MAY 1988

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So get the Fluke 70 Series.

You'll get more meter for your money, whether you choose the affordable 73, the feature-packed 75 or the deluxe 77.

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THIS ISSUE we welcome three new members to the AEM team: Jeff Ralph, as Acting Assistant Editor, Rick Jones, who'll be doing draughting and magazine production, and Corrie Grant, who joins us as our National Advertising Manager.

Jeff Ralph comes to us from a large Japanese company where he was employed as a technical writer. Prior to that he was a secondary school teacher for many years. Jeff is an enthusiast and also a radio amateur, holding the callsign VK2KCQ.

Rick Jones is also an enthusiast, his interests being with electronics in music, and audio. He takes it seriously, being a musician. He plays guitar and is the originator and leader of well-known Sydney band, "Ol' 55".

Corrie Grant joins us with a distinguished track record behind her in advertising sales on suburban newspapers, travel and trade magazines.

PICTURES?

As no doubt you've noticed, we've had some problems with reproduction of photographs recently, for which we apologise. We'd like to thank all those readers who were concerned and caring enough to call or write us about the problem. It's great to know you're not indifferent about such things happening in your magazine!

The problem arose following a necessary alteration to our production arrangements when we moved. I won't bore you with the details, but we've largely sorted it out now and reproduction of pictures should improve markedly from this issue.

Roger Harrison
Editor

NOTE OUR NEW ADDRESS & PHONE NUMBER:
1st Floor, 347 Darling St, BALMAIN 2041 NSW
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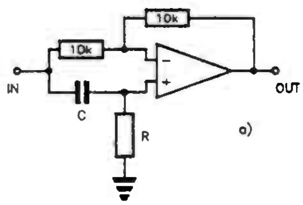
ADVERTISERS INDEX

COVER

These new miniature Vifa speakers from Scan Audio feature in our project section this month. Pic – David Liddle, Design – Val Harrison.

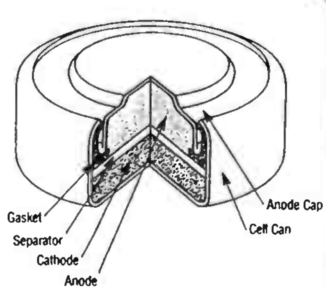
PROJECTS TO BUILD

CIRCUITS & TECHNICAL



ELEKTOR IN AEM

PRACTICAL COMPUTING



NEXT MONTH!

BUILD A 4-INPUT MINI-MIXER

For modest cost, the home movie or video enthusiast can build and use this mixer for audio dubbing, voice-overs, background music, etc. Use it with mics of low to high impedance and various sensitivities. It can be used with signals from tuners, tape recorders, VCRs, CDs, musical instruments, etc. Heaps of other applications.

SAVE THAT CHAIR!

So several of your best chairs have been broken by the family "chair swinger" tilting the chairs back on their rear legs. This novel little gadget should cure them of the habit! Just attach it beneath the chair and when the chair swinger tilts the chair, an embarrassing alarm sounds!

BUILD AN ACTIVE SW ANTENNA TUNER

This antenna tuner with RF preamp will really boost your receiver's performance, especially if you're using a "short" antenna, such as the AEM3106 Flat Dwellers Antenna described in our March issue, or a "random" length of wire.

WHICH VIDEO CAMCORDER?

Looking to buy a video camera/ recorder? Malcolm Goldfinch gives a rundown on the systems around and how to choose one for yourself.

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

Major upgrade for Jindalee over-the-horizon defence radar

Radio Frequency Systems (RFS) Pty Ltd, as a subcontractor to AWA, will design, install and commission high performance improvements to the Jindalee over-the-horizon radar (OTHR), located in the Northern Territory, to be fully operational later this year.

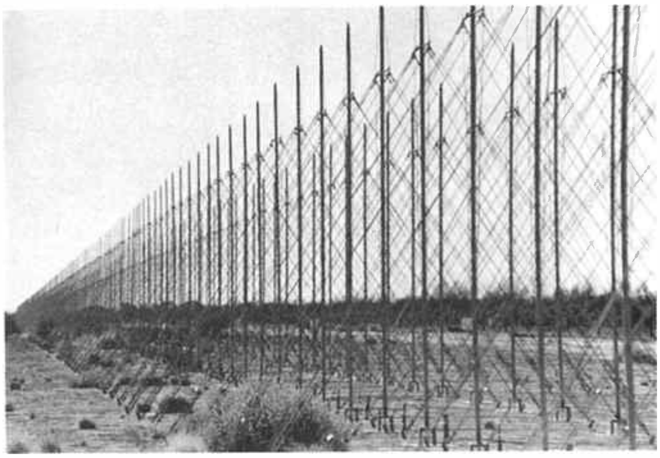
One of the most challenging aspects of the Jindalee project, and one which occupied about 80% of the design effort, was engineering the installation to withstand the cyclonic conditions encountered at the Top End. Custom computer programs were developed for the task.

OTHR systems give far greater coverage than conventional radar systems by beaming the signal skywards, bouncing it off the ionosphere and back to earth. Targets of all sizes can be detected up to 3000 km away, compared to about 43 km by conventional land-based radar.

Besides the obvious military use, the system also has applications in weather observation and forecasting.

The Minister for Defence, Mr Kim Beazley, announced in October 1986 that a network of OTHRs would be developed in Australia. Total R&D expenditure for the system from 1974 to 1986 has been about $40 million. The total cost of the Jindalee project, including the current update and the longer term extension of the network will be in excess of $500 million.

The current phase, worth more than $57 million, involves the upgrading of the experimental radar near Alice Springs to provide a test bed for scientific, engineering and operational development.



RFS Australia was founded in 1967, and in March 1987 Antenna Engineering Australia, a subsidiary of Kabelmetal Electro of West Germany, and Hills Industrial Antenna Systems Division, combined to form the present organisation.

Hotter superconductors

Scientists at the IBM Almaden Research Centre at San Jose, California have developed a compound which exhibits superconductivity, the loss of all electrical resistance, at the relatively high temperature of 125° Kelvin, or 148° Celsius below zero.

It is believed to be the highest superconducting transition temperature yet achieved.

The compound contains the elements thallium, barium, calcium, copper and oxygen. The work is particularly significant because of the stability of the compound, and the demonstrated ability to reproduce the successful results of the tests.

It was established that true bulk superconductivity was occurring at this temperature by showing that the material excludes magnetic fields. This property, called the Meissner effect, is considered to be a crucial test for superconductivity.

Ultimately, it is hoped that research such as this will provide sufficient understanding of superconductivity to guide the search for materials with better properties and yet higher superconducting transition temperatures, perhaps even as high as room temperature.

The IBM Almaden Research Centre scientists who developed this material are Victor Y. Lee, Edward M. Engler and Stuart S.P. Parkin.

Audio researcher honoured

Audio researcher, Dr A.J.M. Kaizer, of Philips Research Laboratories in Eindhoven, the Netherlands, has been appointed a Fellow of the New York-based Audio Engineering Society for his research and development work on loudspeaker systems.

The ceremony was held in Paris on March 3rd.

Dr Kaizer was employed as a scientist at the Eindhoven Research Laboratories for some years before he switched to the Consumer Electronics division to undertake development work.

CORRECTIONS

Aghast! In the "Push-me-pull-you" Loudspeaker published last month, a caption detailing the address of the Australian distributors for Dali was omitted from beneath Figure 4. Dali is distributed by Scan Audio, 52 Crown St, Richmond 3121. (03)429 2199.

SYDNEY'S MOST COMPREHENSIVE RANGE OF DIN41612 CONNECTORS?

Geoff is now stocking most of the DIN41612 range of plugs and sockets. The coding for the uninitiated is as follows -
There are three rows of pin locations A,B and C. E indicates even pins only.
The body size and number of pins is quoted each time thus 96/32 is a 96 hole body fitted with 32 pins
STR = straight connection R/A = Right angled
PCB = circuit board mounting WW = Wire Wrap

PLUGS

BODY/PINS		CONNECTION		PRICE
P64/32	A	STR	PCB	$8.00
P64/64	A+B	STR	PCB	$12.55
P96/32	A	STR	PCB	$8.65
P96/32	A+CE	STR	PCB	$8.65
P96/64	A+C	STR	PCB	$13.55
P96/96	ALL	STR	PCB	$11.45
P64/32	A	R/A	PCB	$5.90
P64/64	A+B	R/A	PCB	$8.40
P96/96	ALL	R/A	PCB	$12.55
P96/32	A	R/A	PCB	$5.85
P96/64	A+C	R/A	PCB	$8.40
P96/32	A	R/A	PCB	$6.40
P96/32	A+CE	R/A	PCB	$6.40
P96/64	A+C	R/A	PCB	$8.40
P64/32	A	STR	WW	$8.65
P64/64	A+B	STR	WW	$13.65
P96/32	A	STR	WW	$10.65
P96/32	A+CE	STR	WW	$10.65
P96/64	A+C	STR	WW	$11.45
P96/96	ALL	STR	WW	$13.55

SOCKETS

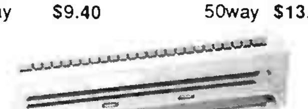
BODY/PINS		CONNECTION		PRICE
S64/32	A	STR	PCB	$8.00
S64/64	A+B	STR	PCB	$13.65
S96/96	ALL	STR	PCB	$16.35
S96/32	A	STR	PCB	$8.00
S96/64	A+C	STR	PCB	$12.55
S96/32	A+CE	STR	PCB	$8.00
S64/32	A	R/A	PCB	$8.00
S96/96	ALL	R/A	PCB	$18.40
S96/64	A+C	R/A	PCB	$13.55
S96/32	A+CE	R/A	PCB	$8.65
S96/32	A	R/A	PCB	$8.65
S64/32	A	STR	PCB	$8.00
S96/32	A	STR	PCB	$8.65
S96/32	A+CE	STR	PCB	$8.00
S64/64	ALL	STR	PCB	$13.55
S96/64	A+C	STR	PCB	$11.45
S32/32	A	STR	WW	$8.65
S64/32	A	STR	WW	$8.65
S96/32	A	STR	WW	$8.65
S96/32	A+CE	STR	WW	$8.65
S96/64	A+C	STR	WW	$11.45
S96/96	ALL	STR	WW	$18.35
S96/96	ALL	STR	WW	$18.35
S96/32	A	STR	WW	$8.65
S96/64	A+C	STR	WW	$13.65
S96/32	A+CE	STR	WW	$8.65

Don't just ask Geoff for DIN41612...

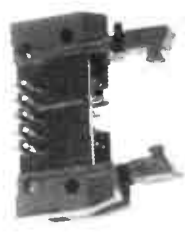
You'll find one of the widest ranges of leading brands of connectors - ex stock - at Geoff Wood's.
So call in and discuss your requirements!

0.1" PITCH IDC CARD EDGE CONNECTORS

26 way	$8.50	40way	$11.55
34 way	$9.40	50way	$13.95



HEADER PLUGS

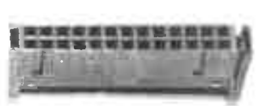


10way	R/A	$6.90
14way	R/A	$7.65
	STR	$5.90
16way	R/A	$4.20
	STR	$4.20
20way	R/A	$7.65
26way	R/A	$4.90
34way	R/A	$6.20
	STR	$5.40
40way	R/A	$8.55
	STR	$9.80
50way	R/A	$10.60
60way	R/A	$11.70

IDC "D" CONNECTORS

9pin	Plug	$6.40
	Socket	$6.40
15pin	Plug	$7.60
	Socket	$7.60
25pin	Plug	$8.40
	Socket	$8.90
37 pin	Plug	$20.40

TRANSITION SOCKETS



10way	$3.55
14way	$4.75
16way	$4.70
26way	$5.20
34way	$5.70
40way	$7.80
50 way	$7.40
64way	$14.85

LED DISPLAY SPECIALS

FND500 REPLACEMENT

So many projects have used the popular FND500 led display. Alas the FND500 is no longer available. But Geoff has found a direct replacement - the LTS543 from Liton. And they're only 80cents each if you buy ten of 'em. But hurry!
LTS543 $8.00/ten
$1.20 each.

0.8" GREEN DISPLAYS

7 segment common cathode with R&L hand decimal points.
Peak wavelength is 565µm
If is 10mA (25mA max)
Only a few available
LTS3403 $4.50

1.02" GREEN DISPLAYS

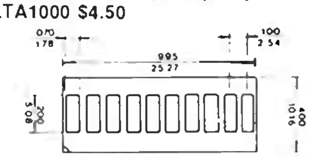
7 segment common cathode with R hand decimal point.
Peak wavelength is 565µm
If is 10mA (25mA max)
Only a few available
LTS1723 $5.50

1.02" RED DOT-MATRIX DISPLAYS

Anode column by cathode row dot matrix display with 35 leds.
Peak wavelength is 655µm
If is 10mA (25mA max)
Only a few available
LTP1057 $7.50

10 POINT BAR GRAPH DISPLAYS

Red, light red, green and yellow
Extremely limited quantity only
LTA1000 $4.50

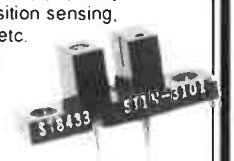


5mm SQUARE LEDS

Parallel sides for easy stackability. Choice of three colours - red, light red and green - all at the same low price of 30c each ($2.70 for ten all the same colour)
And if you're after 3mm **Yellow leds** they're just 20c each!

PHOTO INTERRUPTER

A real handy gadget for anyone into robotics. Consists of a LED(Max If 60mA) and 30V phototransistor facing each other across a 3mmx7mm gap. Any object in the gap stops the light and switches the transistor off. Very fast (5µs).Easy to mount. Use in counting, position sensing, tacho, opto ignition etc.
You could pay more than twice Geoff's price of



$4.00 each.

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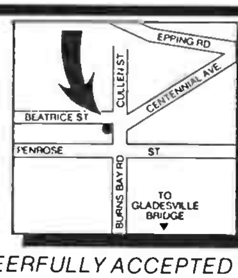

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SUPPORT WORLD WILDLIFE FUND AUSTRALIA

Cells and batteries

– types, choices and applications

Jeff Ralph

Portable power is available to the consumer in a seemingly infinite variety of packages – from tiny button cells providing microamperes to heavy duty lead/acid batteries capable of providing hundreds of amps. Here we discuss some of the practical types of cells and batteries which are in common daily use – and provide information to assist in the choice of the correct power source for the job.

A "VOLTAIC CELL" is a means of converting chemical energy of reaction into electrical energy, generating a voltage at the cell's terminals. The reaction utilised in the case of common voltaic cells is the reduction-oxidation (redox) that takes place when two dissimilar metals (the electrodes) are placed in an electrolyte. Rather than generating heat, the chemical reaction is arranged to provide a potential difference capable of sustaining a current in a load, which may be any piece of equipment from a ghetto blaster to a miniature hearing aid (often in that order).

For most combinations of common electrode and electrolyte materials, the potential difference, or voltage, provided by the cell is in the range of 1.0 – 2.5 V. If a greater voltage is required, as is usually the case with modern portable devices, then a number of cells are connected in series to provide a battery. Although common usage appears to dictate that cells may indeed be called batteries (just look at their labels), we will observe the distinction here for clarity. If you're not convinced of the universal acceptance of the term "battery" for "dry cell", just approach your average local retailer and ask for a "D size dry cell", and watch the reaction.

Modern cells offer a usable development of the simple voltaic cell (such as the ubiquitous lemon with copper and zinc spikes inserted) by, among other things, eliminating the phenomenon of *polarisation*. This is the inability of the electrodes to maintain their achievable potential in the electrolyte (solution or paste) because of reverse emf and physical interference caused by reaction products – principally hydrogen – at one electrode. That is, the positive electrode is effectively isolated from the circuit of the cell by a layer of hydrogen bubbles. Depolarisation is effected in practical dry cells by the oxidising agent manganese dioxide (MnO_2), which also serves as the cathode.

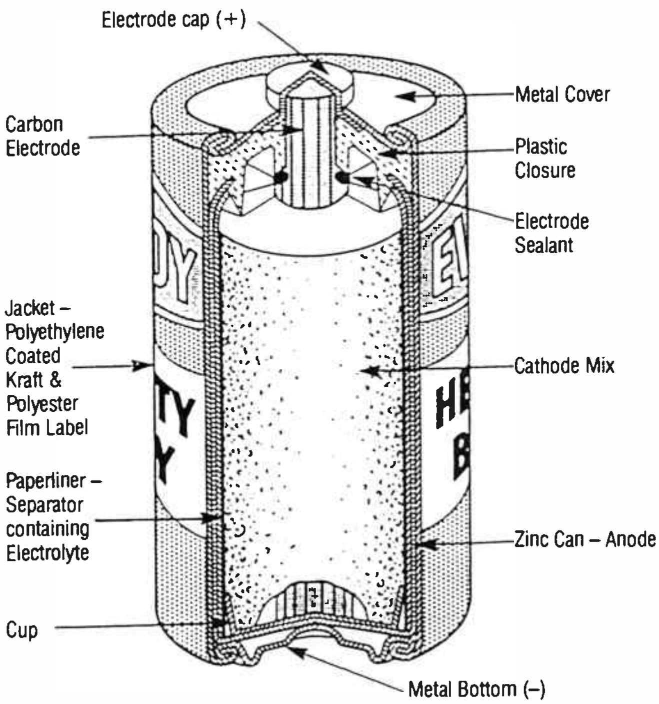


Figure 1. Cutaway view of zinc/carbon cell.

There are two principal classifications for cells – primary and secondary. Primary cells are not rechargeable to any significant degree – indeed recharging must not be attempted – whilst secondary cells are designed to be recharged many hundreds of times.

PRIMARY CELLS

These have a "once-only" life, and are discarded when they are exhausted. The total energy available from a primary cell is that which was available as potential chemical energy when the cell was manufactured – less internal losses. When the chemical reactions during discharge are completed, no more usable energy is available and the cell is discarded.

Common types

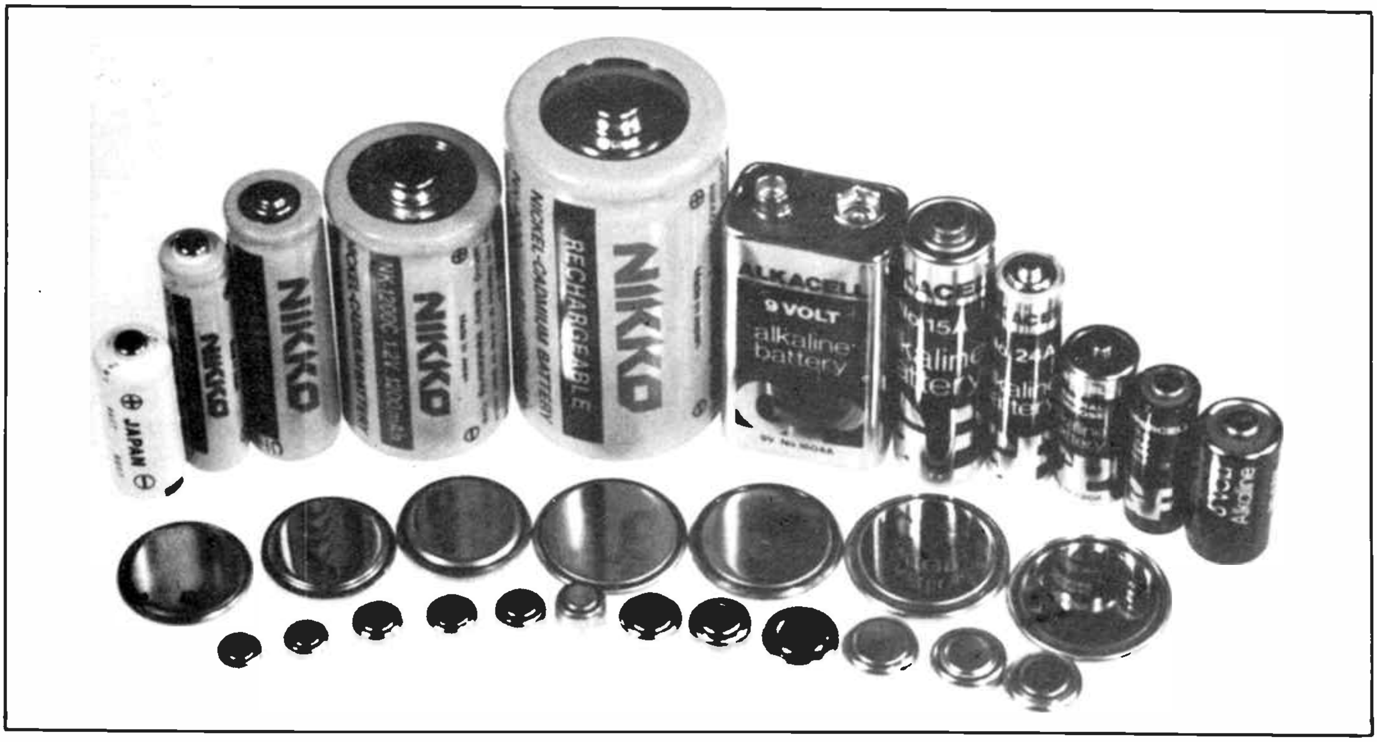
Here follows a guide to primary cells made for "general" consumption. I shall pass over the laboratory curiosities and "standard" cells because they are rarely encountered. If you are curious about such things – see "Further Reading".

Zinc/Carbon. The most common dry cell is a derivative of the Leclanche cell, the zinc/carbon cell. This is a bit of a misnomer, for the manganese dioxide takes part in the overall reaction, and should rightly be considered the cathode. The carbon in the system provides conductivity throughout the cathode mix and while the carbon rod in the centre of the cell is often referred to as the positive electrode, in the electrochemical system the positive electrode is actually the manganese dioxide in combination with two forms of carbon, graphite and carbon black.

Leclanche "dry" cells use an electrolyte of ammonium chloride and zinc chloride, contained in a zinc case which forms the negative electrode of the unit. Surrounding the central carbon rod is a "bobbin" of the cathode mix, as described above, with added electrolyte. This bobbin is physically, though not electrically, separated from the anode by a paper or paste-like separator which is impregnated with electrolyte solution.

