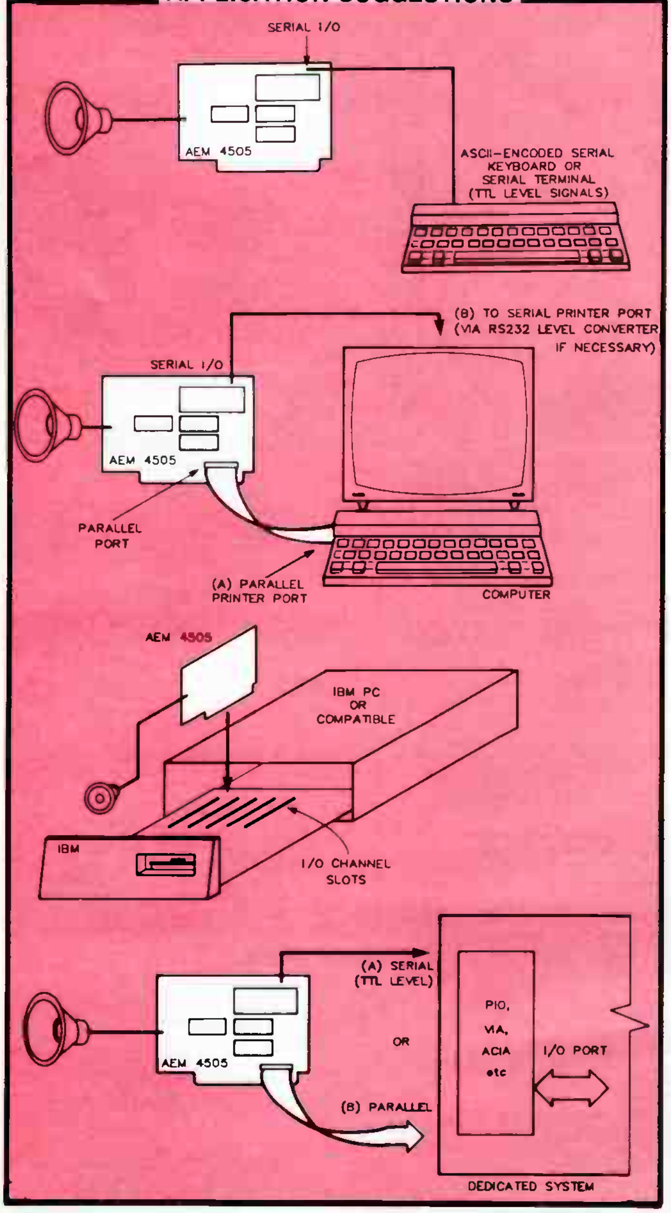

TABLE 2.

SLOT PIN	ASSIGNMENT	SLOT PIN	ASSIGNMENT
A1	-	B1	-
A2	D7	B2	-
A3	D6	B3	+5 V
A4	D5	B4-B9	-
A5	D4	B10	0 V
A6	D3	B11	-
A7	D2	B12	-
A8	D1	B13	IOW
A9	D0	B14	IOR
A10	-	B15-B28	-
A11	AEN	B29	+5 V
A12-A21	-	B30	-
A22	A9	B31	0 V
A23	A8		
A24	A7		
A25	A6		
A26	A5		
A27	A4		
A28	A3		
A29	A2		
A30	A1		
A31	A0		

Operational overview

This description covers the operation of the CTS256A-AL2 in general, and with reference to its implementation in this project.

Upon power-up or following a RESET, the CTS256A-AL2 first determines the configuration of the system with regard to the following five options:

1) RAM selection.

Internal RAM mode has an input buffer which accommodates words or phrases that are no greater than 19 characters in length followed by a delimiter; and an output buffer that accommodates an allophone translation of that word or phrase that is no greater than 26 allophone addresses. Since the translation more often than not results in the output buffer contents being twice that of the input buffer, words no longer than 13 characters in length and number sequences of four numerals or less should be used as a rule of thumb. If the output buffer overflows, you may lose the words not yet spoken and the BUSY line (pin 3) won't necessarily signal that the input buffer's empty, even though it might be. If you overflow the output buffer during a translation, a RESET may be required to clear the system.

External RAM mode can be used to extend the input and output buffers. If no exception-word or user EPROMs are present the default start address is 3000H. The mask-programmed algorithm in the CTS chip searches for the end address by looking for the first non-RAM location at 256-byte intervals, but will not continue beyond 2K. If an EPROM is present, the start and end addresses are redefinable there. The start address must begin on a boundary where the least significant byte of the address is 00; the minimum start address is 200H, and the maximum valid start address is EE00H. The 4505's on-board RAM resides at 3000H. Note RAMs with 250 ns or less access time must be used.

2) **EPROM selection.**
EPROMs may reside anywhere within the decodeable address space of the CTS chip, from 1000H to E000H, providing the start address falls on a 4K boundary. The CTS chip will search from 1000H to E000H in 4K increments for the five-byte sequence — 80, 48, 28, 58, 85 (hex values), which uniquely identifies the presence of an exception-word or user EPROM. If neither are present, the CTS chip reverts to the algorithm default or pin-selectable system options. If only a user EPROM is present, the system options may be re-defined there. If both user and exception-word EPROM programs are present, the system options may be re-defined from the user EPROM. The EPROM location on the 4505 board resides at 4000H. Note EPROMs used here must have an access time of 300 nanoseconds or less.

If a user EPROM is accompanied by an exception-word EPROM, it may reside anywhere. If no exception-word EPROM is present, the user EPROM may reside anywhere from 1000H to E000H, providing uts start address falls on a 4K boundary; and it must then begin with the five-byte sequence given above. A user program may reside in an unused portion of the exception-word EPROM. Exception-word and user EPROM memory maps are given in General Instrument's Application Note AN-0505, along with programming techniques.

3) **Serial/parallel input interface selection.**
In the parallel input mode (parallel port or IBM PC I/O channel), incoming ASCII data is latched by the 74LS374, IC5, upon receipt of an active-low 'data valid' strobe. This strobe also pulses the CTS chip's INT3 line (pin 12), telling its internal algorithm to accept the data. This latch's on-board address is 200H. The parallel port timing requirements are given in Table 3.

In the serial mode, ASCII data is accepted via the CTS chip's SERIAL INPUT, pin 16. This goes to an internal UART that requires TTL-level signals. Input signal baud rate is selectable from 50 to 9600 baud (refer to Table 1, Part 1). The other UART data input parameters are set to internal algorithm default values (asynch., 7 bits/character, 2 stop bits, no parity) or may be hardware selectable via the CTS chip's data bus. The UART baud rate and other data input parameters are re-definable from any on-board exception-word or user EPROM (see [4], below).

In both serial and parallel mode, the input buffer is protected from overflow by a hysteresis subroutine which signals the host when the buffer is full, and when it's ready for more input. The CTS chip's BUSY line (pin 3) provides a handshaking signal to signify the status of the input buffer. This line is active-low. During input, it sits high, toggling low when the input buffer becomes 87.5% full. The host system driving the board may use its discretion to complete the transmission, or part thereof. If the input buffer becomes 100% full, the parallel and serial port interrupts are disabled to prevent overwriting the input buffer. The interrupts are not re-enabled until the input buffer is half empty, at which time the BUSY line will toggle high once more.

4) **UART parameter selection.**
The UART baud rate and other data input parameters may be defined by default values in the CTS chip's internal algorithm or from firmware (the exception-word or user EPROM). The 'x' jumper (for pin 9 of the CTS256A-AL2) selects which option is to be employed. See Table 1, Part 1.

5) **Delimiter selection.**
The CTS algorithm will process any words or phrases as soon as they are followed by a defined 'delimiter'. The 'z' jumper (for pin 11 of the CTS256A-AL2) selects the option. See Table 1, Part 1.

There are eight delimiters — , . ; : ! ? carriage return and space. In the 'any delimiter' mode, the board will speak any text preceeded by any of these delimiters. In the carriage-return-only delimiter mode, it processes and speaks text only after receipt of a carriage return. This mode is meant for use with slow input devices, such as a terminal, where the user wishes to buffer-up a complete phrase so that it is spoken with fluency (i.e: "type-and- talk" applications). When using this mode in conjunction with external RAM (as is the case in this project), the length of a phrase entered before inserting a carriage return should be limited to 150 characters total. This allows for a two-line phrase to be spoken with fluency while ensuring that the 256-byte output buffer won't overflow.

TABLE 3.
Parallel port timing requirements.

SETUP TIME: before data clock low-to-high transition — >20 ns.

HOLD TIME: before data clock low-to-high transition — >10 ns. (width of clock low — >500 ns)

HOLD OFF TIME: from data strobe high-to-low transition, until next data strobe high-to-low — >500 ns.

After completing the initialisation, the unit says "OK" to demonstrate it's ready for input. Then, one of two paths is taken, depending on the system configuration.

If a user EPROM is not present, the CTS algorithm idles as long as the input buffer remains empty. Upon receipt of standard ASCII characters, processing begins with an alphabetical search of the exception-word EPROM, if it is present. If no exact match between the input character string and those residing in the EPROM is found, or if the EPROM is not present, the CTS algorithm employs a letter-to-sound rule table against which main, right and left context matches are performed, to produce speech output. This results in the translation of a particular word into the proper string of allophone addresses necessary for its pronunciation. This list of allophone addresses is sent to the SPO256A-AL2 after a carriage return or after any delimiter, depending on the selected delimiter mode. Where a user EPROM is not present, G.I. dub such a system as a 'dedicated code-to-speech' system.

When a user EPROM is present, G.I. say dub this as the "add speech to user's program" mode. Control of the processor is relinquished to the USER code immediately after completion of initialisation. The USER code may then execute its own code, may pass character strings into the input buffer memory, or may hand off processor control to the code-to-speech algorithm to speak any previously loaded character strings. If speech is initiated, control returns to the USER code after the last delimited character string in the input buffer has been processed.

To successfully incorporate a USER program with the CTS algorithm requires a thorough understanding of the programming and operational concepts detailed in the G.I. Application Note AN-0505, and an in-depth working knowledge of PIC7001 assembly language programming.

Further technical details on the CTS and SPO chips, data sheets and the G.I. Application Note AN-0505 may be obtained from ***Daneva Australia Pty Ltd, PO Box 114, Sandringham 3191 Vic.***

WELLER CROSSWORD COMPETITION NO. 11

Every word in our eleventh crossword begins with the letter C so it's quite easy. The prize for this month's winner is the super Weller WTCPN Controlled Output Soldering Station which would have pride of place on any workbench. Post us your answers, even if you've missed a couple by July 25.

The winner of Weller Crossword No. 9 (May) was
Answers to Crossword No. 10 (June) are on p.

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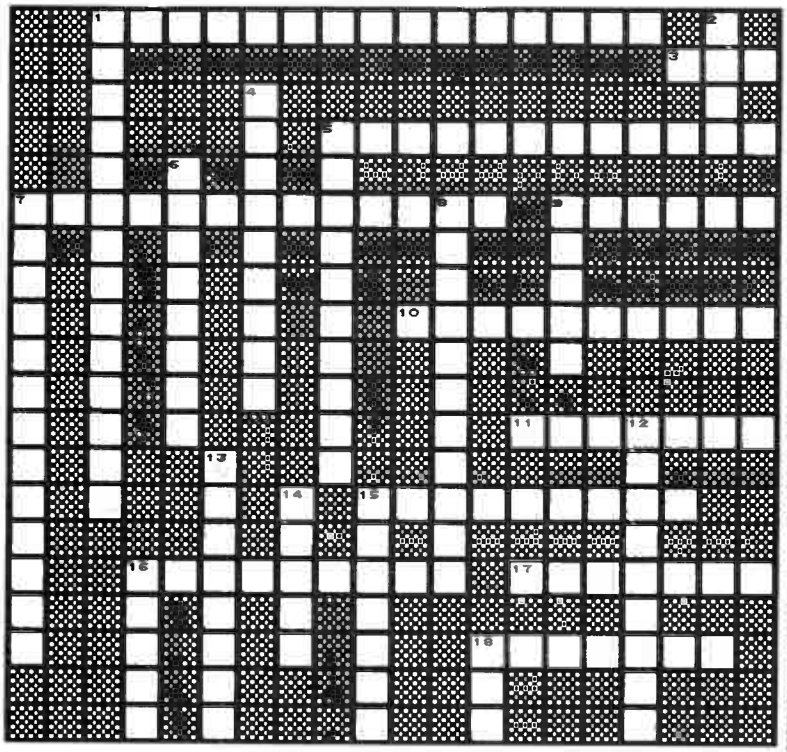
ACROSS

1. Removal of parts from one system to repair another.
3. Computer-Output-Microfilm.
5. Transmission line where one conductor completely surrounds another. (2)
7. An area over the top of some aerials where signals cannot be heard.
9. Shared by two or more circuits. (3)
10. Stream of electrons emitted from the cathode of an evacuated tube.
11. The interconnection of a number of devices in one or more paths to perform a desired electronic function.
15. A material that conducts electricity through the transfer of orbital electrons.
16. To find by measurement by comparison with a standard any variations of an instrument.
17. Box or frame on which components or circuitry can be mounted.
18. A signal which initiates an action in a device.

DOWN

1. A device which detects current leakage and prevents hazards by limiting current flow. (2)
2. Wire wound round an iron core.
4. A point where two conductors that are insulated from each other cross.
5. A device capable of performing mathematical functions.
6. A device for performing mathematical functions.
7. The ability of one unit to be used with another without mismatch.
8. Also called capacity.
9. Common Business Orientated Language.
12. Undesired signals from another circuit in the same system.
13. A combination of characters or words which identify a communication facility.
14. Assembly of one or more conductors in a protective sheath.
15. A single path for transmitting electric signals.
16. Radar confusing reflectors.
18. Computer-aided design.



The competition is open to all persons normally resident in Australia or New Zealand, with the exception of members of the staff of Australian Electronics Monthly, the printers, Offset Alpine, and/or associated companies.
The winning entry will be drawn by the Editor, whose decision is final; no correspondence will be entered into regarding the decision.
Winners will be notified by telegram the day the result is declared and the winner's name and contest results published in the next possible issue of the magazine.

Cut out or photocopy the entry form, complete it and send to:

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Australian Electronics Monthly
PO Box 289,
Wahroonga NSW 2076

In case two or more entrants correctly complete the crossword, we'll have to judge who's best at waxing lyrically, in 30 words or less, over: ***"Why I think the Weller WTCPN is the soldering station for me".***

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Brian Francis

New, or near-new, faces at Jaycar

Jaycar sports a couple of 'new faces' behind the scenes. They're not all that new, really, as they've been plugging away at their appointed tasks in Concord Castle for some months now, but we thought it time to tell you about them!

Brian Francis is Jaycar's near-new kit manager. That is, he's near-new, not the kits, they're new when you get them. Brian hails from Sussex in England and has only recently arrived on our shores. He comes from a background in electronics distribution within the Philips Industries group.

The other 'new boy' at Jaycar, Bill Edge is, in fact, an industry 'identity'. Jaycar purchased Bill Edge's Electronic Agencies back in late '83. Bill goes way back in the business, starting at Radio Despatch (a business now despatched) many years ago. With credentials of that order, Bill does the bits buying.

Bill Edge

PROJECT BUYERS GUIDE

David Tilbrook's 250 watt AEM6000 MOSFET power amp module will prove popular with many readers, we feel sure. Kits will be stocked by Jaycar, with stores in Sydney and Brisbane, and Eagle Electronics in Adelaide. Victorian readers should try All Electronic Components. The ECG461 dual-JFET by NTE, employed in the module's input stage, is stocked by Stewart Electronics in Melbourne, PO Box 281, Oakleigh 3166 Vic. (03) 543 3733. Philips, through their Electronic Components and Materials division, distribute a dual-JFET range suitable for use in this application, types BFQ10 to BFQ15. See if your favourite local supplier will get some in for you, if you can't get the other type. Printed circuit boards for this project will be available, as usual, through the magazine's printed circuit service, advertised elsewhere in this issue.

The AEM4505 Code-to-Speech Synthesiser will be stocked as a kit by Eagle Electronics in Adelaide. You might also try Geoff Wood Electronics in Sydney for boards, the chips and other bits. Daneva Australia may supply data sheets, if required. Communicate via PO Box 114, Sandringham 3191 Vic. They have a Sydney office in Crows Nest and are represented by DC Electronics in Adelaide and Baltec in Brisbane. The double-sided, through-hole plated pc board will be available through our printed circuit service, as usual.

The AEM3503 Satellite FAX Decoder seems destined to follow in the footsteps of our hugely successful AEM3500 Listening Post project. All the components are commonly obtainable. Eagle Electronics, we understand, will be stocking a kit. You might also try All Electronic Components in Melbourne. Sydney enthusiasts should pester Geoff Wood Electronics for pc boards and components. Yes, our pc board service can supply a board for this project.

This month's Star Project, the 1 GHz/8-digit Frequency Counter will be available in kit form through Dick Smith stores.

aem project 6000

An 'ultra-fidelity' MOSFET power amplifier module

Part 2

David Tilbrook

In Part 1 the operation of the power amplifier was described and I discussed the reasons for the choice of the particular topology employed. In this article the construction of the power amp is covered in detail.

AN ASPECT of power amp design that is often given insufficient attention is the pc board layout and overall construction scheme. This is particularly important in the design of power amplifiers employing MOSFET-based output stages. The very high input impedance of the power MOSFET combined with its excellent high-frequency performance and slew rate makes this device particularly prone to oscillation if it is used incorrectly. This oscillation should, however, not be confused with the more common form of amplifier instability which is associated with a poorly controlled phase characteristic within the negative feedback loop. This is by far the most common form of instability in amps employing bipolar transistors in the output stage since the realatively poor high-frequency performance of these output devices limits the phase linearity of such designs.

The use of MOSFET output devices, on the other hand, greatly assists feedback loop stability. The type of oscillation to which power MOSFETs are prone does not involve the feedback loop and is substantially easier to control. In fact, the mechanism that causes the instability is one of interaction between the two n-channel MOSFETs, the 2SK176s, and their associated passive components. The cure for this problem is effected by the use of the low-value resistors R36-R39 and capacitor C13. In addition to these components, the layout of the pc board, particularly around the output stage, must minimise the inductances and certain critical inter-terminal capacitances. One area that is particularly critical for stable operation of power MOSFETs is the wiring to the gates and sources. The physical location of these components can be critical and it is for this reason that the power amp module has been designed so that the power MOSFETs are mounted onto a heatsink bracket and pc board which also contains the associated passive components.

The construction scheme must also facilitate the best possible heat transfer from the MOSFET output devices and bipolar drive transistors to the heatsink. As explained in Part 1, the AEM6000 design employs relatively large amounts of drive stage quiescent current to ensure low drive stage output impedance. This leads to considerable power dissipation in the drive stage, necessitating good heatsinking. As a result, the four drive transistors, Q15-Q18, and the two transistors used for the constant current sources, Q9 and Q10, have been bolted to the main heatsink bracket to ensure good heat dissipation. This arrangement also provides thermal coupling between the drive stage, its current source, and the output stage.

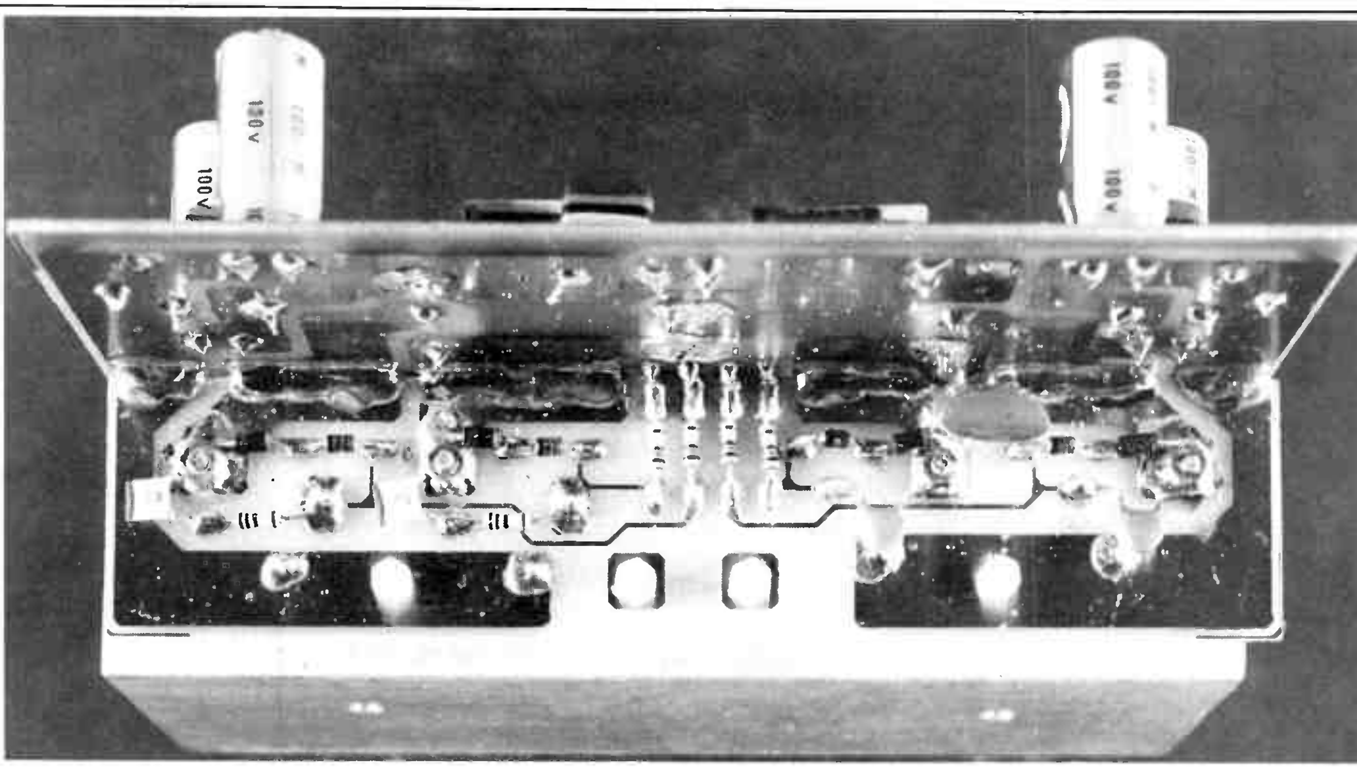
Although the concept of having all of the components, including the output devices, mounted on a pc board greatly assists repeatability of amplifier performance, it also tends to impose certain restrictions. A common construction scheme, for example, and one which we have used for various power amp modules in the past employs, an "L"-bracket in conjunction with a single pc board which contains all of the power amp components. The disadvantage with this scheme is that the pc board is mounted at right angles to the heatsink and can protrude a considerable distance into the chassis. In this case this was unacceptable, since it was decided to maintain the power amp chassis the same width as the AEM6010 preamplifier and to keep the chassis depth to a minimum. Accordingly, a different construction scheme was developed which has proven to be very effective.

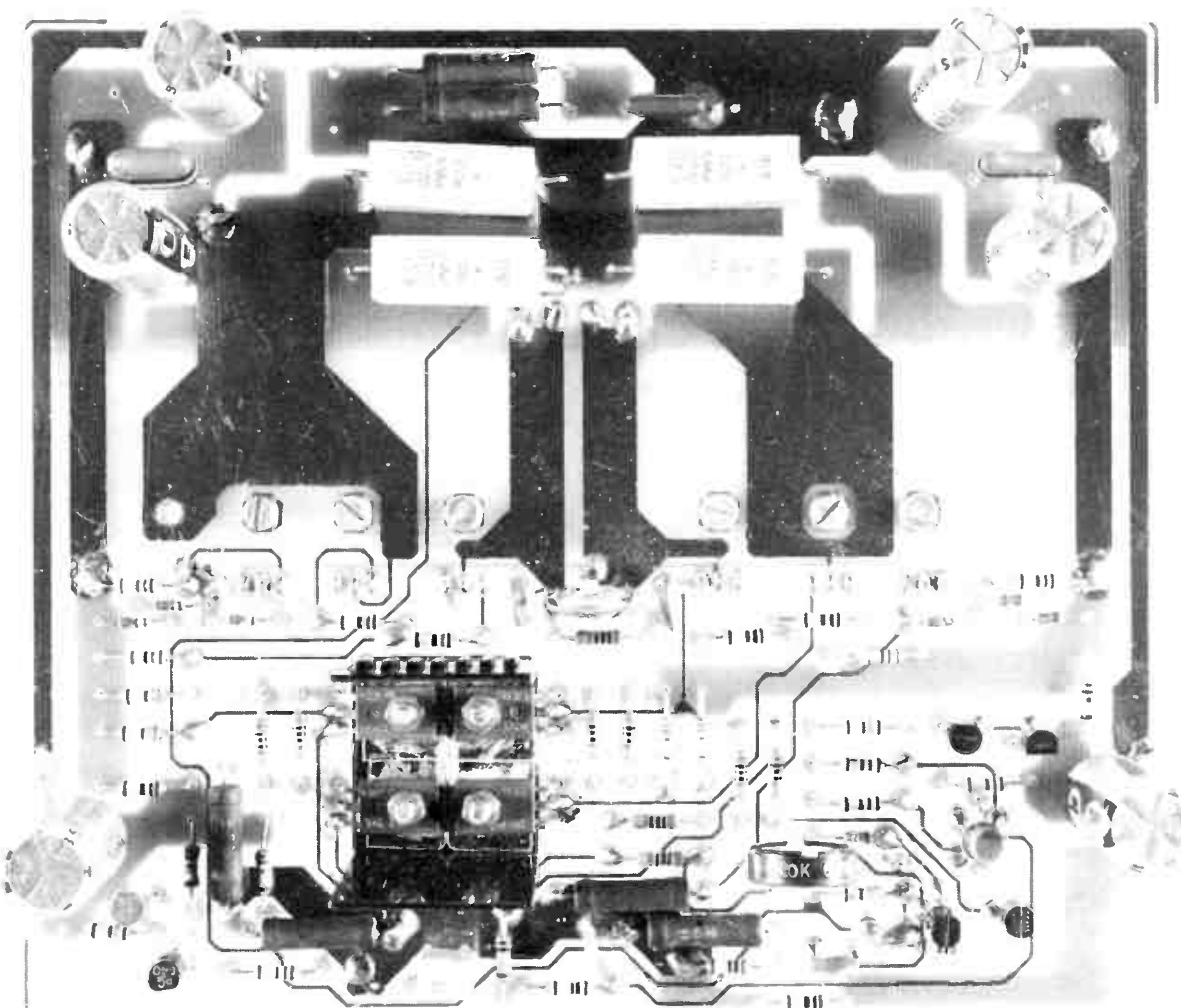
To overcome the problems of minimizing chassis volume occupied by the power amp module, an alternative construction scheme was developed which has proven to be very effective. This scheme uses a heatsink bracket with a "U"-shaped cross-section. As can be seen from the accompanying photographs, this allows the pc board to be mounted parallel to the heatsink. Furthermore, the module can be removed from the chassis in the event that servicing becomes necessary by removing the bolts through the heatsink.

The development of this construction scheme has taken some effort, with many of the earlier prototypes proving to be completely unaccaptable. One of the earlier schemes used the U-bracket as shown but with the MOSFETs mounted to the side of the U so that the MOSFET pins could be soldered directly onto the pc board. This scheme had the advantage that only one pc board was required. Unfortunately, the thermal conduction from the MOSFETs to the heatsink was entirely inadequate with the result that the output devices ran approximately 30 degrees Celcius hotter than the heatsink!