The separator can be either a cylinder of paper or a paste-like layer of flour and starch. The latter method was the norm until the more economical paper separator was developed by some manufacturers. The anode of the cell is formed by the zinc casing, and here the chemistry of the cell is complete. The outside cover is either paper or plastic, depending on brand and type.

After manufacture, and during subsequent storage, chemical reaction inside a dry cell is not entirely inhibited by the



cell construction. This reaction essentially involves the solution of zinc in the electrolyte and oxidation of hydrogen ions by the depolariser/cathode mix, generating heat instead of power, and forming some ammonia.

For about three months after manufacture, the open circuit voltage drops a few tenths of a volt and then remains reasonably constant for a long time as the ammonia is absorbed to form a compound with the zinc chloride in the electrolyte (diamine zinc chloride). This material stabilises the acidity of the cell, but it is precipitated within it, increasing the internal resistance of the cell from a small fraction of an Ohm to many Ohms.

Eventually, the cell becomes unusable under load simply because of the high internal resistance. The same phenomena contributes to failure in use. A Leclanche-type dry cell deteriorates fairly rapidly – the poorer grades may last as little as a year from manufacture until they are effectively flat – even without use.

Internal resistance is the factor which determines the degree of depletion of a zinc/carbon cell, and this cannot be gauged by measuring the open circuit voltage of a cell. This will remain quite close to 1.5 V until the cell is so flat that its internal resistance is approaching that of the meter movement used to measure it!

In order to measure the internal resistance, and hence the state of charge of a zinc/carbon cell, a suitable load must be placed across the terminals of the cell, and the voltage then measured.

Taking the example of a fairly fresh cell first, let's say the open circuit voltage of 1.5 V drops to 1.4 V when loaded with a 3 Ohm resistor. By Ohm's law, the load current is:

$$\frac{E}{R} = \frac{1.4\text{ V}}{3.0\text{ Ohms}} = 0.47\text{ A}$$

Therefore the internal resistance equals:

$$\frac{E}{I} = \frac{0.1\text{ V (voltage drop)}}{0.47\text{ A}} = 0.214\text{ Ohms,}$$

a not-too-significant value.

If, however, the loaded voltage dropped to 0.75 V, one half the open circuit value, the load current would be:

$$\frac{E}{R} = \frac{0.75\text{ V}}{3\text{ Ohms}} = 0.25\text{ A}$$

And the internal resistance equals

$$\frac{E}{I} = \frac{0.75\text{ V}}{0.25\text{ A}} = 3\text{ Ohms,}$$

a fairly significant amount, and a good indication that the cell is close to complete exhaustion.

There is no hard-and-fast measure which determines when a cell is "flat". As shown above, open circuit voltage is a not very meaningful measure of a cell's actual condition – a load must be applied.

The working load varies enormously according to application and is not just dependent on the device in use, but also the level of use and the period of rest in between. As well as that, the minimum acceptable cell voltage can vary between applications by as much as a factor of two. For example, an electronic flash gun will cease to operate when the cell voltage has dropped by only a few tenths of a volt, but a typical transistor radio will keep plugging away even with cell voltages as low as half a volt.

Therefore a cell which is "dead flat" for a flash gun may still be able to provide sterling service in a portable radio for many months.

Heavy duty Zinc/Carbon cells. The descriptions of the chemistry of Leclanche cells given above have been in the most general terms – without specific reference to precise compositions or proportions of the various mixes. The total storage capacity, internal resistance characteristics and overall quality of a dry cell is determined to a very great degree by these proportions and by the degree of refinement of the raw materials. That is, the quality of the raw materials will significantly affect the quality (or performance) of the manufactured cell.

Zinc/carbon cells, as with any manufactured item, are made to a price. The least expensive mixes and materials pro- ▷

duce the "general purpose" category of cells – the cheap ones. An improvement in specifications is obtained by simply improving the constituent parts.

The next step is the "heavy duty" category, and the highest quality cell fits into the "super heavy duty" mix. The proportions of carbon to manganese dioxide will be different, the latter may well be more refined, but the electrochemistry and physical construction of all three types of cells is the same.

Figure 2 illustrates the different capacities of the three types of zinc/carbon cells, and compares them to the alkaline and NiCad varieties. Bear in mind when interpreting the graph that the "Typical Service Capacities (mAh)" refer to one particular set of load and duration conditions, and will vary widely under different circumstances. Interpretation should be based on comparison of the different types, rather than extrapolation of the absolute values achieved.

Alkaline cells. The appearance of alkaline cells and the choice of electrodes (zinc and manganese dioxide) may well be the same as for zinc/carbon cells but there, all similarity ends. The most obvious difference, and the one from which the name derives, is the use of an alkaline electrolyte, potassium hydroxide.

Unlike the zinc/carbon cell, the case is constructed of steel and takes no part in the chemical reaction. It does function as a terminal for the cell, but in this case is the cathode, or positive "top" terminal. In this respect the alkaline cell resembles an upside-down zinc/carbon cell! The steel case must be insulated from the negative base terminal of the cell, and this connection to the anode is made with a separate cap in contact with the central anode of the cell.

The zinc electrode is not present in sheet metal form, but instead is powdered, amalgamated (combined with mercury) and mixed with electrolyte in a fabric container, the separator. Surrounding the separator is the cathode mix of manganese dioxide and electrolyte, contained by the steel case which serves as the cathode collector.

The central anode collector (which takes no part in the reaction, but simply collects the current) takes one of two different forms, depending on the brand of the cell. One is a nail, or spike which runs up the centre of the cell in the anode mix, and makes contact with the plated steel base terminal.

The other form, illustrated in Figure 3, is that of a semi-circular curved rectangular plate, once again embedded in the anode mix and contacting the base. The latter form, as employed by Eveready's Energiser cells, provides a greater surface area. In both cases, the material used for the collector is usually brass.

Alkaline cells have a considerably longer potential shelf life than zinc/carbon cells, and their intrinsically lower internal resistance makes them capable of delivering higher currents for longer periods of time. In addition, the total service capacities of alkaline cells is somewhere between two and four times that of zinc/carbon cells. All of the above suggest that alkaline cells are well suited to high current intermittent usage, such as flashguns, but may not be particularly economical in low current drain long- term applications such as transistor radios.

Incidentally, if you intend to get your own first-hand view of the insides of common dry cells, by all means do so, but proceed with caution. Rubber gloves are a necessity, and goggles are strongly recommended, as some cells build up considerable internal pressure before their internal vents open. This can cause strongly caustic solutions to be sprayed right across a room when a cell is dismantled. (You think I'm making this up ? Not so !) In the case of the alkaline cell, the strongly caustic potassium hydroxide electrolyte is present in large, quite liquid quantities. Be careful – if the solutions come in contact with bare skin, wash them off with large volumes of running water. (No kidding – they bite!)

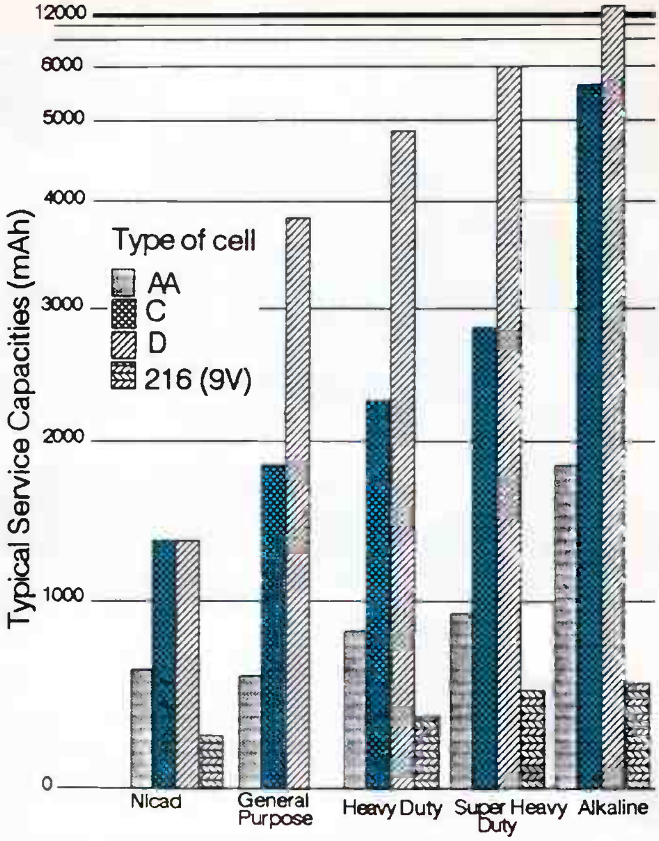


Figure 2. Total storage capacities of common cell types.

Button cells. These are the small, flat cells developed for use in watches, cameras and calculators. The three principal types are the alkaline, the silver oxide and the mercuric oxide. The physical construction of these three cells is to all intents and purposes identical – the differences being in the choice of cathode and the consequent individual performance characteristics. Lithium cells also make a significant contribution to this technology.

Alkaline miniature cells share the same chemistry as the regular size alkaline cells, and hence have similar charac-

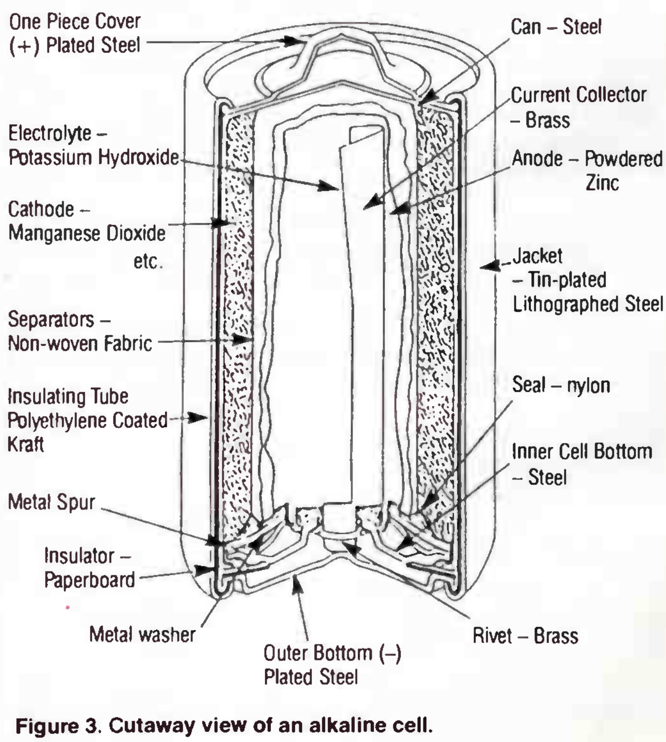
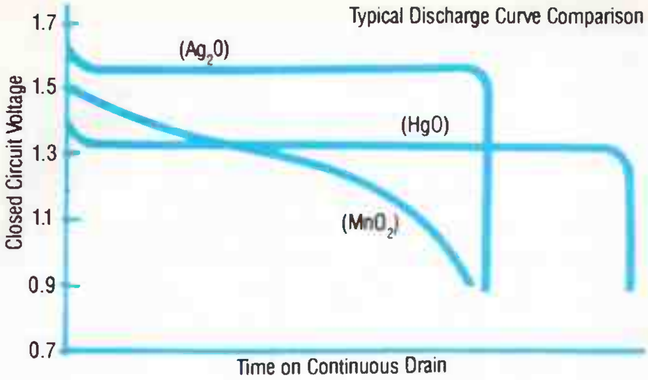


Figure 3. Cutaway view of an alkaline cell.



teristics – 1.5 V output, low and constant internal resistance and a gradually reducing output voltage during use. Sizes typically range from 11.6 mm to 24.4 mm diameter. These cells typically exhibit expansion of the cathode on discharge, which results in a characteristic "bulge" which must be allowed for by the manufacturer.

Although they offer longer life (including shelf life) than other button cells, manganese alkaline cells are limited in their application by their sloping discharge curve.

Silver oxide and mercuric oxide miniature cells offer far greater voltage stability than alkaline cells. Figure 4 illustrates their extraordinarily flat discharge curves in comparison to the more usual sloping curve of the manganese alkaline cell. This feature makes them particularly well suited to voltage-dependent applications such as timepieces, exposure meters etc., provided that a spare cell is kept available, as no indication of impending exhaustion is apparent. A camera's built-in battery tester may well indicate a perfectly satisfactory cell, which three or four shots later is quite dead.

Miniature silver oxide cells provide 1.5 V, with typical capacities ranging from 11 to 200 mAh. Sizes range from 5.8 mm to 11.6 mm diameter. The cathode mix is silver oxide, magnesium dioxide and carbon. Anodes are a gelled mixture of amalgamated zinc powder and electrolyte. The insulating and sealing gaskets, as shown in the cutaway diagram, Figure 5, are moulded of nylon. Choice of electrolyte, either potassium hydroxide (KOH) or sodium hydroxide, (NaOH) depends on application. KOH electrolyte offers less resistance, and allows greater current flow, but are more difficult to seal.

Miniature mercuric oxide cells provide 1.35 V, with typical capacities ranging from 50 to 220 mAh. Sizes range from 7.8 mm to 11.6 mm diameter. These cells offer a greater energy density than silver oxide cells and are typically used for exposure meters, watches, voltage reference cells, radiation detection meters and other voltage-sensitive applications. ▷

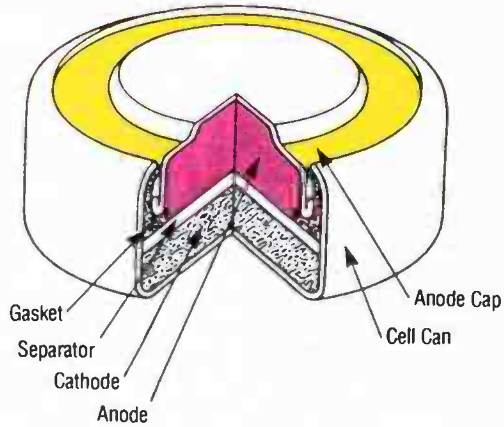


Figure 5. Cutaway view of typical button cell.

Mixed composition cathodes are used for less critical applications, such as hearing aids.

Lithium cells are characterised by exceptionally long lifetimes provided at low current drains. LCD display wrist watches are commonly powered by this variety of cell, and can provide useful service for over five years continuous use in this capacity.

Lithium batteries are widely used as backup batteries for static RAM chips, an otherwise volatile storage medium, in small computer systems, or for providing supply backup for a real time clock in a personal computer. A typical lithium cell, 20 mm in diameter, provides a respectable 3 V with a capacity of between 60 and 140 mAh, depending on its thickness.

Leakproof – are they?

Modern dry cells are very well sealed, resulting in leakproof operation in most normal circumstances. The most common cause of leakage is reverse polarity operation, which may be caused in a number of ways.

Dry primary cells must not be recharged. To attempt to do so will generate gases which the cell's chemistry is not equipped to handle, resulting in the eventual rupture or opening of the venting mechanism, and the spillage of corrosive materials into the device providing the charge. Therefore it is important that equipment which allows the option of recharging their cells internally (such as many walkie-talkies or tape recorders) not be allowed to do so when non-rechargeable primary cells are used.

A less deliberate instance of attempting to recharge a primary cell will occur if a cell is replaced in its compartment backwards. Devices which use only a few cells will probably not be affected, as the user will notice immediately that something is wrong when the unit is turned on. In a device with only two cells, no voltage will be available at all, so it will appear quite dead, and presumably the user will turn it off to investigate.

Incidentally, this arrangement offers a splendid way of transporting a two-cell torch (or similar item) without risk of accidentally leaving it left turned on, discharging the cells in your suitcase. Even if it is left on, no current will flow until the errant cell is removed and replaced correctly.

A three-cell device, with a nominal working voltage of 4.5 V and one cell reversed, will suffer a loss of 3 V, leaving only 1.5 V which is almost certain (hopefully!) to be detected. There are many devices, however, which require eight or more cells. In this case the drop of 3 V may not be significant enough to alert the operator to the presence of an incorrectly installed cell, and the device might be operated as usual. Under these circumstances the reversed cell is subjected to a "charging" current which will may well cause the failure and leakage described above.

The final likely source of leakage is the combination of new and used cells in one device. When one of the older cells is exhausted completely, its own working voltage will drop down to zero, and can then be driven into reverse polarity by the remaining cells, possibly causing leakage. NiCads experience similar difficulties, and must be treated with particular respect.

A similar effect is possible if cells of different types or capacities, such as zinc/carbon and alkaline cells are used together. The lower capacity cell, greater internal resistance notwithstanding, is likely to be exhausted before the higher capacity type. This is the reason that manufacturers urge that all cells be replaced at the same time with similar type cells – not just for crass capitalist motives, but to prevent damage to expensive devices.

SECONDARY CELLS

Like Norman Lindsay's magic pudding, secondary cells seem to provide the promise of endless capacity. The reality, however, is not quite so rosy. Secondary cells (storage, or accumulator cells) employ a reversible chemical process in which either an electric potential is supplied to an external load, causing the depletion (discharging) of the cell or an external source of emf is applied to the cell, causing it's replenishment (charging).

Unlike primary cells, the total potential energy output of a secondary cell is much greater than the chemical energy potential present in the cell immediately after manufacture. The total output can be "topped-up" many hundreds or, in some special applications, thousands of times by charging.

Unfortunately however, there are many factors which lessen the desirability of the reusable cell/battery. More on them later.

Common types

There are many varieties of practical secondary cells available. For a more complete description of the range, readers are referred to "The ins and outs of rechargeable batteries", in May 1987 AEM.

Two types of cell together make up such an enormous proportion of the total worldwide usage of rechargeable cells that their coverage alone is sufficient for a practical discussion. They are the lead/acid and nickel/cadmium types.

Lead/Acid: Today, lead acid cells/batteries provide the most widely used source of stored, rechargeable electric energy in the world, the familiar car battery being the most common example.

The electrodes of a lead/acid cell consist of plates made of an open grid of lead/antimony alloy into which the active material is pressed. The antimony is added to the plates to stiffen the otherwise soft lead. The active material at the cathode is lead peroxide (red lead), which appears chocolate brown in colour. The anode comprises slate-grey coloured lead in a relatively pure, porous spongy form. The electrolyte is dilute sulphuric acid.

The open circuit voltage of a fully charged cell is between 2.3 – 2.4 V. Hence a 12 V car battery is often reckoned to have an equivalent voltage of 13.8 V. The same cell under load will produce between 2.0 – 2.2 V under load, typically falling to 1.85 V or less when discharged. The cell nominally produces 2 V.

During normal load conditions, lead sulphide is formed on both plates, and water is produced, diluting the electrolyte solution. Recharging reverses the process, removing the lead sulphide from the plates, reconcentrating the electrolyte and liberating hydrogen gas in the process. The latter is vented to the atmosphere during charging, which explains the need for ventilation during the process, as hydrogen and air is a very explosive mix (remember the Hindenberg?)

Figure 6 shows an idealised representation of the reactions which take place during charging and discharging of a conventional lead/acid cell. The actual reactions involved are not as simple, and would not be able to continue to the extent indicated, but the principles are well illustrated by the equation.

Shown on the left side of the equation is a completely discharged cell, consisting of plates coated in lead sulphide, immersed in water. With the application of external current, the sulphide ions go into solution in the water, forming dilute sulphuric acid. Therefore, as the charging process continues the acidity of the electrolyte solution similarly increases.

This provides a convenient means of measuring the state of charge of the cell. As acidity increases, so does specific gravity. A hydrometer will give a reasonably accurate indication of the mass of the electrolyte in relation to water (its specific gravity) and hence its acidity and state of charge.

Figure 7 shows the relationship between typical specific gravities and the appropriate application or state of charge. A value of 1.250 is generally taken to indicate a fully charged cell in good condition, and 1.180 is an indication of a discharged cell. With a conventional 12 V car battery, it is good practice to check each cell individually (at least occasionally) in order to detect any anomalies in single cells.

As can be seen from the Figure 7, discharging does not in fact continue until the acid is fully converted to water. When the S.G. reaches 1.180, the cell is said to be discharged, and any further applications of load can result in the cell becoming deep-discharged. In this condition, lead sulphide is permanently bonded to the plates, with a consequent loss in capacity. This condition can be partly alleviated by slight overcharging for a few charge/discharge cycles, but permanent damage is likely if the battery is allowed to discharge too far, or if the battery is allowed to remain in the discharged state for too long. Even the highest quality lead/acid batteries will suffer if allowed to remain discharged longer than a few weeks.

The state of charge of a lead/acid cell may also be determined from its voltage, as can be seen in Figure 8, where the voltage is shown to rise to a maximum of 2.6 V per cell at full charge. This corresponds to a total value of almost 16 V for a ▷

APPLICATION/CONDITION	SPECIFIC GRAVITY
Heavy discharge (e.g: truck and tractor)	1.275
Regular discharge (car)	1.260
Nominal condition at new	1.250
Light duty and intermittent use (alarms)	1.245
Low duty cycle (emergency lighting)	1.210
Discharged	1.180

Figure 7. Specific gravity variations of the lead/acid cell.

Figure 8. Typical voltage characteristics of a lead/acid cell.

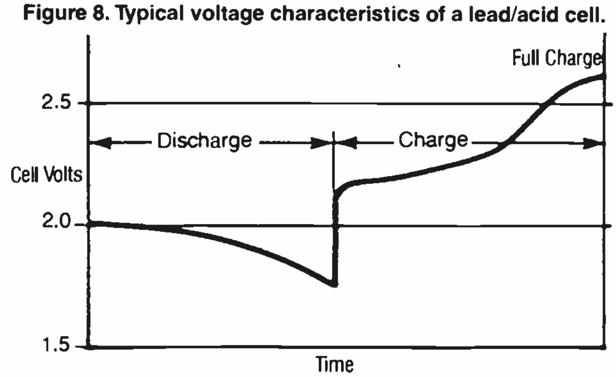


Figure 6. Basic reactions in a lead/acid cell

Cell discharged						Cell charged				
+ve plate		-ve plate						+ve plate		-ve plate
$PbSO_4$ lead sulphate	+	$PbSO_4$ lead sulphate	+	$2H_2O$ water peroxide	——> <——	PbO_2 lead peroxide	+ acid	Pb lead	+	$2H_2SO_4$ sulphuric

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NORMALLY $8.95 each

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10+ $5.50 ea

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Cat. CE-2323
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Cat. NS-3025 5 metre pack
Please note: braid is not loaded with flux and will not work quite as well as normal desolder braid.

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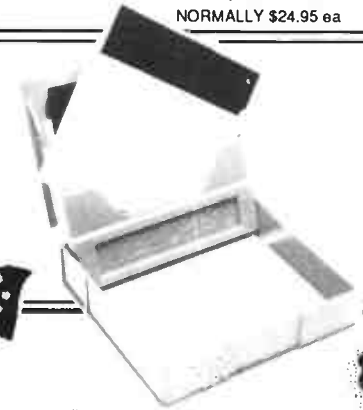

Another unbelievable scoop purchase by Jaycar. We have available a quantity of US brand "Discimate" 5.25" SSDD discs. They are supplied in a handy plastic box of 10 which opens to allow easy access to discs. The box has one of the best opening actions we've seen. We can offer a 5 year warranty. These discs are so cheap we can only sell them in boxes of 10.
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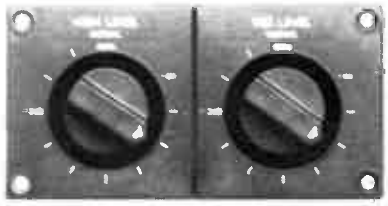

NEW '88

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DIRT CHEAP!!

Sanyo Model T1087RA

Yet another fabulous scoop purchase.
A compact high quality tuner that operates from 526-814MHz (corresponding to channels 28 thru 63). This tuner is designed for Australian standard reception (AS1053 1973). and is offered at a very low price. You can grab one now for the silly price of $29.95! This price includes circuit diagrams and connection drawing. You can have a photocopy of the complete manual for $4 but a lot of the info is in Japanese! This is a very cheap way to convert a VHF only TV to UHF! (Some skill may be required).

Specs:
Power +12V DC nominal @ 14mA. Case neg. Bandwidth 526-814MHz (28-63 ch). AFT +6.5V. Dimensions 150 x 65 x 28mm. Tuning multirotation of 1/4" shaft. Knob not supplied.
Cat. DM-1000

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Cat. No.	Colour	Size	Price
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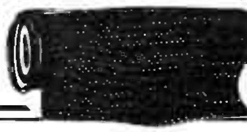
CF-2752	Black	1m x 1.7m	$13.50
CF-2754	Brown	1m x 1m	$9.95
CF-2755	Brown	1m x 1.7m	$13.50



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One of the great Australian Dreams is to own your own business. Most people dream of it but NOW is your chance to do something about it.
HOW?
We all know that shoplifting and vanalism cost a small fortune very year. It has been demonstrated that television surveillance cameras in the right environment can discourage this activity.
This is where you come in.
We have made a great purchase of realistic-looking Dummy TV Cameras.
They are Australian made, are supplied with adjustable swivel mounting bracket, fixing screws, flashing LED circuit board and 2 flashing LEDs. One red LED is mounted in a bezel on the front of the camera to add reality and the other - would you believe - is mounted BEHIND the dummy cameras lens! It looks really corny when it flashes and you COULD disconnect that LED but if a thief was ignorant of the cameras operation it may make the camera look more realistic to him. Also supplied is the 2 x D cell nylon battery holder to power the flasher circuit. A fake cable wallplate is also supplied as well as a very conspicuous 210(W) x 160(H) self adhesive sign which says "THESE PREMISES ARE PROTECTED BY TIME-LAPSE ANTI-THEFT CAMERAS" The text of the sign is in orange-red fluorescent ink against a black background.
You can start your own business by installing these devices in your area. Liquor shops, service stations, car parks, other shops in fact anywhere where the proprietor of a business has a security problem.
Dummy TV Cameras generally sell for about $90 each PLUS installation. By using your skill as an electronic enthusiast you could MAKE A FORTUNE by SELLING AND INSTALLING this camera for less than the cost of a normal camera. You could easily double your money every time you sold and installed a camera!
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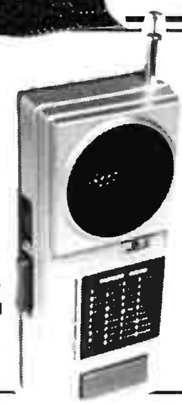

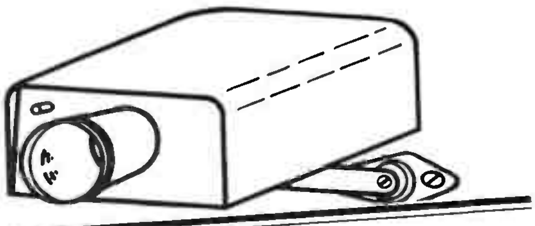

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NiCad CHARGER

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Will fully charge then trickle charge - or trickle charge only.
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As used in the Silicon Chip pH meter. This polypropylene bodied probe is a price breakthrough. The membrane protector is an integral part of the barrel. The QP-2230 has a 'spear' shaped membrane which allows easy and effective cleaning with a cotton bud.
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NEW'88

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All project specified parts in the kit.
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RF DETECTOR PROBE

Ref: EA May 1988
This simple but very effective RF probe enables you to troubleshoot RF circuits by enabling you to 'hear' the RF signal! You can 'trace' RF just like audio!
Kit includes all specified parts except the felt tip pen case. The project must be used in conjunction with the KA-1699 Bench Amp ($39.95) described in April 1988 EA.

Cat. KA-1701

LOW COST 50MHz 4 DIGIT DIGITAL FREQUENCY METER

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- Ground open circuit or O.K.
- Active/Neutral swapped or O.K.
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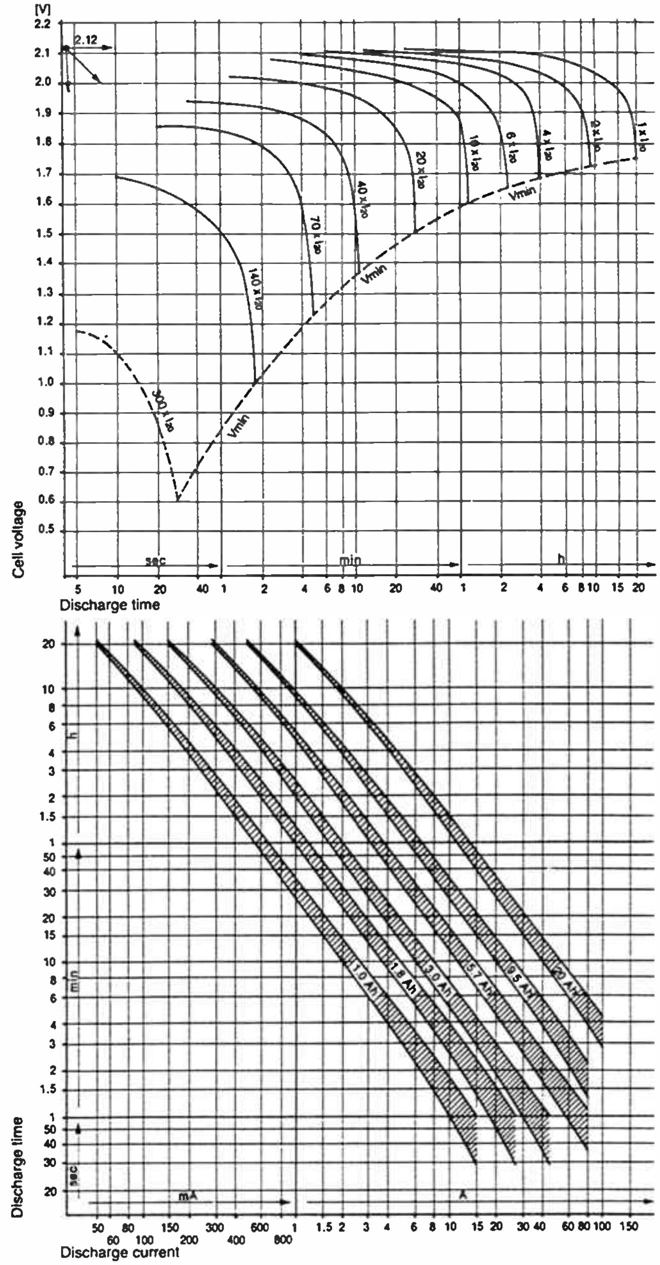

Figure 9. Typical discharge time and voltage curves for a lead/acid cell.

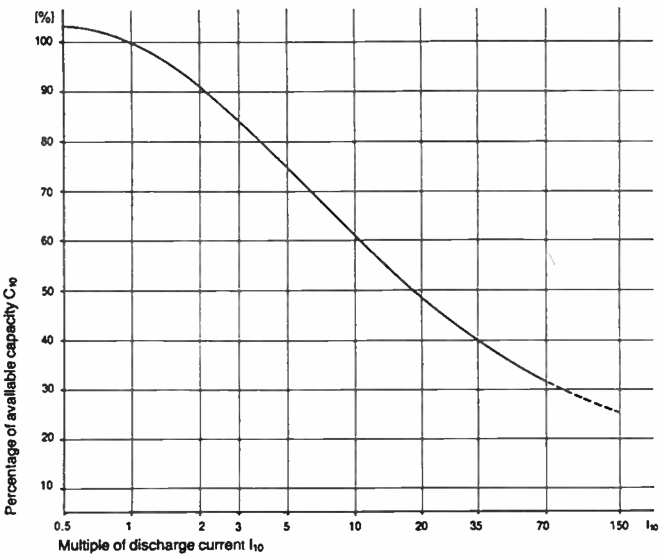

Figure 10. Capacity vs load – lead/acid cell.

conventional car battery – but this figure drops rapidly to the nominal value once the charging current is removed and a load is placed on the battery. Equipment manufacturers, however, must allow for the relatively high voltage which is available immediately after charging.

A more meaningful test of the total cell condition than either of the above methods may be made by measuring the voltage of the cell under load. The value of discharge current chosen for this test is very high – about three times the figure of the amp/hour rating – in order to show up weak or failing components or connections inside the cell or battery. A 40 Ah battery would be tested at 120 A for 15- 20 seconds. A battery is considered to be in reasonable condition if the cell voltage doesn't drop below 1.6 V – i.e: around 10 V at the terminals for a standard car battery. If the voltage continues to fall below that value, then the condition of the cell is poor.

The graph in Figure 9 illustrates the voltage supplied by a typical cell under varying load conditions. The dotted line which joins the endpoints of the discharge curves indicates the discharge cut-off voltage for the appropriate capacity.

As can be gauged from the above test and graphs, lead/acid batteries are capable of delivering very high currents for a short time with only a moderate voltage drop. A 40 Ah battery conforming to the graph would be able to supply 280 A for almost two minutes! The practical load limit is governed, among other things, by the temperature generated in the electrolyte solution, which should not be allowed to exceed 38 degrees C.

The capacity ratings for lead/acid batteries, in amp/hours, assume a fixed discharge time, usually of 10 hours. For example, a 40 Ah battery is reckoned to be able to provide 4 A for 10 hours. If, however, the current is doubled to 8 A, the time to discharge would be less than half – somewhere around four and a half hours. The effect is more dramatic as the discharge current increases – ten times the current would halve the total capacity, so the same battery could supply 40 A for only about 30 minutes. Figure 10 illustrates this effect of diminishing capacity for a high quality battery at 20° C.

Nickel cadmium: The nickel/cadmium, or NiCad cell employs a technology which has been in service for more than 50 years. The original industrial type is constructed along similar lines to the lead/acid cell, but with a completely different chemistry. The steel plates are perforated and folded in order to provide many small pockets which contain the active electrode material. The pocketed plates are sandwiched between plastic insulator strips, and housed in a rectangular polypropylene case. The electrolyte is a solution of potassium hydroxide.

These "pocket" cells can provide high currents, have very long life-spans (typically 15-25 years), and are very tolerant of electrical abuse such as overcharging or deep-discharging. They suffer from large size and weight, high initial cost and a 1.2 V nominal voltage.

Of more interest to the average consumer is the modern hermetically sealed dry NiCad cell. The construction of these cells, shown in Figure 11, is not dissimilar to electrolytic capacitors – namely two long rectangular strips wound into a spiral arrangement fitted into a cylindrical can.

The plates, or electrodes of the portable NiCad cell are made either by sintering or dry powder pressing. Sintering is achieved by firing finely divided nickel powder until it fuses and forms a porous and highly conductive supportive struc-

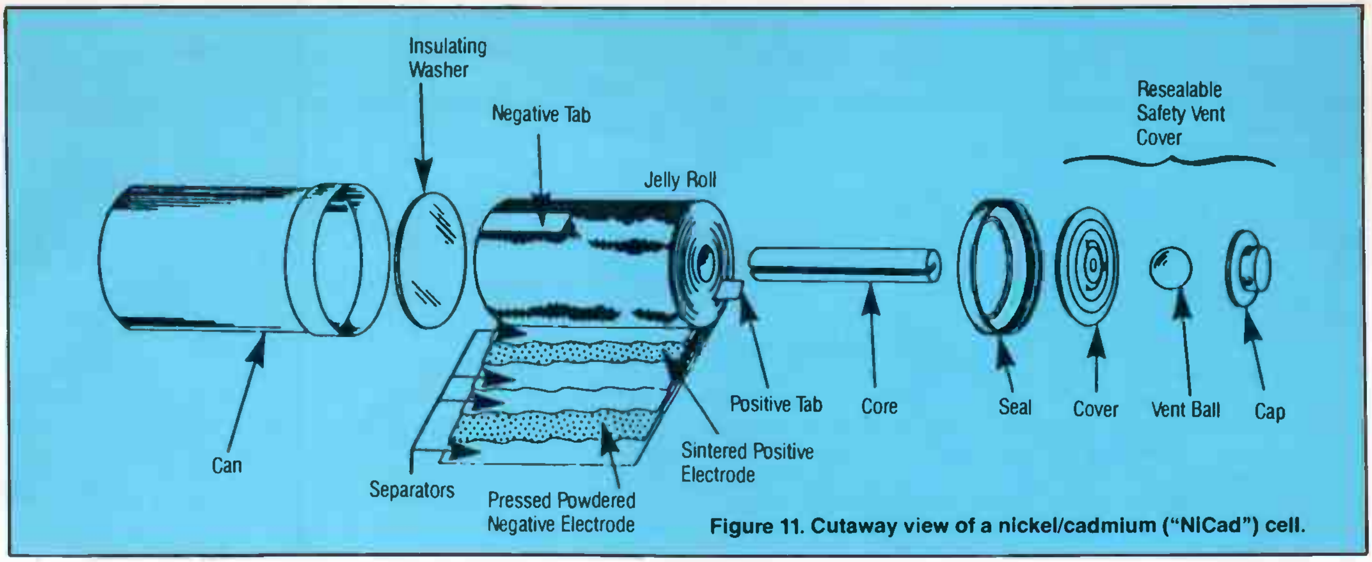

Figure 11. Cutaway view of a nickel/cadmium ("NiCad") cell.

ture for the electrode material. Positive electrodes are commonly formed this way. Negative electrodes are more commonly formed by pressing dry blended active materials into an expanded metal carrier. The positive electrode is nickel hydroxide, and the negative electrode is cadmium.

Sealed NiCad cells can provide a very cost-effective solution to dry cell needs, but they are not a panacea for portable power procurement. Cell voltage remains very constant during discharge, at around 1.2 V, until the "knee" of the discharge curve is reached and the voltage under load rapidly drops.

The low terminal voltage can render NiCads unusable with some equipment. As mentioned earlier, there is no single, fixed "end-point", or "dead-flat" voltage value for dry cells – the voltage at which a cell ceases to provide usable power depends on the load, the application, the cycle of usage, the ambient temperature and the personal preferences of the user.

Most battery-operated devices should operate satisfactorily on NiCads, although some will display reduced efficiency and a rare few will refuse to operate at all. Equipment which is designed sensibly to operate to a lower cut-off threshold, around 0.8 – 0.9 V, will accept NiCads as well as offering substantially more economy with conventional primary cells. The user must, however, determine beforehand if the lower terminal voltage will be adequate for the job at hand.

NiCads offer very low internal resistance and consequently have the ability to deliver substantial currents for short ▷

periods. This is highly advantageous for some applications, but could prove troublesome if the device were to develop a low resistance fault, or worse, a short circuit. Very high temperatures could be generated by the cells under these circumstances.

NiCads provide lower total storage capacity per cycle than any conventional cell, with the exception of the general purpose AA size – to which it is roughly equivalent. The graph in Figure 2 shows this comparison for the four common dry cell/battery sizes. Of course Nicads, being rechargeable, have far greater total potential capacity than even the most efficient equivalent primary cell.

The advantage of greater ultimate capacity is tempered by the inconvenience of having to remove and recharge the cells at fairly short intervals. The benefit is further reduced by the flat discharge curve with its sharp "knee", providing very little warning of impending total discharge. The only satisfactory solution to these two irritations is the purchase of a second set of cells which may be left on charge while the other set is being used. Considering that fully charged NiCads have only one quarter the capacity of alkaline cells, more than one set of spares could be required under circumstances of very heavy use. This may well render NiCads economically impractical for the purpose.

Which type to use?

The consumer is faced with a bewildering choice of types, sizes, chemistries and brands of cells to choose from. In many cases the choice is very straightforward, however. If an equipment manufacturer recommends one particular type or style of cell, then that is the cell which should be used. This is particularly the case for photographic equipment or other small devices which use button cells or relatively uncommon battery styles. Cells of the wrong voltage and with unsatisfactory discharge characteristics can be easily confused with the correct cells because of their almost identical size and appearance. Moral: Check and match the part number carefully, and don't substitute others unless the equipment manufacturer approves.

The debate for and against the use of NiCads has raged for some time, with some of the arguments presented earlier. In summary, the choice depends on how heavy a user of cells the appliance in question is. If you find that you're buying a lot of new cells on a regular basis, then you should check if NiCads would work satisfactorily. If on the other hand, a set of cells seems to last for ages, then NiCads would probably be a poor investment.

The most significant savings in cash and improvements in performance can be realised by the simple application of "caveat emptor". Variations between brands can be more significant than variations between types within one brand. Some brands are made to a price, and it shows. Surprising bargains can be made with the generic brands available in supermarkets. Granted, some are duds, but others are magnificent, and easily on par with the best branded cells.

Shop around, make your own comparisons between brands (the way you use the cell will determine its life), replace or recharge all the cells in a device at once, don't mix different types and remove them when they are flat. Following these precautions will prevent any possible charges by your equipment of assault and battery.

FURTHER READING

Electrical Technology, by Edward Hughes, published by Longmans. Chapters 1 and 21 provide enlightening reading.

Electrical Principles for the Electrical Trades, by J.R. Jennison, published by McGraw Hill. Chapter 3 covers the topic well.

KITS

8-Channel Infra-Red Remote Controller

Think about the possibilities — remote control for your TV, CD, VCR, model railway or ... almost anything!

Transmitter/receiver can handle up to 8 functions plus mute and Up/Down! What's more, it allows you to custom build the kit to suit yourself — construct with all functions or just a few!
Cat K-3434

Receiver
Measures 200 × 160 × 70mm. **$119.95**

Hand Held IR Transmitter

Pre-punched and screened front panel. Cat K-3433

$49.95

There's only one kit supplier you can trust for quality, range and professional back-up. With our "Sorry Dick, it doesn't work!" service and our specialist R&D department to rely on — there's only one No.1 In Kits: Dick Smith Electronics!

TV Colour Bar & Pattern Generator

Easy to build, it's just the thing for servicemen, technicians or hobbyists! It can even be constructed for NTSC operation.

The TV Pattern Generator is portable (so it's great for field work) and is powered by a 12 volt AC plug pack. Provides 8 patterns including colour bars, cross hatch and dot pattern. Much better value than commercial models! Cat K-3473

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Wireless Stereo Headphone Link

Ever had someone trip over your headphone cable? Having your ears ripped off is no fun at all! With the DSE Infrared Headphone Transmitter/Receiver you can enjoy high quality sound reproduction without messy cables.

Relatively easy to built, both the transmitter and receiver have volume controls and a range more than adequate for a larger than average size room. They're great value too!

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NiCad F-A-S-T Charger

$98.95

If you use NiCads at all — you'll find this project a great time saver! With the NiCad Fast Charger you can charge up to 12 volts of cells in series to near rated capacity — in a hurry. Because it's timer controlled it can't overcharge them either! Cat K-3476

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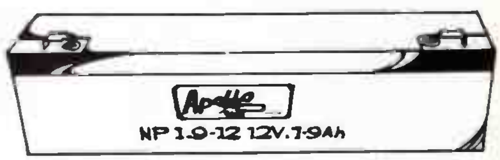
AAA 180mAh	S-3350	$4.95	**$4.50**
AA 500mAh	S-3351	$4.75	**$4.50**
C 1800mAh	S-3352	$12.95	**$9.95**
D 1200mAh	S-3353	$11.95	**$10.95**

Rechargeable Gel Cells

High power, no mess. Ideal for alarms, etc or where a slow trickle charge is at hand.

Type	Cat No.	Price
12V 1.2Ah	S-3315	**$34.95**
12V 1.9Ah	S-3316	**$35.95**
12V 2.6Ah	S-3320	**$36.95**
12V 6.5Ah	S-3322	**$54.95**



DICK SMITH ELECTRONICS
PTY LTD

What's new in handheld multimeters?

Jeff Ralph

The multimeter remains the fundamental test instrument for electronics professionals and hobbyists. General advances in technology are reflected in multimeter design, and every year sees a crop of new and improved models to choose from.