The final scheme settled upon employs two pc boards mounted at right angles to each other so that the output devices can be mounted on the base of the U channel in close proximity to the heatsink. The MOSFET gate and source pins protrude through the bottom of the channel and a pc board is bolted on that side, track side outermost, to provide connection to the MOSFET terminals. The source and gate components are mounted on the track side of this pc board, allowing layout to be optimised for minimum inductance, helping to ensure maximum stability and best possible transient performance. The connection between the two pc boards is made with a 'butt-joint', bridged by solder using adjacent low impedance tracks.

In Part 1 we included a photograph of one of the prototype pc boards developed during the design of this power amp. As can be seen from the photograph included here, which shows the final pc board design, the earlier design differs substantially. These two pc boards contain exactly the same circuitry, yet they differ markedly in their performance. The later design brings the four differential voltage amplifier devices, Q11-Q14, onto the one small heatsink so that these ▶





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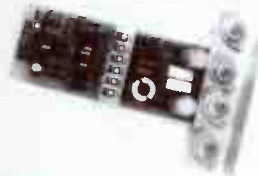
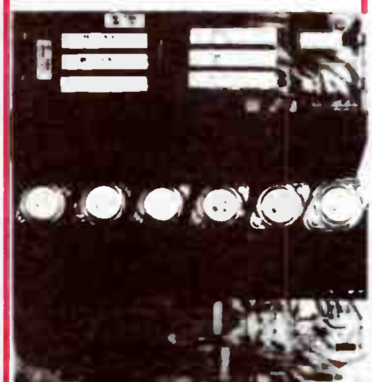
Cat KA 1624 **$7.95**

PLAYMASTER 60 + 60 AMP
Cat KA 1650 **$249.00**

UNIVERSAL MOSFET AMP MODULES AEM 6500 60/120 WATTS
Ref AEM July 1985
Cat KM 3010 60 WATTS **$55.00**
Cat KM 3012 100 WATTS **$69.50**



300 WATT PLAYMASTER AMPLIFIER
Ref EA June 1980
This rugged design provides 200 watts rms into 8 ohms and 300 watts rms into 4 ohms
Cat KA 1115 **$99.95**

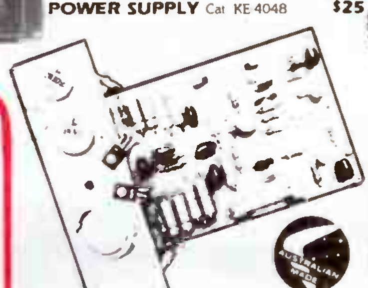


300W AMP POWER SUPPLY KIT
Cat KA 1116 **$99.95**

SPEAKER PROTECTOR for PLAYMASTER 300W AMP
Ref EA July 1980
Cat KA 1117 **$15.95**

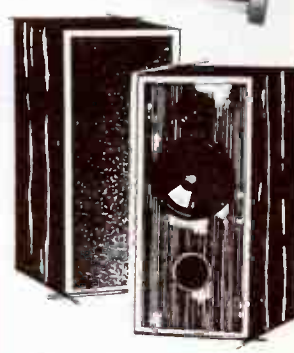
DRUM SYNTHESISER
JOIN THE DRUM REVOLUTION
Cat KJ-6502 **$39.50**

ETI 480 SERIES AMP MODULES
Ref ETI Dec 1976 & ETI's 30 Audio Projects
ETI 480/100 WATTS
Cat KE 4052 **$29.50**
ETI 480/50 WATTS
Cat KE 4050 **$25.00**
Suitable power transformer 28-0-28V 2A
Cat MF 1095 **$34.50**
POWER SUPPLY Cat KE 4048 **$25**



MUSICOLOR IV
Ref EA August 1981
Cat KA 1010 **$109.90**

8 CHANNEL AUDIO MIXER JAYCAR 8002
A balanced input/output 8 channel mixer with features found in units costing well over $2000!
MAIN FEATURES: • Balanced (600 ohm) mic inputs/line inputs • Input attenuators • Cannon connectors included in the price • Bass, mid and treble equalisation on each input • Effects (i.e. echo, etc) capability • Foldback on all 8 inputs • Stereo pan on all 8 inputs • 60mm slide faders used throughout • 19" rack mount capability (or console mount) • Professional black front panel with format borders and multicoloured knobs to assist function identification • Designed for quick and easy service • VU metering • Only high quality components used • 5534A OP amps used for low noise and very low distortion
Cat KJ-6504 ***$560.00***



AEM 6102 - 2 WAY VIFA KIT
SPEAKER KIT Cat CS 2460
ONLY $499.00
CABINET KIT Cat CB 2650
ONLY $179.00
OR TOGETHER
FOR $599.00
SAVE $79.00
COMMERCIAL UNITS COST ABOUT $1,400

AEM 6103 - 3 WAY VIFA KIT
SPEAKER KIT Cat CS-2465
ONLY $790 pair
CABINET KIT Cat CS 2652
$319.00 pair
SAVE A MASSIVE $110.00
BUY BOTH TOGETHER FOR $999.00

STEREO AM DECODER (AUSTRALIAN STANDARD)
Ref EA October 1984
This unit uses the Australian standard Motorola CQUAM decoder chip. It will decode the new AM stereo transmissions (with suitable AM tuners)
Cat KA-1555 **$26.50**
You will need two whistle filters. You can use the one already in your radio for one channel and we can supply the other one
Cat LF-1300 **$23.95**

STOP PRESS - NEW
LIGHT SAVER
Ref EA June 1986
Without plate and epoxy
Cat KA 1670
ONLY $14.99

PHONE CONTROLLER
Ref EA June 1986
Cat KA 1672 **$P.O.A.**

MAIL ORDER HOTLINE (02) 747 1888

BRAND NEW 100 page 1986/7 ENGINEERING CATALOGUE OUT NOW SEND LARGE S.A.E.

1ST BIRTHDAY CONTEST No. 4.

What an incredible opportunity to win a top quality professional soldering station! All you have to do is answer these simple questions and tell us what features of the Ersa MS1500 soldering station most attract you.

Q1: Who first applied for a patent on an electrically-heated soldering iron, and in what year?

....

Q2: What is the 'eutectic point'' temperature of "60/40" solder?

....

Q3: Components sensitive to voltage 'spikes' may be damaged by on-off switch type soldering iron heater temperature control systems. What is the name given to the widely used alternative temperature control system that avoids such voltage spike problems?

....

Now tell us, on a separate sheet of paper, using 30 words or less, what features of the Ersa MS1500 most attract you?

Name ....

Address ....

.... Postcode ....

I have read the rules of the contest and agree to abide by their conditions.

Signed: ....

The Contest Rules are set out on page 6 of this issue.

Win this Ersa temperature-controlled soldering station with two irons, Model MS1500 from Meltec Pty Ltd

The Ersa MS1500 miniature soldering station is ideal for precision electronic soldering on today's high density pc boards. It comes with a 'Minor soldering needle' rated at 5 W, for very fine work, and the 8 W Multitip for general use. Fully variable temperature control setting is featured, providing temperature ranges of 100-340 degrees C for the Minor iron and 100-350 degrees C for the Multitip. The irons operate from a safe 6 V supply via a safety isolation transformer. The holder and sponge can be mounted on the left or right. An earthing terminal on the station provides for operator earthing while working on static sensitive equipment.

Prize kindly donated by Meltec Pty Ltd, PO Box 20, Greenacre 2190 NSW.

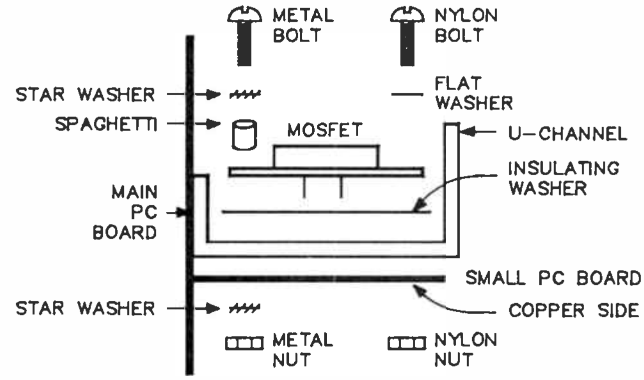
devices will track each other thermally. In the earlier design, this was not done and the amp suffered from significant drift of its output dc voltage. This problem stems from the fact that the npn and the pnp transistors forming the symmetric differential amplifier stage do not have equal power dissipation. Remember that the collectors of transistors Q3 and Q4 are at a voltage approximately 22 volts less than the positive supply rail and this means that the bases of the differential amp following then are also 22 volts below the positive rail. Transistors Q11 and Q12 will therefore drop around 21 volts between their collectors and their emitters, whereas transistors Q13 and Q14 will drop around 120 volts if the module is powered from a +/- 70 volt supply. This leads to a significant temperature difference between these two pairs of transistors which upsets the symmetry of operation and leads to the net dc output voltage.

Construction

It is wisest for the reasons discussed above to base the construction of this power amp on the two pc board designs given here. With this in mind, the construction is not difficult although the use of two pc boards does complicate things slightly.

Commence construction by preparing the heatsink bracket which is fabricated from a 158 mm length of 50 x 40 x 6 mm aluminium U extrusion. A detailed mechanical drawing has been included with this article. Ensure that all holes are clean and free of burrs that might otherwise pierce the insulating washers used with the output devices.

Mount the power MOSFETs to the heatsink bracket so that they are located in the U with their leads protruding through to the small pc board mounted flush against the other side of the aluminium bracket. Insulating washers must be used between the power MOSFETs and the heatsink bracket since the cases of the MOSFETs are connected internally to their sources which will be shorted to chassis if they not correctly insulated. The four mounting bolts closest to the main pc board are used to make the connections between the sources and the rest of the circuit. These bolts must make good contact with both the cases of the MOSFETs and the pc board but remain insulated from the heatsink bracket. To achieve this, star washers should be used beneath the bolt head and the nut and insulating spaghetti should be used covering that section of the bolt which passes through the heatsink bracket. The other four mounting bolts, those furthest away from the main pc board, must be insulated both from the MOSFETs and from the pc board. The easiest way to achieve this is to use nylon nuts and bolts although some care should be exercised not to overtighten these which can strip the nylon thread. Alternatively, metal bolts can be used with insulating washers fitted to both the top and bottom of the bolts. A detailed drawing showing the mounting of the output devices has been included here to clarify this aspect of the construction.

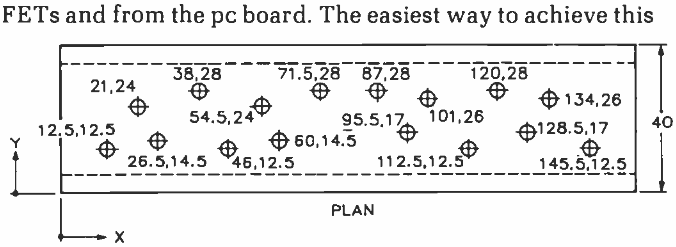


The next step is to mount the passive components to the track side of the small MOSFET pc board. This can be done after mounting the main pc board but it is easier at this stage. Follow the component overlay included here. Several of these components are mounted across adjacent tracks so some care should be exercised to ensure that they do not short to any of these intervening tracks.

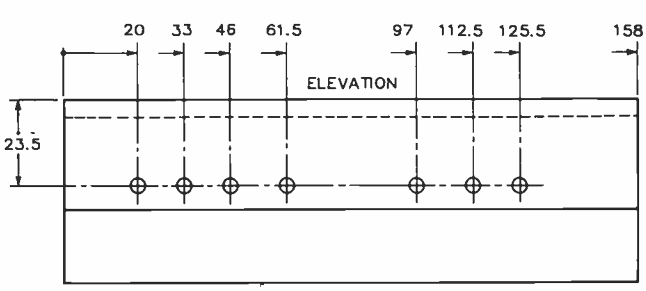
Once this is complete the assembly can be mounted to the main pc board. This is accomplished by first mounting the six flat-pack transistors to the underside of the heatsink bracket so that the leads can pass through the main pc board to its components side. Once again, these devices must be insulated from the heatsink bracket using insulating washers. Be carfeul not to confuse the MJE340 and MJE350 types. Bolt the devices into place using the same bolts to hold the main pc board to the heatsink bracket. The main pc board must be mounted the correct way around so that the area marked with the rectangular border is adjacent to the heatsink bracket. Before tightening these mounting bolts line up the two pc boards so that their adjacent copper tacks mate correctly. Once this is achieved, the bolts can be tightened and the two pc boards soldered to each other by running a fillet of solder along the copper tracks, ensuring that a good connection is made to both boards.

The leads to the six-flat pack devices can now be soldered. Some of these require soldering to both sides of the main pc board. Be careful not to introduce any solder bridges across the adjacent leads of these devices. Soldering to the bottom side of the pc board can be a little difficult since this requires working between the heatsink bracket and the main pc board. A reasonably fine soldering iron tip will greatly assist to ensure freedom from solder bridges in this area.

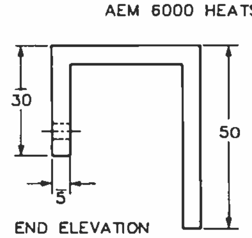
The remainder of the components mount on the top side of the main pc board in the usual fashion. Start by soldering the resistors and capacitors in place. Those components with tracks on the top side of the pc board should be soldered on ▶



N.B. HOLES ARE GIVEN BY CO-ORDINATES (X,Y)



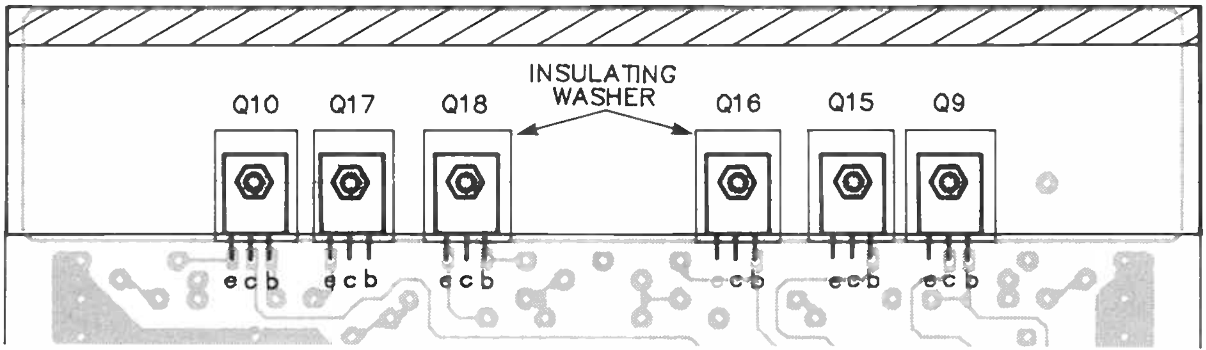
AEM 6000 HEATSINK BRACKET DRILLING DETAILS



THE BRACKET IS A 158mm LENGTH OF 50x40x50 ALUMINIUM CHANNEL. 5mm THICK

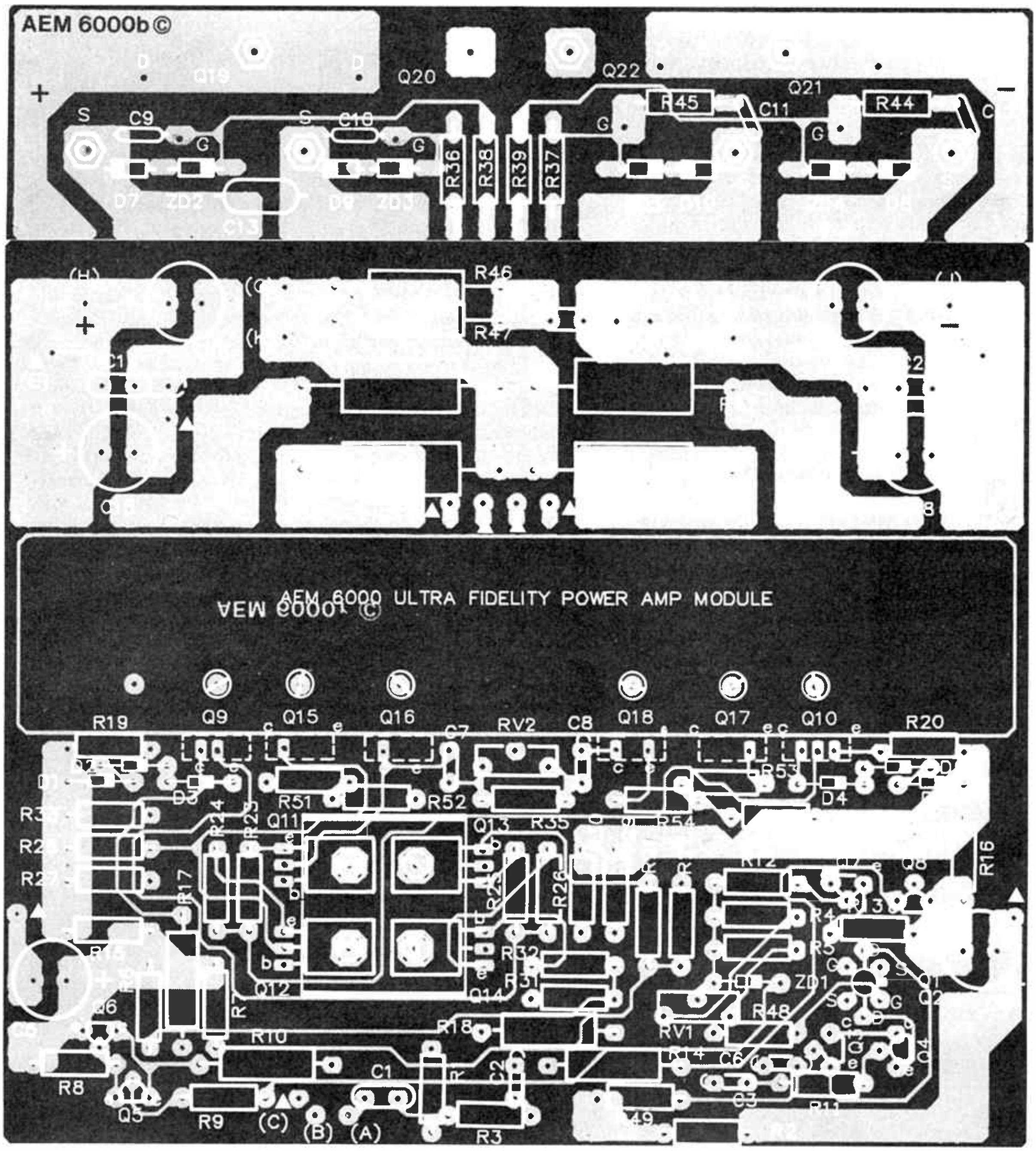
ALL HOLES ARE 4mm DIAMETER
ALL DIMENSIONS IN mm

HEATSINK CHANNEL BRACKET

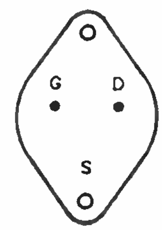


▲ FEEDTHROUGH LINK

ALL TOPSIDE COMPONENT PADS MUST BE SOLDERED

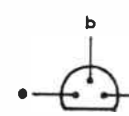


2SK176
2SJ56



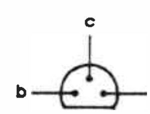
MOSFET PINOUT
BOTTOM VIEW

BC547



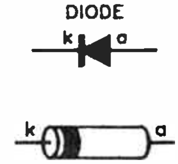
BOTTOM
VIEW

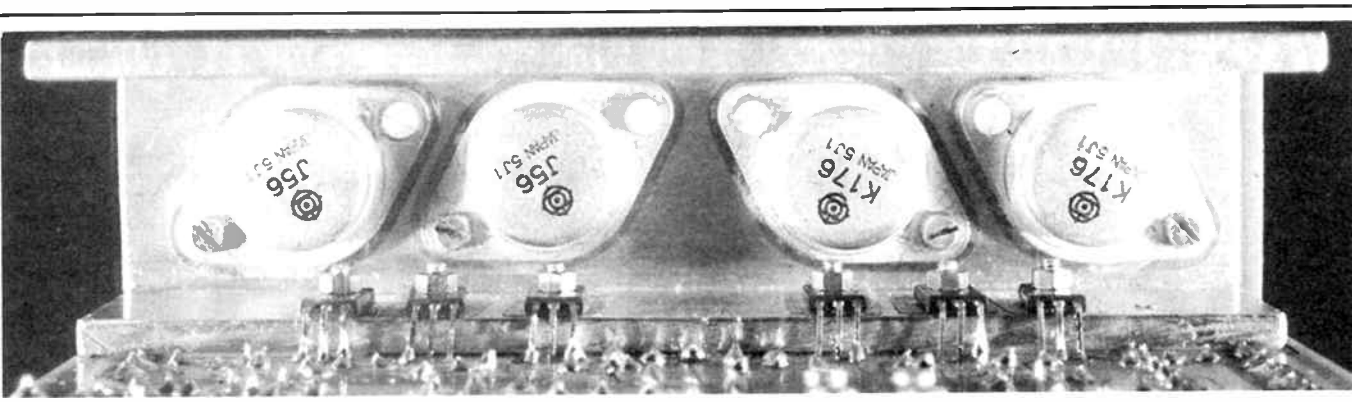
BC639
BC640



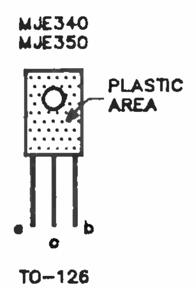
BOTTOM
VIEW

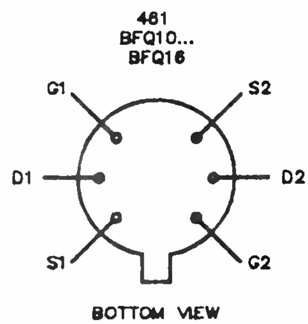
DIODE





COMPONENT PINOUTS





AEM 6000 PARTS LIST

Semiconductors

Q1, Q2 ..... ECG461 or equiv.
Q3, Q4 ..... BC639
Q5 ..... BC640
Q6 ..... BC557
Q7 ..... BC639
Q8 ..... BC547
Q9 ..... MJE350
Q10, Q11, Q12 ..... MJE340
Q13-Q16 ..... MJE350
Q17, Q18 ..... MJE340
Q19, Q20 ..... 2SK176
Q21, Q22 ..... 2SJ56
D1-D6 ..... 1N914 or equiv.
D7-D10 ..... 100V, 1A fast recovery
ZD1 ..... 12V, 400 mW zener
ZD2-ZD5 ..... 12V, 1W zener

Resistors all 1/4W, 5% unless noted.

R1 ..... 100k
R2 ..... 10R
R3 ..... 1k
R4, R5 ..... 220R
R6, R7 ..... 33k, 1%
R8 ..... 180R, 1%
R9 ..... 3k3
R10 ..... 10k, 1W
R11 ..... 1k
R12 ..... 2k7
R13 ..... 120R, 1%
R14 ..... 10K, 1W
R15, R16 ..... 10R
R17, R18 ..... 10k, 1W
R19, R20 ..... 220R 1% *see below*
R21-R26 ..... 100R, 1%
R27-R30 ..... 680R, 1%
R31, R32 ..... 100R, 1%
R33, R34 ..... 33R, 1%
R35 ..... 100R
R36-R39 ..... 270R
R40-R43 ..... 0R22, 5W
R44, R45 ..... 22R
R46, R47 ..... 22R, 1W
R48 ..... 47k
R49 ..... 1k
R50 ..... not used
R51-R54 ..... 10R
RV1 ..... 20k
RV2 ..... 200R

Capacitors

C1 ..... 470n MKP else MKT (see text)
C2 ..... 1n MKP else MKT
C3 ..... 47p ceramic
C4, C5 . 100µ/100V RB electro.
C6 ..... 15p ceramic
C7, C8 ..... 18p ceramic
C9, C10 ..... 330p KP else ceramic
C11, C12 ..... 33p ceramic
C13 ..... 220n MKP else MKT
C14 ..... 22n MKP else MKT
C15-C18 . 100µ/100V RB electro.
C19, C20 . 100n MKP else MKT

Miscellaneous

PC boards, AEM6000, AEM6000B; AEM6000 heatsink; wire; four T03 mounting kits; thermal paste; nuts & bolts; heatsink bracket.

* R19, R20 are 150R to 270R, depending upon the number of output devices employed. In the case of the module as described (i.e: four output devices) use 220R 1%.

Expected cost:
$110-$125

both sides of the board. Mount the higher power resistors so that they stand off the pc board by approximately 1-2 mm to allow adequate ventilation. Ensure that the electrolytic capacitors are mounted with the correct orientation. These are polarised devices and will be damaged if the module is powered-up with these incorrectly inserted. The diodes and small transistors can be soldered next, leaving mounting of the small heatsink until last. This should be drilled according to the drilling details given elsewhere, once again being sure to clean the holes of burrs that may cause problems with the insulating washers. The heatsink is held in place by the bolts used to secure the four flat-pack transistors to the pc board. The transistors must be insulated from the heatsink, and therefore from each other, by the use of insulating washers. After bolting these devices into place solder their leads,. as before, on both sides of the pc board.

Powering-up

Before attempting to power up the module, make some preliminary checks with a multimeter and give the entire module a close visual inspection. Power amplifiers often fail somewhat spectacularly if a mistake has been made and the result are often expensive to repair. Check that the MOSFETs are correctly insulated from the heatsink bracket by checking the resistance from the cases of the devices to the bracket. If a short circuit is found, unbolt the device and rectify the problem. Apply the same test to all of the flat-pack transistors, checking for shorts between their centre leads and the heatsinks to which they are mounted.

If all is well, the module can be connected to a power supply. The recommended power supply rail voltages for the module lie in the range from +/- 50 V to +/- 75 V.

Connect the power supply to the module using the two 10R series resistors shown in the circuit diagram of the test power supply. These resistors help to minimise damage to the module in the event of a fault being present when the module is powered-up. Most serious faults will result in these resistors being burnt out immediately upon powering-up. These resistors also serve the purpose of enabling the quiescent current to be measured by measuring the voltage drop across them. Use a heavy gauge multistrand hookup wire, such as 32 x 0.2 mm as a minimum, to wire-up the moduleto the positive and negative supplies. Note that the module is connected to the 0 V on the power supply at two different points. The main connection is from the 0 V point closest to the output terminal on the module. This connection should be made ▶

NOTES & ERRATA regarding Part 1.
The earth connection to capacitor C5 in the circuit diagram is shown as 'clean earth'. This should be shown as 'noisy earth'.

The values of resistors R19 and R20 are shown in the circuit diagram incorrectly as 150R. These should be 220R as specified in the parts list.

using heavy gauge wire, like that used for the positive and negative supply rails. The second connection can be made using lighter gauge wire to the 0 V connection near the module's input. The reasons for having these two separate earth connections, called "clean earth" and "noisy earth", will be detailed in Part 3.