WE HAVE SELECTED and profiled a range of handheld multimeters which have become available over the last twelve months, and examined and compared their individual benefits. Both analogue and digital meters are included – some feature both methods – and prices range from under $25 to over $600 recommended retail.

Inclusion or exclusion of any particular multimeter doesn't imply approval or otherwise of a product. The meters examined were simply those which were indicated to us as being recent releases. Many other existing meters offering similar specifications and value-for-money are available. These are the new ones, however, obtained from information supplied by distributors who submitted material in response to our survey request sent in January.

In time gone by the choice of an appropriate multimeter was straightforward – one simply bought the best one in the price range. Nowadays the choice is not so simple. One has to choose between analogue and digital (or combinations of both), different styles of case, extra functions available and a considerable variance in the number and magnitude of ranges provided.

Some meters do not provide dc current measurement, only about half of the ones profiled here include an ac current range, and some of them have rather restrictive upper limits. An intending purchaser would be well advised to consider what they need in a multimeter in terms of ranges and resolutions provided. Otherwise it simply may not be capable of performing the job it was intended for. A good idea of functions and features available in various price brackets can be gleaned by studying the comparison table here.

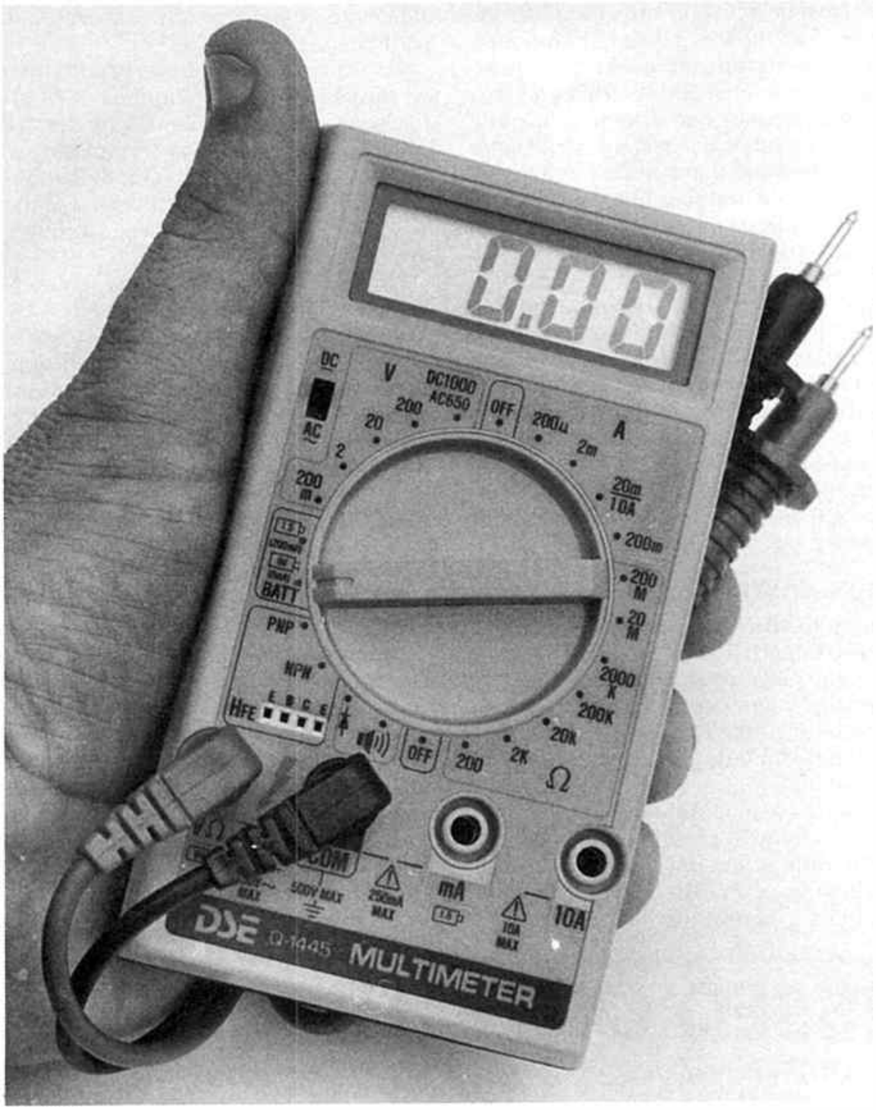
The table

The table gives the specifications, available ranges, and some of the features provided by a cross-section of hand held multimeters recently released to the Australian market. If a value or a figure is missing from the table it doesn't necessarily mean that the feature is unavailable – it may simply mean that the figure was not listed in the specification sheets from which the table was compiled.

The multimeters included were chosen on the basis of having been released or significantly upgraded in the last year or so. The prices quoted are Recommended Retail Price, that is including sales tax, and some of the strange figures no doubt reflect these calculations. It seems likely that slightly better prices

HANDHELD MULTIMETERS – SPECIFICATIONS RANGES AND FEATURES

Brand/Distributor	Model No.	R.R.P.	Dimensions (mm)
DSE	Q-1015	$24-95	105 x 90 x 35
Tandy/Micronta	22-171	$44-95	108 x 54 x 8
DSE	Q-1440	$49-95	110 x 65 x 22
Emona	EDM-70H	$57-70	
DSE	Q-1521	$59-95	150 x 74 x 35
Emona/Iskra	Unimer 43	$62-65	140 x 100 x 35
Emona	EDM-70B	$64-95	
Tandy/Micronta	22-214	$69-95	170 x 124 x 60
Emona	EDM-55	$79-33	
Tandy/Micronta	22-220	$89-95	180 x 140 x 70
Emona/Emtek	ETK-1101	$98-60	
Tandy/Micronta	22-185	$99-95	170 x 78 x 32
Benelec/Univolt	DT-777	$106-09	127 x 69 x 25
Emona	DM6012D	$130-13	180 x 86 x 35
Emona	EDM-1122	$146-98	
DSE	Q-1777	$149-00	145 x 86 x 34
Benelec/Univolt	DT-910	$208-77	141 x 70 x 35
DSE	Q-1666	$249-00	
Emona/Iskra	Unimer 06	$286-50	
Benelec/Univolt	DT-4100	$338-80	176 x 80 x 37
Philips	PM2518	$630-00	170 x 118 x 55



could be negotiated on some of the meters, but these are the figures quoted by the distributors. The meters are ranked in order of ascending price.

The digital display has certainly taken over from the analogue, if the proportions represented in this survey can be taken as a guide. The most significant objection to the digital display – difficulty in observing nulls, peaks and fluctuating signals – has been answered neatly by the provision of bar graph displays by five of the meters.

The most common display configuration is still the 3.5- digit LCD type. In its standard form, the maximum count (full-scale deflection?) of these displays is 1999 units, but this value has been stretched on two of the meters to 3000 and 4000. The displays are still referred to as 3.5 digit, but the greater maximum count is noted.

One meter has the rather unusual configuration of an electronic bar graph display without the digital accompaniment, and another has a conventional analogue moving needle with auto polarity indication! Perhaps the technology hasn't stabilised yet.

The figures quoted for sensitivity refer to the impedance imposed on the circuit under test during measurements of dc voltage, and are the typical values. In some cases much better results are available on the lower ranges. Likewise the accuracy figures refer to typical values of dc measurements.

The number of ranges available for each function is shown, followed by the maximum value which may be read. ▷

			RANGES							
			dc volts		ac volts		dc amps		ac amps	
Display type	**Sens.**	**Accuracy**	**No.**	**max**	**No.**	**max**	**No.**	**max**	**No.**	**max**
analogue	10k		4	1k	4	1k	2	250m		
3.5 LCD				400		400				
3.5 LCD	1M		4	1k	2	500	3	200m		
3.5 LCD		0.5%	5	1k	2	750	5	2		
3.5 LCD	10M		4	1k	2	750	3	10		
analogue	200k		9	1k	6	1k	6	5	6	10
3.5 LCD		0.5%	5	1k	2	750	5	2		
analogue	50k		12	1k	8	1k	5	10		
3.5 LCD		2%	5	500	4	500				
analogue	10M		7	1k	5	1k	4	10		
3.5 LCD		0.8%	1k	750	3	15	3	15		
3.5 LCD	10M		5	1k	4	750	4	10	4	10
3.5 LCD	10M		5	1k	4	500	3	10	3	10
3.5 LCD	10M	0.8%	5	1k	5	750	5	15	5	15
3.5 LCD		0.5%	5	1k	5	750	6	20	6	20
105-step bar	5M	1%	6	1k	4	750	3	250m		
3.5 LCD	10M		5	1k	4	750	4	10	4	10
3.5 LCD & bar	10M		5	1k	4	750	3	10	3	10
analogue	10M		11	1k	11	1k	16	30	16	30
3.5 LCD & bar	10M		5	1k	5	750	3	10	3	10
4.5 LCD & bar	10M	0.1%	4	1k	4	1k	4	10	4	10

The meters examined

Here follows some brief information on the instruments featured in the table.

DICK SMITH ELECTRONICS

DSE's range is well represented here, with five new models ranging from a $25 cheapie to a sophisticated dual-scale extended range model. The Q-1015 provides a particularly low-cost solution to the "second-meter-for-the-car-or-toolbox" problem. In addition, it is the only meter featured here which provides a tester for dry cells and 9 V batteries. Sensitivity is adequate for the intended general purpose applications.

For twice the price, the Q-1440 provides digital accuracy and the ability to test diodes and transistors. A further ten dollars expenditure get you the Q-1521, which imposes the "industry-standard" load of 10M impedance to a circuit under test. This is the cheapest meter surveyed with a "data hold" facility, which allows the user to make a measurement in a confined or congested space, and then read the measured value after the probes are removed.

The next DSE offering represents a substantial leap in price (more than double) and a curious application of display technology. The display is a 105-step LCD bar graph, which provides a pseudo-analogue measurement. The scale can be expanded 10x for more precision, and there is a data hold function and a maximum (or peak) hold function. Unlike most DMMs (this one isn't really analogue) sampling time is quite fast, at ten times per second. This meter would provide good results when following rapid fluctuations, unimpeded as it is by inertia in the meter movement.

DSE's top of the line DMM, the Q-1666, features a 3.5- digit LCD display which counts to 4000 – thereby improving the resolution of measurements beginning with a "2" or a "3" by one digit, without the added expense of a 4.5-digit display. A small bar graph display is included below the numerals, for reasons discussed earlier. The display is illuminated, making reading possible during blackouts or when down coal mines.

EMONA INSTRUMENTS

Emona Instruments carry a range of 20 analogue and digital multimeters and over 20 specialist meters, such as light intensity, temperature, inductance, capacitance etc. The new releases featured here include two analogue and six digital meters.

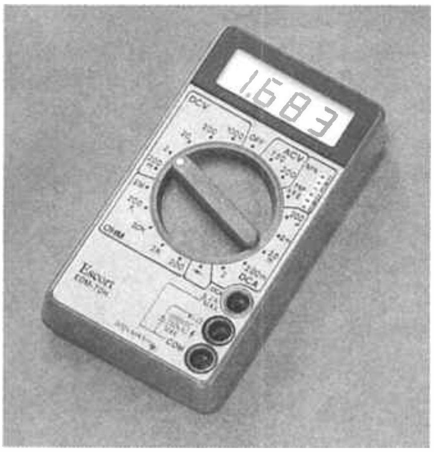
Emona's two pocket-size DMMs share almost identical specifications and differ by only a few dollars in price. The distinction is that the EDM-70B model includes a continuity test buzzer, but deletes the transistor hFE test which is available in the EDM-70H.

Positioned between these two in price is the Emona/Iskra Unimer 43, an analogue whose distinguishing feature is the provision of six ac current ranges, from 1 mA to 10 A full scale deflection (FSD). This meter is the cheapest of the new releases surveyed here to provide ac current measurement.

The EDM-55 is a compact autoranging DMM built into a "pen" style case with one probe integral to the case – where the "nib" would be. This design allows rapid interpretation of readings without having to look away from the circuit under test, as the display is close at hand. No current ranges are provided and the continuity check responds quickly, both of which further suggest that the meter is intended for use in testing or troubleshooting of built up circuits, rather than as an aid to development.

The next model, the Emtek ETK-1101, is a hand held 3.5- digit (counts to 3000) LCD model with autoranging on the voltage and resistance scales. Current ranges, both ac and dc, are manually switched to a very handy maximum of 15 A.

The "all-bells-and-whistles" EDM-1122 has the conventional DMM ranges plus ac current to 20 A, capacitance to 20 uF, frequency to 200 kHz, logic level



test and a top resistance range of 2G (yes, that's 2000M!). The display is considerably larger than usual, at 17 mm high.

The analogue Unimer 06 has more ranges per function than any of the other meters featured here – 16 are provided for current measurement, from 1uA to 30 A FSD. Perhaps even more of a distinction is the provision of auto-polarity selection – in an analogue meter! Polarity is indicated by a small LCD window at the top left of the display. Just imagine – no more slamming of the needle against the left hand stop. Input impedance is good, at 10M.

The final Emona offering does not strictly belong in a review of new meters, but its companion unit does, so here it is! The DM6012D is a fairly conventional DMM with pushbutton range selection. It's claim to fame is an inbuilt serial interface, the LT-DATA BUS, which allows the meter to connect directly to a proprietary printer. The newly-released BF-232 Buffer (RRP $190.32) allows the connection of the meter to a PC via an RS-232 port. By this means the meter can be configured as a data logger, recorder, control system, data analyser or as part of an automatic testing unit. Optional adapters are available to allow the meter to read temperature, humidity, rpm, light intensity or dc current through a clamp mechanism.

BENELEC

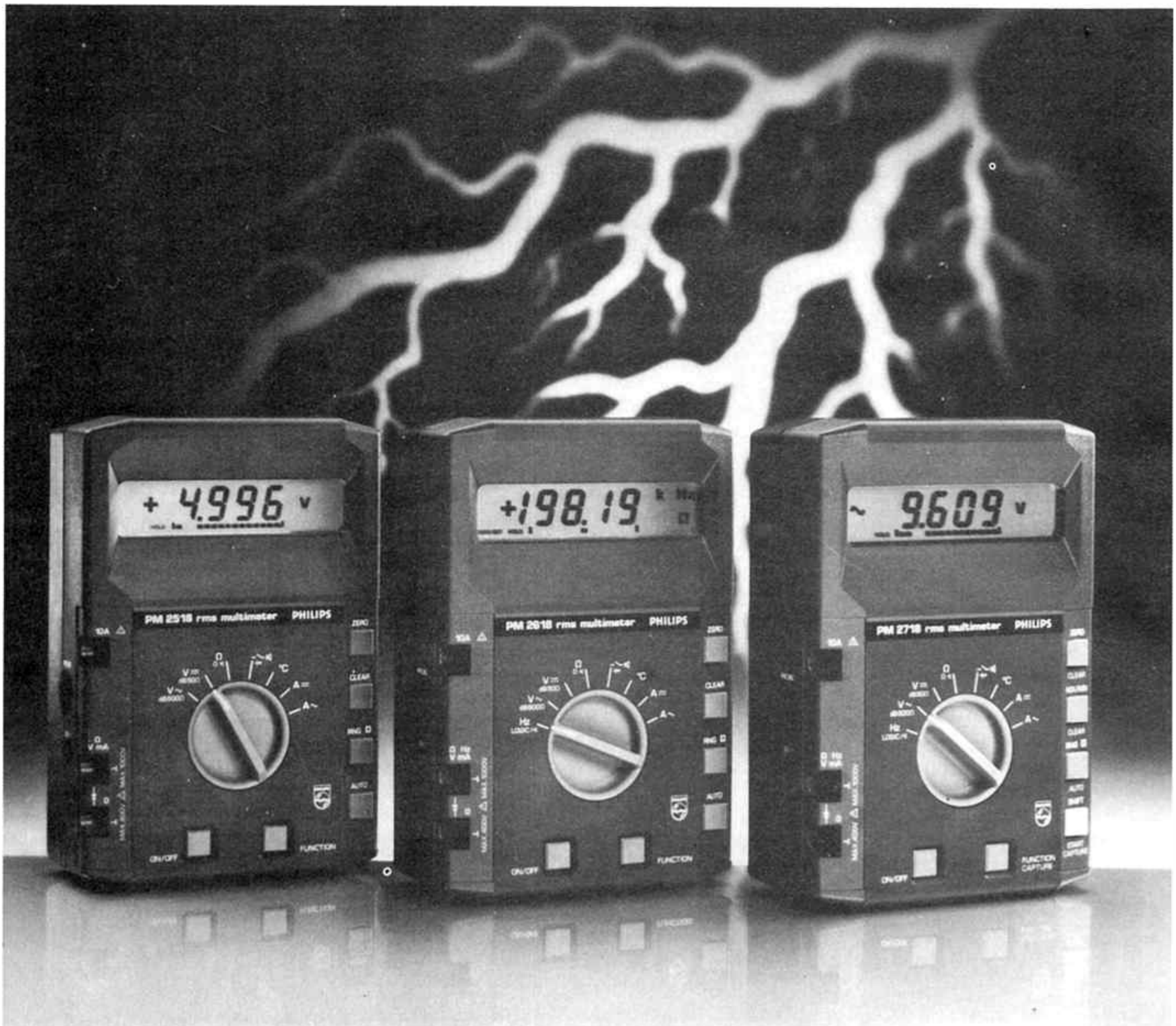
Benelec's range of Univolt DMMs include three new models, the DT-777, 910 and 4100. The former two are conventional 3.5 digit LCD meters with autoranging and data hold. The latter two have a special position on the selector switch for optional adapters, which are available for temperature, high current (200 Adc), current by clamp probe and capacitance (up to 200 uF).

The DT-4100 features a 4000-count display with integral 40-segment bar graph. It has a frequency range with

measurement to 100 kHz as standard, and data hold and diode check facilities.

TANDY

Tandy's range of Micronta meters has four recent additions. The 22-171 is a genuine pocket-size DMM – just a little longer than a credit card, same width and only 8 mm thick. Ranges are selected automatically, and a diode check facility is included. Current ▷



ranges are not included.

The 22-214 and the 22-220 are conventional analogue meters, the latter providing FET input with 10M impedance. Both meters feature an audible continuity indication, a fairly rare inclusion in analogue devices.

Micronta's top of the range handheld DMM is the 22-185. The 3.5-digit LCD reads to 3000, and features autopolarity and a diode check.

PHILIPS

Philips Series 18 DMMs, re-released in improved form, are 4.5-digit LCD meters with integral bar graph. An automatic backlight for the display is available for this series. This switches on automatically in low light situations, and turns off again in a short time if no measurements are made. The three models are the PM-2518, 2618 and 2718. The first of the three only is featured in the table, as the others share common specifications – the difference being mainly in improved accuracy and the provision of a logic testing function in the latter two.

A unique feature of these meters is the "crest factor overload" warning, which indicates a possible loss of accuracy in ac measurements due to distorted input signals. The user must then switch to a less sensitive range which can handle the high crest factor present.

Philips claim that audible continuity checks are instant, which would eliminate one of the more irritating habits of DMMs – that of waiting a noticeable time to make up their mind whether a circuit is continuous or not. This feature is a distinct advantage when checking for shorts, for example, between the pins of large ICs.

Accuracy for dc voltage measurements are 0.1%, 0.07% and 0.04% for the three meters respectively. This is considerably more accurate than any of the other meters surveyed here, relecting the Series 18's 4.5 digit display – and their price. You get what you pay for.

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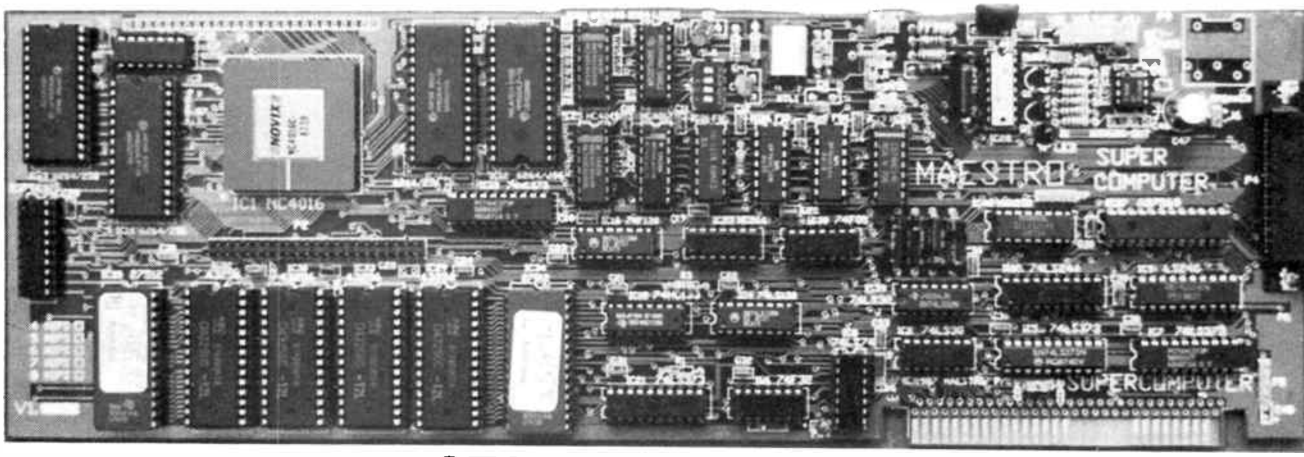

STATE-OF-THE-ART

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I enclose $________ total. I am paying by:

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Money Order, No: . . . .

* Make cheques or money orders payable to "Maestro Distributors"

Bankcard, No: . . . .

Mastercard, No: . . . .

Visa, No: . . . .

Signature: . . . .
(unsigned credit card orders cannot be accepted.)

Name: . . . .

Address: . . . .

. . . . **Postcode:** . . . .

(Orders despatched to Maestro within 24 hrs of receipt at AEM.)

Limited Edition cassette tape from TDK

A "Limited Edition" cassette tape using TDK's new Super Avilyn (SA) tape formulation, first developed by TDK in 1973, has been released here in a special cassette.

TDK claim world-wide industry standard status for the Super Avilyn tape.

The SA-LTD is available in C-90 size only. Smaller particle size and higher packing density give the SA-LTD an extremely low bias noise, -63 dB, making it second only to TDK's SA-X, which is claimed to be the quietest tape in the world.

Super Avilyn was developed to out-perform chromium dioxide. TDK claim high coercivity (magnetic energy effectiveness) and high remanence to wear with the formulation.

SA particles have a gamma ferric oxide core with an ultra thin cobalt ion layer. Careful control of the amount of cobalt ions allows control of the coercivity to within precise tolerances.

The cassette mechanism for the SA-LTD is a "Super Precision, Anti-Resonance" unit, claimed to offer 35% more rigidity, minimising the danger of physical distortion. Tolerances during production are controlled to within one micron (one millionth of a metre).

The SA-LTD is available from TDK dealers for $8.60 (rrp).

Removing hiss from tapesss

A special "sliding-filter" has been employed in a new professional audio noise reduction unit from dbx, the dbx 929 module, developed to reduce or even eliminate hiss in audio or video tapes.

The module contains two channels of single-ended, one-step noise reduction for sources that have a continuous unchanging hiss "floor" beneath the desired signal. The hiss is removed with little or no sacrifice of high frequencies and treble overtones, dbx claim. The module also has applications in cleaning up broadcast signals.

The dbx 929 is distributed in Australia by Amber Technology. For further information, contact **Karl Seglins, Amber technology, PO Box 942, Brookvale 2100 NSW. (02)975 1211.**

Tannoy launches new loudspeaker

Tannoy UK, for 60 years one of the world's leading manufacturers of high quality studio monitors and loudspeakers, has announced the release of a new addition to their range of domestic loudspeakers.

The Eclipse is a two-way loudspeaker featuring a ferrofluid cooled polyamide dome high frequency unit, designed to give smooth response and improved dispersion.

The Eclipse cabinet is rigidly constructed from 12/15 mm high density particle board. The crossover is hard wired using low loss components and heavy duty terminals which will accept the majority of high quality audio cables.

Finished in black ash, the will retail for a recommended price of $499 a pair.

Arista needling stylus retailers

With the decline of LP record sales in favour of compact discs, it stands to reason that records will become more difficult to replace, and hence more valuable. Now, then, is the time to ensure that your valuable collection isn't being carved up by an inadequate stylus.

Arista Electronics recently surveyed stylus retailers and say they found that many of their offerings were sub-standard and overpriced.

Happily for all involved, Arista has released a full range of replacement styli featuring a one-piece injection moulded carbon compound cantilever assembly which the claim assures excellent orientation of the diamond tip, along with low mass.

Arista are making a concerted attempt to capture a large portion of the future stylus market, with a very complete programme of brochures, identification books, fast-finder systems and a wide range of styli.

For more information, contact **Arista Electronics Pty Ltd, 57 Vore Street, Silverwater 2141 NSW.**

1.2 kg camcorder

Sharp's latest release VHS-C video camera, the VL-C73XA, is light and compact, weighing in at just 1.2 kg. The new model features an eight-times power zoom with pressure sensitive variable speed control and a macro function for close-up photography.

The high speed electronic shutter allows the capture of quickly moving objects and, with a three or four head VCR slow motion or still frames are stable and free of noise bars. Provision is made for easy dubbing of background sound tracks.

Automatic settings for focus, white balance and exposure and the provision of auto standby contribute to simple one-step operation.

Sharp's new higher density Charge Coupled Device (CCD) image pick-up has contributed to dramatically improved picture quality and allows recording in light levels as low as 10 lux.

Other features include playback via the viewfinder, an automatic date/clock function which can be superimposed on the recording, a record review function to check the last few seconds of each scene and an index search system to help locate specific recordings.

The VL-C73XA comes complete with all accessories for $3299 (rrp). For more information, contact your local Sharp video and camera specialist.

ONE STOP, BARGAIN BUYING!

RED HOT BUYS

METEX 4500H MULTIMETER

10A, 4½ digit multimeter with digital hold, transistor tester and audible continuity tester.

The Metex 4500H is perfect for the technician, engineer or enthusiast who requires the higher accuracy of a 4½ digit multimeter. This meter is exceotionally accurate, (just look at the specifications), and yet, still retains an exceptionally low price!

The Metex 4500H features digital hold which is normally only found on very expensive multimeters. This enables you take a reading and hold that reading on display even after you have removed the probes simply by pressing the hold button.

CHECK THESE FEATURES...
- Readout hold
- Transistor Tester
- 4½ digit x ½" (H) LCD
- Audible continuity tester
- Push-button ON/OFF switch
- Quality set of probes
- Single function, 30 position easy to use rotary switch for FUNCTION and RANGE selection
- Built in tilting bail
- Instruction manual
- Full overload protection
- hFE test
- Battery and Spare fuse
- Diode Tester
- Vinyl case

Q91560 .... Normally $175
Special, only $159

DB25 CONNECTOR SPECIALS!

P10884	DE9P	R A	Plug	$3.65
P10885	DE9S	R A	Skt	$4.25
P10890	DA15P Male			$2.10
P10891	DA15S Female			$2.25
P10892	DA15C Cover			$1.25
P10894	DA15P	R A	Plug	$4.25
P10895	DA15S	R A	Skt	$5.00
P10900	DB25P Male			$1.00
P10901	DB25S Female			$1.20
P10902	DB25C Cover			$1.25
P10904	DB25P	R A	Plug	$4.50
P10905	DB25S	R A	Skt	$5.95

NICADS!

Save a fortune on expensive throw away batteries with these quality Nicads and Rechargers!

Size	Desc.	1-9	10+	100+
AA	450 mA H	$2.95	$2.75	$2.50
C	1 2 A H	$9.95	$9.50	$8.95
D	1 2 A H	$9.95	$9.50	$8.95

PUSH BUTTON DIALLERS

Tired of old fashion dialling and re-dialling engaged numbers? These convenient push button diallers include last number redial (up to 16 digits) and instructions for an easy changeover.

Cat A12030 .... Normally $19.95
SPECIAL, ONLY $14.95
(Note: Not Telecom approved)

MINIATURE HOBBY VICE

- Lever operated suction grip base for instant mounting and portability
- Mounts on smooth non-porous surfaces
- Ideal for holding components and other small/light objects

Cat.T12458 ... **only $5.45**

ADCOLA E024 SOLDER SYSTEM

The E024 is a top quality, Australian made soldering station suitable for use with either the Adcola CT-6, CT-7 irons or desoldering pencil. The E024 features a continuosly adjustable temperature range from 200°C to 400°C. The E024's electronic temperature control circuit monitors the temperature element in each of the irons, allowing it to maintain a constant temperature to within an incredible +/- 5°C of the temperature dial setting on the front panel.

Power to the irons is via a "zero crossing" controller. The power to the irons is switched on/off at a point on the AC power supply where the voltage passes through zero. Hazardous spikes caused by commutated AC are avoided using this technique.

Mains spikes are virtually eliminated by an electrostatic shield wound between the primary and secondry of the power transformer, an important safegaurd for easily damaged MOS devices. To further safegaurd sensitive components, an auxiliary ground lead earths the equipment to be soldered to the same level as the solder station, limiting the effective tip EMF to approximately 10mV. (Well below the damage level for MOS devices) If static control is important, the E024 unit is an excellent choice.

E024 Base Station & CT7 Iron
Cat.T12570 .... **$195**

UV EPROM ERASER

Erase your EPROMs quickly and safely. This unit is the cost effective solution to your problems. It will erase up to 9 x 24 pin devices in complete safety, in about 40 minutes (less for less chips)
Features include:
- Chip drawer has conductive foam pad
- Mains powered
- High UV intensity at chip surface ensures EPROMs are thoroughly erased
- Engineered to prevent UV exposure
- Dimensions 217 x 80 x 68mm

WITHOUT TIMER
Cat X14950 .... Normally $97
Special, $79

WITH BUILT-IN TIMER
Cat X14955 .... $139
Special, $99

BRAND NEW FANS

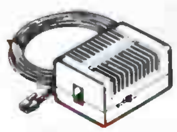
Quality, new fans for use in power amps, computers, hotspot cooling etc. Anywhere you need plenty of air.

240V	4⅝"	Cat T12461	$14.95
115V	4⅝"	Cat T12463	$14.95
240V	3½"	Cat T12465	$14.95
115V	3½"	Cat T12467	$14.95

10+ fans (mixed) only $10 each!

FAN GUARDS TO SUIT

4⅝"	Cat	T12471	$3.95
3½"	Cat	T12475	$3.95



TELEPHONE EXTENSION BELL

- 10 metre length extension cord
- Features US type plug
- Use with US/Australian adaptor

Y16043 .... **$25.95**

½" HIGH INTENSITY RED LED DISPLAYS

(Available in Common Cathode and Common Anode)

Dimensions:
Overall: 12.7mm across, 19mm high
Display: 12.7mm(H) x 7.3mm(W)
Segment Width: 1.2mm
Brightness: 3400 ucd I_F = 10mA

COMMON CATHODE:

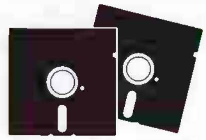
Pin 1 Segment E	Pin 6 Segment B
Pin 2 Segment D	Pin 7 Segment A
Pin 3 CC	Pin 8 CC
Pin 4 Segment C	Pin 9 Segment F
Pin 5 Segment Dp	Pin 10 Segment G

Cat No	1-9	10+	100+
Z10190	$1.95	$1.75	$1.50

COMMON ANODE:

Pin 1 Segment E	Pin 6 Segment B
Pin 2 Segment D	Pin 7 Segment A
Pin 3 CA	Pin 8 CA
Pin 4 Segment C	Pin 9 Segment F
Pin 5 Segment Dp	Pin 10 Segment G

Cat No	1-9	10+	100+
Z10191	$1.95	$1.75	$1.50



"NO BRAND" DISKS!!

Now you can buy absolute top quality disks that are also the cheapest in Australia! They even come with a 5 year guarantee! So why pay 2-3 times the price for the same quality?

Packs of 10, D/S D/D without boxes, or brand name, just their white paper jacket, and index labels.
(5¼" disks includes write protects)

5¼" "NO BRAND" DISKS

DOUBLE SIDED/DOUBLE DENSITY

10+ DISKS	100+ DISKS	1,000+ DISKS
$9·00**	$8·50**	$8·00**

(ALL PRICES PER 10 DISKS)

3½" "NO BRAND" DISKS

DOUBLE SIDED/DOUBLE DENSITY

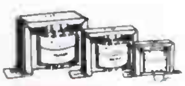
10+ DISKS	100+ DISKS	1,000+ DISKS
$27	$26	$24

(ALL PRICES PER 10 DISKS)

PASSIVE INFRA-RED DETECTOR
(WP-800)

FEATURES:
- Walk test LED indicator
- Wall/corner/ceiling mount
- Micro switch tamper proof protection
- 24 detection beams in 3 different ranges
- N.C. silent S.P.S.T. dry relay contact output
- Alarm auto reset approximately 3 seconds after triggered
- Superior RFI immunity protection
- Extremely low power consumption
- Adjustable mounting bracket
- Easy installation, easy adjustment
- Dual element, low noise, high signal to noise ratio pyroelectric
- Detection degree indicator
- D.C. 8-16V power operating

S15079 .... **$89.95**



ECONOMY TRANSFORMERS

	1-9	10+
2155 240V 6-15V 1A, Cat M12155	$9.95	$8.95
2156 240V 6-15V 2A, Cat M12156	$14.95	$13.95
2840 240V 9V CT, Cat M12840	$5.95	$4.95
2851 240V 12·6V CT 150mA, Cat M12851	$5.95	$5.50
2860 240V 15V CT 250mA, Cat M12860	$5.95	$4.95
6672 240V 15-30V 1A tapped, Cat M16672	$14.95	$13.95

RECHARGEABLE 12V GELL BATTERIES

Leakproof and in 3 convenient sizes, these long service life batteries are ideal for burgular systems, emergency lighting or as a computer backup power supply. Ideal for many power needs.

Cat S15029 12V 1.2 AH **$17.50**
Cat S15031 12V 2.6 AH **$32.50**
Cat S15033 12V 4.5 AH **$39.50**

RS232 FAST CABLER

Makes RS232 interface configurating fast and simple. 3 slide switches enable line swapping functions, positive and negative voltages are displayed on 6 tricolour LED's.

SPECIFICATIONS:
Connector: DB25 plug on 100mm cable and DB25 socket on 100mm cable
Indicators: Tricolour LED's for pins 2(TD), 3(RD), 4(RTS), 5(CTS), 6(DSR), 20(DTR)
Switches: 3 Slide switches to swap leads
Power: Interface power
Enclosure: Black, high impact plastic
Dimensions: 85 x 95 x 30mm

X15710 .... **$145**

ECONOMY ROTARY SWITCHES

Cat. No.	Description	Price
S13021	1 pol 2-12 pos	$1.95
S13022	2 pol 2-6 pos	$1.95
S13033	4 pol 2-3 pos	$1.95
S13035	3 pol 2-4 pos	$1.95

SUPERB VIFA/EA 60+60 SPEAKER KIT!

The Vifa/EA 60 + 60 loudspeaker kit has been designed to completely out perform any similarly priced speakers. This is a 2-way design incorporating drivers which give a deeper, more natural bass response and 19mm soft-dome ferro fluid cooled tweeters which provide clear uncoloured sound reproduction.

These Vifa drivers are identical to the ones used in such fine speakers as Mission, Rogers, Bang & Olufsen, Monitor Audio and Haybrook just to name a few. Some of which cost well over $1,000 a pair!

The dividing network is of the highest quality and produce no inherent sound characteristics of their own, they simply act as passive devices which accurately distribute the frequency range between both drivers in each speaker.

The fully enclosed acoustic suspension cabinets are easily assembled. All you need are normal household tools and a couple of hours and you've built yourself the finest pair of speakers in their class!

D19 TWEETER SPECIFICATIONS:
Nominal Impedance: 8 ohms
Frequency Range: 2.5 - 20KHz
Free Air Resonance: 1,700Hz
Sensitivity 1W at 1m: 89dB
Nominal Power: 80 Watts (fo 5,000Hz, 12dB/oct)
Voice Coil Diameter: 19mm
Voice Coil Resistance: 6.2 ohms
Moving Mass: 0.2 grams
Weight: 0.28kg
Cat C10301 .... **$38**

C20 WOOFER SPECIFICATIONS:
Nominal Impedance: 8 ohms
Frequency Range: 35 - 6,000Hz
Resonance Frequency: 39Hz
Sensitivity 1W at 1m: 90dB
Nominal Power: 50 Watts (12dB/oct)
Voice Coil Diameter: 25mm
Voice Coil Resistance: 5.5 ohms
Moving Mass: 15 grams
Cat C10322 .... **$89**

Cat K86092 (speakers only) **$379**
Cat K86091 (complete kit) **$449**

BIG MOUTH CAR ALARM

FEATURES.....
- Easy installation
- Automatic on/off
- Loud alarm signal
- Auto reset
- Low Price!

SPECIFICATIONS:
Power: DC 12V battery
Current Consumption: 10mA at 12V DC
Dimensions: 139 x 165 x 136mm
Exit Delay: 60 seconds approx
Entry Delay: 12 seconds approx
Auto reset: 90 Seconds approx

S15048 .... **$39.95**

KEY SWITCHES

Cat S12500 .... Normally $7.95

1-9	10+	25+
$4.95ea	$4.25ea	$3.95ea

rie

Rod Irving Electronics

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

NORTHCOTE: 425 High St
Phone (03) 489 8866

CLAYTON: 56 Renver Rd
Phone (03) 543 7877

SOUTH AUSTRALIA
Electronic Discounters P/L,
305 Morphett St, ADELAIDE
Phone (08) 212 1799

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Interstate Orders: (008) 33 5757
All Inquiries: (03) 543 7877

CORRESPONDENCE
P.O. Box 620, CLAYTON 3168
Telex: AA 151938
Fax: (03) 543 2648

MAIL ORDER HOTLINE
008 335757
(TOLL FREE)
(STRICTLY ORDERS ONLY!)

LOCAL ORDERS & INQUIRIES
(03) 543 7877

POSTAGE RATES

$1	$9.99	$2.00
$10	$24.99	$3.00
$25	$49.99	$4.00
$50	$99.99	$5.00
$100	$199	$7.50
$200	$499	$10.00
$500 plus		$12.50

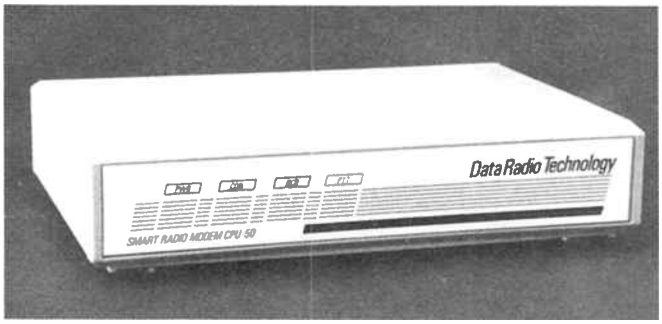
The above postage rates are for basic postage only. Road Freight, bulky and fragile items will be charged at different rates.

All sales tax exempt orders and wholesale inquiries to
RITRONICS WHOLESALE,
56 Renver Rd, Clayton
Ph. (03) 543 2166 (3 lines)

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

008 335757 TOLL FREE MAILORDER HOTLINE FOR CREDIT CARD ORDERS!!

Locally made smart packet radio modem



Data Radio Technology has announced the release of their new Smart Packet Radio Modem, model CPU-50, which has been designed to complement their already popular CPU-100 Smart Radio series.

The CPU-50 incorporates a number of features which its confident makers believe will bring it to the forefront and make it the top selling radio modem in the country.

Based on an X.25 protocol adapted for radio applications, the CPU-50 provides full error correction, automatic digital repeater operations, networking for many hundreds of units, unidirectional broadcast operation, standard RS-232 interfacing as well as full and half duplex radio operation.

The CPU-50 has been specially designed for HF SSB operation, providing high data throughput at 600 baud during average conditions, or 1200 baud if an excellent path exists. VHF/UHF FM operation is also available.

Small size (160 x 105 x 34 mm) and low power consumption (30 mA at 12 Vdc) make the modem well suited to remote area operation where only solar power is available – such as remote sensing and telemetry work.

The CPU-50 features over 90 configuration option commands, which are stored in non-volatile RAM for once-only entry.

Use of a standard protocol ensures compatibility with other packet-type radio modems.

Data Radio Technology, a wholly owned subsidiary of GFS Electronics, is making the modem available from their distributors from the second quarter of 1988. More details from **Data Radio Technology, 17 McKeon Road, Mitcham 3132 Vic. (03)873 3777.**

New dual-bander from Icom

Icom Australia has just released the IC-575A, a 6 and 10 m companion to the 2 m band IC-275A and the IC-475A 70 cm all-mode transceivers.

All three base/mobile transceivers share the same features, including a built-in 240 Vac 100% duty cycle power supply and 13.8 Vdc mobile operation.

The IC-575A features Icom's unique Direct Digital Synthesis (DDS) frequency generation circuitry, touted as the modern successor to Phase locked Loop (PLL).

The DDS replaces all PLL circuitry with a computer designed digital synthesis for fast (5 ms) lock-up, fast switching for advanced digital modes and claimed superb frequency stability through the mixing of DDS-generated source frequencies in an advanced double PLL system.

All three transceivers in the series have 99 user- programmable memories plus two priority channels, and remote control capabilities through Icom's CI-V (Computer Interface –V) standard, connecting to any standard RS-232C serial port.

A high-integrity LCD with soft orange illumination, just the shot for those romantic late-night QSOs, displays eight operating parameters.

In the receiver front end is a pair of low-noise high-gain 2SK125 JFET RF amplifiers, providing high sensitivity and dynamic range.

Receive sensitivity is claimed at less then 0.13 uV for 10 dB S/N (SSB/CW), while selectivity is claimed to be 2.3 kHz (–6 dB). Transmitter power is continuously adjustable from 1 – 10 W (1 – 4 W AM) from the front panel.

The Icom IC-575A is available for inspection at your nearest authorised Icom dealer. For details of their whereabouts, contact **Icom Australia, 7 Duke St, Windsor 3181 Vic. (008)33 8915.**

SERG Convention

The South East Radio Group, a thriving and long-lived amateur radio club based in Mt Gambier in south-east South Australia, will be holding its popular SERG Convention during the Queen's Birthday weekend in June (11-13).

The general public, amateur operator or not, is invited to attend the Convention on the Sunday afternoon (June 12th).

A display of vintage commercial and amateur radio equipment will be held, and an invitation is open for anyone to bring their favourite piece of equipment for display. A prize will be given for the best single piece of equipment displayed.

There will be trade displays of state-of-the-art technology including satellite television and the latest in computers.

There will also be a working ham shack displaying some of the modes available to amateurs. The Bicentenary callsign, VI88SA, will be used during the Convention, providing all amateurs an opportunity to work this "once-in-a-lifetime" callsign.

Registration forms and convention programmes are available from the **South East Radio Group Inc., PO Box 1103, Mt Gambier 5290 SA.**

New H-P signal generator

Hewlett Packard Australia has released a new synthesised 1040 MHz signal generator designed for in-channel receiver testing. Hewlett Packard says the new HP 8657A is quite reasonably priced for an HP instrument, offers –130 dBc phase noise at 500 MHz, dc FM with less than 10 Hz/hour drift and for in-channel measurements such as distortion, sensitivity, hum and noise, less than 4 Hz of residual FM.

At 1 GHz, the specified SSB phase noise is – 124 dBc 20 kHz from the carrier, while spurs are –60 dBc. Selectivity can be measured on receivers with specifications ranging from –60 to –90 dB.

H-P has enhanced the reliability of the unit by replacing mechanical relays with solid-state components. Using PIN diodes with three million hours MTBF (mean time between failures), the attenuator has an estimated 0.2% failure rate.