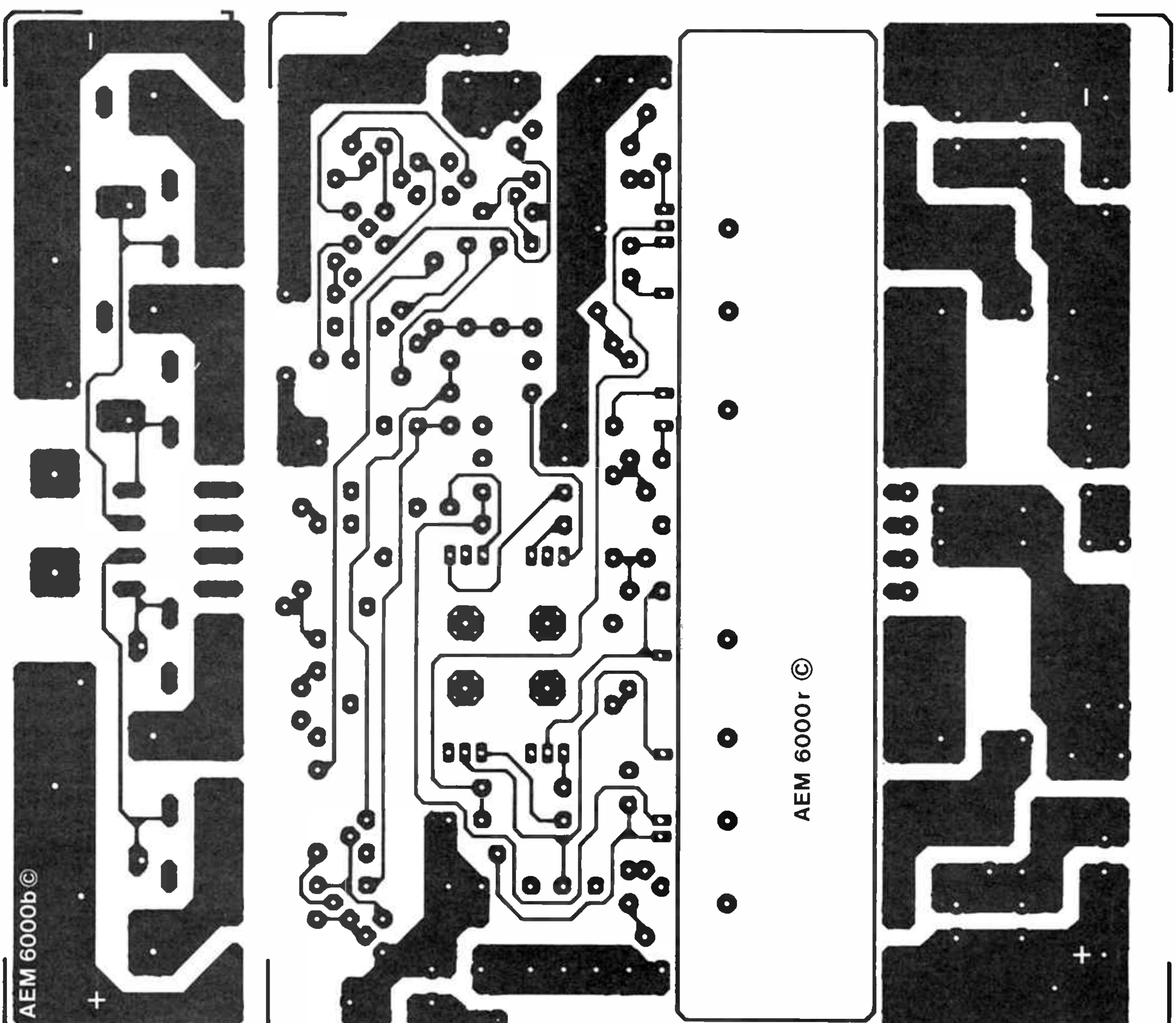
Once all of the connections have been made between the module and the power supply, ensure that preset RV1 is turned to the centre and preset RV2 is turned fully counterclockwise, then apply power to the unit. Watch for any signs of excessive power dissipation in the two 10R resistors (smoke!). Should problems arise, switch off and trace the fault. If all is well, connect a multimeter across the 10R resistor in series with the positive rail and adjust RV2 so that the meter reads 2.6 V.

The final adjustment necessary is to set the dc output offset voltage. This is done by measuring the voltage from the output terminal of the power amp module with respect to 0 V. Set the multimeter to the 200 mVdc range, if available, or the lowest dc range it has and, after letting the module warm up for about five minutes, adjust the dc voltage on the output to within 20 mV of zero.

Your module is ready to go!

AEM6000 pc board artwork

More pc board artwork is on p. 95



1ST BIRTHDAY CONTEST No. 5.

Win this Regency HX1000 VHF/UHF handheld scanner from Emtronics.

The Regency HX1000 handheld scanner covers six bands: 30-50 MHz, 144-148 MHz, 148-174 MHz, 440-450 MHz, 450-470 MHz and 470-512 MHz. It features keyboard programming and you can store up to 30 channel frequencies to scan your favourite channels at 16 channels per second, or scan the VHF bands at 17 seconds per MHz and the UHF bands at eight seconds per MHz. Sensitivity for 12 dB SINAD on the VHF bands is given as 0.5 μV on UHF. It is powered from 9.6 Vdc, battery source or mains power supply. The HX1000 measures just 70 × 48 × 197 mm.

Wouldn't you like to win this great little scanner? It's simple — just answer correctly the questions here and write us a little essay on what you could do with the HX1000 scanner.

1ST BIRTHDAY CONTEST No. 5.

Q1: What are the frequency limits of the UHF CRS band?

....

Q2: What are the search frequency increments of the HX1000 on VHF and UHF?

....

Q3: What does the term "SINAD" stand for?

....

Now write for us, on a separate sheet of paper, using 30 words or less, on what you would like to do with a HX1000 scanner.

Name ....

Address ....

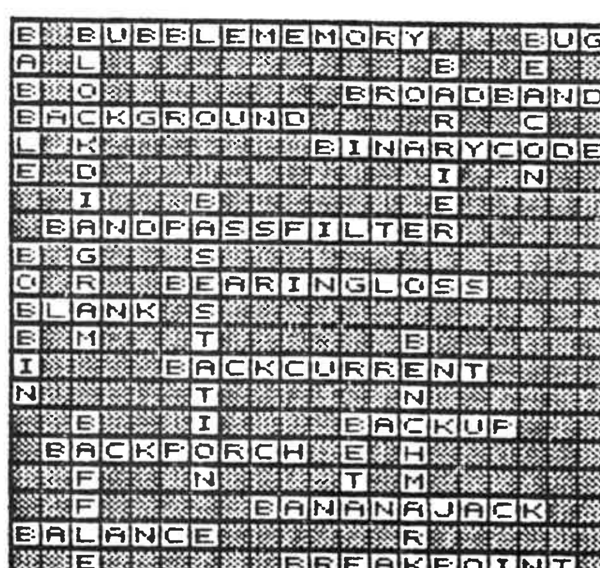
.... **Postcode** ....

I have read the rules of the contest and agree to abide by their conditions.

Signed: ....

**The Contest Rules are set out on page 6 of this issue.*

ANSWERS TO THE WELLER CROSSWORD COMPETITION NO.10



Low-cost, locally made weather fax to be launched world-wide

Hobart-based computer equipment manufacturer, Flexible Systems, has come up with a low-cost design for a radio facsimile picture ('FAX') decoder that prints, on a standard computer printer, weather information maps continuously transmitted by a world-wide network of stations.

The unit connects between the audio output of a single sideband HF receiver and a standard dot-matrix printer, translating the frequency-shift keyed (FSK) transmissions into the digital data required by the printer operating in dot graphics mode. It takes nine minutes to print a complete weather FAX picture.

Dubbed the 'Navimate', it's aimed at people who need more immediate weather information than the usual broadcast or published data, such as off-shore fishermen and cruising yachts (hence its name), country fire brigades and country airports frequented by gliding enthusiasts, for example. The system comprises two main units — the decoder itself and a standard Brother HR5 thermal dot-matrix printer. The system is powered from 12 Vdc.

According to Flexible System's owner, Adrian Firth, the unit will cost about $2500, around one-third the cost of the electromechanical machines currently used for the purpose. They plan to use the local market as a base from which to market the unit world-wide. North America and Britain are the biggest potential markets, says Firth.

The unit was designed and developed by Tom Moffat, electronics designer with Flexible Systems,who is well-known to AEM readers and, as you have no doubt already suspected, it's based on an idea employed in his hugely popular project, the Listening Post, featured in AEM's first issue.

The Navimate comprises a phase-locked loop FSK decoder and a dedicated Z80-based computer system. Internally resident software provides the necessary data shuffling to drive a standard dot-matrix printer. In addition to decoding and printing weather maps, the Navimate can provide decoding and printout of radioteletype (RTTY) transmissions. It also provides a printout of the operating instructions on command!

"While the FAX printouts are not of the same quality as the costlier machines, they are readable and, we think, provide printout of an acceptable standard for the intended applications", Moffat said.

"Apart from being substantially lower in cost than current FAX machines, the Navimate is simple to use", Tom Moffat explained. "The unit includes detection of the FAX start and stop tones, providing fully automatic operation."

There are three pushbuttons and five indicator LEDs on the unit. The pushbuttons provide selection of the READY/FAX/RTTY functions and the LEDs confirm what's happening.

The unit was developed over the past 12 months, and Tom used a standard Microbee for software development and to blow ROMs for the prototypes.

Further details from **Flexible Systems, 219 Liverpool St, Hobart 7000 Tas. (002)34 3064.**

Tom Moffat and the Navimate FAX machine he developed for Flexible Systems.

Communications Day '86

The Shepparton and District Amateur Radio Club is holding its Communications Day again. This year the big day is Sunday the 7th of September. The event was previously held in 1983 and 1984 and proved popular with amateurs and others from throughout Victoria and southern New South Wales.

This year the event will liven up its reputation of showing the latest in equipment and radio techniques. On display will be a home-type AUSSAT receiver station. This will almost certainly be the first time that many amateurs will have the chance to see the picture quality from Australia's own satellite.

Early indications are that there will be a very large range of new equipment on display. The "disposals" type of gear will also be available as will a range of components.

Demonstrations of packet radio, hopefully on HF as well as VHF, plus RTTY and a comprehensive demonstration station will give plenty to see and talk about.

The club will also be launching the Wombat Award. This is the club's first entry into the field and these numbered awards should be eagerly sought.

Venue is the Shepparton Showgrounds. Tea and coffee will flow all day and lunch will be available. For further information, contact **Peter O'Keefe, VK3YF on (058) 21 6070, PO Box 692, Shepparton 3630 Vic.**

Build this low-cost decoder to print weather satellite pictures with your computer

There are a number of polar-orbiting satellites that take continuous images of the Earth as they pass over, continuously transmitting the 'pictures' built up on VHF around 137 MHz. They are readily received with simple equipment (like a scanner) and, using this project and some simple software, you can print the weather pictures transmitted.

Tom Moffat VK7TM
39 Pillinger Drive, Fern Tree, Tas. 7101

ELECTRONICS AND COMPUTER enthusiasts are starting to look upward, as well as outward nowadays. The feature project published in the first issue of AEM, July 1985, the *Listening Post*, allowed a home computer to intercept teletype, Morse code, and facsimile transmissions from shortwave stations. This project has been a roaring success as more and more people get hooked on "spectrum snooping".

But it seems having your own shortwave listening post just isn't good enough . . . all you people out there want to get directly into satellites, of all things! So here we go with our first satellite receiving project. This one may not be the ultimate in sophistication, but it's designed to give you a taste of direct satellite reception using the least amount of effort and expense.

The satellites we are setting our sights on are the easiest ones to receive, the low altitude "automatic picture transmitters" or APTs that orbit the Earth at a height of about 800 km. These are set in near-polar orbits so that they spin around in a north/south plane as the earth rotates below them. This ensures that each point on the Earth's surface comes into view of each satellite at least once a day.

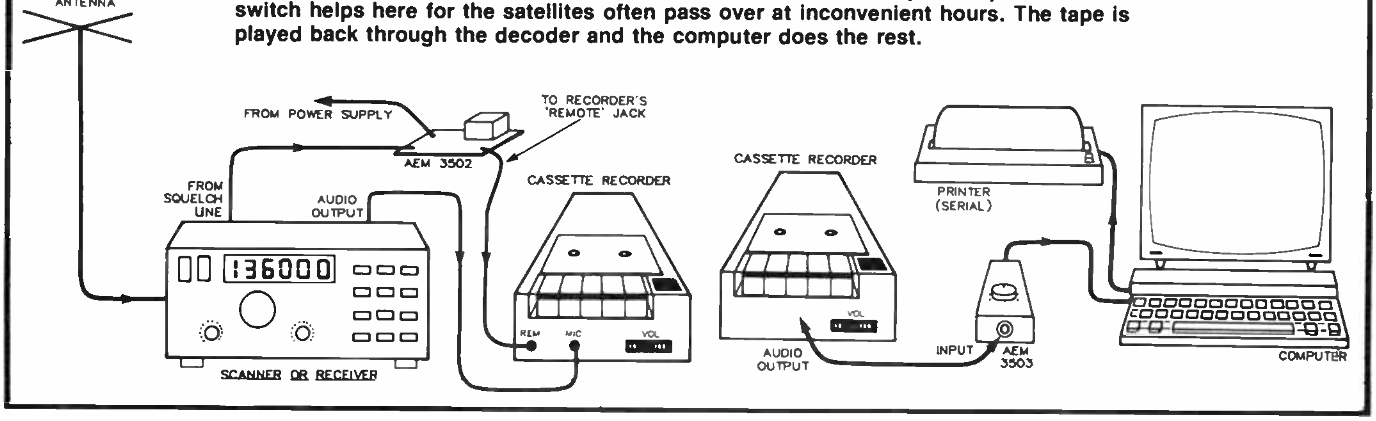
There are other APT satellites in much higher equatorial orbits, such that they rotate at the same speed as the earth and effectively stay above one spot on the surface all the time. These are called geostationary satellites. They produce the kind of weather picture served up on your TV set at the end of the news every night. Since the techniques needed to receive geostationary satellite pictures are much more involved (and expensive) than for the low altitude orbiters, we'll give the big fellas a miss this time around and concentrate on the easy stuff.

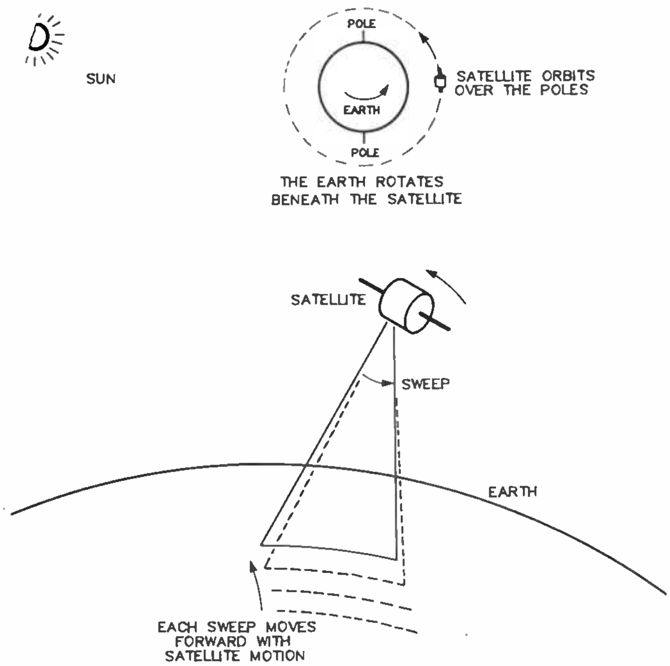
Our "ground station" will be pretty simple. We'll need a VHF receiver or a scanner capable of receiving frequencies around 137 MHz. (Watch out! Some scanners specifically miss out this frequency band.) We'll also need some kind of VHF antenna, possibly a preamplifier to boost the signal up a bit, a cassette recorder, a home computer, and the AEM3503 satellite signal decoder, You probably own most of this equipment already. The only thing you'll have to build is the decoder, and it's pretty simple.

The spacecraft

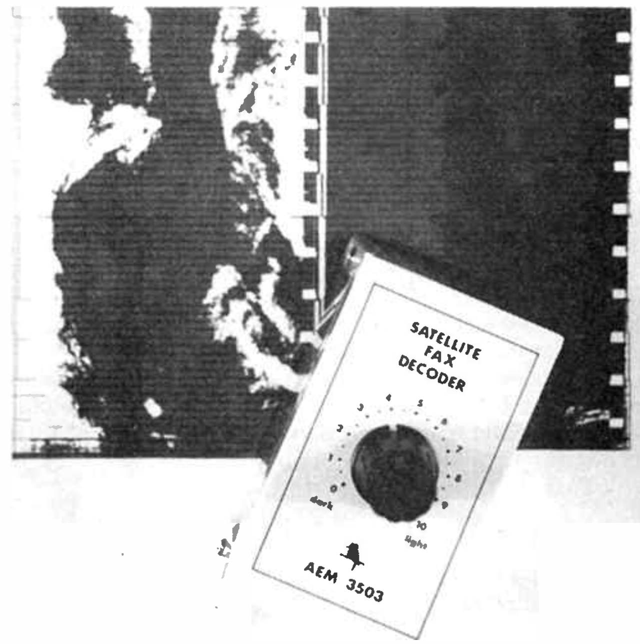
The low-level APTs carry a device called a "scanning radiometer". This is sort of a camera to take pictures of clouds and land masses, but it's not really a camera at all, there's no film, and there's not even a complete picture. The only information an APT has stored inside it at one time is one

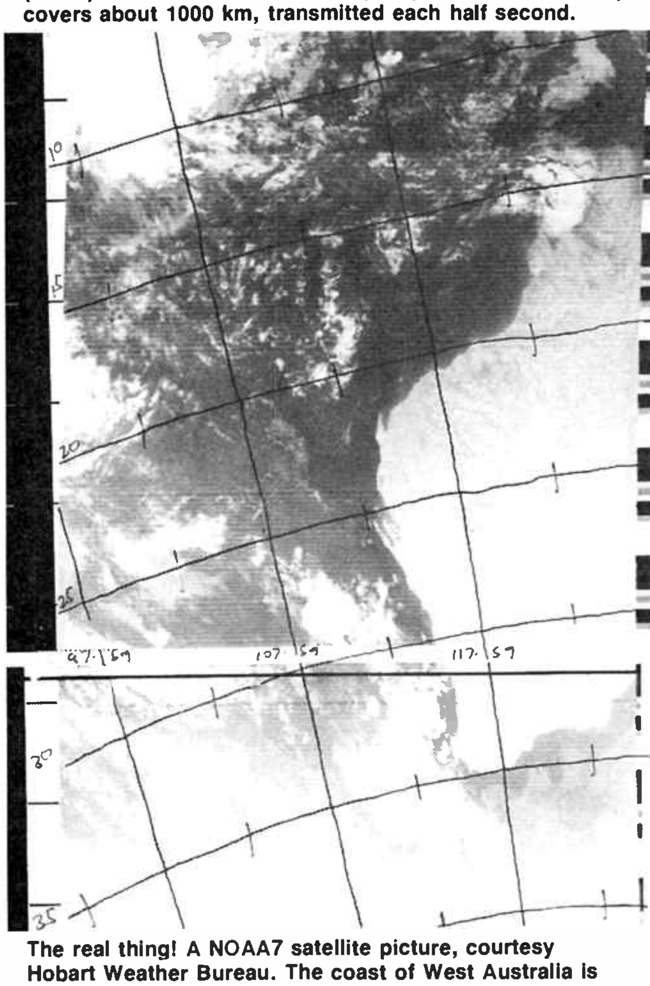
Showing the general setup for using recording and printing out weather satellite FAX pictures. First, make a tape of the satellite transmissions. Our squelch-operated cassette switch helps here for the satellites often pass over at inconvenient hours. The tape is played back through the decoder and the computer does the rest.





How the polar-orbiting automatic picture transmission ('APT') weather satellites build up a 'picture'. Each sweep covers about 1000 km, transmitted each half second.





The real thing! A NOAA7 satellite picture, courtesy Hobart Weather Bureau. The coast of West Australia is clearly visible. The 'grid' has been drawn on the print by hand.

horizontal line, like one scanning line on a television screen.

The scanning radiometer points straight down, and scans the same line over and over. But it's not really the same line because, as the radiometer is scanning back and forth (sideways), the spacecraft is moving forward in its orbit, over the Earth's surface. So the internal scanner is providing what would correspond to the 'horizontal' scan on a TV picture, and the satellite's own motion along its orbit is providing the 'vertical' scan. The result is a two-dimensional picture of various clouds, oceans, and continents that lie directly below the satellite's path. The picture is about 1000 km wide, but it is infinitely long since the "vertical scanning" never stops and the automatic picture transmitter runs continuously.

One horizontal line of picture is transmitted each half-second. It is scanned, stored, synchronizing pulses are added, and then it's transmitted down a radio link and got rid of before the next horizontal line is scanned. So the image coming in on your receiver at a given instant is no more than half a second old! It's effectively coming to you in "real time".

The scanning radiometer is an interesting device. In these days of digital electronic everythings, would you believe the scanning is done by a spinning mirror, driven by a good old electric motor? Even though it's a bit "mechanical", the system must be pretty reliable. Some of those APTs have been up there for over ten years, and they're still going strong. The radiometer detector is simply a fixed cell, like a photodiode. The mirror spins in the vertical plane, bending what it sees through a right angle and into the detector.

It's not all that simple though, at least in the American "NOAA" APT satellites. There are some further optical goodies to split the scanned line into two sections and shoot each section through its own optical filter. The sections are then laid side by side before they're transmitted. So the picture you get on the ground is two images, side by side.

It is normal to sense one image in the visible spectrum, and the other in the infra-red. Since the detector element is a radiometer instead of a photometer, it is capable of directly registering the *temperature* of clouds, instead of just brightness. This is considered of enormous value by weather forecasters. ▶

The Russian "Meteor" satellites don't use the split beam, they send one picture that covers the whole width of the frame, except for an area taken up by some synchronizing pulses. Overall, they seem to provide a nicer image than the NOAAs, with especially good shading of the light and dark areas. But, using our "minimum" receiving system, you won't see the nice shades of grey!

The pictures from all the low orbiter APTs are transmitted on a frequency between 136 and 137 MHz. The transmitter power is five watts, which is quite a big boomer as satellites go. This is why they're fairly easy to receive. At the same time, the pictures are transmitted in a higher resolution format on a frequency of around 1700 MHz, a lot higher than your average VHF receiver goes. So we'll forget about 1700 MHz for now.

The carrier is frequency modulated by a 2400 Hz audio tone, which is itself modulated by the spacecraft's picture video. The audio can be easily recorded on a cassette recorder.

Receiving the pictures

This is not a description of the best *way* to collect satellite transmissions, this is a discussion of how I did it using existing equipment.

The Antenna

Mounted near the peak of our roof is one of those "facia mounts" which has two TV aerials on it. The lower one is an ordinary TV array, pointed at the transmitters on Mt. Wellington in Hobart. Above it is a home-made 11-element Yagi for Channel 9, pointed at Launceston. This one has its own little home-made preamplifier.

At the very top of this bit of pipe is a 560mm (22 inch) long whip, attached with a CB antenna vehicle mirror mount, acting as sort of the 'active' part of a 'groundplane' antenna, although there is no proper groundplane. I'm assuming that the Channel 9 antenna directly below is serving the purpose. About five metres of good quality 50 ohm coaxial cable comes down from the whip, through a window and onto my desk.

This type of antenna is certainly not what is recommended for satellite reception, but it got the system going quickly. What's really needed is a circularly polarized multi-element antenna specially designed for the purpose. (See *Practicalities* elsewhere in this article.) Perhaps I'll give one a try one day. Maybe it will also have a pre-amp of the type on the existing Channel 9 TV antenna.

The Receiver

This is a Yaesu FRG-9600, as reviewed in AEM, September '85. Since the frequency deviation of the APT signal is ±17 kHz, it is necessary to use the "Wide band FM" mode of the receiver. This mode on the FRG-9600 is about three times as wide as needed, at 180 kHz, but it works fairly well. I added a "Corona" two metre amateur band preamp (sold by Dick Smith) between the antenna and the receiver input. The preamp's two little adjusters have been screwed down to peak it up to 137 mHz, and it makes quite an improvement. It would probably be better still if mounted at the antenna end of the coaxial cable.

An FRG-8800 general coverage receiver with a VHF converter can hear the satellites as well, even without a preamp, but it's FM bandwidth is too narrow. Yaesu have a wideband FM filter available (in Japan). I'm trying to get one of these to try out; if it works it will allow owners of these shortwave receivers to use them for satellites as well.

Our house is quite near the summit of Mt. Wellington where there is a grand collection of TV, FM, and other radio transmitters. In fact the ABC Channel 2 signal is so strong it causes bad "frame buzz" in my son's crystal set! It even gets into the stereo audio leads. In the midst of all this, we are trying to intercept a little bitty signal from a satellite many kilometres away. The noise from those big signals causes a lot of problems; and I'm surprised it works as well as it does.

The Cassette Recorder

It would be fair to say that just about any old cassette recorder should work to record the pictures you receive. I have used two different battery-powered "dictation" recorders, a Sony and an Aiwa. They are both quite old, but they both work well.

You must be sure that the recorder is compatible with the audio levels coming out of the receiver, before expecting to get good recordings of satellite pictures. You might try to record one of your local FM broadcast stations. Many of these receivers have quite good audio quality, and if your recording isn't clean as a whistle, something is wrong.

An accessory that's almost a must is the AEM3502 signal-operated Cassette recorder Controller project from the March '86 issue. You can set it up to start recording when the satellite signal appears on a chosen frequency, and to stop recording when the satellite goes out of range. Some satellite passes occur around 5.30 in the morning and there's no way I'm going to get out of bed to record then manually!

The picture you'll be getting

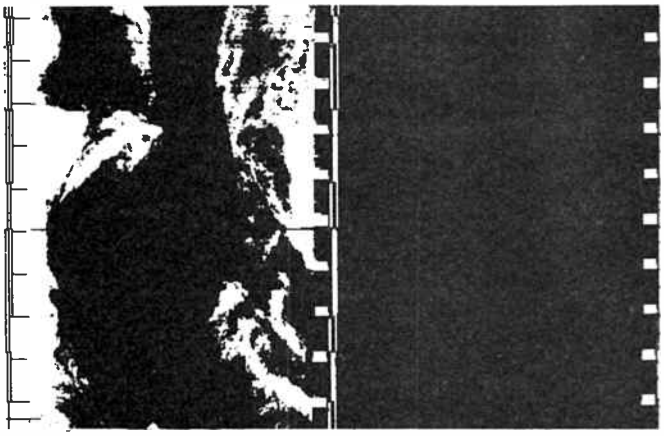
Cast your eyes now upon the collection of images presented herewith. They were recorded on a cassette, decoded with the project and a Microbee computer, then printed on a CP-80 dot matrix printer. The first thing you'll notice is the intense contrast. There ain't no shades of grey, folks, dot matrix printers print a dot, or no dot, but not half a dot! Still, it's easy to see that the pictures are of clouds.

One thing we can do with the AEM3503 decoder is adjust the level of brightness at which the picture will jump from black to white, using the **light/Dark** control. So you can play one picture cassette through the system several times, using a different Light/Dark setting each time to bring up different aspects of the picture. This has been done in Picture 1, recorded from an American NOAA satellite.