Further details can be had from **Hewlett Packard, 31-41 Joseph St, Blackburn 3130 Vic. (03)895 2895.**

THE WORLD WIDE HOBBY!
AMATEUR RADIO
ARE YOU A MEMBER OF THE WIA?

Why not become a radio amateur by joining the Wireless Institute of Australia? The Institute can assist and advise you in how to obtain a Department of Communications licence, which will allow you to communicate with others having similar interests in Australia and throughout the world.

The Wireless Institute of Australia is a non-profit society founded in 1910. Since its inception it has nurtured the interests of all Australian amateurs by liaison at all Governmental levels.

Apart from many other benefits as a member, you receive a monthly plastic encapsulated 64 page magazine called Amateur Radio in your letter box each month.

This magazine contains information on all aspects of the hobby such as Technical Projects, Hints and Kinks, Computer Programs, Free Classified Advertisements and Technical Reviews. Regular columnists give details of Contesting, Awards, DX News, Ionospheric Predictions and Solar Activity, Overseas News and VHF/UHF Activity, to name but a few.

SUPPORT YOUR HOBBY — become a member!

For further information, including a sample magazine, write to:
WIRELESS INSTITUTE OF AUSTRALIA
PO BOX 300
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Registered Address: 3/105 Hawthorn Road, Caulfield North, Vic.

BKP—AD87012

Thirteenth amateur radio satellite ready to fly

After numerous launch delays the new AMSAT amateur radio satellite Phase IIIC (P3-C) is to be launched aboard an ARIANE IV rocket from Kourou in French Guiana on the first of June. Following a successful launch it should be bestowed the title of Oscar 13, in accordance with tradition.

AMSAT P3-C is a technically improved version of the successful and popular OSCAR 10 satellite. The ARIANE IV launch vehicle is a new development which can transport a payload of four tons into orbit. AMSAT PC-3 will have a mass of 140 kg at launch and 90 kg when stabilised in final orbit. The bulk of the ARIANE's payload will be occupied by two other satellites – a Meteostat weather satellite and a Panamsat communications satellite.

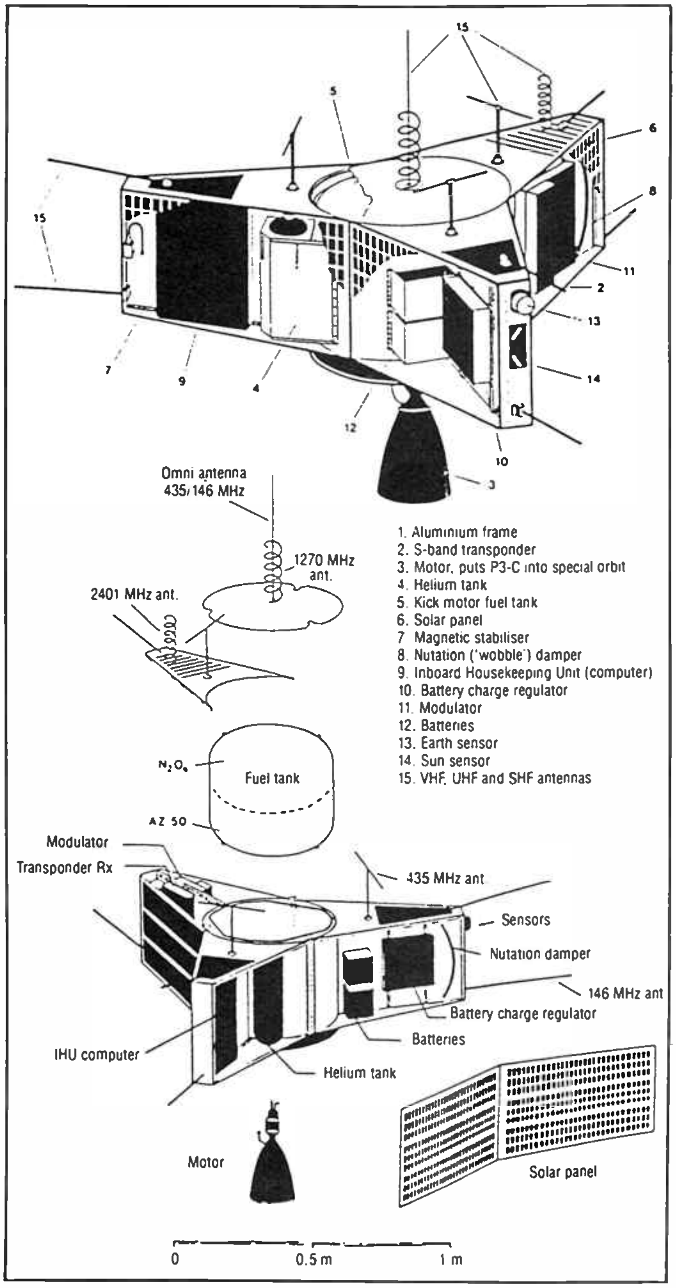
AMSAT P3-C is a spin-stabilised satellite, which can alter its orientation in space by means of a built-in electrically-controllable magnetic system operated by the on-board computer. The navigational information required is supplied by two sun sensors, one earth sensor, as well as two "up" and "down" sensors. This data is first processed by the sensor electronics module before being passed along to the on-board computer. The satellite is controlled almost completely autonomously, with intervention by ground control stations only necessary under very special circumstances.

After separation from the launch vehicle, P3-C will assume a highly elliptical orbit with an apogee (highest point) of 35 800 km and a perigee (lowest point) of 200 km. The inclination (angle referenced to the equator) will be 10 degrees. Following an orientation phase, the in-built 400 Newton rocket motor will be used to alter this orbit to the more stable perigee of 1500 km, with a new inclination around 57 degrees. The apogee will remain unaltered.

The orbital period will be nearly 11 hours, and access time will be enhanced by the elliptical orbit. This special orbit, known as a "Molniya Orbit", makes for easy satellite tracking and stations here can talk with other stations in Europe, Japan and North America, for example, using quite modest equipment.

Three hours after separation P3-C will begin transmitting telemetry data at 400 bps via the general beacon (GB) on 145.812 MHz. Occasionally this data will be transmitted in CW (Morse) and radioteletype (RTTY).

The satellite was designed and constructed under the auspices of the West German amateur satellite organisation, AMSAT DL, under Karl Meinzer DJ4ZC. Those involved in the project included Hans Peter Kuhlen DK1YQ, Peter Geulow DB2OS and Werner Haas DJ5KQ, and in the US, AMSAT US Vice President Jan King W3GEY, Bill Korz and Chip Angle N6CA.

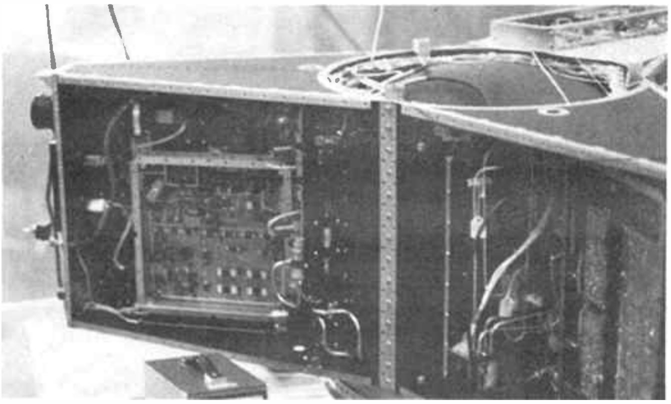


1. Aluminium frame
2. S-band transponder
3. Motor, puts P3-C into special orbit
4. Helium tank
5. Kick motor fuel tank
6. Solar panel
7. Magnetic stabiliser
8. Nutation ('wobble') damper
9. Inboard Housekeeping Unit (computer)
10. Battery charge regulator
11. Modulator
12. Batteries
13. Earth sensor
14. Sun sensor
15. VHF, UHF and SHF antennas

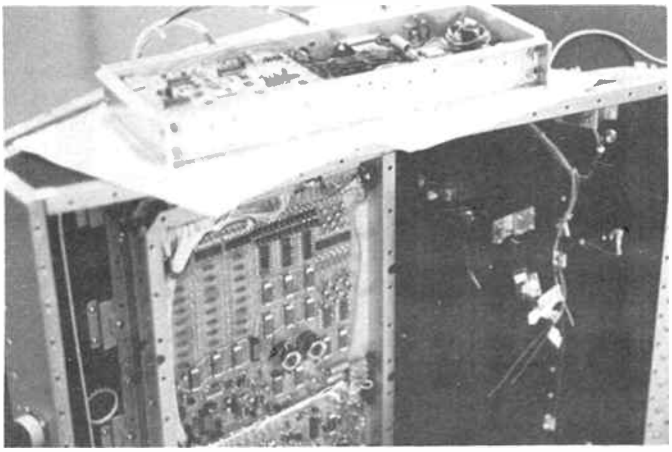
The equipment

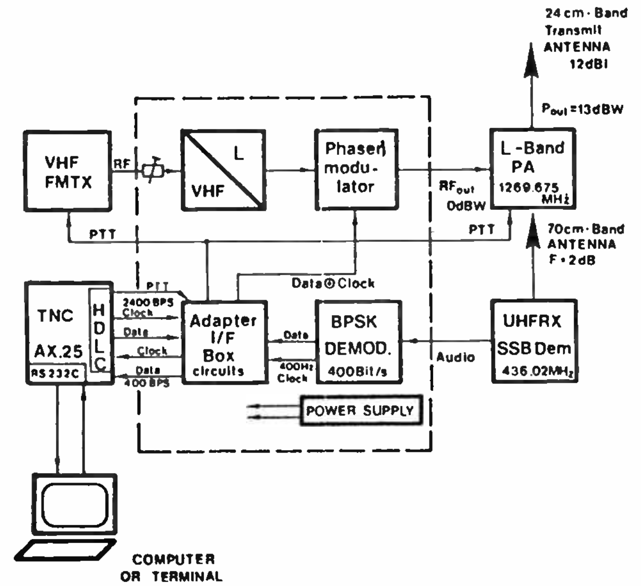
The P3-C is equipped with three transponders – U, L, and S – as shown in Table 1. Two are "linear" translators, that is they will repeat signals within their input passband at their output. These are the U and L transponders, with packet radio facilities available on a single channel associated with the L transponder. The S transponder is a single channel "hard limiting" type, for FM transmissions, with input on a single 36 kHz wide channel of 435.601- 435.637 MHz with output on 2400.711-2400.747 MHz. Owing to its relatively high power consumption, its operation will be limited to designated occasions.

To access the U transponder, which has its uplink on 70 cm and the downlink on 2 m, you will need a transmitter power



Here the Earth and Sun sensors can be seen on the far left, with the sensing hardware behind it inside the satellite. At the far right, the transponders can just be seen.





Equipment setup to access the RUDAK packet radio facilities of the Phase 3C amateur satellite.

Transponder	Input range (MHz)	Output range (MHz)	Beacons (MHz)	Power
U (Mode B)	435.420-435.570 145.985	145.825-145.975	145.812	50 W PEP
L (1)	1269.620-1269.330	435.715-436.005	435.651	50 W PEP
(2)	144.425-144.475	435.990-435.940		
Rudak	1269.71	435.677	6 W	
S	435.601-435.637	2400.711-2400.747	2400.325	1 W

TABLE 1. AMSAT Phase IIIC transponder frequencies.

of 10 W and an antenna of 12 dB gain (referred to an 'isotropic' antenna) to achieve a 20 dB signal-to-noise ratio on the downlink (received) signal, which is quite a fair signal, allowing some margin for fading. The S transponder requires a similar setup, but the L transponder needs either more power or greater antenna gain, or a bit of each. As greater antenna gain is readily achieved on 23 cm, use of a 24 dB gain antenna would require only three watts power on the uplink.

OSCAR 10's 70 cm uplink/2 m downlink transponder, known as "Mode B", was the most popularly used and it is expected P3-C's U transponder will also be heavily used as equipment is widely available.

AMSAT P3-C has five antennas, an omnidirectional on 23 cm and 2 m, two directional antennas on 70 cm and 2 m, and two helicals on 23 cm and 13 cm. The latter four have been designed to provide right hand circular polarisation, and receiving antennas for these bands should employ right hand circular polarisation also.

The three solar panels have an initial capacity of 40 W, which is expected to decline to 25 W after three years in orbit. The expected life-span of the satellite is expected to be six years.

Packet radio

Packet radio is accommodated on P3-C by RUDAK, a dedicated device which operates on a set frequencies via the L transponder. Input on 23 cm is at 2400 bps DPSK and output on 70 cm is at 400 bps. Since ground stations transmit in an uncoordinated manner, the likelihood exists that the transmitted packets will overlap and hence be garbled on arrival at the satellite. The packet must then be retransmitted by the ground station. For this reason the uplink data rate is six times higher than the downlink.

AMSAT Australia

AMSAT Australia, the radio amateur satellite organisation of the WIA, which coordinates and represents amateur satellite activity here, recently made a contribution of DM2000 (over $1600) to AMSAT in Germany. This sum was donated by amateurs across Australia, and will go towards the payment of the insurance premium for the Phase IIIC project.

Compiled from information and photographs supplied by Tony Bartel VK3ZOT, with additional information taken from the AMSAT Australia Newsletter compiled by Graham Ratcliff VK5AGR. If you're interested in amateur satellites, you can subscribe to this excellent monthly newsletter by contacting AMSAT Australia at GPO Box 2141, Adelaide 5001 S.A.

Elektor Electronics in AEM

CONTENTS

PROJECTS

ARTICLES

The projects and circuits chosen for inclusion in the Elektor section are selected on the basis of interest, local relevance and component availability. Intending constructors should consult our 'PROJECT BUYERS GUIDE' in this issue for a guide to component sources and possible kit suppliers.

TUNEABLE PREAMPLIFIERS FOR VHF AND UHF TV

The second, final, article on remote-tuned, masthead mounted, RF preamplifiers deals with high-performance aerial boosters for the VHF and UHF TV bands. These circuits give a considerable improvement in reception compared to run-of-the-mill wideband aerial boosters. Connected to a good directional aerial, they are ideal for picking up signals that are normally noisy, or impaired by cross-modulation from strong nearby transmitters. But TV DXers need not be told . . .

The preamplifiers described can be built by anyone with reasonable experience constructing electronic circuits. Special care has been taken in the designs to minimize the necessary work on inductors, while alignment is straightforward, because in most cases it only entails setting a direct current. The amplifiers are built on high-quality printed circuit boards available through our Readers' Services, and are tuned and powered from the master tuning/supply unit described last month.

VHF preamplifier: circuit description

What is commonly referred to as the VHF TV band is roughly the frequency range between 45 and 68 MHz (Band 1), but also that between 175 and 225 MHz (Band 3). Band 2 is the FM radio broadcast band. It is important to note here that the above band limits are given as guidance only, because they are set differently in many countries and regions in the world. This also goes for the TV system used (PAL, SECAM, NTSC, positive/negative video, horizontal/vertical polarization, number of lines, channel assignment, frequency of the sound subcarrier, etc.). In the United Kingdom, Band 1 is currently allocated to military communications; the former TV services in that band have been transferred to UHF in 1983.

The circuit diagram of the VHF preamplifier is given in Fig. 1. Unbalanced (50..75 Ω) or balanced (200. . .300 Ω) cables are connected to input inductor L_{1A}. The aerial signal is coupled inductively to the base of low-noise RF transistor T_1 via L_{1B} and C_1, which is connected on a tap for impedance matching. The input inductor, L_1, is tuned to the relevant TV channel by the series capacitance formed by varactors D_3-D_4. The voltage at the junction of these variable capacitance diodes is the voltage on the downlead cable minus 8.2 V. The junction capacitance of a varactor decreases with the reverse voltage on it, so that the lowest value of the downlead voltage, 9 V, causes the input inductor, L_1, to resonate at the lowest frequency, i.e., the preamplifier is tuned to the lowest TV channel.

The amplifier can be set up for operation in TV Band 1 or Band 3 simply by fitting the appropriate inductor in position L_1 (this will be reverted to under *Construction*).

Choke L_3 forms a high impedance for the amplified RF signal on the downlead coax cable, and feeds the tuning/supply voltage to series regulator T_2 and zener-diode D_1. The function of these components is similar to IC_1 and D_3 in the FM-band preamplifier described last month. The forward drop across LED D_1 is fairly constant, and provides the reference voltage at the base of regulator T_2. Preset P_1 makes it possible to set the optimum collector current for the RF amplifier transistor, T_1. RF signals at the base and collector of the BFG65 are blocked from the bias voltages by chokes L_2 and L_4, respectively. Gain of the preamplifier is fairly constant at about 18 dB, both in Band 1 and Band 3. The noise figure was not measured, but should be of the order of 1. . .2 dB, i.e., considerably lower than almost any conventional wideband aerial booster.

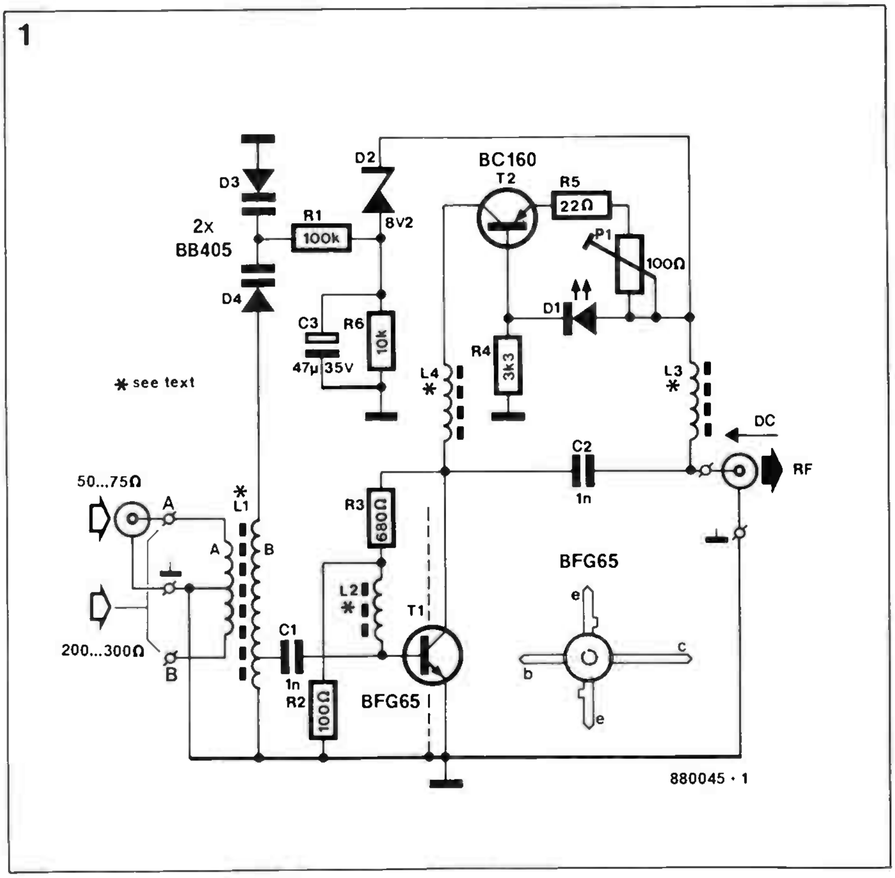


Fig. 1. Circuit diagram of the low-noise, remote-tuned, preamplifier for VHF TV Band 1 or 3.

VHF preamplifier: construction

Commence the construction with making L_1 as required for the relevant frequency range (note that this may extend beyond the indicated band limits). Do not skip the constructional hints in the following paragraphs if you intend to build the Band 1 version of the preamplifier.

Band 3 (175—225 MHz):

1. Close-wind L_{1B} as 4 turns ∅1 mm (SWG19) enamelled copper wire around a ∅6 mm plastic former. Use a miniature screwdriver to spread the turns evenly at about 1 mm. Study the position of the inductor on the board, and bend the wire ends towards the holes provided. Use a scalpel or sharp hobby knife to remove the enamel coating on the wire ends over a length of about 3 mm. Pretin the connections, scratch off residual solder resin, and pretin once more. Check for a smooth, tinned, surface.

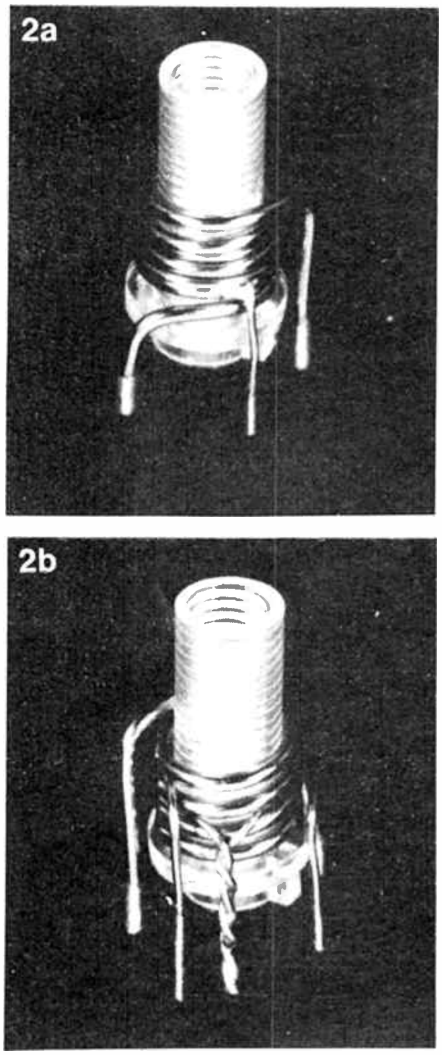


Fig. 2. Close-up photographs showing inductor L_1 in the VHF Band 3 preamplifier. Fig. 2a: seen from the side of L_{1B}; Fig. 2b: seen from the side of L_{1A} (note the tap made in twisted wire).