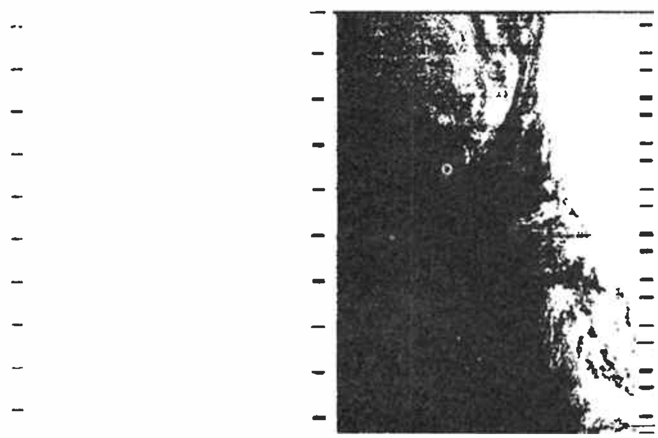
Picture 1a was produced by running the cassette through with the Light/Dark control set more or less in the middle. The picture is about 1000 km wide (east/west) and about 1500 km high (north/south). It shows lots of nice pretty clouds. At the very left of the frame are some synchronizing pulses. At the right of each of the two images are things that look like sprocket holes in movie film. They are really grey scales, forced into a black/white-only format, so the size of the holes varies with the Light/Dark setting, with the scales looking bigger as the picture is lightened.

The right side of the picture is the infra-red image. Most of it is totally black with the Light/Dark control set to properly reproduce the left hand picture. The IR channel suddenly comes good at the bottom; perhaps the satellite changed filters or exposure at that time. The whole picture represents about 12 minutes of satellite transmission time.

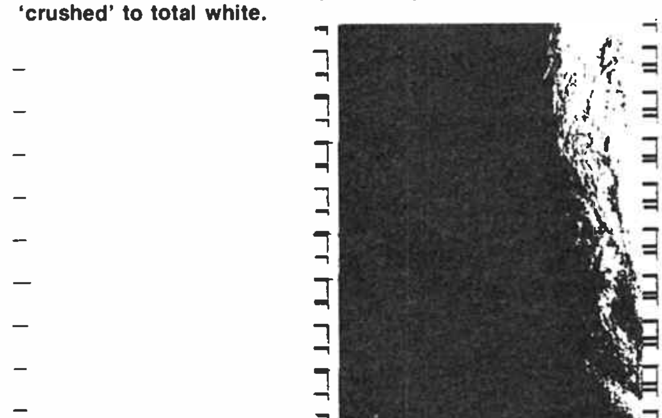
Picture 1b is the same cassette played again, only with the Light/Dark control set to bring out the most possible white. The grey scales have expanded so that they are almost all white. The visibly light half of the picture (left) is burned-out to total white, but the IR channel has come up nicely, showing some wispy clouds and a big mass of white on the



Picture 1a: A NOAA Satellite picture; 'visible spectrum' frame to the left, infra-red frame to the right. The latter is too dark to resolve.



Picture 1b: Same picture as 1a but with the Light/Dark control set to bring out the most possible white in the infra-red frame. The visible spectrum picture video is 'crushed' to total white.

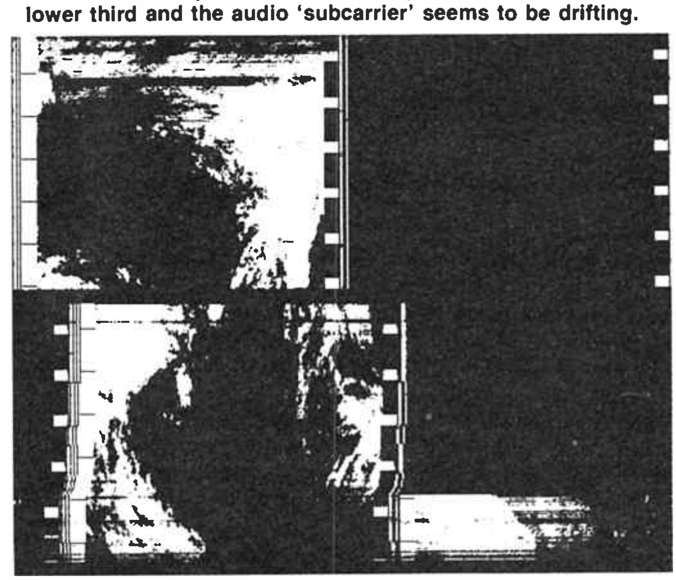


Picture 1c: Same picture again, although here the Light/Dark control has been backed-off to favour more black content. The cloud formation in the upper centre of 1b has disappeared here, but more detail now shows at the right of the frame.

right side. Is this the coast of Western Australia? It certainly looks like it.

Picture 1c is the same scene yet again, but with the Light/Dark control backed off a bit to try to resolve the white blob in picture b. The wispy cloud has completely disappeared, but the white blob now shows some detail. It is still unclear whether there is a land mass there or not. The other picture here is a "proper" APT picture supplied by the Hobart

Picture 2: This one's from a Russian Meteor satellite on 137.4 MHz. The picture shows a couple of fades in the lower third and the audio 'subcarrier' seems to be drifting.



Picture 3: Some strange effects happen when the satellite signal goes into a deep fade. The decoder 'loses lock' during a deep fade at the centre of the frame, then 'recaptures' it later, but note that it's now out of sync.

weather bureau. It shows what Western Australia is supposed to look like.

Picture 2 is from a Russian Meteor satellite. There are synchronizing pulses down the left (lots of them!) and then a full-frame picture. This one has a little problem with the vertical lines leaning a bit. This is because our computer's half-second-per-line timing is derived from the spacecraft's 2400 Hz tone frequency, and the Russian satellites aren't renowned for their frequency accuracy. If we had actually synchronized to the sync pulses as the Russian designers intended, the picture would have been quite all right.

There are a couple of fuzzy horizontal bars through Picture 2. They were caused when the radio signal faded somewhat.

Picture 3 shows what happens when things go wrong. You'll see plenty like Picture 3 in the early stages. The picture went nicely until about half way along, when the satellite signal just disappeared. This happened because the signal went into a deep fade, and the receiver's squelch closed, cutting it off completely. It came good again after a few seconds, but only after the picture had lost sync and slipped to the right of the frame.

Later on, it started to lose sync again, gradually. This picture was made just on sundown, and I suspect the satellite IR channel got darker and darker until there was so little tone level that the decoder had trouble staying locked to it. You'll notice the IR channel brightened suddenly, and the syncs came good at the same time. ▶

The project design

Following the Editor's 'kiss' principle (keep it simple, Sam!), the project design is relatively simple, but enough to do the job. Like the very popular AEM3500 Listening Post, I've used a phase-locked loop (PLL) IC to demodulate the received audio signal. Here, I used a 4046 'Micropower PLL' and it works very effectively indeed. A 4013 dual flip-flop derives a 120 Hz 'clock' from the satellite signal for timing in the computer, while I've used a comparator, in conjunction with the other half of the flip-flop to derive the 'video'. This part of the circuit 'decides' when a 'dot' will be printed or not printed, controlled by the Light/Dark control.

It all goes on a small pc board and cost is quite low because the components are common, low-cost items. The circuit requires a 5 V supply and, as it draws little current, this can be derived from your computer if a suitable output is available.

When, where, what frequency?

Ah, I was afraid you'd ask that! It is, of course, possible to predict exactly what time a particular satellite will come into range, exactly what part of the Earth it will be over at any time, and when it will disappear. But to work out this information, either manually or with a computer, you need access to certain information called "orbital parameters", and I've found this generally a little hard to come by. Your resourceful Editor may well do better.

The Australian weather bureau doesn't rely on the APT satellite so much nowadays; their prime source of weather pictures is now the Japanese geostationary satellite, GMS-2. But they maintain a receiving capability for the APTs, just in case GMS-2 goes bung. The APTs are still considered super-reliable.

The Weather Bureau's radio station AXM transmits via teletype, every day, some "APT PREDICTIONS" which are labelled "DAY PART 1", "DAY PART 2", "NIGHT PART 1", "NIGHT PART 2", etc. Then comes strings of numbers. A trip to the Hobart weather bureau failed to shed any light on how this information is used. It seems they get big books full of computer listings with the satellite orbital parameters already calculated.

As to figuring out what area is depicted in a satellite picture, the weather bureau had plenty of information, and their technical man spent a lot of time explaining it to me. They have some transparent overlays with lines of latitude and longitude on them, which are simply laid on top of the picture. But the overlays assume that the picture was received at a particular place, and printed onto a certain size of paper. So that technique won't be of much use to us, with various picture sizes, and locations scattered all over the world.

The best way to get the pictures, I've found, is to choose some frequency and then lay in wait for the satellite. The AEM3502 signal-operated switch can do the waiting for you.

There are several satellites on several different frequencies, and they fall into three general types: *Tick-tocks*, *Whizzers*, and Goose satellites! Huh? Well, that may not be too scientific, but that's how they sound!

Tick-tocks are the American NOAA satellites, and they sound exactly like a 2400 Hz tone with a grandfather clock superimposed on it. They go tick-tock-tick-tock as they scan over first the visible and then the infra-red channels. You'll instantly recognize the sound when you hear one. Tick-tocks transmit continuously, on 137.5 and 137.62 MHz.

Goose satellites are the Russian Meteors. They go Honk! Honk! Honk!, once every half second. The honks are the sound of the burst of sync pulses as seen in Picture 2. Goose ▶

CIRCUIT DESCRIPTION

If you look at the circuit diagram in Figure 1, you'll see there's not a lot there. But the device has many useful functions. It demodulates the amplitude modulation on the 2400 Hz audio tone (the 'subcarried') and produces a binary video signal representing the picture from the satellite. It also locks onto the tone, producing the modulation. This 1200 Hz copy can be used as a clock signal by the computer, since exactly 600 cycles of it occur for each line of picture transmitted.

This circuit was a joy to design, and it worked on the first try. It was one of those rare cases where you work out what you want it to do, and the circuit does it! The waveforms in Figure 2 were actually scribbled out as an idea before the first component was inserted, and the damn thing worked. Amazing!

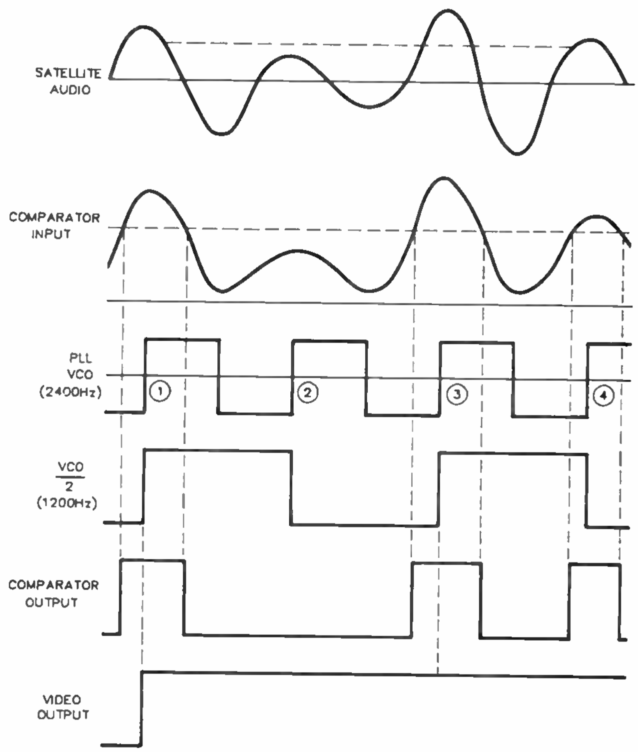


Figure 2. Showing operation of the 4046 PLL.

Even though the circuit demodulates the audio signal, there is no demodulator, hence no problems trying to recover video information of sufficient bandwidth, while getting rid of the 2400 Hz carrier frequency. We simply use some precise timing and a characteristic of a phase-locked loop (PLL) to snip samples of the carrier at the appropriate moments and build them into a video signal.

The top waveform in Figure 2 is what comes out of your cassette recorder. It's sent off to two places, the input of a 4046 phase-locked loop chip (IC1), and the input of a comparator (IC3, an LM311). A germanium diode on the comparator input clamps the bottom of the waveform near zero, such that all excursions of the signal go up. This puts them in the same range as the voltage from the Light/Dark control, which is the voltage the signal is compared against. The 'clamped' audio is shown in the second waveform in Figure 2.

Now to the phase-locked loop: it is a fairly standard design, straight out of the data book. We won't go into detail about how it works; that could be the subject of a whole book in itself! It's purpose is to lock onto a synchronizing signal and then oscillate in step with it, even though the signal may jump up and down in level, or even fade into noise. People familiar with PLL design will notice that there is a whacking big electrolytic capacitor in the loop filter. This makes the circuit respond rather gently to jumps in the signal's frequency, amplitude, or noise content. It just keeps oscillating away regardless.

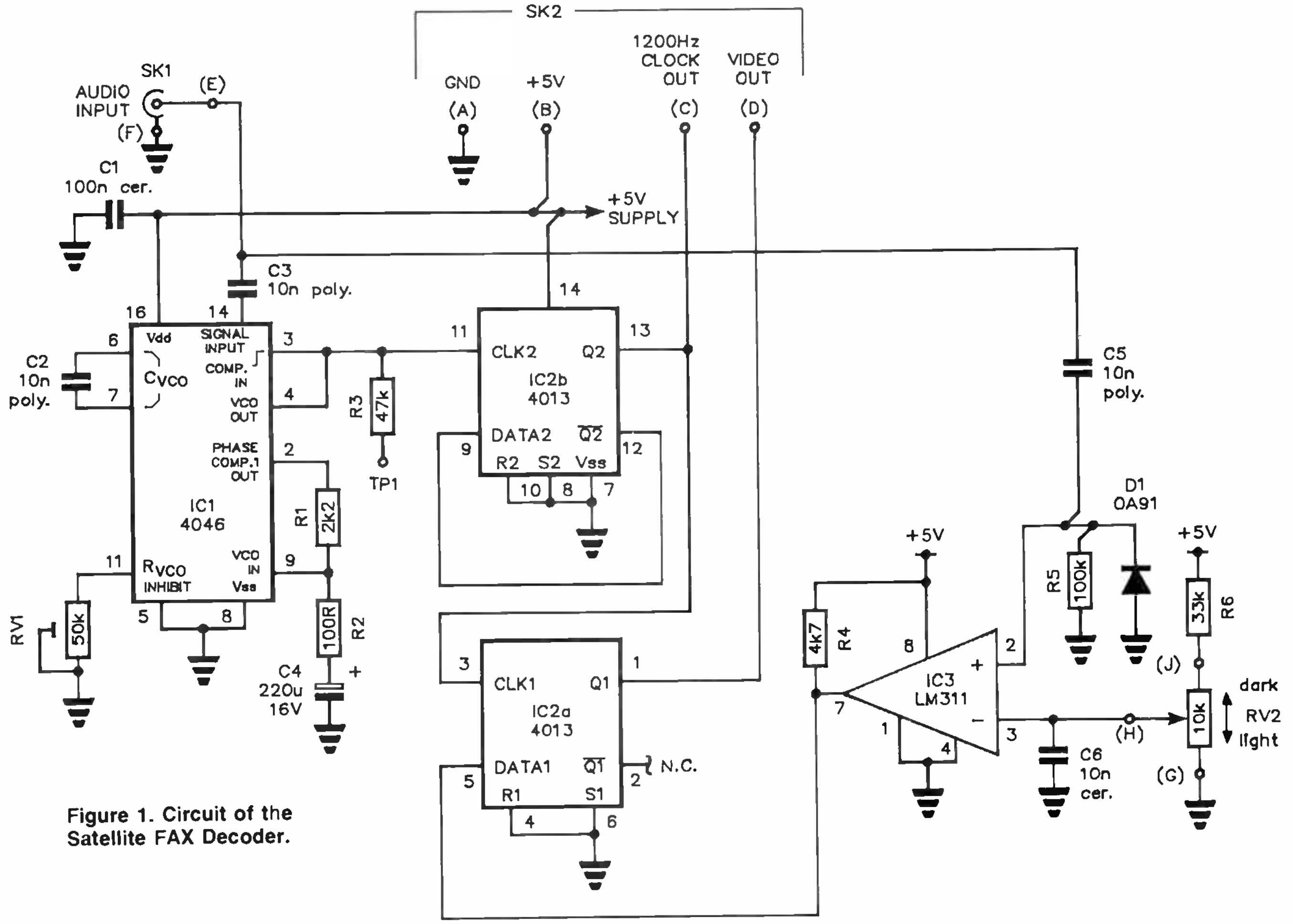


Figure 1. Circuit of the Satellite FAX Decoder.

An interesting characteristic of a phase-locked loop of this type is that when the PLL is in lock with the incoming signal, the internal voltage-controlled oscillator (VCO) frequency is exactly 90 degrees out of phase with the incoming signal. This means that the VCO flips from high to low or low to high while the incoming signal is at its minimum or maximum.

The third waveform in Figure 2 is the PLL output. You'll see that its first transition, marked "1", occurs exactly during a peak in the incoming satellite audio. The PLL then drops low again at the very bottom of the satellite audio signal. When it goes high again at "2", the satellite audio is again at a peak, and so it goes.

Now here comes the good bit. If you arrange a computer or some other circuit to take note of the state of the incoming audio *only at the upward transitions of the PLL signal* (the parts marked 1, 2, 3 and 4), what it will see is the *modulation*, the recovered video.

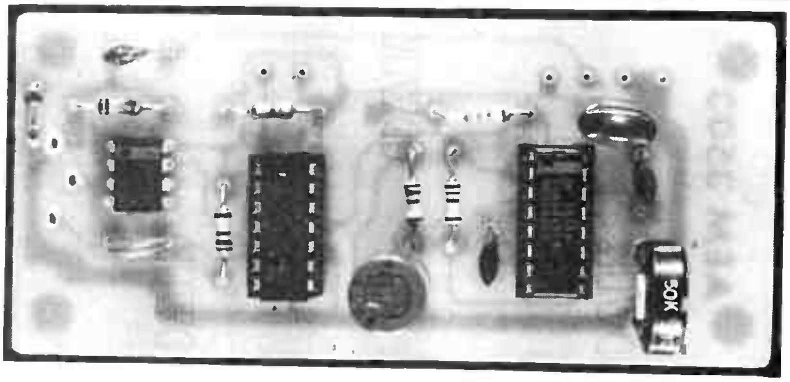
Now back to the comparator: The broken horizontal line through the comparator input waveform in Figure 2 represents the level at which we have set the Light/Dark control. Any audio above that level will cause the comparator to operate. Cycle 1 is above the level, cycle 2 isn't, cycles 3 and 4 are above it. So the comparator operated on cycles 1, 3, and 4, as shown in the fifth waveform in Figure 2. The state of the comparator determines whether or not a dot will be printed by the printer when that particular cycle is sampled.

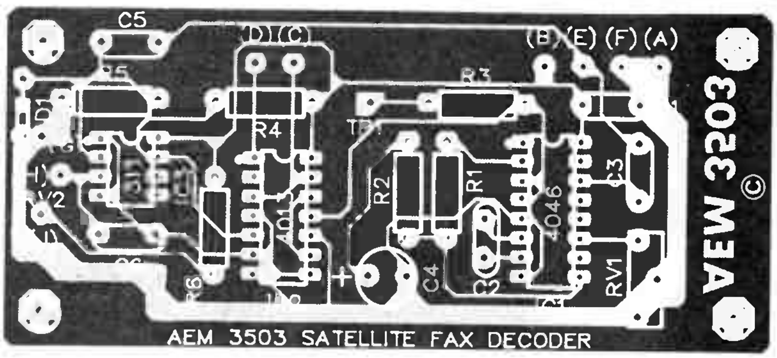
Now, with the PLL oscillating away at 2400 Hz, there are 1200 opportunities to sample the spacecraft audio during each half-second picture line. But we don't need 1200 printer dots for each line of picture, 600 is a more reasonable figure. So we divide the PLL frequency by two using half of a 4013 flip-flop (IC2). This new frequency is shown in the fourth waveform in Figure 2. We are now ignoring every second cycle from the spacecraft, and taking note of numbers 1, 3, etc.

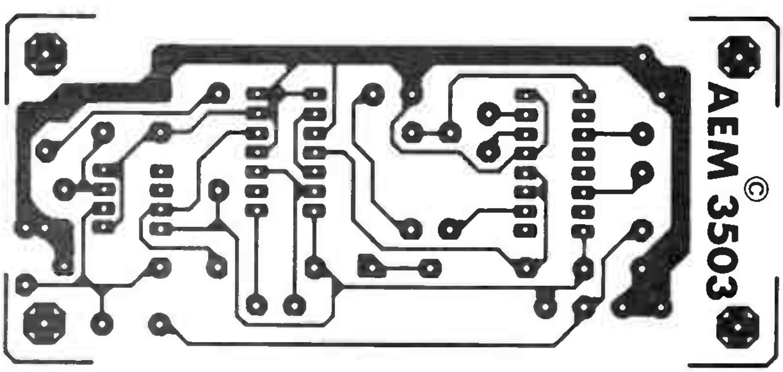
Finally, we are using the second half of the 4013 as a storage register for the current state of the demodulated picture. It will be high when the picture is white, and low when it is black. The register is only allowed to change states when it is "clocked" by the 1200 Hz square wave.

The bottom waveform in Figure 2 is what is sent to your computer. Assuming the picture was black at the start of the trace, cycle 1 toggles the video high as the audio modulation goes high. At cycle 2 the comparator goes low again, but this is ignored and the computer still sees a white picture. At cycle 3 the comparator goes high again, but there's no change in the video output since it was already high. At cycle 4 it still remains high.

In the original Microbee version of this system, the second half of the 4013 wasn't used, and the comparator output was fed straight to the computer. The 1200 Hz signal was then used to trigger an interrupt that caused the 'Bee to take note of the comparator at that instant. This worked nicely, although timing was critical; the samples had to be taken at just the right instant. But with the signal now being stored in the decoder itself, the computer can take a sample any old time it feels like it. This should simplify software development for other computers. The 1200 Hz clock signal is, of course, still available if Commodore/Apple type people have any use for it. The Microbee still uses this signal as its primary "heartbeat".







AEM3503 PARTS LIST

Semiconductors
IC1 4046
IC2 4013
IC3 .... LM311, uA311
D1 .... OA91

Resistors All ¼W, 5%
R1 .... 2k2
R2 .... 100R
R3 .... 47k
R4 .... 4k7
R5 .... 100k
R6 .... 33k
RV1 .... 50k vert. trimpot
RV2 .... 10k/A pot.

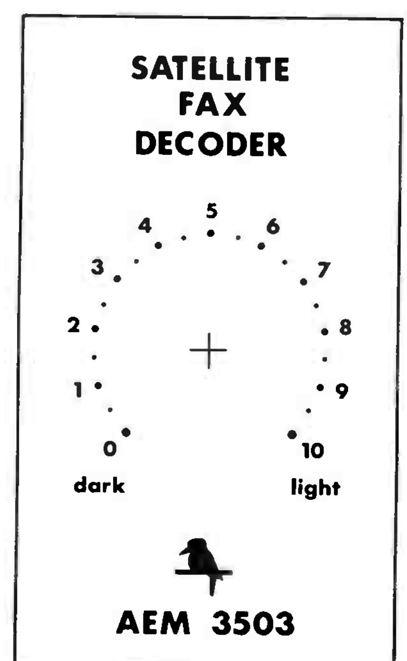
Capacitors
C1 .... 100n cer.
C2, C3 .... 10n poly.
C4 ... 220u/16 V RBLL electro.
C5 .... 10n poly.
C6 .... 10n cer.

Miscellaneous
SK1 .... RCA skt, panel-mount
SK2 .... 5-pin DIN skt, chassis-mount.

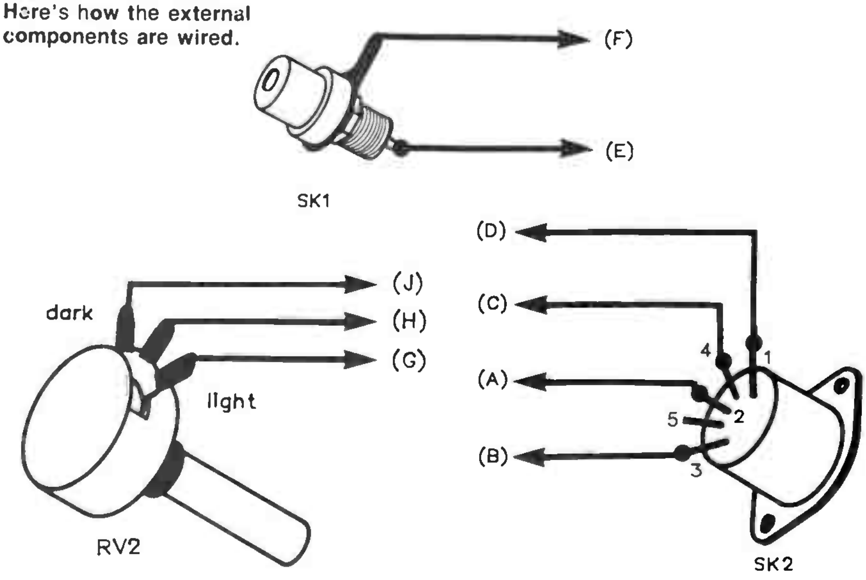
AEM3503 pc board; AEM3503 Scotchcal front panel (if required); small metal box, size to suit; computer interface connector; nuts, bolts, wire, etc.

Expected Cost: $22-$28.

Left: full-size reproduction of the pc board artwork and, below — the front panel artwork.



Here's how the external components are wired.



satellites don't seem to transmit all the time, but as this was being written one was fairly active on 137.4 MHz.

Whizzers won't be of much use to you. They transmit their pictures at 240 lines a minute instead of the usual 120, and they seem to use a tone frequency that's much higher than 2400 Hz. So this decoder project probably wouldn't be able to cope with them. A Whizzer can sometimes be heard on 136.77 MHz.

Setting it up

This is easy. There is one adjustment, the 50k trimpot (RV1) on the circuit board. You will need a pair of headphones of some sort (pinched from your stereo, Walkman or whatever), and a cassette with a satellite picture on it.

First apply power to the circuit and check for smoke, bad smells, etc. Nothing? Good. Set the trimpot in about the centre of its range. Now use some bits of wire or clip leads and connect the headphones, or one side of them, between Test Point 1 and Ground. You will probably hear nothing yet.

Now connect the cassette recorder, set the volume about half way up, and play the tape. You should now hear a tone of some sort in the earphones. If there is nothing, rock the trimpot around a bit. If still nothing, you've got a problem; go back and check your wiring.

Once you hear the tone, stop the tape. The tone will probably slide higher or lower in pitch. Start the tape again and the tone should jump back to the original pitch. You then adjust the trimpot so that the tone pitch is the same when the tape is running, as when it is stopped. The idea is to set the tone frequency so that the PLL has the minimum amount of work to do to keep it in lock with the incoming signal. That's it, you're finished with the construction now, you can disconnect your headphones and put the lid on the box!

Software

Just to kick things off, we present with this article some software to produce satellite pictures with a Microbee, directly onto a dot matrix graphics printer. The printer used in the development was a CP-80, which is allegedly Epson, compatible. Since the Microbee's parallel port is already occupied by the AEM3503 decoder, you must use a serial printer.

The CP-80 I used was actually a parallel model, fed through one of those serial-to-parallel converter kits you see advertised in the magazines. This is an easy way to get a serial printer, although you must be sure to shoot some text through to the printer after the computer is first turned on, and before using the satellite software. It seems that the converter comes up with garbage in its receive register, so you must "clear its throat". Otherwise the computer's first graphics commands may be misinterpreted and the printer may go haywire!

There are two versions of the program, one for ROM-based Microbees, and the other for disk-based machines. You can enter the hexadecimal listings using your monitor or something like DDT, or take the easy way out and order the software through AEM's software service.

PIN	FUNCTION	DIN PLUG
1	+5V	(B)
2	BIT 7 (1200Hz CLOCK)	(C)
7	GROUND	(A)
13	BIT 0 (VIDEO)	(D)

MICROBEE PARALLEL PORT CONNECTIONS

This software is a bit different from other facsimile-type programs, in that it brings data into the computer and shoots it out to the printer, all at the same time. That is, it runs continuously as long as there's a signal coming in and there's paper in the printer! This is done using interrupts, and the picture sampling rate and the printer baud rate are all integrated and all linked to that original 2400 Hz audio oscillator up there in the spacecraft.

How this comes about is very complicated and quite messy, and to explain all of it would take another article this size on its own. So we will dispense with the source code listing and a detailed program explanation, which few people would bother to read anyway.

Once you've entered, or purchased the program, you load it as you would a game under BASIC in a ROM-based 'Bee. On a disk Microbee the program is a ".COM" file; you just type in its name "WTHRSAT". When the program begins you will see a message "STOPPED! Hit any key to start". Now make sure your decoder and printer are plugged into the computer, the cassette recorder is connected to the decoder, and the printer is switched on. When everything is right, start the tape playing and press any key.

You will see another message: "RUNNING: Hit [ESC] to stop". The printer should immediately do a line feed and then sit there for precisely 24 seconds as the computer prepares the first lot of data. Then the printer should begin printing, with a new line of picture appearing every eight seconds until the cassette runs out or you hit [ESC]. It's best to use [ESC] before the picture fizzles out completely. Otherwise the PLL tries to lock up on noise and the printer begins printing gibberish, messing up the paper at the bottom of your nice pretty picture.

The program has a sync pulse detector at the start; in fact it's the very same one used in the Listening Post project. It seems to work well, although I must admit I'm not entirely sure how! It works better than other things I've tried, so I left it there, as is. The computer will generally lock up on the left hand edge of either the visible or the infra-red picture. If it doesn't you can stop the program with [ESC] and then re-start it for another go at synchronizing.

When you are finished, the only way to leave the program is with the RESET key. This is a rather inelegant way to get out, but it's necessary to restore all the computer's interrupt functions to normal. Otherwise something might set off a spurious interrupt later on, causing a crash of truly monumental proportions.

Construction

A small pc board holds all the components, and this is best mounted in a small aluminium utility box. The Light/Dark pot can be mounted on the lid with a Scotchcal lable to dress it up. Audio input is via an RCA socket mounted on one end of the box. Connection to your computer is via a 5-pin DIN socket mounted on the opposite end.

Start with the boring mechanical bits. Use the front panel artwork here (or a photocopy) as a template to mark the hole for the Light/Dark pot. The blank pc board can be used to mark out the mounting hole positions. The RCA and DIN sockets are positioned such that they are readily accessible and do not foul the other items mounted in the box. The only earth connection between the case and the circuitry is made via the RCA socket earth lug.

Now you can get on with the pc board. First, no matter whether you've made your own or have a 'bought one', check that all holes are drilled and are the correct diameter. See that there are no broken tracks or small 'bridges' between ▶

closely-spaced tracks, particularly around the IC pins. Correct any faults. Assembly is quite straightforward, just keep in mind the usual rules: take care with the orientation of C4, see that all the semiconductors are inserted the right way round. The accompanying component overlay makes it all clear. Sockets may be used for the ICs if you wish. Note that all the ICs face the same way. All the resistors and capacitors should be mounted right down on the board, not 'stood up' on their leads. Light duty hookup wire is attached to all the off-board connection points, all of which are marked alphabetically. Use different colours to help identification when wiring later. Ensure you have plenty of length in these leads so that they easily reach where they need to go. TP1 is used in setting-up the decoder. A short length of tinned copper wire may be soldered in place here, or you could use a more elegant 'pc stake'.

A comment about several of the components is in order, as they affect the successful operation of the project. Firstly, I found that SGS-made 4046 PLLs caused problems, exhibiting sluggish VCO oscillation and locking problems. I had no trouble with National Semiconductor 4046s. Capacitor C4 should be a 'low-leakage' electrolytic, such as the Elna 'RBLL', or good quality electrolytic, such as the Siemens B41326. Also, note that, where I have specified 'poly' capacitors (C2, C3 and C5), do not use ceramics. Any of the plastic film capacitor types should work well — the ubiquitous 'greencap' (some makes of which are blue or brown), MKTs or MKPs.

It is wise to check the board before mounting it in the box, ensuring the semiconductors and C4 are all correctly orientated.

SOFTWARE

Here are hex dumps of the software for ROM and disk Microbees, respectively. They should be entered using Monitor or EDASM and a copy saved before running. Check carefully for errors after entering it. Tape and disk software will be available through the magazine's software service.

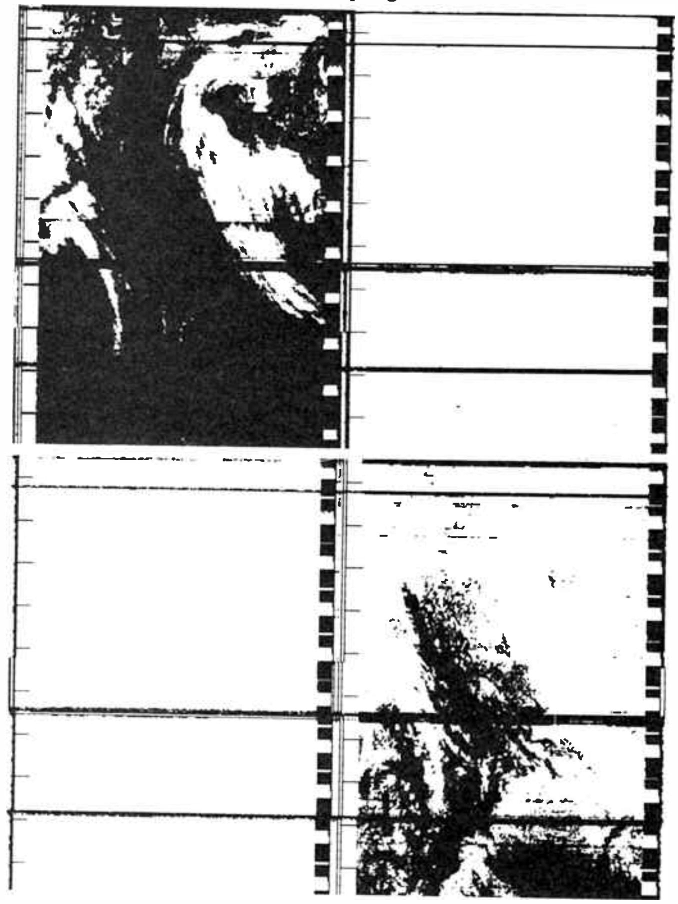
ROM version

```
Ø4ØØ:  F3 3E CF D3  Ø1 3E DF D3  Ø1 3E 97 D3  Ø1 3E 7F D3
Ø41Ø:  Ø1 21 E8 Ø4  22 88 ØØ F3  CD D1 Ø4 53  54 4F 5Ø 5Ø
Ø42Ø:  45 44 21 2Ø  48 69 74 2Ø  61 6E 79 2Ø  6B 65 79 2Ø
Ø43Ø:  74 6F 2Ø 73  74 61 72 74  2E ØA ØD ØØ  CD Ø6 8Ø CD
Ø44Ø:  D1 Ø4 52 55  4E 4E 49 4E  47 3A 2Ø 48  69 74 2Ø 3C
Ø45Ø:  45 53 43 3E  2Ø 74 6F 2Ø  73 74 6F 7Ø  2E ØA ØD ØØ
Ø46Ø:  FB Ø6 1Ø 76  DB ØØ ØF 38  F8 1Ø F8 76  DB ØØ ØF 3Ø
Ø47Ø:  FA Ø1 8Ø Ø3  21 58 22 3E  26 32 1C Ø5  D9 26 26 E5
Ø48Ø:  CD DB Ø4 1B  31 ØD ØA 1B  4B 58 Ø2 ØØ  E1 CB CC 76
Ø49Ø:  CD Ø9 8Ø FE  1B 28 8Ø 3A  1C Ø5 BC 28  F2 67 2E 58
Ø4AØ:  4E CD AD Ø4  2B 3E Ø3 A4  B5 2Ø F5 18  D2 76 DB Ø2
Ø4BØ:  CB 5F 28 F9  E6 DF D3 Ø2  Ø6 Ø8 76 DB  Ø2 E6 DF CB
Ø4CØ:  19 3Ø Ø2 F6  2Ø D3 Ø2 1Ø  F1 76 DB Ø2  F6 2Ø D3 Ø2
Ø4DØ:  C9 E1 7E 23  B7 C4 42 8Ø  2Ø F8 E9 E1  7E 23 4F B7
Ø4EØ:  F5 C4 AD Ø4  F1 2Ø F5 E9  D9 F5 DB ØØ  5F 79 2F 57
Ø4FØ:  3E Ø3 B8 7E  2Ø Ø1 A2 CB  ØB 38 Ø1 B1  77 2B 3E Ø3
Ø5ØØ:  A4 B5 2Ø 13  11 58 Ø2 19  1Ø ØD Ø6 Ø3  CB Ø9 3Ø Ø7
Ø51Ø:  7C 32 1C Ø5  EE Ø4 67 F1  D9 FB ED 4D  ØØ ØØ ØØ ØØ
```

DISK version

```
Ø1ØØ: F3 21 8Ø ØØ 7C ED 47 3E CF D3 Ø1 3E DF D3 Ø1 7D
Ø11Ø: D3 Ø1 3E 97 D3 Ø1 3E 7F D3 Ø1 21 Ø1 Ø2 22 8Ø ØØ
Ø12Ø: F3 CD E3 Ø1 53 54 4F 5Ø 5Ø 45 44 21 2Ø 48 69 74
Ø13Ø: 2Ø 61 6E 79 2Ø 6B 65 79 2Ø 74 6F 2Ø 73 74 61 72
Ø14Ø: 74 2E ØA ØD ØØ ØE Ø1 CD Ø5 ØØ CD E3 Ø1 52 55 4E
Ø15Ø: 4E 49 4E 47 3A 2Ø 48 69 74 2Ø 3C 45 53 43 3E 2Ø
Ø16Ø: 74 6F 2Ø 73 74 6F 7Ø 2E ØA ØD ØØ FB Ø6 1Ø 76 DB
Ø17Ø: ØØ ØF 38 F8 1Ø F8 76 DB ØØ ØF 3Ø FA Ø1 8Ø Ø3 21
Ø18Ø: 58 22 3E 26 32 35 Ø2 D9 26 26 E5 CD F4 Ø1 1B 31
Ø19Ø: ØD ØA 1B 4B 58 Ø2 ØØ E1 CB CC 76 E5 ØE Ø6 1E FF
Ø1AØ: CD Ø5 ØØ E1 FE 1B CA 2Ø Ø1 3A 35 Ø2 BC 28 EB 67
Ø1BØ: 2E 58 4E CD BF Ø1 2B 3E Ø3 A4 B5 2Ø F5 18 CB 76
Ø1CØ: DB Ø2 CB 5F 28 F9 E6 DF D3 Ø2 Ø6 Ø8 76 DB Ø2 E6
Ø1DØ: DF CB 19 3Ø Ø2 F6 2Ø D3 Ø2 1Ø F1 76 DB Ø2 F6 2Ø
Ø1EØ: D3 Ø2 C9 E1 7E 23 ØE Ø2 5F B7 F5 E5 C4 Ø5 ØØ E1
Ø1FØ: F1 2Ø F1 E9 E1 7E 23 4F B7 F5 C4 BF Ø1 F1 2Ø F5
Ø2ØØ: E9 D9 F5 DB ØØ 5F 79 2F 57 3E Ø3 B8 7E 2Ø Ø1 A2
Ø21Ø: CB ØB 38 Ø1 B1 77 2B 3E Ø3 A4 B5 2Ø 13 11 58 Ø2
Ø22Ø: 19 1Ø ØD Ø6 Ø3 CB Ø9 3Ø Ø7 7C 32 35 Ø2 EE Ø4 67
Ø23Ø: F1 D9 FB ED 4D ØØ ØØ ØØ ØØ ØØ ØØ ØØ ØØ ØØ ØØ ØØ
```

Mount the board in the box, using several nuts or short spacers to space the track side of the board off the box panel. Carefully wire-up the board to the Light/Dark pot, and the RCA and DIN sockets. Note that pin 2 of the 5-pin DIN socket goes to the earth on the pc board. If you use a shielded cable between the decoder and your computer, the shield should connect to pin 2 on the DIN plug.



Here's a recent recording of a NOAA satellite, made at 1900 EAST on 28 May, 137.50 MHz. Both are prints from the infra-red channel transmission. A few signal fades are visible. It was very clear over Hobart. In the upper picture not a lot of cloud shows with the Light/Dark control set at 'medium'. In the lower picture, the Light/Dark control was set much lighter to bring out detail from the great mass of black at the bottom of the other print.

Software for other computers

As this is being written, the only software for the project is for the Microbee. But, as with the Listening Post, we know there will be a demand for computers such as Commodore, Apple, BBC, etc. By the time you read this, the wheels should be turning and those masters of the art who did the Listening Post programs, and others, should hopefully be getting stuck into this project.

If you want to write some software, here are a few hints: If past performance is any indicator, you will probably want to display the pictures on the screen of the computer instead of going straight to a printer (the older Microbees can't really do this, but the Premium is another matter). Your program has to look at the incoming video signal and produce a horizontal row of pixels from the signal every half-second. This shouldn't be much trouble.

However, since the pictures are recorded on tape, you will have to find a way to nullify speed variations in the cassette recorder; otherwise it will be just about impossible to make vertical details in the picture line up one below the other. Remember that the 1200 Hz clock signal from the decoder is directly related to picture content, so if you lock your computer onto it somehow, cassette speed variations should be no problem.

The future

The AEM3503 is only a start. There can certainly be lots of improvements in our satellite receiving system. Perhaps, if there's enough interest, a future project could involve a better receiving antenna. This would hopefully give a dramatic increase in performance for little cost.

Going one step further, perhaps there is a case for a complete stand-alone receiver as a kit, eliminating the need to own an expensive VHF receiver such as an FRG-9600 (although if you've got one of these, you'll be using it more and more for space applications).

It would also be nice to be able to get at those signals around 1695 MHz. I've never been beyond 500 MHz myself, so I'm a bit in the dark. Maybe that's a good project for our noble Editor, Roger Harrison, he's into the fancy stuff. You listening, O Great Designer of Sooper Dooper UHF Receivers?

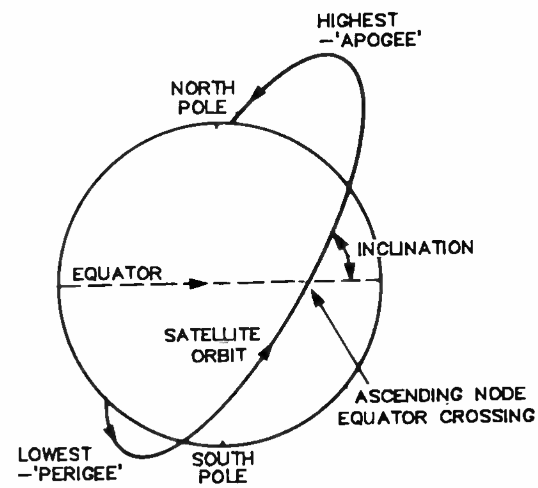
SOME WEATHER SATELLITE DATA

Satellite APT frequencies (in MHz)

136.32	136.50	136.80	137.30	137.40	137.50	137.62	137.77	137.85
GEOS3	NIMBUS4	EGRS13	METEORs	METEORs COSMOS	NOAA6 NOAA8	NOAA9	NOAA7	METEOR

Typical polar-orbiting weather satellite orbital data

Satellite (name/no.)	Inclination (degrees)	Period (mins)	Apogee (km)	Perigee (km)
EGRS13	99.7	107.2	1127	1068
GEOS3	115.0	101.7	935	826
NIMBUS4	99.5	107.1	1098	1086
NOAA6	98.6	101.0	815	797
NOAA7	99.0	101.9	856	836
NOAA8	98.7	101.2	826	802
NOAA9	98.95	102.03	883	862
METEORs 2-8	82.5	104.0	958	936
METEOR10	81.2	101.2	885	749
METEOR11	82.5	104.1	962	945



The accompanying diagram shows the various orbital parameters. The time to complete one revolution of the orbit is called the 'period'. The angle between the orbital plane and the geographic equator (or equatorial plane) is called the 'inclination'. When the satellite is furthest from Earth, it is said to be at its 'apogee', when closest to Earth it is said to be at 'perigee'. The point (longitude) and the time at which the satellite crosses the Earth's equator going north is called the 'ascending node equator crossing (EQX)'. It is usually given in degrees west of the zero (Greenwich) meridian and UTC (coordinated universal time).

Typical APT signal characteristics

Satellite transmitter power	5 watts (+37 dBm eirp)
Modulation	FM
Transmission bandwidth	+/- 17 kHz
Subcarrier	2400 Hz
Maximum Doppler shift	+/- 4 kHz
Antenna polarisation	righthand circular

A receiver employed to receive APT satellite signals should be used in the FM mode, and from the above it is apparent that an IF bandwidth of at least 50 kHz would be required, taking Doppler shift into account. Average path loss for the polar-orbiting satellites is around 135 dB, give or take a few dB, resulting in a signal at the antenna of around –100 dBm or so. Assuming no antenna gain and little feedline loss, this gives a signal at the antenna input of the receiver of around 2.0-2.5 μV. This will result in quite a strong signal in most modern scanners which have sensitivities of around 1.0 μV for a 10 dB signal-to-noise ratio in wideband FM mode at these frequencies.

Simple antennas for weather satellite reception

Roger Harrison VK2ZTB

You don't need an elaborate arrangement of beams rotatable in azimuth and elevation in order to receive weather satellite transmissions. The antennas described here have been employed by many satellite enthusiasts over the years and are simple to construct and erect.

THE POLAR-ORBITING APT weather satellite transmissions were designed to be received on relatively simple, low-cost equipment. Their transmitter output powers are relatively high at around five watts, producing quite a string signal at the ground for they pass overhead at heights typically ranging between 800 and 1100 km. Even when they pass by low on the horizon, the distance from your antenna to the satellite is only around 2200 km or so, which only drops the signal level a few dB.

Over the years, two simple antennas have been widely used by satellite enthusiasts the world over: the 'groundplane' and the 'turnstile with reflector'.

The groundplane

This comprises a vertical element a quarterwave long, with four 'groundplane' elements about 5% longer than a quarter wave. It is conveniently fed with coaxial cable being an unvalanced design.To raise the feedpoint impedance to about 50 ohms for a convenient match to common coax such as RG58 or RG213, the groundplane elements are 'drooped' about 45 degrees from the horizontal. The general arrangement is shown in Figure 1.

A groundplane antenna of this design can be quickly and simply assembled from an SO239 coax socket and heavy gauge wire, as shown in Figure 2. Only two groundplane elements are shown, for clarity. You can use tinned copper wire or enamelled copper wire. As a minimum, 18 gauge wire is suggested. The antenna is then linked to the receiver with a suitable length of RG58C/U or RG213/U coax, with a PL259 attached to the antenna end and a connector to suit your receiver at the other. If the cable run is less than 10 metres, RG58C/U will suffice, but for longer runs the lower loss RG213/U should be used.

This simple antenna can be mounted in a variety of ways to suit yourself. You can erect a short length of pipe of about 20-25 mm i.d., and drop the coax through it, letting the SO239 sit in the top of the pipe, as illustrated in Figure 3. The mast that holds your TV antenna may be a suitable diameter and the groundplane can be mounted atop that.

The groundplane has one drawback. It has a radiation pattern like that shown in Figure 4. When a satellite passes overhead at a high angle, where the antenna has a minimum in its response, the signal will fade and may become too weak to read. However, it has a very good response to satellites passing lower towards the horizon.

The antenna need not be mounted very high, but keep it clear of nearby obstructions, particularly metallic bodies like downpipes, tanks etc.

The turnstile with reflector

A turnstile antenna comprises halfwave dipoles set at right angles and connected together 90 degrees out of phase. The axis is the imaginary line passing perpendicular to the plane of the dipoles and through their common mid-point. With

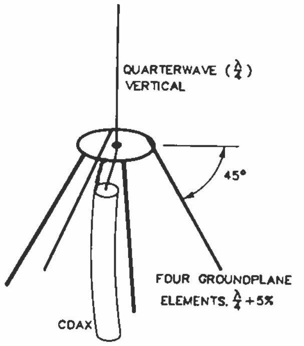


Figure 1. General arrangement of the 'groundplane' antenna.

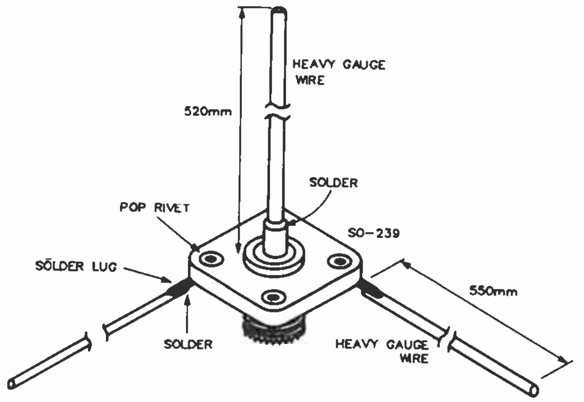


Figure 2. Construction details of a simple groundplane for reception on the 136-138 MHz satellite band.

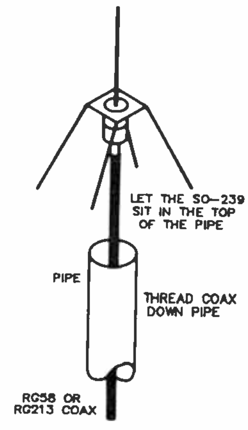


Figure 3. A simple mounting arrangement for the groundplane.

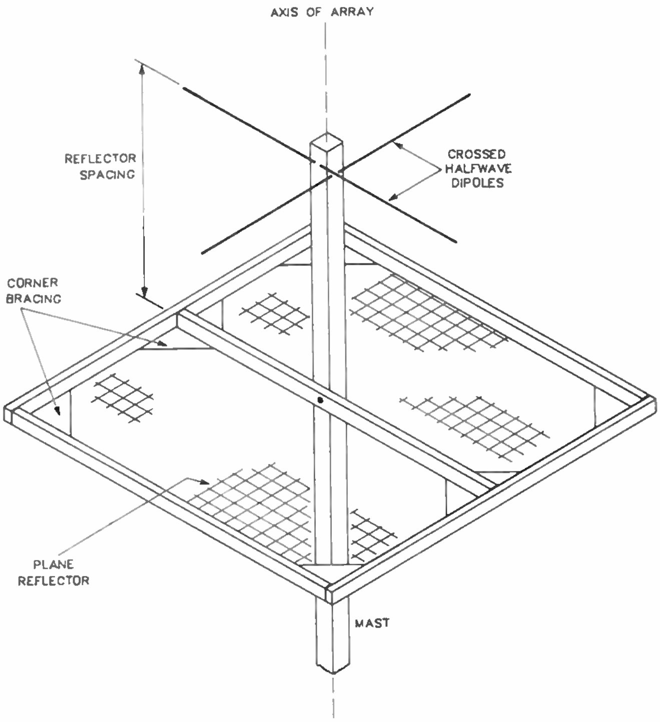


Figure 5. General arrangement of the turnstile with reflector antenna. The mast and frame are simply made with dressed timber, sealed with a stain or epoxy lacquer for outdoor use. Western red cedar is a good, durable timber to use.

TABLE 1.

Turnstile with reflector, relevant dimensions.

Dipole length, tip-to-tip	1040 mm
Reflector spacing:	
0.22 wavelength	480 mm
0.37 wavelength	820 mm
Reflector, length per side	1300 mm

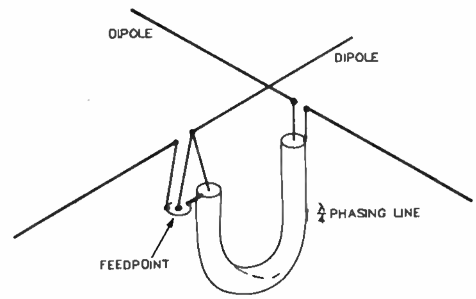


Figure 8. The two dipoles are connected via an 'electrically' quarterwave long phasing line; that is, the line's velocity factor has to be taken into account. This provides the circular polarisation. Because the two dipoles are connected in parallel, this effectively halves the feedpoint impedance compared to that of a single dipole.

a screen reflector of at least 0.6 wavelength per side placed a certain distance behind them, the radiation pattern looks like a balloon facing directly upwards. It exhibits a modest gain of about 6 dB. The general arrangement is illustrated in Figure 5. Directly overhead (on-axis) the antenna response is circularly polarised, off-axis it is elliptically polarised. The balloon-like radiation pattern and circular polarisation are its two greatest advantages in this application.

The reflector spacing is important for two reasons; it determines the radiation pattern and feedpoint impedance of the antenna. Figure 6 shows the radiation pattern exhibited with a reflector spacing of 0.22 wavelength, showing the desired ballon-shaped response pointed upward. At this reflector spacing the feedpoint of each dipole is close to 70 ohms, which is convenient in certain circumstances, as we shall see later. Figure 7 shows the radiation pattern resulting from a reflector spacing of 0.37 wavelength — note the flattening of the response directly overhead. This reduces the very strong signals that occur when a satellite passes overhead, helping prevent receiver overload problems (which can occur!), and improves the response to signals from satellites passing over at lower angles. In addition, the feedpoint impedance of each dipole at this reflector spacing is close to 100 ohms, which is also convenient as we shall shortly see.

The crossed dipoles are connected via a quarterwave phasing line, the feedpoint of the turnstile being connected to one of the dipoles. The arrangement is illustrated in Figure 8. The physical length of the phasing line is shorter than a 'true' quarterwave owing to the 'velocity factor' of the coax used. The dielectric 'slows down' the speed of electromagnetic energy conducted within the coax, hence physically shortening the wavelength of signals at any frequency. Typically, with common coax cables, the velocity factor is around 0.66.

The phasing line connects the two dipoles in parallel, hence halving the impedance presented to the feedline. With a reflector spacing of 0.22 wavelength, giving a feedpoint impedance of 70 ohms for each dipole (as we saw above), this results in a combined feedpoint impedance of 35 ohms. A ▶

Figure 4. Typical radiation pattern of the groundplane antenna. This represents a 'slice' through the pattern, which resembles a donut flattened on the bottom.

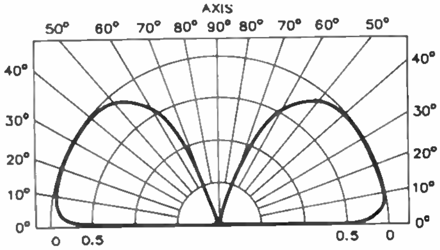


Figure 6. The resulting radiation pattern of a turnstile with a reflector spacing of 0.22 wavelength.