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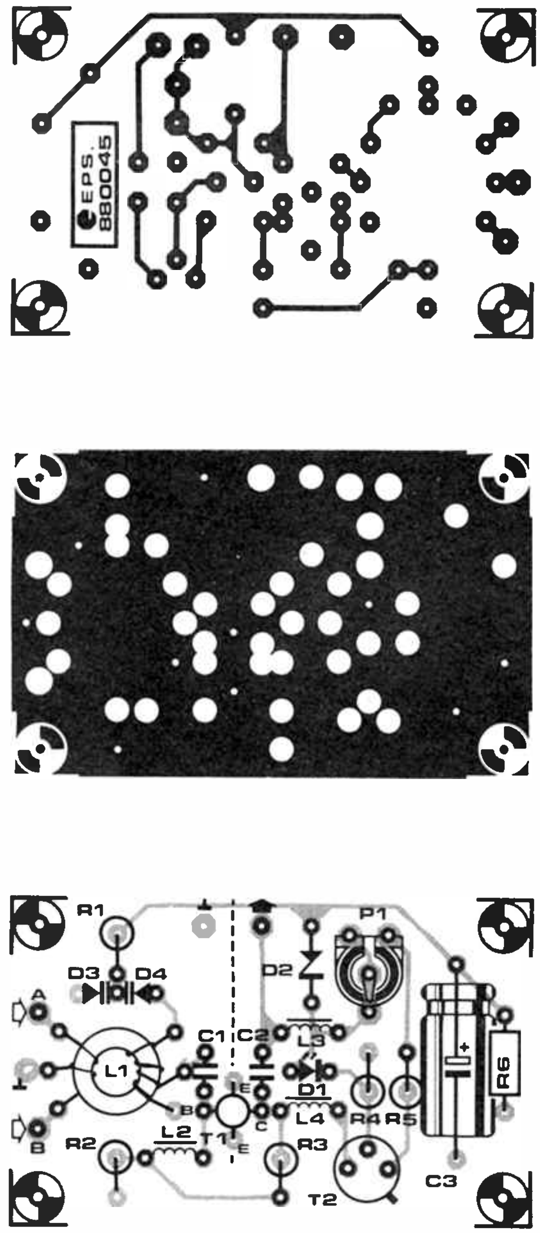

Fig. 3. The printed circuit board for the VHF Band 1 or 3 preamplifier.

Parts list

VHF PREAMPLIFIER. CIRCUIT DIAGRAM: FIG. 1.

Resistors (±5%):

R_1 = 100K
R_2 = 100R
R_3 = 680R
R_4 = 3K3
R_5 = 22R
R_6 = 10K
P_1 = 100R preset H

Capacitors:

C_1;C_2 = 1n0 miniature ceramic plate; pitch: 5 mm.
C_3 = 47μ; 35 V; axial

Semiconductors:

D_1 = red LED
D_2 = zenerdiode 8V2; 400 mW
D_3;D_4 = BB405
T_1 = BFG65
T_2 = BC160

Inductors:

Winding data and materials are stated in the text.

Miscellaneous:

PCB Type 880045

2. Locate the position of the tap on L_{1B} at 1 turn from the ground connection. Carefully scratch off the enamel locally, pretin the small copper area, and connect a short length of ∅0.5 mm (SWG25) enamelled copper wire. Place the plastic former plus inductor onto the PCB, and bend the tap wire towards the relevant hole. Do not solder any connection as yet. Make sure that the tap does not create a short-circuit between the turns of L_{1B}.
3. The input coupling inductor, L_{1A}, is wound as 2 turns ∅0.5 mm (SWG25) enamelled copper wire, with a tap at the centre. Wind this inductor in between the turns of L_{1B} to assure the necessary inductive coupling. Insert the wire below the turn of L_{1B} that has the tap on it. Wind the wire upwards into the free space between the turns of L_{1B}, until it is opposite the connections of L_{1B}. Draw out about 4 cm of the wire, fold it back again towards the former, and wind the last turn upwards into L_{1B}.
4. Use precision pliers to twist the 2 cm long wire pair that forms the tap on L_{1A}. Hold the end of the wires in the pliers, and carefully revolve these in your hand until the wires cross practically at the body of the plastic former.
5. Place the former with the inductors on it onto the PCB, and revolve both L_{1A} and L_{1B} until all six wires can be inserted in the respective holes. Scratch off the enamel coating from the tap and the ends of L_{1A}, pretin, clean again by scratching, and ensure a smooth soldering surface. Press L_{1B} together to lock up the turns of L_{1A}. The final appearance of the completed inductor is shown in the photographs of Fig. 2.

Drill and file the hole that receives the plastic former. Fit the wires of L_1 into the respective holes, and verify correct continuity. Do not use a core in L_1.

Band 1 (45—68 MHz):

For the lower frequency range, L_1 is wound on a Type T50-12 ferrite core (∅12 mm) from Micrometals.

1. Wind L1A as 8 turns ∅0.5 mm (SWG25) enamelled copper wire, with a twisted centre tap created as discussed above.
2. Wind L_{1B} as 20 turns of ∅0.5 mm (SWG25) enamelled copper wire, with a twisted tap at 4 turns from the ground connection.
3. Fit the complete inductor onto the PCB, making sure that the windings remain secure on the ferrite ring.

Chokes L_2, L_3 and L_4 are identical for both versions of the VHF preamplifier. They are wound as 4 turns ∅0.2 mm (SWG36) enamelled copper wire through small ferrite beads (length: approx. 3 mm).

The printed circuit board for the VHF preamplifier is shown in Fig. 3 (note that the component overlay is relevant to the version for Band 1). Completion of the preamplifier should not present problems. Grounded component wires and terminals are soldered at both sides of the board. Coupling capacitors C_1 and C_2 are miniature, plate or disc, ceramic types with a lead spacing of 5 mm. Mount these as close as possible to the PCB surface. Conversely, mount T_2 in a manner that rules out any likelihood of a short-circuit between the TO5 case (which is at collector potential) and the PCB ground surface. Finally, fit a 15 mm high brass or tin metal sheet across T_1 as indicated by the dashed line on the component overlay.

The UHF preamplifier: circuit description.

The circuit diagram of the low-noise, remote-tuned, UHF preamplifier for masthead mounting is shown in Fig. 4. Like the VHF booster, this amplifier is based on the Type BFG65 RF transistor from Valvo (Philips/Mullard), but in this application has tuned input and output circuits. The tuning voltage for varactor pairs D_1-D_2 and D_3-D_4 is obtained as in the FM-band and VHF preamplifiers, namely by subtracting the fixed drop across a zenerdiode from the voltage carried on the downlead coax connected to the master tuning/supply control. The tuning range of the amplifier covers the entire UHF TV band (470—860 MHz). The shaded rectangular blocks in the circuit diagram are straight lengths of silver-plated wire that function as inductors (L_1; L_2). Balanced aerials or feeder systems with a termination impedance of 200...300 Ω are connected to L_{1B}. This coupling inductor is omitted when the input signal is unbalanced (50...75 Ω). In this case, the centre core of the coax cable is connected direct to a matching tap close to the ground connection (*cold end*) of L_{1A}. Regulator IC_1 ensures that T_1 is fed with a constant supply of 8 V, while P_1 is used for setting the optimum collector current (this can be read on a microammeter connected to test points TP1 and TP2).

The UHF amplifier has a typical gain of 12 dB and, like the VHF version, achieves a noise figure that beats the vast majority of wideband aerial boosters.

The UHF preamplifier: construction

The UHF TV band preamplifier is constructed on the PC board shown in

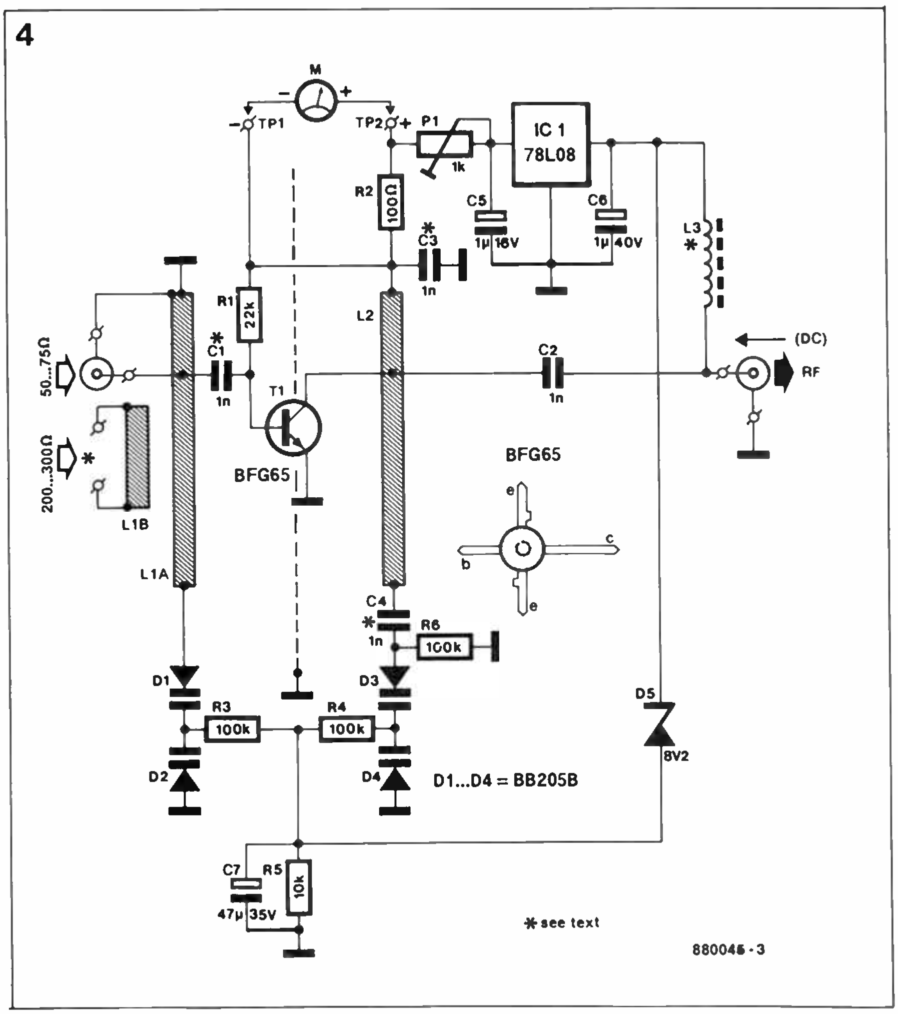

Fig. 4. Circuit diagram of the preamplifier for UHF TV reception.

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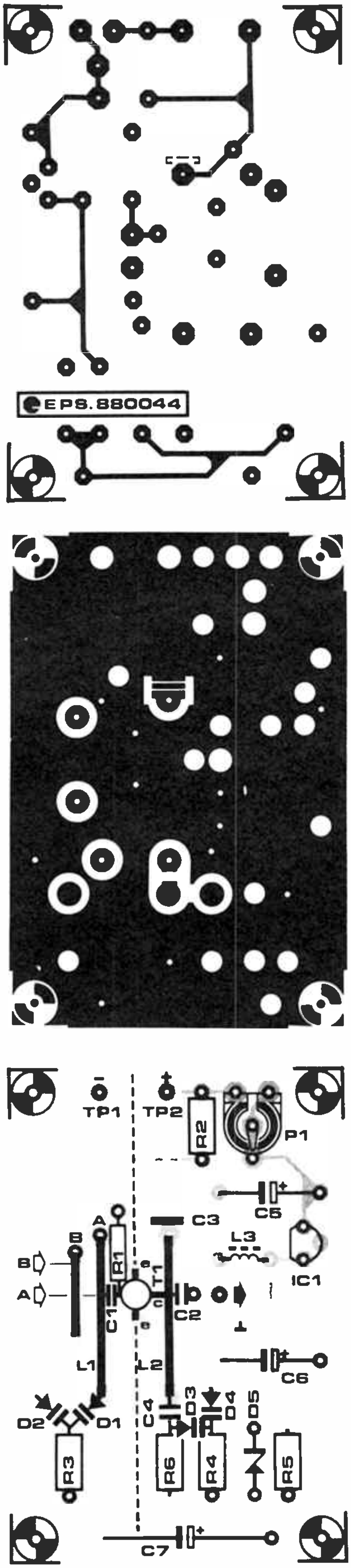


Fig. 5. Track layout and component mounting plan of the PCB for the UHF preamplifier.

Fig. 5. Study the component overlay, and bend L_{1A} (if required), L_{1B} and L_2 to size from Ø1 mm silver plated copper wire (CuAg). Do not solder these inductors in place, however, until they run straight over the full length, and are positioned so that the top of the wire is always exactly 3 mm above the PCB surface. Fit leadless disc or rectangular decoupling capacitor C_3 in the slot provided in the PCB. This (brittle!) capacitor is soldered once at the track side (connection to L_2), and twice at the component side (ground and, again, L_2). Now position the RF transistor, T_1, in between the wire inductors, and solder the 2 emitter terminals direct to the ground surface. Carefully bend the collector terminal upwards, cut it to length, and solder it to the tap on L_2. One terminal of coupling capacitor C_2 is also connected direct to this junction, while the other terminal is secured in a PCB hole—see the photograph of Fig. 6. Bend the base terminal of T_1 upwards, and carefully cut this to a length of about 2 mm. Solder a 1nF SMD capacitor, C_1, in between the tap on L_{1A} and the base terminal. R_1 is also soldered direct to the base junction. Fit a 15 mm high screen across T_1 as indicated on the component overlay.
Wind choke L_3 as 6 turns Ø0.2 mm (SWG25) through a small (3 mm long) ferrite bead. The fitting of the remainder of the components is straightforward,

Parts list

UHF PREAMPLIFIER. CIRCUIT DIAGRAM: FIG. 3.

Resistors (±5%):

R_1 = 22K
R_2 = 100R
R_3;R_4;R_6 = 100K
R_5 = 10K
P_1 = 1K0 preset H

Capacitors:

C_1;C_4 = 1n0 SMD
C_2 = 1n0 miniature plate ceramic.
C_3 = 1n0 leadless ceramic (disc or rectangular).
C_5 = 1µ0; 16 V; axial
C_6 = 1µ0; 40 V; axial
C_7 = 47µ; 35 V; axial

Semiconductors:

D_1 . . . D_4 incl. = BB205B
D_5 = zenerdiode 8V2; 400 mW
IC_1 = 78L08
T_1 = BFG65

Inductors:

Winding data and materials are given in the text.

Miscellaneous:

PCB Type 880044

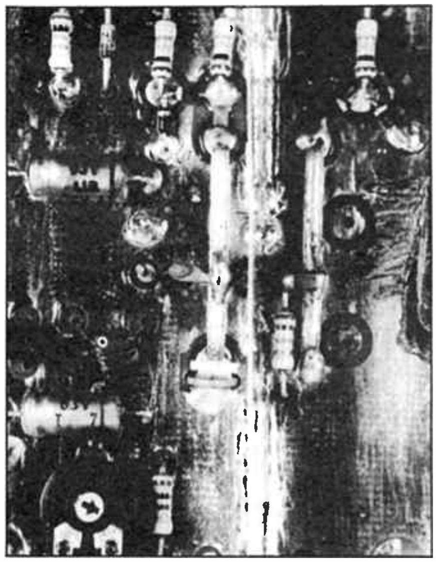


Fig. 6. Top view of the line inductors in the preamplifier for UHF TV.

and should not present problems. Be sure, however, to observe the polarity of the 3 electrolytic capacitors and the 5 diodes!
Figure 7 shows completed prototypes of the VHF and the UHF aerial boosters.

Setting up

The setting up of the preamplifiers merely entails adjusting the collector current of the RF transistor, and finding out which value of the tuning voltage corresponds to a particular TV channel.

VHF preamplifier:

Insert an ammeter between the collector of T_2 and L_4. Connect the power supply/tuning unit described last month, and set the output voltage to 20 V. Adjust P_1 for a reading of 5 mA, then verify the presence of about +11 V on the varactor junction. Vary the tuning voltage, and verify that the collector current of T_1 remains constant. The LED will light dimly.
Connect the preamplifier to the aerial and the supply/tuning unit. Also connect the TV set, and set up a tuning scale by marking the channel numbers as a function of the tuning voltage. In the case of the Band 3 preamplifier, the tuning range can be corrected by carefully compressing or stretching the turns of L_{1B}.
The collector current of T_1 is optimized by tuning to a weak transmission, and setting P_1 for minimum noise. This setting is typically found at collector currents between 3 and 10 mA.

UHF preamplifier:

Connect a millivolt meter to TP1 and TP2 as shown in the circuit diagram. Set P_1 for a reading of 500 mV. Make notes of the tuning voltage required for a number of TV channels in the UHF band, and provide a UHF tuning scale on the master supply/tuning unit.

General considerations

The values stated for the operating current of T_1 are given as a compomise between a low noise figure (low collector current), and high amplification in combination with good intermodulation characteristics (high collector current). The collector current may, therefore, be set to different values to suit the application in question.

As stated in last month's article, there is little point in installing the remote-tuned preamplifiers in any place other than *as near as possible to the relevant aerial*. This is the only way to prevent the attenuation introduced by the downlead coax cable degrading the system noise figure. The preamplifiers described have sufficient gain to bring the system noise figure down to practically the preamplifier noise figure, but only if they are properly aligned and installed. *B*

Readers interested in TV-DXing are advised to contact the British Amateur Television Club • Mr Dave Lawton G0ANO • "Grenehurst" • Pinewood Road • High Wycombe • Bucks HP12 4DD.

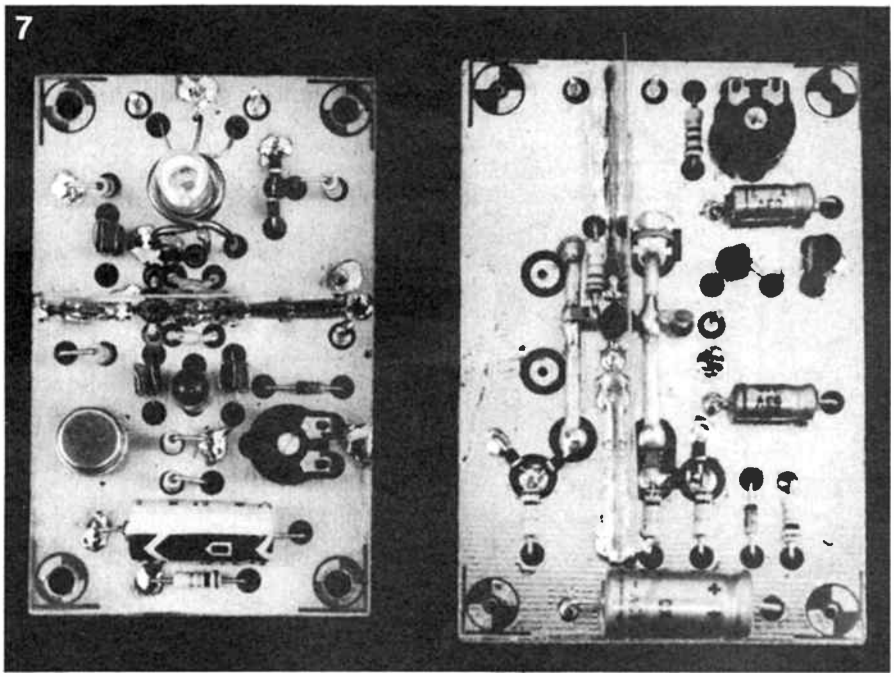


Fig. 7. Prototypes of the VHF preamplifier (left; Band 3 version), and the UHF preamplifier (right).

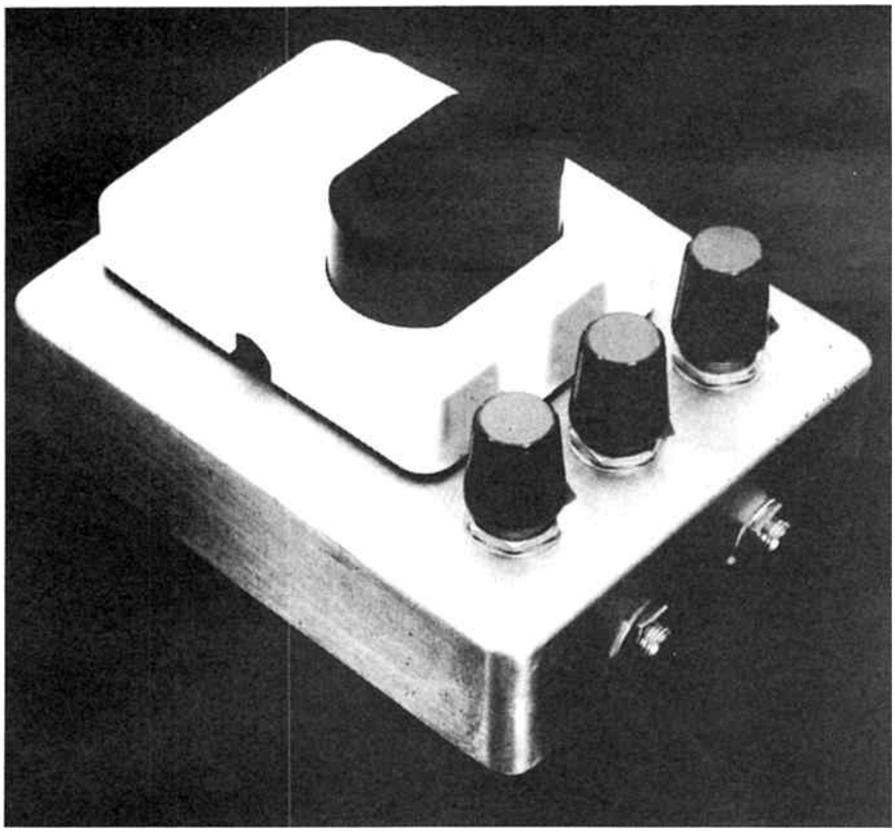
FUZZ UNIT FOR GUITARS

Players of the lead or rhythm guitar will appreciate the wide range of sounds produced by this low-cost fuzz unit.

The fuzz unit described here is simple to build from commonly available parts, yet gives excellent results with almost any combination of lead or rhythm guitar and guitar amplifier (valve or transistor). It has three controls that guarantee a wide range of available effects, and is relatively simple to align.