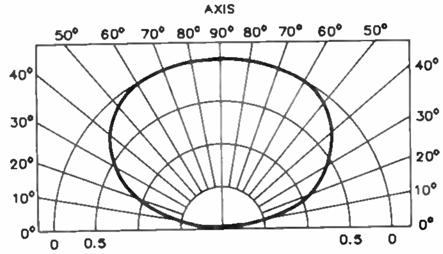
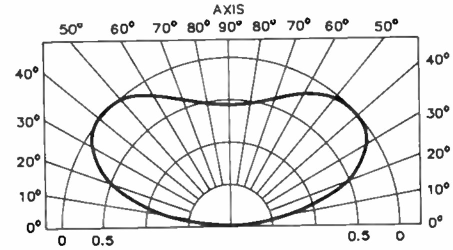


Figure 7. Radiation pattern of the turnstile with a reflector spacing increased to 0.37 wavelength. This improves its response to satellites passing at relatively low angles and reduces the really strong signals from satellites passing directly overhead.



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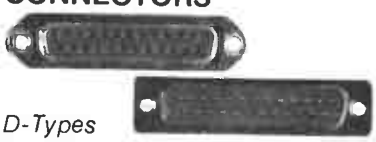

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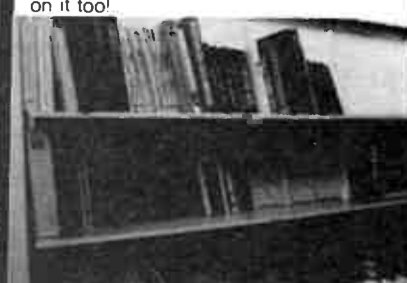

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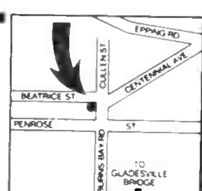

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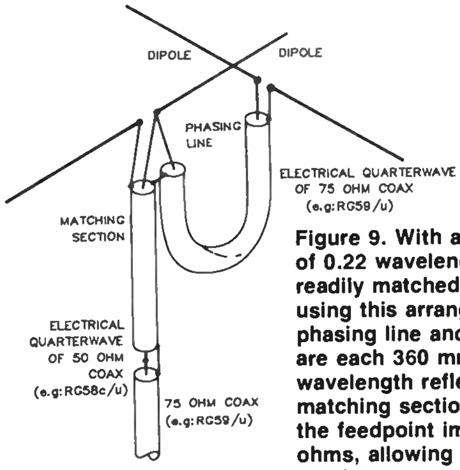


Figure 9. With a reflector spacing of 0.22 wavelength, the turnstile is readily matched to 75 ohm coax using this arrangement. The phasing line and matching section are each 360 mm long. With 0.37 wavelength reflector spacing, no matching section is necessary and the feedpoint impedance is 50 ohms, allowing use of a common 50 ohm coax.

quarterwave matching section, having an impedance which is the geometric mean of the feedpoint and feedline impedances, is used to 'transform' between the two impedances. If we use a 75 ohm feedline, the matching section impedance is determined from:

$$Z(\text{matching line}) = \sqrt{Z(\text{feedpoint}) \times Z(\text{phasing line})}$$

Thus,

$$Z(\text{matching line}) = \sqrt{35 \times 75} = \sqrt{2625} = \sim 51 \text{ ohms}$$

Hence we can use common 50 ohm RG58C/U for the matching section and common RG59/U (or a common TV coax) for the phasing line and the feedline to the receiver. The general arrangement is illustrated in Figure 9. Using RG59/U for the phasing line, with a velocity factor of 0.659, the required length for 137 MHz operation (middle of the 136-138 MHz satellite band) would be 360 mm, accurate to within a few mm. The matching section could employ RG58C/U. This has a velocity factor of 0.66, giving a length of 360 mm, accurate to within a few mm.

With a reflector spacing of 0.37 wavelength, the dipole impedances are close to 100 ohms, yielding a feedpoint impedance of 50 ohms, enabling us to do away with the matching section. The phasing line in this case should use 75 ohm coax which, for RG59/U, would need to be 360 mm long.

The general construction is shown in Figure 5. The mast may be simply 50 mm square dressed timber. It need not be very long, its length depending on where and how you mount the array. The reflector frame is made from light lath strips, with corner bracing of plywood or plank offcuts. The reflector itself is simply 'chicken wire' laid over the frame and tacked or wired in place. Either large- or small-weave chicken wire will do the job. The wood used should be recommended for outdoor use and I would suggest you seal it with an outdoors stain or epoxy lacquer.

The dipoles may be made from aluminium tube or perhaps brazing rod, secured to the mast by screws. The coax may be attached directly to the dipole centre connections and sealed with silicone sealing compound to prevent the ingress of water. Note that the reflector is not actually connected to any part of the antenna system. Relevant dimensions for the dipoles and suggested reflector spacings for operation at 137 MHz are given in Table 1.

The antenna need not be mounted very high, so long as it is largely unobstructed from about 15-20 degrees above the horizontal. Quite successful results have been obtained with this sort of antenna sitting directly on the ground.

Build this low-cost 8-digit, 1 GHz frequency counter

Dick Smith Electronics
Research & Development Division

These days, a digital frequency counter would rate as an essential item in any service workshop, amateur shack or electronics hobbyist's test instrument inventory. This economical project has been designed to simplify assembly and provide good performance. It features readout to 1000 MHz in three ranges and good sensitivity right across the range for ease of measurement on even low level signals.

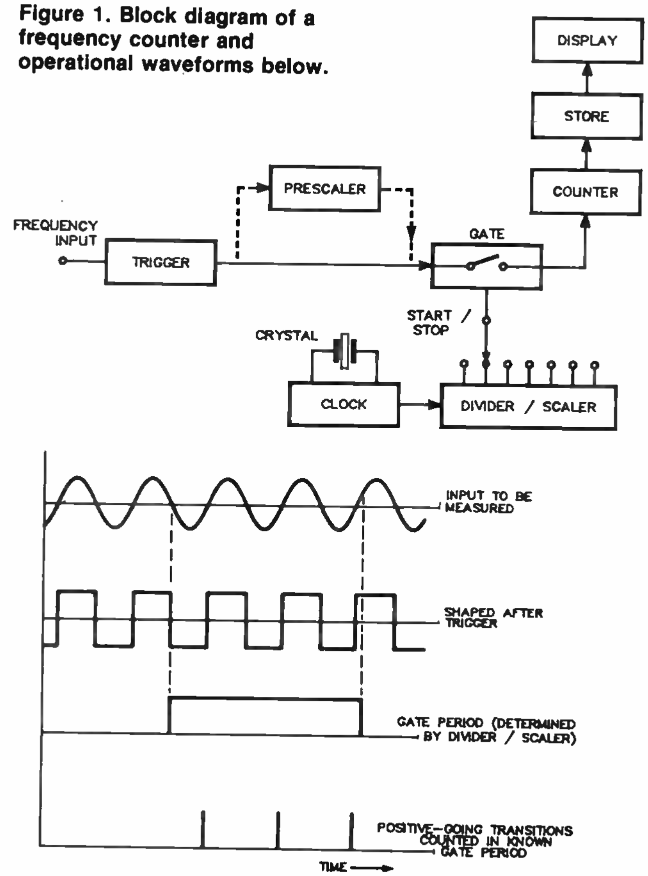
IN ELECTRONICS MEASUREMENT, after volts, amps and ohms, the next most required quantity one needs to measure would undoubtedly be *frequency*. The nature of frequency measurement demands knowing a numerical quantity to some order of accuracy, and hence the most convenient method is via a digital display.

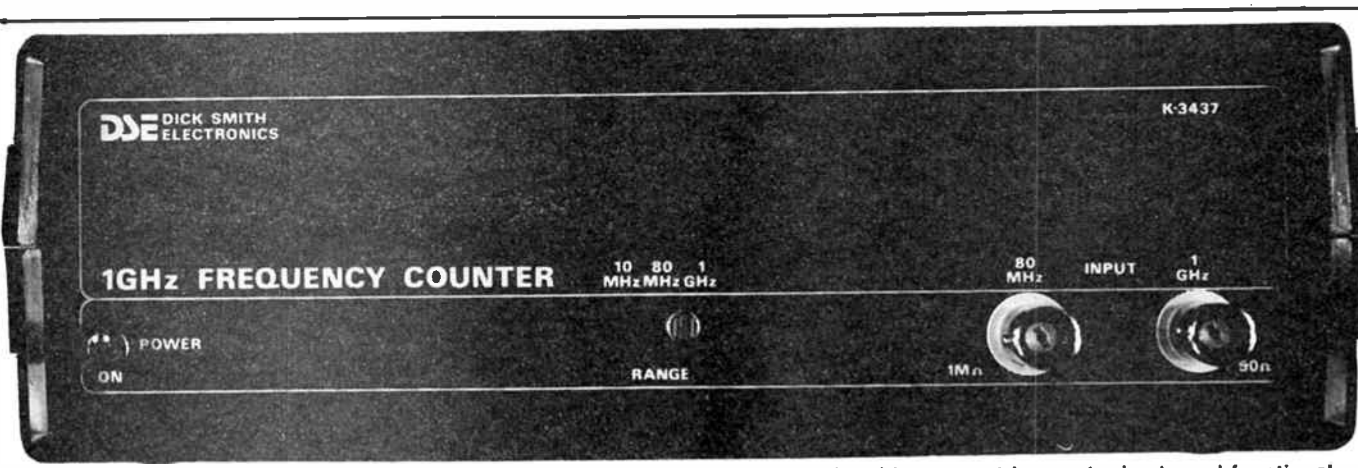
The *frequency* of any repetitive signal can be defined as the number of cycles that occur per unit of time. It is expressed in *Hertz* (after Heinrich Hertz, who demonstrated physical proof of James Clerk Maxwell's theory of electromagnetic radiation), this being the fundamental expression of *cycles per second*. The usual metric multipliers are applied — 1000 Hz = 1 kiloherz (kHz), 1 000 000 Hz (1000 kHz) = 1 megaherz (MHz), 1000 MHz = 1 gigaherz (GHz), etc.

The principle of digital frequency measurement is relatively simple. Imagine a flock of Farmer Smith's sheep galloping across a paddock. Now, we all know that sheep tend to play 'follow the leader', so they all run more or less in line. To count how many go past per second, Farmer Smith has his dog herd them towards a little contraption at the end of the paddock. This contraption is a funnel-shaped fence that forces them to go down a runway single file. Partway down the runway Farmer Smith stands by a gate which diverts the line of sheep into a side paddock where stands his deaf-mute offsider who counts the sheep that enter the paddock. Farmer Smith opens the gate for a pre-arranged fixed period, timed by his wristwatch. There are a lot of sheep and they're running fast, so he opens the gate for 10 seconds. His offsider counts the sheep and, knowing Farmer Smith opened the gate for 10 seconds, divides the number of sheep by 10 to get the number of sheep per second. As he can't call out the result, he writes it on a blackboard for Farmer Smith to see. It so happens that 112 sheep entered the paddock while the gate was open. The offsider, knowing the gate was open for 10 seconds, divides 112 by 10, giving 11.2, so Farmer Smith sees his offsider write '11.2' on the blackboard. Thus, he knows his flock was galloping by at 11.2 sheep per second.

Figure 1 shows a block diagram of a digital frequency counter. Note the similarities to Farmer Smith's contraption. There's a clock (Farmer Smith's wristwatch), a gate, the opening of which is timed by the clock, a counter (the deaf-mute offsider) and a display (the blackboard). Now, in the 'real world' the input signal may be sinusoidal, or some other waveshape, so it is generally 'conditioned' before passing to the counter via the gate as digital circuitry requires on/off signals. The *trigger* performs this function. The period for which the gate allows the signal to pass to the counter is determined by the output from the *divider/scaler*, which has selectable output periods. The number of pulses per gate period are counted, stored and displayed. The counter output is stored in order to provide a steady display which would otherwise turn off between gate periods. In practice, gate periods generally ranging from 1 μs to one second are employed. It is the gate period which determines the fundamental display resolution.

Figure 1. Block diagram of a frequency counter and operational waveforms below.





The completed instrument is smart, simple and functional. The front panel is a piece of translucent red perspex which provides a filter to improve visibility of the 7-segment LED displays.

For the sake of accuracy, the clock almost always employs a quartz crystal oscillator. Inevitably, it is the accuracy and stability of this oscillator that determines the ultimate accuracy of the instrument. To provide a number of different frequency ranges, either the clock frequency can be changed or the input can be divided-down by a *pre-scaler*, or both.

In practice, frequency counters employ some amplification before the trigger circuitry to provide adequate sensitivity for measuring low-level signals.

Design details

Not so long ago, an 8-digit frequency counter capable of measuring up to 1 GHz would have been constructed of around 30 or more discrete ICs requiring a substantial power supply and housed in a case some 350 mm wide and 200 mm or more deep. Thanks to the wonders of large-scale integration, the circuitry these days is largely "swallowed up" in a single chip which provides the clock, divider, gate, counter and display driver functions.

The 'heart' of this project is just such a device, made by Intersil, the ICM7216C. This is a basic 10 MHz, 8-digit counter that will drive 7-segment LED displays. Some peripheral logic has been added to provide three measurement ranges of 10 MHz, 80 MHz and 1 GHz, along with two input stages. One covers the 10/80 MHz ranges, providing signal amplification and conditioning, the other providing amplification and pre-scaling for the 1 GHz input. The accompanying table gives the overall specification of the instrument.

Controls and functions have been kept to a minimum in order that the instrument be both low in cost and simple to use, without sacrificing the main requirements in frequency measurement.

Construction

The pc boards and front panel have been designed as an integrated unit to fit the H-2505 plastic instrument case, resulting in an easily assembled unit that both functions well and looks good. The relatively simple circuitry enabled a clean board layout and the elimination of point-to-point internal wiring, except for the mains cable. A 'motherboard', bolted to the case bottom, carries most of the electronics and the power supply. A vertical board, carrying the 7-segment displays, mounts behind the front panel, butted to the motherboard and secured by grooves in the case sides. Only simple links are required between the two boards, virtually eliminating the chance of wiring errors. The front panel is a piece of translucent red perspex, enabling the 8-digit display to be seen through it. The instrument annotation is silk-screen ▶

SPECIFICATION

Frequency ranges	20 Hz to 10 MHz 20 Hz to 80 MHz 30 MHz to 1 GH z
Gate time	1s, 10 MHz & 80 MHz ranges 1.28s, 1 GHz range
Resolution	1 Hz on 10 MHz range 10 Hz on 80 MHz range 100 Hz on 1 GHz range
Readout accuracy	+/- least significant digit, +/- timebase accuracy
Timebase accuracy	+/- 1 part per million for Tamb. 0-40 deg. Celsius (both ranges).
Input coupling	ac, dc blocking: 50 V max.

Input impedance	
10-80 MHz input:	1M//50 pF
1 GHz input:	50 ohms
Maximum input	
10-80 MHz input:	5 V RMS
1 GHz input:	(a) 5 Vp-p without R20, D3-D4. (b) 10 Vp-p with optional components.
Input sensitivity	
10-80 MHz input	
20 Hz — 10 MHz:	40 mV RMS (typically <20 mV RMS)
10 MHz — 50 MHz:	40 mV RMS (typically <30 mV RMS)
50 MHz — 80 MHz:	200 mV RMS max. (40 mV RMS min.)
1 GHz input	
30 MHz — 50 MHz:	40 mV RMS max. (typically <20 mV RMS)
50 MHz — 1 GHz:	20 mV RMS max. (typically <15 mV RMS)

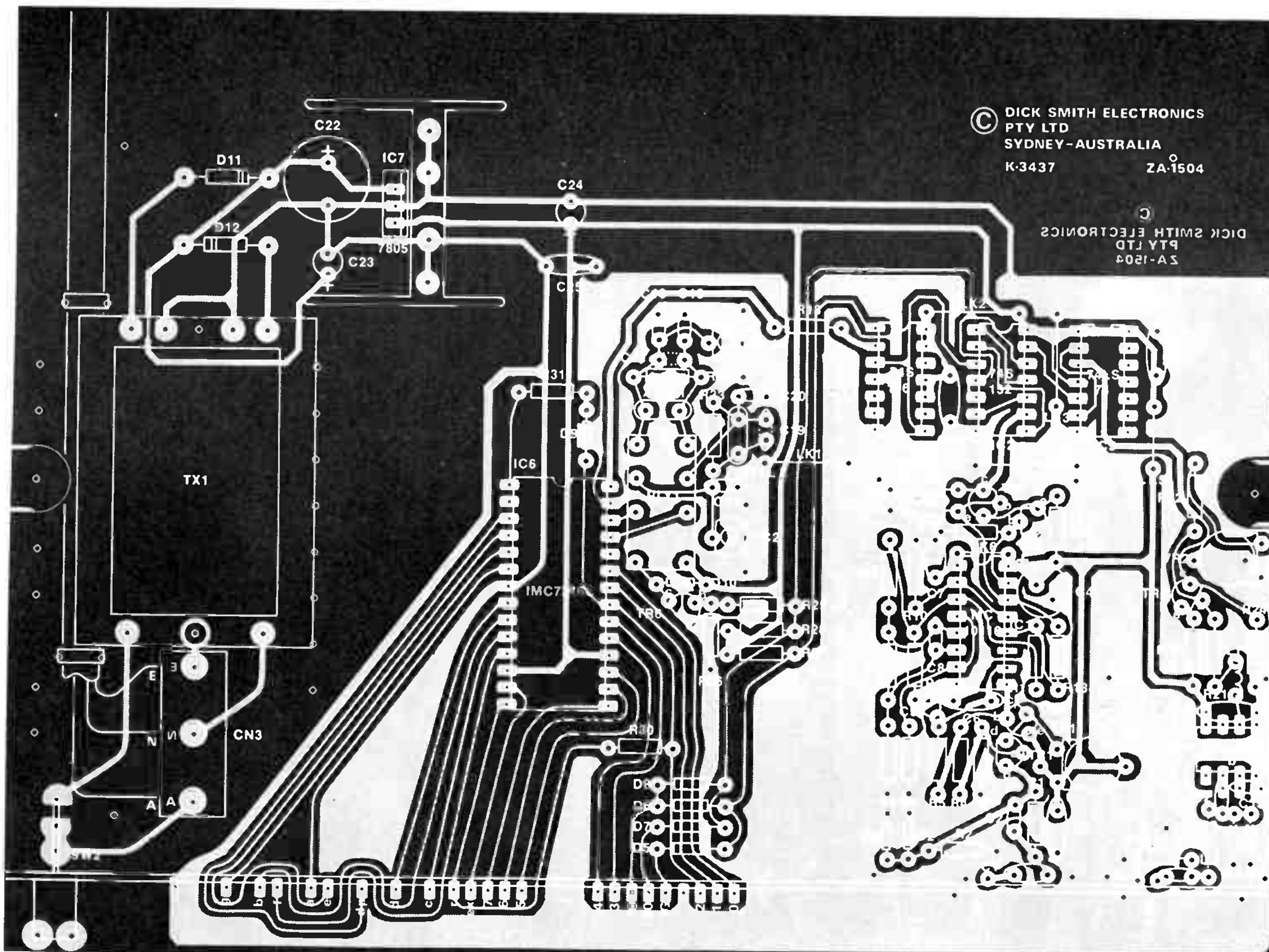
printed on it. Ventilation holes for the pcb-mounted mains transformer are drilled in the motherboard and the area of the case beneath it. The rear panel has slots top and bottom for general case ventilation.

The construction is best tackled in a logical order, and we suggest you follow the progression laid down here.

First, the motherboard

All the low profile components can be loaded, trimmed and soldered into the board. The only critical point to note is that all the component leads around the input stages should be *kept as short as possible.* The body of these components should be flush with the board. If necessary, scrape the ceramic insulation off the legs of the capacitors to get them to sit down correctly. Long leads may introduce an inductive component into the active circuits and cause instability in the amplifiers.

The coil L1 is tightly wound with enamelled wire on a 5 mm mandrel. This diameter is not critical, but keep it somewhere near this size. Clean off the enamel at each end and tin the leads before inserting it into the board. ▶



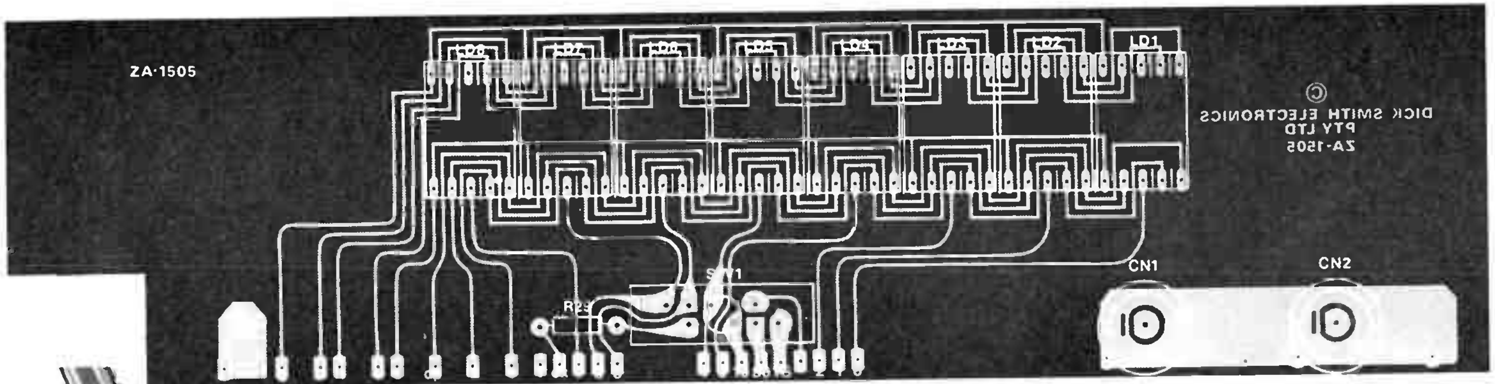
PARTS LIST
1 GHz COUNTER

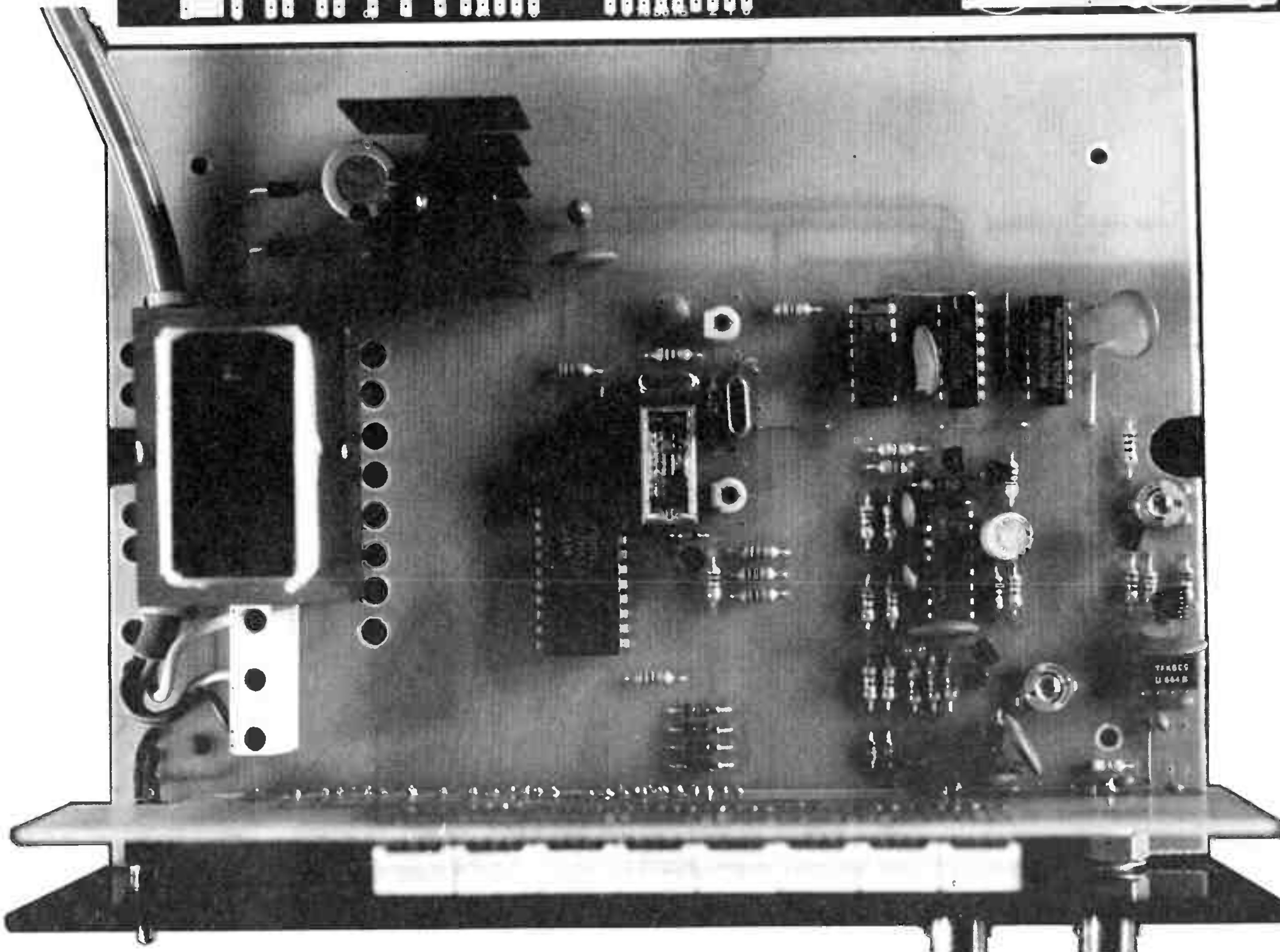
Semiconductors
D1, D2 .... BA243, BA244
D3, D4 ...... BA243, BA244*
D5-D8 .... OA47
D9, D10 ...... IN914, IN4148
D11, D12 .... IN4002
IC1 .... MC10116P
IC2 .... 64S132
IC3 .... 74S196
IC4 .... U664B prescaler
IC5 .... 74LS74
IC6 ...... ICM7216C counter
IC7 7805
LD1-LD8 .... LTS546AR-G
TR1 .... 2N5486, MPF105
TR2-TR5 .... PN4258
TR6 .... BC547, DS547
*optional — see text.

Resistors
R1 .... 100k
R2 .... 1M
R3 .... 220R
R4-R6 .... 470R
R7 .... 330R
R8 .... 470R
R9 .... 330R
R10 .... 470R
R11 .... 330R
R12 .... 470R
R13 .... 220R
R14, R15 .... 470R
R16 .... 22R
R17 .... 68R
R18 .... 10R
R19 .... 56R
R20 .... 220R*
R21 .... 150R
R22 .... 2k2
R23 .... 22R
R24 .... 330R
R25, R26 .... 10k
R27, R28 .... 1k
R29-R31 .... 10k
R32, R33 .... 10M

VR1 .. 500R min. hor. trimpot
VR2 ..... 5k min. hor. trimpot
*optional — see text.

Capacitors
C1 .... 47n ceramic
C2 .... 100p ceramic
C3 .... 100n ceramic
C4 .... 100u/16 V RB electro.
C5 ...... 10u/25 V TAG tant.





C6 .... 100n ceramic
C7 .... 47n ceramic
C8 .... 82p ceramic
C9 .... (not used)
C10 .... 100n ceramic
C11-C13 .... 1n ceramic
C14, C15 ...... 100n ceramic
C16 ...... 39p NPO ceramic
C17 ....
C18 ..... 33p NPO ceramic#
C19 ....
C20 ...... 33p NPO ceramic
C21 ...... 33p NPO ceramic
C22 .. 1000u/16 V RB electro.
C23, C24 . 10u/25 V TAG tant.
C25 .... 100n ceramic

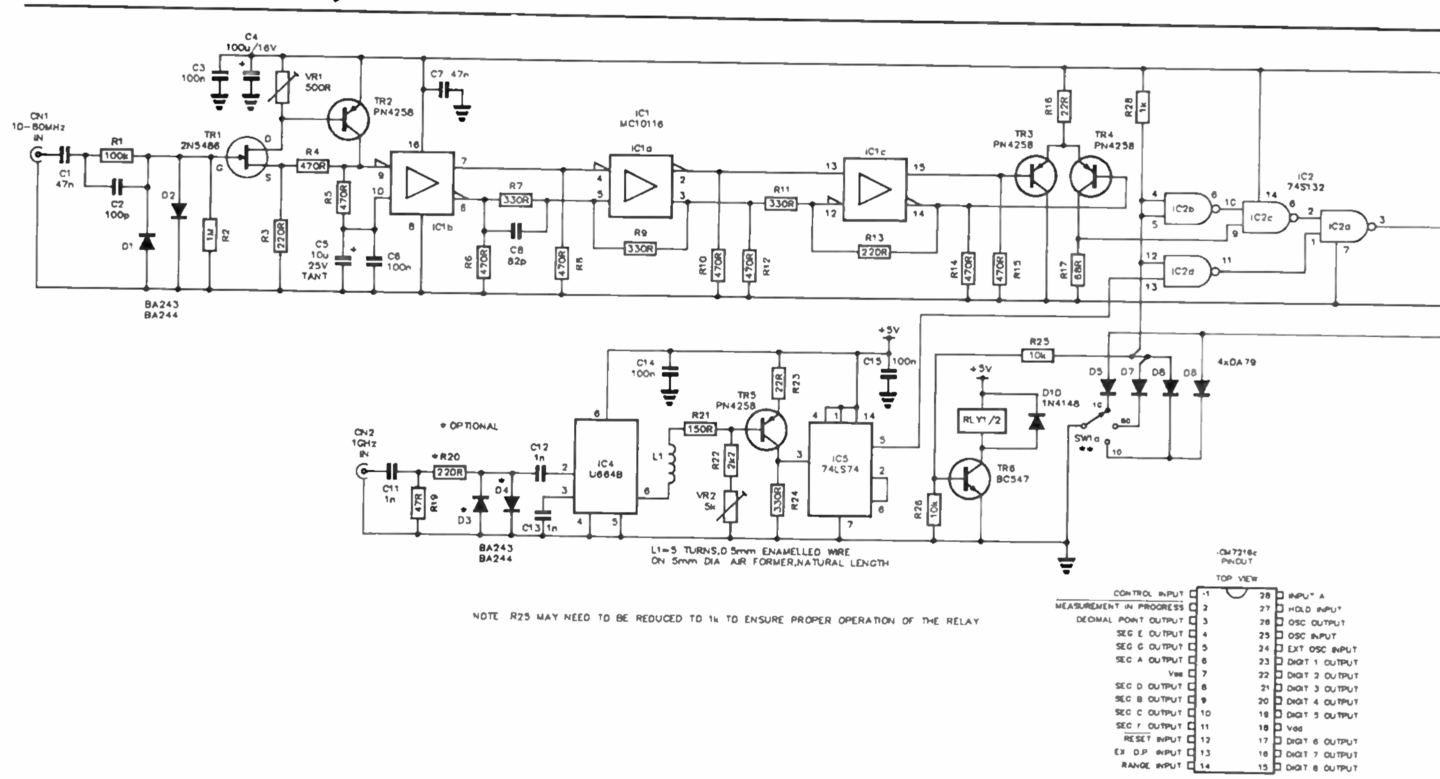
VC1, VC2 .... 4.2-20p Murata ceramic

#depends on crystal supplied.

Miscellaneous

CN1, CN2 ..... BNC chassis-mount sockets
CN3 .. 3-way pc-mount mains screw terminal block.
L1 .... 5 turns, on 5 mm i.d., airwound with 0.5 mm enamelled copper wire.
RLY1 .. DPDT miniature relay with 5 V coil.
SW1 .... 2-pole, 3-pos. slide switch
SW2 .... SPDT pc-mount toggle switch
TX1 ..... AL7VA/15 A&R pc-mount mains transformer, 7V5-0-7V5 secondary.
XTAL1 .. 7.8125 MHz parallel resonant crystal (Co 22 pF, Rs <35R, 0.001% tolerance).
XTAL2 ... 10.000 MHz, same spec. as XTAL1.

1 x motherboard ZA-1504; 1 x display pc board ZA-1505; 3-core mains cable with moulded plug; heatsink pc-mount 30x30x30 mm DSE H3495; plastic instrument case DSE H-2505 with punched and screened front and rear panels; one No. A8 rubber grommet to suit 6 mm dia. cable; two small cable ties; 75 mm length of spaghetti insulation; length of 0.5 mm dia. tinned copper wire; four M3 x 6 mm screws.



CIRCUIT OPERATION

The circuit comprises three basic blocks:

- a wideband amplifier covering from near dc to 80 MHz
- a 1 GHz pre-scaler with signal conditioner, and
- an integrated 10 MHz 8-digit counter/display driver.

The heart of the counter is built around an Intersil ICM7216 series 8-digit counter-display driver IC. This provides, in a single chip, a high frequency timebase oscillator, a decade timebase counter, multiplexed 7-segment decoder/display drivers for common-anode LED displays and the logic circuitry required to implement a total counter system.

The ICM7216C has provision for gating times between 10 milliseconds and 10 seconds. In this project, we have only used the one second period. In practical use, little is to be gained with other accumulation times and the fixed gate considerably simplifies the overall design. The need for a gate time switch is eliminated and so too is the decimal point shift with reference to this time and the input frequency range scaling.

The only front panel control made available is the range-select switch. This three position, two pole slider caters to the input frequency range of up to 1 GHz in three steps. One pole of the switch is devoted to decimal point select, the other controls the logic switching required to interface either the 10/80 MHz amplifier or the 1 GHz pre-scaler.

The time base reference for the ICM7216C is normally a 10 MHz crystal and this satisfys the requirements of a 10 MHz input frequency. This is also true with an input of 100 MHz or 1000 MHz if a 10:1 or 100:1 (respectively) divider is used. This is the case in this design with respect to the 10 MHz and 100 MHz (80 MHz) ranges. A 10:1 divider stage is implemented using a 74S196. A 10 MHz crystal and the surrounding components provide the reference via the contacts of the RLY1 relay.

On the 1 GHZ range, the division ratio is not a factor of 10. The U664b pre-scaler divides the input frequency by 64. A further divid-by-two stage is provided by a 74LS74. The input frequency therefore has been pre-scaled by a factor of 128. In order that the final readout is 10 MHz, the intermediate reference has to be a factor of the input frequency divided by the pre-scaler division ratio. This makes the crystal required 7.8125 MHz. The changeover to this crystal and its surrounding components is provided by the relay.

The necessary gating and switching is provided by the simple diode network connected to SW1 and the transistor TR6.

Some readers may be quick to question why this second reference is necessary when the normal 10 MHz crystal would be correct if the pre-scaling ratio suited the 64 division of the input stage. This could be arranged by using two 5:4 stages. A 74167 synchronous decade rate multiplier could be used to do this job nicely. The total ratio would then be 64:1 × 5:4 × 5:4 resulting in 100:1. This certainly meets the requirements of a 10 MHz reference and the 10 MHz counter. The factor that is not obvious at face value is the input waveform to the 7216. The minimum period of any part of the incoming waveform cannot be less than 50 ns for proper operation. It can be seen that after the first divide-by-64 stage, the resultant frequency (with 1 GHz input) will be 15.625 MHz. This sets the half cycle period at 32 ns. Because the division function of the following 5:4 stage does not result in a 50% duty cycle (even though the frequency division is correct), some of the shortest periods in this division train will still only be 32 ns wide. The same applies to the following stage. This means that the final pulse train presented to the 7216 input will still contain periods of 32 ns, far less than the 50 ns minimum requirement.

1 GHz pre-scaler

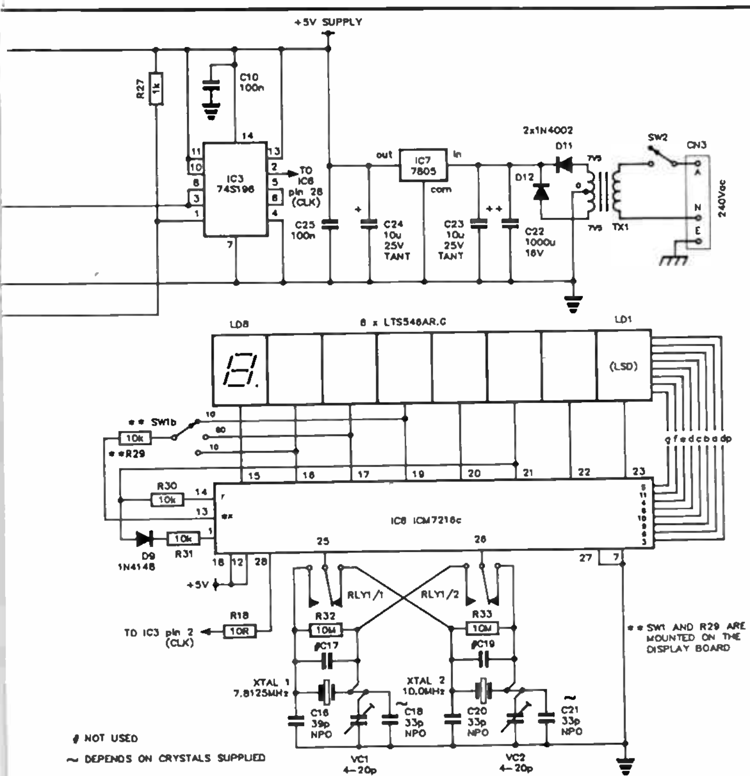
The U664b pre-scaler was originally designed for use in frequency synthesizers in CATV tuners. Not only is it capable of operating up to 1 GHz but also has considerably high sensitivity in the frequency range between 30 MHz and 1 GHz. The IC operates from a 5 V rail. This makes the power supply requirements simple as other stages in the counter also run from this same potential.

The input stage is kept very simple. The circuit shows components R20, D3 and D4 as optional. These are only included if there is a likelihood that in use, the input may be above 5 Vp-p. A problem may arise if the counter is to be used around high power transmitters or if the input is to be placed on a test point with a high dc potential.

Following the pre-scaler is an output buffer and a dc level-shift stage. A bias adjust pot (VR2) is provided to set the threshold point for the following divider stage. The 74LS74 D-type flip-flop is configured to operate in a divide-by-two toggle mode. The other half of the chip is not used.

10 MHz/80 MHz input stage

This section uses the tried and proven MC10116 ECL triple line



receiver. the second and third stages of this chip are configured to operate as Schmitt triggers.

The input stage uses a FED/transistor pair as a low gain, wideband amplifier. VR1 provides an adjustment range to cater to parameter spreads in active components. The pot in reality becomes the sensitivity set point. The following differential amplifier is dc-coupled throughout. The transistor output pair TR3/TR4 provide the interface between the ECL differential output of the MC10116 and the input of the following 74S132 Schmitt trigger.

Logic control switch

To avoid running signal lines to the range switch, relatively simple control is achieved by the use of the 72S132 NAND two-input gate. In this system, the output from the 10/80 MHz stage is gated via section c. The output from the 1 GHz pre-scaler is gated via section d. Only the steady dc logic value of the control gates is required to make the changeover. Pins 4, 5 and 12 carry the state from the remote range switch. This dc switching confines the high frequency signal lines to the short runs of the pc board tracks around the critical areas.

The 74S196 also plays a role in the dc switching system. If either the 10 MHz or 1 GHz range is selected, this pre-settable decade counter is configured to follow the input when pin 1 is held low. If the 80 MHz range is selected, pin 1 will be high and this sets the counter in a divide-by-10 mode.

IC1 and IC3 are Schottky devices to achieve the high speed switching rates from the 10/80 MHz stage. It is IC3, the 74S196 that limits the input frequency to 80 MHz. This is not because of any ability to clock at any frequency above this figure but again because of the internal frequency division mode. The configuration uses a divide-by-two followed by a divide-by-five function. It is this latter divider that sets a 4:5 duty cycle in the output pulse train that is the limiting factor. The shortest period is less than the 50 ns minimum requirement of the 7216c if frequencies in excess of 80 MHz are applied.

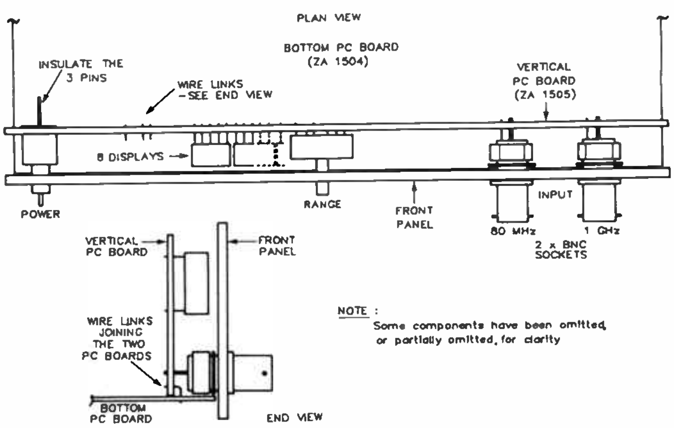
The power supply is straightforward and uses a 7805 three-terminal regulator to provide the 5 V for the system. Ceramic bypass capacitors are spread around the supply rail on the board, providing distributed high frequency bypassing. Bypassing at the lower frequencies is provided by C4 and C24, the latter also ensuring the stability of the 7805 regulator.

The mains switch should be installed flush to the board. Before insertion, place three lengths of spaghetti over the legs. The 7805 regulator (IC7), along with the heatsink, can now be fitted. Make sure that the mounting screw hole aligns with the heatsink before soldering the regulator into the final position.

Mount the power transformer flush to the board. Two mounting holes are provided if you wish to secure with M2.6 x 5 mm PK screws.

Next, the display board

The 7-segment displays are mounted up off the board so that they reach as close to the front panel as possible. Load them all on the board on a flat spacer-guide between the body and the board as illustrated in the diagram here. The standoff space should be enough to allow the pins to just penetrate the board enough for soldering. Don't solder them in place until you have them all in line and level. Resistor R28 can be inserted and soldered next. Mount the slider switch flush to the board but only solder one leg at this stage. At the final assembly into the case, it may be necessary to slightly adjust the position to fit the front panel.



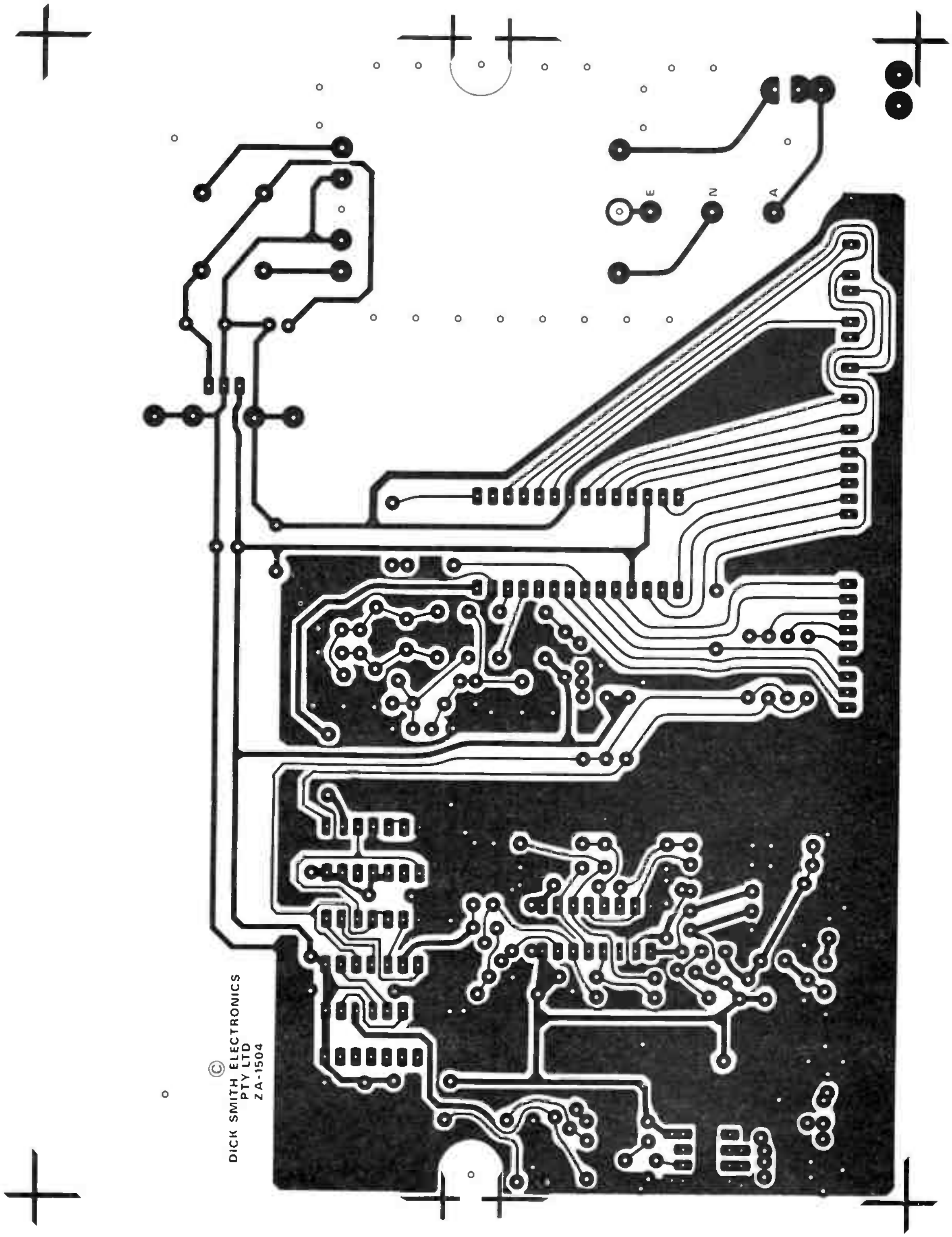
A series of short tinned copper links can now be soldered to the series of holes along the bottom edge of the board. Cut these to about 15 mm long and bend them at right angles, pointing away from the board, so that they will align with the holes in the motherboard. The two boards can now be brought together so that all the wire links thread through the holes in the motherboard. The edge of the display board should butt up to the surface of the other. With the boards held at right angles, solder all the links.

Mounting in the case

At this stage, try fitting the assembly into the case. The display panel should slide down in the rear slot of the three near the front edge. The four mounting holes in the motherboard should align over the appropriate posts. Adjust to fit if necessary.

Remove the assembly and fit the mains cable. Don't forget to thread it through the back panel first using a grommet in the panel. Use two cable ties to secure it in position under the transformer core and along the board.

Now comes the final tricky bit! Fit the two BNC connectors to the front panel. The nuts should only be tightened to the point where the connector can just be turned in the hole. Orientate the sockets so that the pins fit the appropriate holes in the display board as you bring the two sections together. The flat of the nuts should lay on the surface of the mother board. The mains switch should fit the hole at the other end of the panel. Now slide the total assembly back into the case. The front panel position now dictates the final position of the slider switch and the two BNC sockets. Solder these ▶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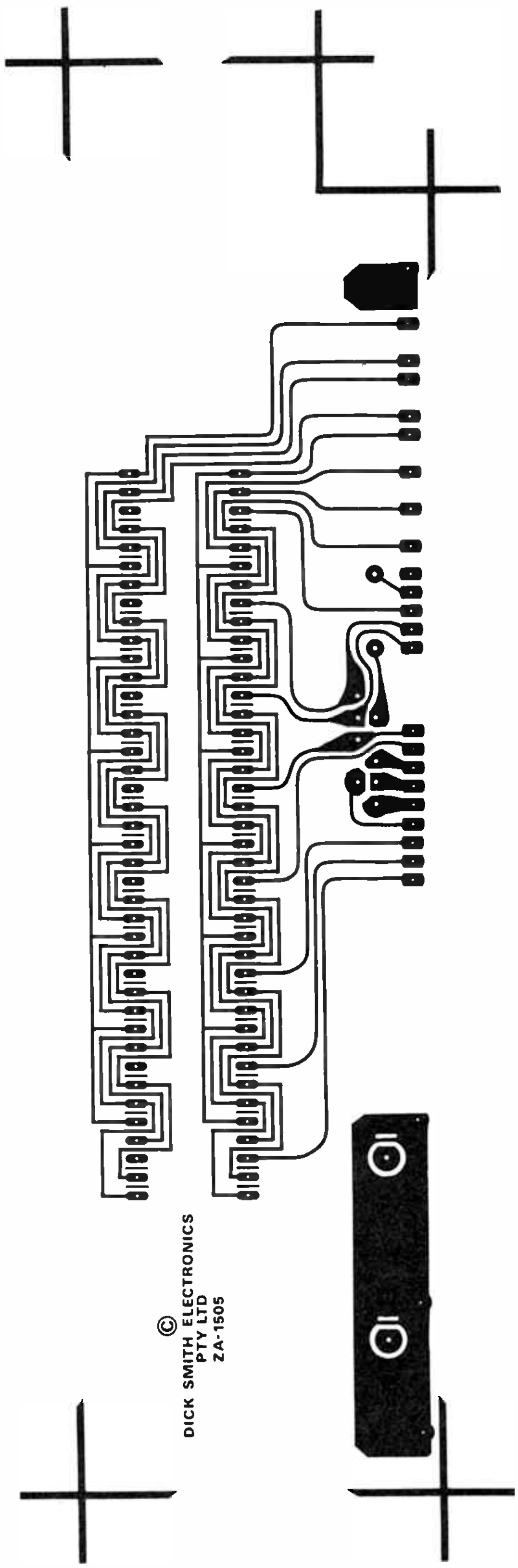

points. All that remains is to solder four links from the BNC pins to the motherboard. Four 4 × 6 mm pk screws are used to secure the board in place after all checking and calibration has been carried out.

Powering up

Before the unit is switched on, a final check should be made of the position, orientation and soldering of components. If possible, get someone else to check your work.

WARNING: Keep your fingers away from the mains wiring and connection around the transformer. If necessary, guard this area with some form of insulation while testing.

Before switching on, adjust the two trimpots, VR1 and VR2, to the mid-position.

When the counter is first switched on, the display should light up. Only the displays to the right hand side of the decimal point should light. If only the least significant digit (LSD) lights to a high level of brightness, it indicates the 7216C oscillator section is not operating and therefore no multiplexing occurs to display the other digits. If the operation doesn't appear normal, check out the component placement, orientation and soldering. Measure the supply rail to see if it is around 5 volts.

Calibration

To calibrate the unit, a known reference frequency standard will have to be sought. e.g: Another frequency counter, a transmitter of known frequency, a crystal oscillator of known accuracy or a signal generator with suitable accuracy.

Select the range and input socket and feed in the reference signal at a level suitable for the frequency (see sensitivity figures). This level is not critical but a value around or lower than the threshold will tend to give an unstable, inaccurate reading. It may be necessary at this stage to adjust the sensitivity pots to get stable readings (see section below).

Adjust the appropriate trimmer capacitor (VC1 for 1 GHz range, VC2 for the 10-80 MHz range) until the reading agrees with the known reference. It would be preferable to use a non-metal tool for this adjustment. It not, a conventional screwdriver will do but you will have to adjust then remove the tool from the trimmer each time a change is made.

For greatest accuracy, let the counter run for an hour inside the case before you do the final calibration. This will give the reference oscillator section time to stabilise.

Sensitivity setting

If you have access to an RF signal generator, then this adjustment will be made easy. If not, you may have to arrange some form of 'loose' coupling. A 'sniffer coil' to receive the output of a low power transmitter will do fine.

Connect the signal source and increase the output amplitude until the reading is stable. On the 18 MHz or 80 MHz range, adjust VR1 to find mid-point position. You will find the reading will change or disappear either side of the set point. Reduce the input signal level and re-adjust the trimmer. Repeat this procedure to find the most sensitive point that produces a correct, stable reading. Carry out the same method to adjust the other input stage. You will find that the setting on this pot is reasonably wide. Set it to the mid-position.

Input cable

For best results, use quality 50 ohm coaxial cable with BNC connectors. Low quality cable may give less than preferable results and downgrade the performance of the instrument.

AUSTRALIAN ELECTRONICS MONTHLY INDEX Vol. 1. 1985-86

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NOTES & ERRATA

WE WANT YOUR WORDS!

— and circuit sketches, and ideas, and news, and views, and letters.

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if you have a completed, or part completed article outline — 'phone, write or call us. You might get your words of wisdom in print! And a little cash in your hand.

CONTACT: The Editor, Roger Harrison Australian Electronics Monthly, PO Box 289, Wahroonga 2076 NSW (02) 487 2700.

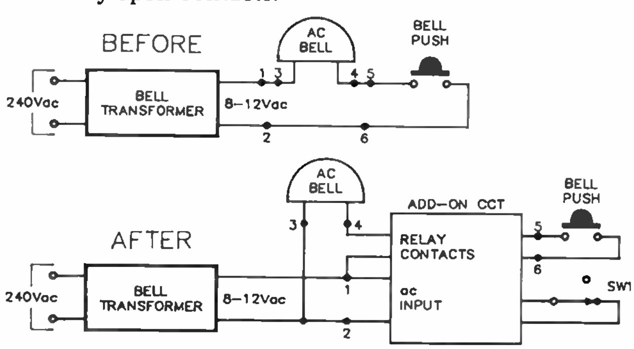
Electronic doorbell control

This circuit was designed and built to be used in conjunction with a standard doorbell running off the 240 volt mains supply via a bell transformer. The purpose of this accessory, primarily, is to indicate the door being opened by persons unannounced. This situation will activate the doorbell very briefly (to reduce the audible nuisance). Also built into the circuit is the ability to disable this facility if the bell-push has been operated immediately prior to entry. The reasons for the latter requirement are twofold: Firstly, if the bell-push has been used (indicating a visitor) there is no reason for the bell to be rung when the door is opened. Secondly, if the occupant is away from home, and upon returning the bell does not ring when the door is opened, it indicates there has been a visitor.

Principal requirements of the circuit were small physical size (as it had to fit into the existing bell unit casing), simplicity and low cost.

The door sensor is a reed switch/magnet, mounted such that the switch is within the permanent magnet's field and closed when the door is closed. This holds pin 1 of IC1 high. IC1(a) and IC2(d) form a monostable with an output approximately 100 ms in duration, this time depending on the values of R2 and C2.

The output from the monostable is inverted by IC1(d) and taken to a NAND gate, IC1(c). At this stage, assuming the NAND gate input pin 8 is high, the output will be low, which in turn changes the state of the NAND gate IC1(b), operating the relay and applying ac power to the door-bell via its normally-open contacts.



The original bell-push is inverted by IC2(c) and the output taken to the other input of IC1(b), providing direct operation of the doorbell.

The "memory" section of the design centres on IC4, a 4013 dual flip-flop. The output from the monostable at point A is gated with the output from F/F(b) and taken to both F/F(a) and (b) clear inputs; this is the reset function when the door is closed.

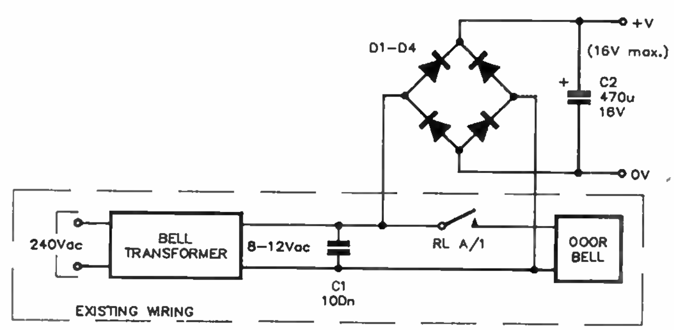
Point D is taken to F/F(a) preset input, and if the bell-push is operated, F/F(a) will change state.

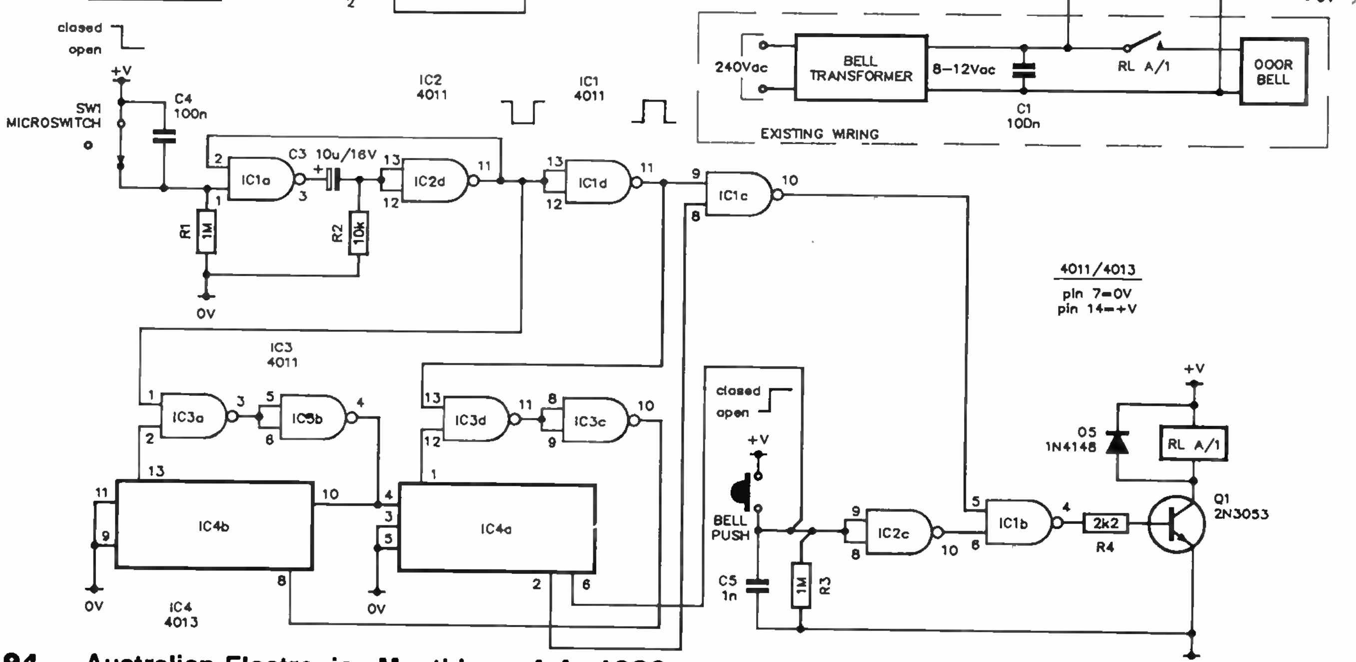
This means the input (pin 8) of IC1(c) is now low and so no signal will pass through the gate to operate the relay. If the door is opened, the NAND gate IC3(d) is now enabled and allows the inverted output (from point B) of the monostable to set F/F(b) on the rising edge of the pulse. Now that F/F(b) is operated, IC3(a) is enabled, which means once the monostable pulse is finished (high) both F/Fs clear inputs are made high, resetting both to normal condition.

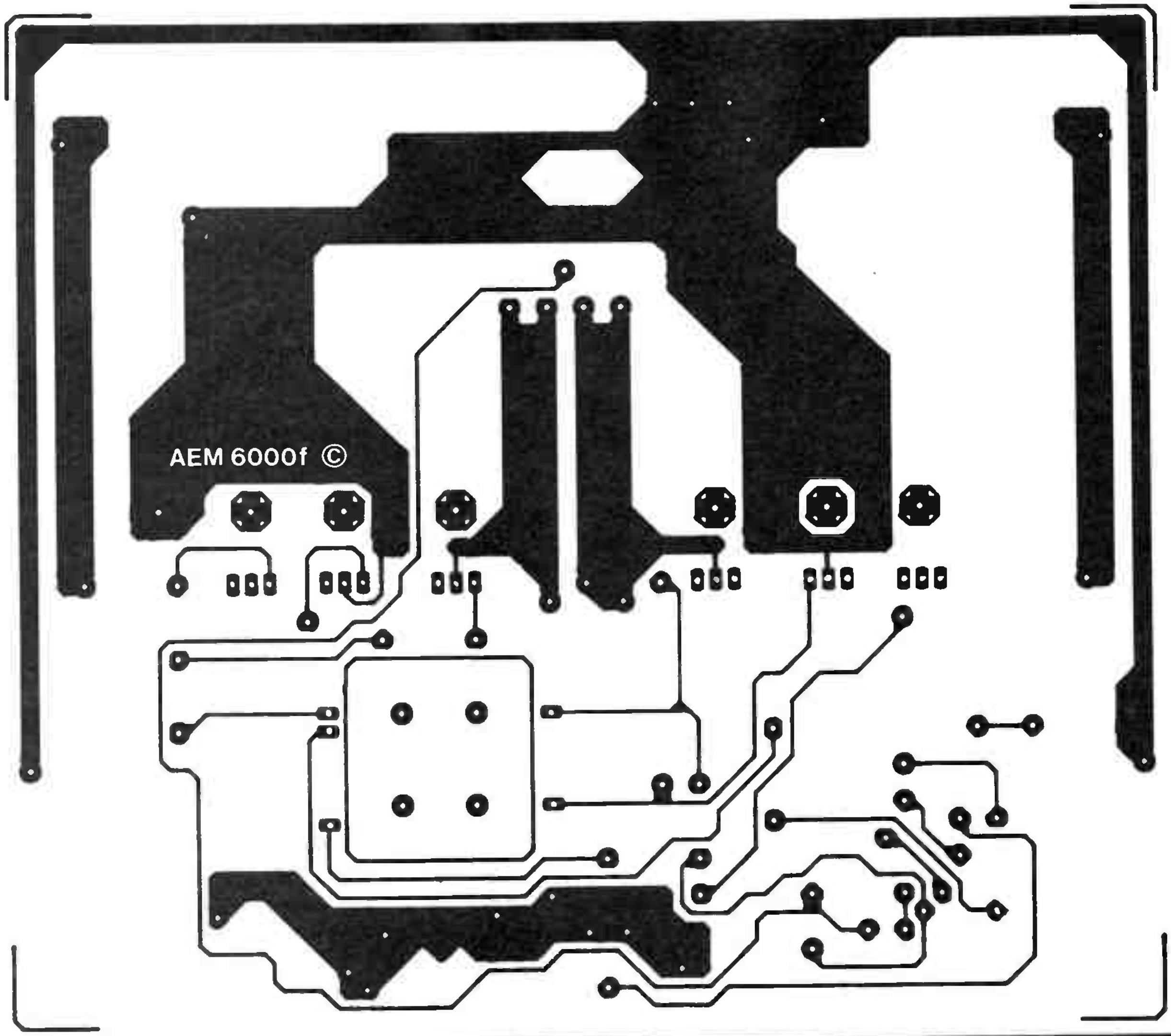
Included is a simple dc supply consisting of a large capacitor and a bridge rectifier, but keep a careful watch on the ac output of the bell transformer and change the tapping if necessary. As a maximum, don't use more than approximately 10 volts ac input to the bridge. The capacitor is included across the bell as very high levels of noise are created in operation and this capacitor provides reliable operation of the electronics.

The inclusion of the ceramic capacitor C5 is very important as this prevents induced signals triggering the circuit and setting the F/F(a). Capacitor C1, across the microswitch, provides switch debouncing when the door is being closed. Omission of this capacitor causes operation of the monostable when the door closes due to switch bounce producing what is, in effect, a rapid series of highs/lows before stabilizing at the required high level,

R.N. Sinclair
Baulkham Hills, NSW






AEM 6000f ©

CD vs vinyl

Dear Sir,

I wish to discuss the Editorial of April 1986, which contained statements along the lines of, "... both pressed from the same master (presumably!) ... compared to the vinyl pressing of the same performance ... CD was clearly inferior soundwise (Brothers in Arms) ...".

Hi-fi reviewers and listeners are continually asserting that analogue (LP) music reproduction sounds better. However, sound and recording engineers consistently make the opposite assertion: that digital (CD) sources yield vastly superior sound *reproduction*. This situation has serious implications since it alludes that the music industry is not catering for its clientele. I disagree strongly with Roger Harrison's conclusions in this matter.

What is the home listener's reference for assessing CD? The familiar LP. What are the engineers' references? The live sound and the master tape. Clearly the listeners are judging euphonic qualities, whereas engineers judge fidelity. For assessing CD vs LP as a sound reproduction medium, only fidelity is a valid criterion.

As for euphonics or the "niceness" of the sound, those in the studios/halls/cathedrals, and who like the original sound, prefer the sound of LP to the qualities of the original sound. As Tony Faulkner (English recording engineer, mostly classical) said in *Practical HiFi, March 1983*, "I don't listen to records because of (their characteristic) sound quality ... the sound I heard off CD is exactly the sort of noise I'd expect from any one of twenty one studios ... the quality of that is a studio sound. The fact that you actually like what the record process does ...". Yes, if you actually *like* that sound it is more an indictment of your tastes than the valid criticism of CD.

In defence of those who claim to sincerely prefer records, some old master tapes which were pre-equalised in a vain attempt to cope with the lousy limitations of vinyl, got put directly onto CD and sound unpleasant. But where possible different equalisations are used for records than for CD's — never assume you are comparing CD vs LP from the same master: if you are the CD has not been properly equalised and might well sound worse. But preferably you won't be, since even old recordings should be remixed for issue on CD.

Take my advice: forget about lounge-room comparisons where you only judge your acquired tastes, and think a lot harder before dedicating entire Page Three editorials to uninformed argument.

Grant Selleck,
Hallett Cove, S.A.

My April Editorial endeavoured to show two sides of the same coin, and my discussion was not about the "euphonics" of CD versus vinyl LPs, it was about reproduced fidelity. My experience with music and music listening is not confined to "lounge-room comparisons" and I am quite acquainted with the 'sound' of live music performances in both 'real' and 'unreal' settings. I play a number of instruments (all acoustic), my wife is a trained singer (opera, jazz, some light popular), our youngest child learns violin.

Personally, I have always felt dissatisfied in some measure with what recording and reproducing (and broadcasting) systems do to performances, how the sound of instruments and voices are affected. However, **only** *on CD have I heard what I would call the "characteristic" sound of familiar instruments recorded and reproduced anything like 'faithfully'.*

This aural pattern recognition is a complex thing, and undoubtedly at the root of the whole debate. I wholly agree with Tony Faulkner, but I did not say I **liked** *the sound of the Dire Straits LP, rather that it showed marked differences to the CD in two specific areas. I know that many recordings on CD that are parallelled on vinyl are not from the selfsame master, but I think the two examples chosen, neither coming from an analogue master, provide fair grounds for comparison.*

While I can readily "... forget about lounge-room comparisons", what about those that have only that means? A conclusion based on lounge-room comparisons would be quite valid for that's the major means by which they have to judge both the performances recorded and the euphonics of the recordings. Few are in the position of the recording engineer to judge the differences live vs recorded.

Roger Harrison

Cool technique and human warmth

Dear Mr Harrison,

Some positive feedback (1 + [R2/R1]):

You and your staff have developed a very friendly style in presentation of projects and descriptive material. I particulary enjoy Robert Fitzell's excellent balance of cool technique and human warmth.

Please continue putting back the homo sapiens into the world of silicon.

Helmut Lopaczuk,
Monbulk, Vic.

Preamps & speakers

Dear Sir,

Congratulations on a fine magazine. It's about time an electronic magazine catered to everybody and not just computer fanatics.

My area of concern is the construction of the AEM6010 Ultra-Fidelity Preamplifier (Oct., Nov., Dec. '85). In all the pictures of the completed 6010LL board the centre area shows four capacitors and at least four resistors. The circuit does not include them, the text indicates that it is for power supply expansion for future additions. My concern is that to do this at a later date will mean dismantling the preamp to get the board out to attach these components, so why not do it now and save the aggravation and possible damage? You did it, why not give us the same opportunity?

Also, on page 55 of the October '85 issue there is a diagram of the 6010LL board showing capacitor positioning on the underside of the boards. That's great, no problem. On page 51 of the December issue there is this feeble, faded little diagram depicting capacitors on the underside of the 6010MA board. Most of the capacitor leads aren't connected to anything; C132, C133 and C32 only have one leg on a track. Can we please have a better diagram with leads connected to the exact positions?

In addition, why no headphone jack? I always reckon it's the best way to listen to hi-fi music. Very strange. Not as strange as facilities for separate AM and FM tuners; I don't see the point. Two tapes, yes, but two tuners!

My other queries concern the AEM6102 bass reflex speakers. I want to mount the crossover boards in a box on the back of the cabinet to have better access to them in the case of a fault. Once the drivers are in I don't want to have to pull them out to gain access to the board, in case of accidental damage. What can I put in its place to stop air bouncing off the back wall and impeding the accurate movement of the woofer? Someone suggest gluing an egg carton to the back of the cabinet, what do you suggest?

My other query concering the speakers is that I have never been impressed by speakers using Vifa drivers. People rave about Mission 770s which your speakers are similar to. I reckon their bass response is muddy; don't like them. Another Scan Audio product is Scan-speak drivers; more expensive, but they are excellent. If I use Scanspeak drivers in my cabinets do I need to use a different crossover board or will yours work just as well with these new drivers?

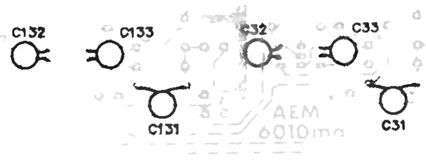
While we are on speakers, can we expect a cabinet with a few drivers in it to match up with the Bandbox project? Also, in the current range of speakers you're doing, what's the chance of a sub-woofer and satellite speaker to go with it?

Thanks for listening to me, hope I haven't been too much of a nitpicker; it's just that I know what I want, and your magazine is my only source of supply, so if you haven't got what I want, I don't get it! The other well-known electronic magazines seem to have forgotten about people like me and think that computers are the only thing.

Bruce Curtin,
Grange, S.A.

The space in the centre of the AEM6010LL pc board was originally allowed to accommodate the addition of power supply filtering components for an additional moving coil pre-preamp stage. We have subsequently decided not to proceed with the development of this as it was felt that the likely improvements in sound quality would only be marginal if any.

Our apologies for the overlay pattern shown on page 51 of the December issue. During the press plate-making process in preparation for printing, the alignment of the components to that of the background tracks became displaced. The correct overlay was shown in the Errata on page 99 of the January issue. We have reproduced it here for your convenience.



With regards to the headphone socket, please see my answer Mr. Ben Brown's letter on p.105 of the June issue.

The placement of the crossover at the rear of the loudspeaker cabinet is intended only for convenient access via the woofer hole at the front baffle. Moving the crossover to the outside rear of the cabinet will not cause any difficulties in terms of the sound quality of the loudspeaker. If you wish, line the inside rear of the loudspeaker with 25 mm thick overlay foam.

The replacement of the Vifa drivers specified with Scan-speak drivers will necessitate changes to both the crossover and the port length.

The crossover will need to be changed to correct for the sensitivities of the Scan-speak drivers. Also the volume of the loudspeaker cabinet and its port length have been chosen by computer modelling to be optimum for the particular Vifa driver. The replacement of this driver for a completely different type will almost certainly destroy the bass end performance. In my opinion, the Vifa drivers do not have a muddy bass end when used in the correct enclosure.

Your idea for a sound reinforcement loudspeaker to accompany the Bandbox project is a good one and we will look into it closely.

At this stage we are committed, for the time being, to the development of electronic (active) loudspeaker projects, so the development of a satellite system must be shelved for the time being.

Thanks for your comments and helpful suggestions.

Dave Tilbrook

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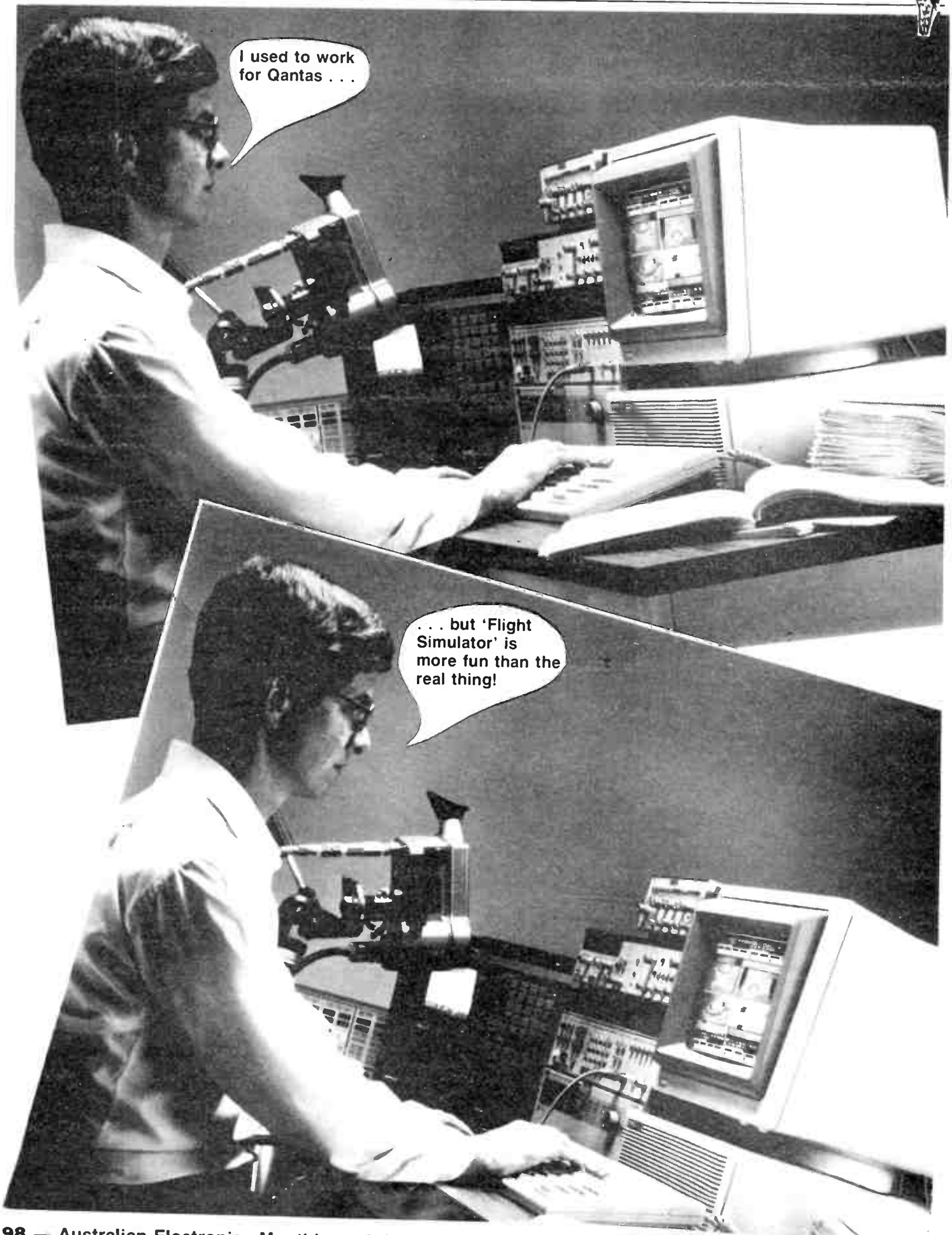

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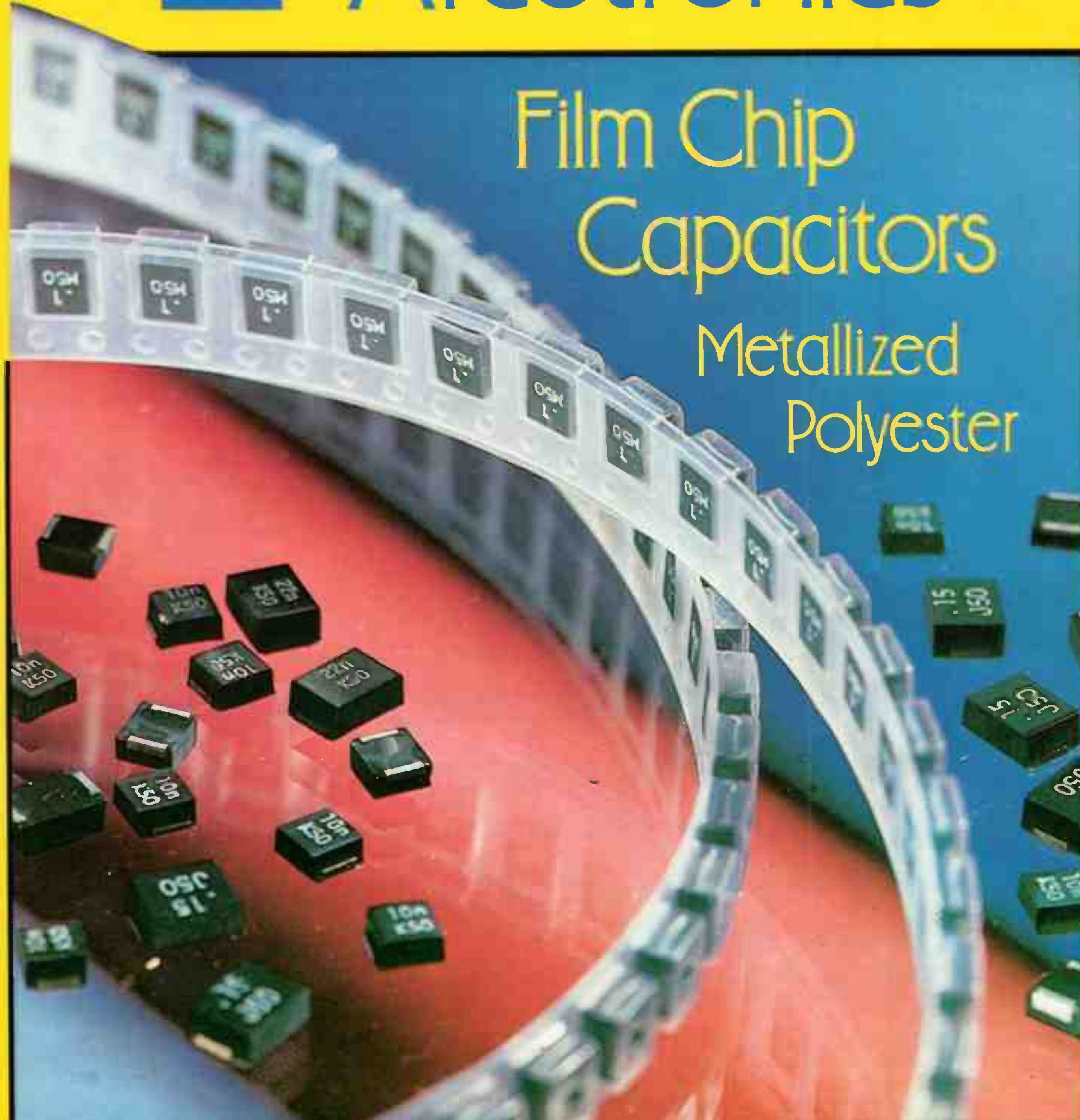

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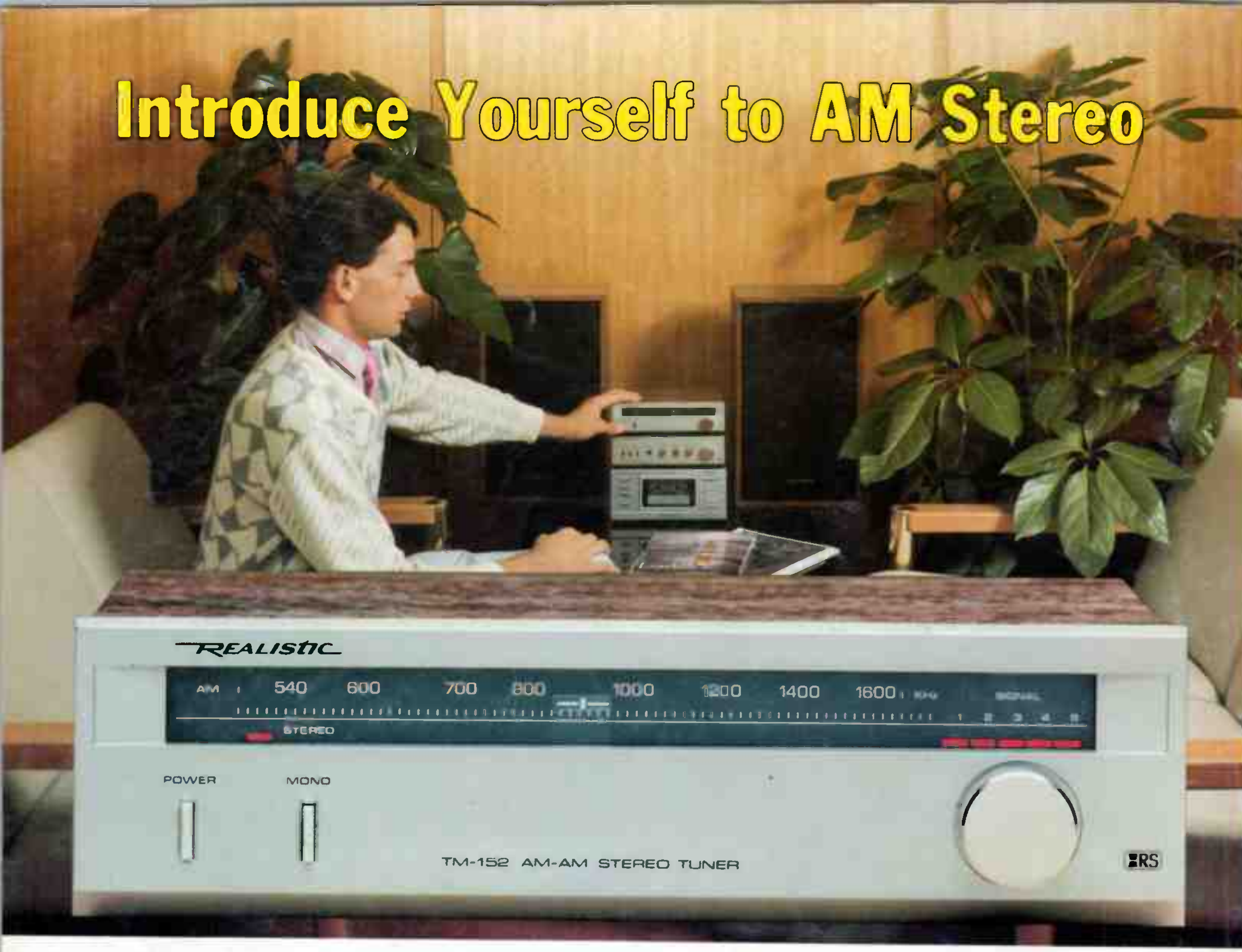

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