Circuit description

With reference to the circuit diagram of Fig. 1, the fuzz unit is powered via switch S_1, which is automatically closed when a jack plug is inserted in socket K_2. The output of the circuit remains short-circuited to ground, however, until a plug is inserted in K_1. This arrangement effectively prevents clicks and noises in the guitar amplifier when the effects unit is being connected. The guitar signal is applied to electronic switches IC_{3A} and IC_{3B} via coupling capacitor C_{19}. The configuration of the electronic switches is controlled by foot switch S_3 and inverter/LED driver T_1. When the foot switch is open, i.e., not actuated, R_{20} takes the control input of IC_{3B} to the positive supply level, so that the guitar signal is passed from K_1 to K_2 with a series resistance of about 90 Ω, formed by the closed electronic switch. When the foot switch is closed, T_3 conducts, LED D_9 lights, IC_{3B} is opened, and IC_{3A} and IC_{3D} are closed. The guitar signal is fed to the distortion circuit via IC_{3A} and C_1, and is returned to the amplifier via C_{16} and IC_{3D}.
The circuit around opamp IC_1, FET T_1, T_2 and rectifier D_1 is a peak limiter (clipper) whose onset-level is defined by P_1. The distortion effect is, however, not complete as yet. Coupling capacitor C_5 feeds the signal to a passive filter network. High-frequency components in the signal are boosted or attenuated when BRIGHT switch S_2 is set to position A or B, respectively. When S_2 is set to position C, the filter is largely ineffective. The filter characteristics may be defined to individual taste by redimensioning of C_{10}: the roll-off frequency of the network decreases with increasing capacitance.
Preset P_2 serves to set the optimum signal amplitude for the distortion stage set up around IC_2. The feedback network of this opamp includes R_{17} and anti-parallel diodes D_3-D_4, which introduce the required distortion. The distortion level can be set with P_3. The signal is then fed through an R-C lowpass, a diode limiter and a volume adjustment, before it is applied to the electronic switch configuration discussed above.



Construction and adjustment

Construction of the fuzz unit is a routine job: simply fit all the parts in accordance with the PCB overlay (see Fig. 3) and the parts list. Be sure to observe the polarity of the diodes and the radial electrolytic capacitors.

The completed circuit board is best fitted in a sturdy diecast enclosure, as shown in Fig. 2. The foot switch, LED, and COMPRESSION and DISTORTION controls are fitted onto the bottom plate of the enclosure. Sufficient room should be left inside to accomodate the 9 V PP3 battery, which is preferably secured with double-sided adhesive tape.

The circuit is, of course, best set up with the aid of a sinewave generator and an oscilloscope, but a rather simpler alignment procedure is set out below for constructors not in possession of these instruments. Connect the fuzz unit to the electric guitar and the power amplifier, and verify that it is being powered by the battery. Actuate the foot switch, set P_3 to the minimal resistance position, and switch off the BRIGHT filter (set S_2 to position C). Play an h note on the guitar ($f \approx 1$ kHz), and set P_1 for minimum audible distortion. Adjust P_2 and actuate the foot switch a few times until the

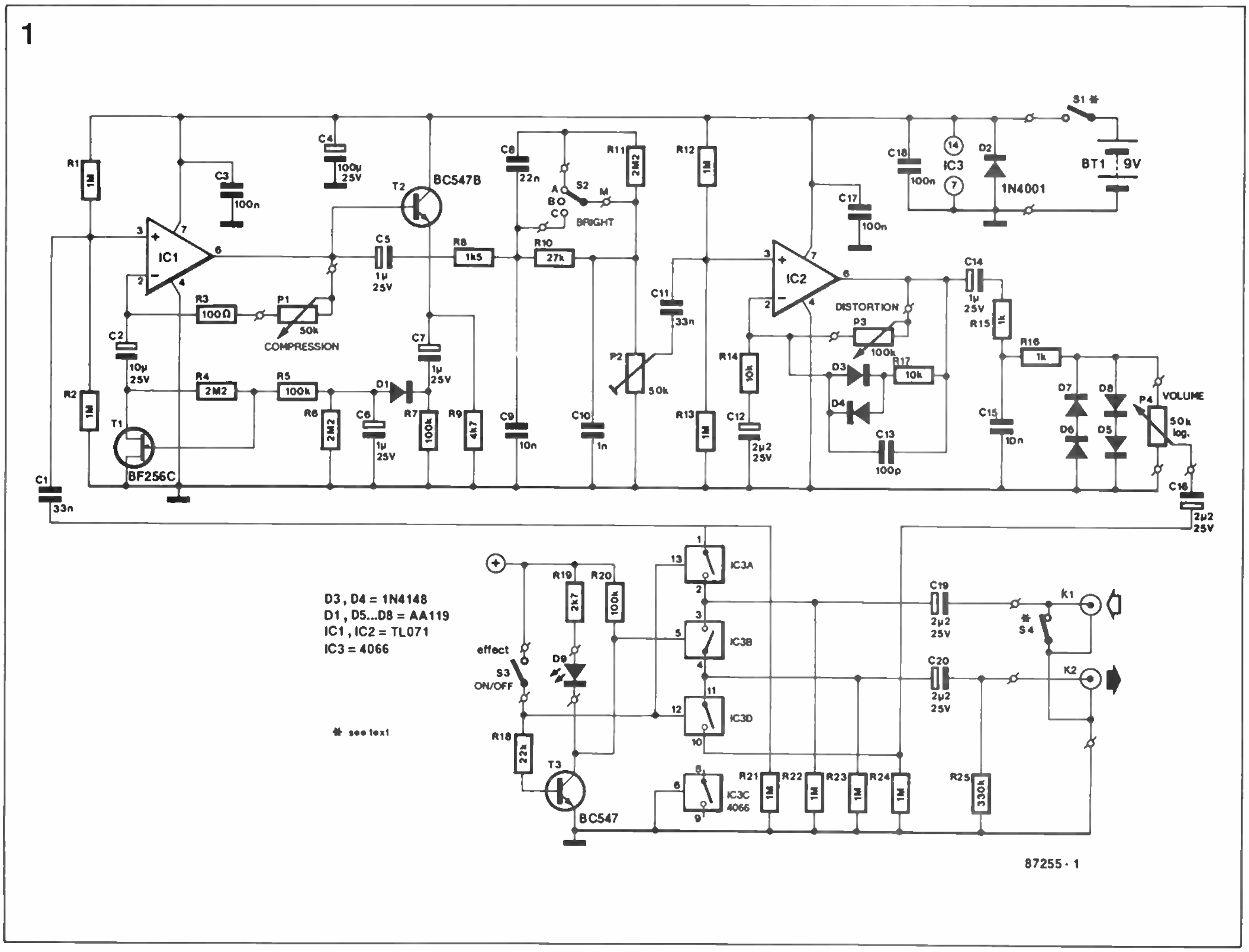


Fig. 1. Circuit diagram of the fuzz unit for electric guitars.

signal from the effects unit and the "dry" guitar signal are of equal amplitude (this also depends on the position of VOLUME control P_4).

Adjust the circuit as follows if the previously mentioned test equipment is to hand. Apply a 1 kHz sinewave of 150 mV amplitude to the input of the fuzz unit. Set the BRIGHT switch to position C (off). Connect the scope to junction S_2-P_2, and adjust P_1 for maximum amplification without running into noticeable distortion. Increase the signal amplitude to 300 mV, and reduce the distortion observed on the oscilloscope as far as possible by carefully re-adjusting P_1. Replace T_1 with a another BF256C if the distortion can not be reduced to an acceptable level: these FETs are manufactured to a relatively wide tolerance in respect of dynamic characteristics. Set the volume of the effects unit as outlined above.

The fuzz unit has a moderate current consumption, so that an alkaline PP3 battery should last for about 300 hours. This is reduced to about 40 hours, however, if D_9 is fitted. Much of the battery capacitance can be saved by using a high-efficiency LED, and increasing the value of the series resistor, R_{19}. Diode D_2 protects the fuzz unit against reverse voltage when the battery is connected with the wrong polarity. *B*

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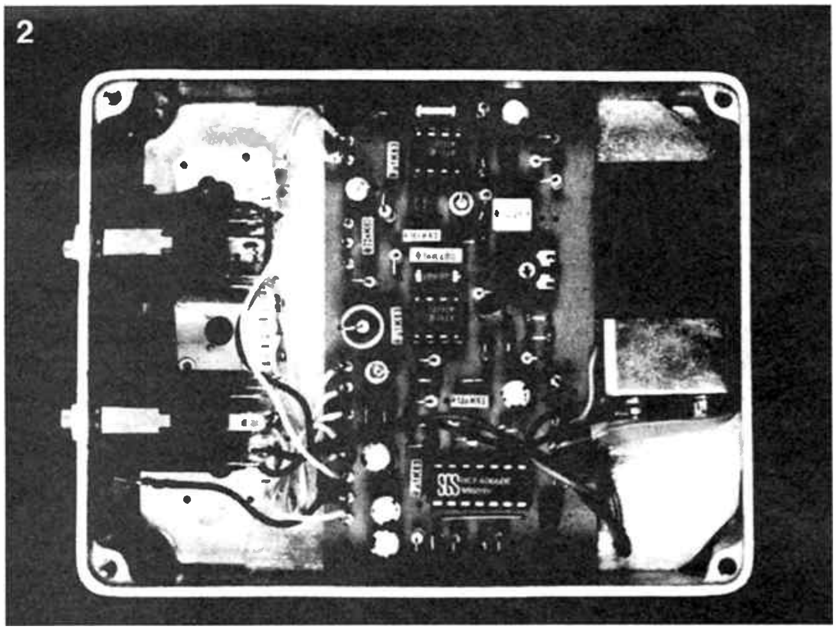

Fig. 2. Internal view of the prototype. The input and output sockets are types with a built-in switch contact.

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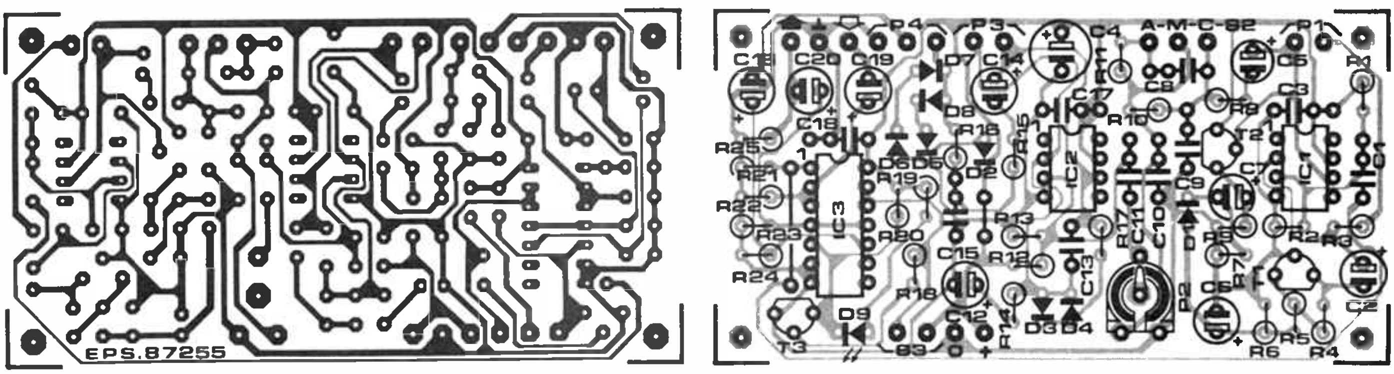


Fig. 3. The printed circuit board for building the fuzz unit.

Parts list

Resistors (±5%):

R_1;R_2;R_{12};R_{13};R_{21} . . . R_{24} incl. = 1M0
R_3 = 100R
R_4;R_6;R_{11} = 2M2
R_5;R_7;R_{20} = 100K
R_8 = 1K5
R_9 = 4K7
R_{10} = 27K
R_{14};R_{17} = 10K
R_{15};R_{16} = 1K0
R_{18} = 22K
R_{19} = 2K7
R_{25} = 330K
P_1 = 50K linear potentiometer
P_2 = 50K preset H
P_3 = 100K linear potentiometer
P_4 = 50K logarithmic potentiometer

Capacitors:
C_1;C_{11} = 33n
C_2 = 10µ; 25 V; radial
C_3;C_{17};C_{18} = 100n
C_4 = 100µ; 25 V; radial
C_5;C_6;C_7;C_{14} = 1µ0; 25 V; radial
C_8 = 22n
C_9 = 10n
C_{10} = 1n0
C_{12};C_{16};C_{19};C_{20} = 2µ2; 25 V; radial
C_{13} = 100p
C_{15} = 10n

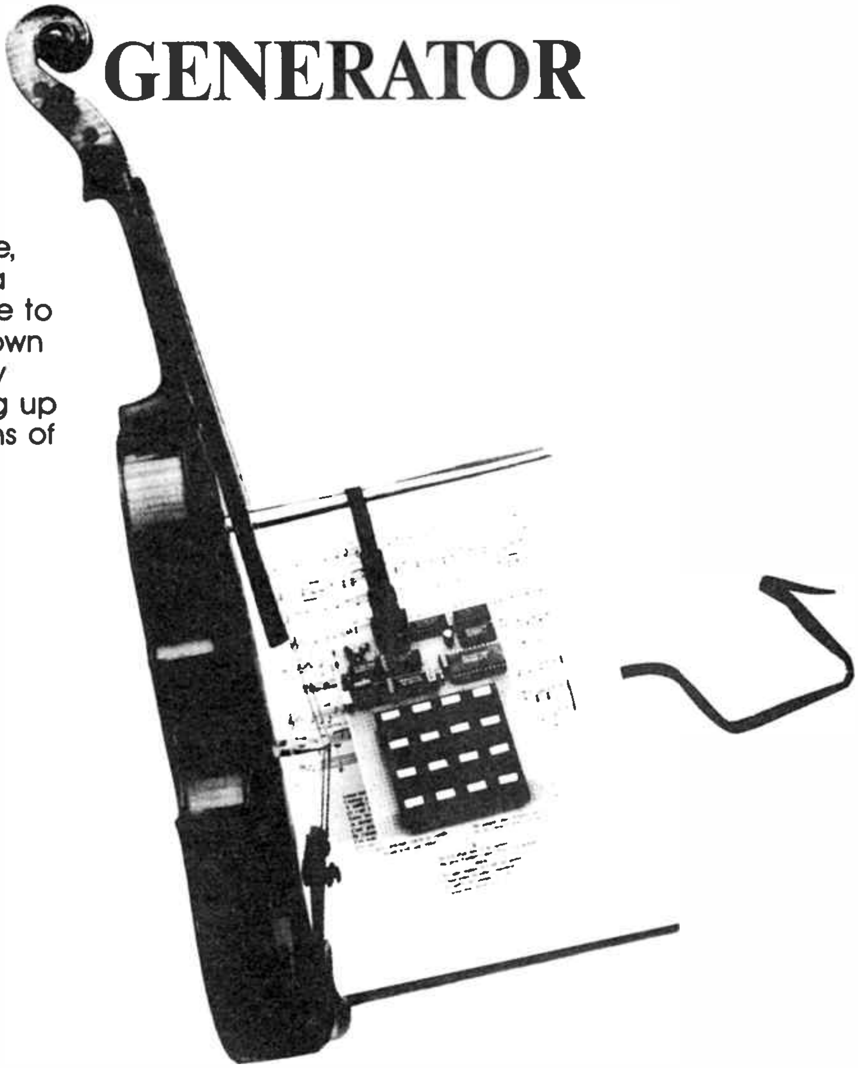
Semiconductors:

D_1;D_5 . . . D_8 incl. = AA119
D_2 = 1N4001
D_3;D_4 = 1N4148
D_9 = LED (red)
T_1 = BF256C
T_2 = BC547B
T_3 = BC547
IC_1;IC_2 = TL071
IC_3 = 4066

Miscellaneous:

K_1;K_2 = headphone socket for 6.3 mm plug (with built-in switch).
S_1 = SPST switch in socket (normally open).
S_2 = 3-way, single-pole, rotary switch.
S_3 = foot switch.
S_4 = SPST switch in socket (normally closed).
PCB Type 87255

MIDI CODE GENERATOR



In line with this month's theme, electrophonics, we present a handy, versatile and inexpensive to build tool that helps tracing down and resolving incompatibility problems encountered in setting up relatively complex configurations of MIDI instruments.

by R. Degen

The acronym MIDI (MUSICAL INSTRUMENT DIGITAL INTERFACE) is nowadays known to virtually every user of electronic instruments and associated equipment. Since its introduction in 1983, the MIDI standard has gained wide acceptance, and has proved relatively simple to implement thanks to the use of a serial transmission standard for data exchange between compatible instruments in a network. Experienced users of MIDI equipment are, however, also aware of the system's limitations. One of the best known problems associated with the MIDI standard is that it becomes more difficult to manage with increasing complexity of the equipment configuration: the more instruments, the more instrument-specific codes, and the greater the risk of addressing equipment with incorrect or non-recognized codes.

Troubleshooting

Any electronic musical instrument fitted with a serial asynchronous interface to the MIDI standard (31.25 Kbit/s; ±1%) has a receiver and/or transmitter circuit. Transmission of an 8-bit dataword commences with one start bit, and is terminated with one stop bit. The 10-bit pulse train has a duration of 320 μs. The interface is essentially a 15 mA current loop built around an opto-coupler. Each output preferably drives only one input, and received signals are, therefore, reshaped and fed to a MIDI THRU output. The MIDI communications protocol distinguishes between status bytes (>127), followed by one or more databytes (<128), real time messages, and exclusive messages.

The code generator proposed here is a MIDI compatible accessory device that enables sending any 8-bit hexadecimal code (0...255_{10} or 00...FF_{HEX}) to an instrument fitted with a MIDI input. But why bother to generate single commands at typing speed when the MIDI interface is geared to high-speed communication? The answer has already been hinted at in the above introduction. The need for developing the MIDI code generator arose from difficulties encountered in working with incompatible MIDI instruments of different type and make. It often happens that a relatively complex set-up of instruments and other devices connected via MIDI links simply does not work as required. Finding the cause of the malfunction is not easy, especially in relatively complex instrument set-ups. The speed at which data is carried between instruments is so high as to make code analysis without relatively complex equipment virtually impossible. A simple test device as described here allows sending MIDI datawords sequentially to an individual instrument by pressing 2 keys on a keypad. In this way, even the most complex MIDI control strings can be generated to enable checking the instrument's response. This way of testing may be compared to using an AF test generator plus oscilloscope to trace down a fault in an amplifier.

Most MIDI instruments are supplied with a manual that gives more or less detailed tables listing the MIDI codes that are recognized or transmitted by the instrument. These 2-character codes (MIDI datawords) can be supplied by the circuit described here: the code is generated and transmitted by sequentially pressing the 2 appropriate keys on a hexadecimal keyboard. LEDs indicate the transmission of the first and second character in the MIDI dataword.

The code generator is essentially composed of the following functional blocks: keyboard encoder, parallel-to-serial converter, central clock, and a driver for the status indication LEDs. The unit operates autonomously from a regulated power supply.

Circuit description

Essentially, the circuit fetches two hexadecimal characters from the 16-key keypad, combines them into a single dataword, and transmits this in the previously discussed MIDI format. There is no parity bit, and the serial dataline is logic "1" in the non-activated state.

Figure 1 shows the circuit diagram of the MIDI code generator. The circuit is composed entirely of conventional HCMOS integrated circuits, and is, therefore, inexpensive to build.

Oscillator N_1-N_2 feeds the central clock signal via N_3 and N_7 to binary counter IC_6, whose 4-bit output QA...QD supplies the binary equivalents of numbers 0...15 incl. to keyboard encoder IC_1, latch IC_2 and shift register IC_5. The clock signal for counter IC_6 is inhibited in N_7 by the "keyboard activity" signal obtained via Schmitt-trigger N_{10} and inverter N_6.

When power is applied to the circuit, bistable FF_1 is reset by network R_3-C_2. Output Q of FF_1 is logic low, so that N_5 provides a logic high level to LED driver T_1. D_1 lights to indicate that the code generator awaits the first, most significant, hexadecimal character (MS nibble).

Assuming that none of the keys is pressed, N_7 passes the clock pulses to counter IC_6. The keyboard encoder, IC_1, is a 4-to-16 demultiplexer that translates the 4-bit binary code at its inputs A...D into a low pulse at the relevant output. Each demultiplexer output is connected to a key, S_1...S_{16}. If, for example, key S_{11} is pressed (nibble A_H), the clock signal is inhibited the instant IC_1 activates output 10. This means that the binary equivalent of "10" is latched in IC_2, becauses the rising edge of the pulse supplied by N_{10} causes FF_1 to toggle and clock IC_2 via output Q. Latch IC_2 supplies the 4-bit binary code corresponding to the MS nibble of the MIDI dataword to the parallel load inputs of shift registers IC_4 (inputs G and H) and IC_5 (inputs A and B). Inverter N_5 supplies a logic low level to T_1, D_1 is turned off, and D_2 lights to prompt the user to enter the LS nibble on the keypad. Releasing the key restores the clock signal for IC_6, and restarts the keyboard scan activity. When the second character is typed in, the corresponding binary code of the LS nibble is present on inputs C...F of IC_5. Output Q of FF_1 goes logic high, and N_9 activates the SHIFT / $\overline{LOAD}$ inputs of the shift registers, IC_4 and IC_5. These load the 8-bit datawords at their inputs A...H, and are switched to the SHIFT mode when the output of N_9 goes high, which happens when the key is released.

The MIDI dataword is converted to serial format, and shifted out via inverter N_4. Simultaneously, FF_1 receives a new clock pulse, and output Q reverts to logic low. Counter IC_6 is clocked again, and LED D_1 indicates that a new MS nibble may be entered via the keyboard.

The start and stop bit required in the MIDI dataword are obtained by connecting output Q_H of IC_4 to input SER of IC_5. It is seen that SER on IC_4 is made permanently logic high, together with

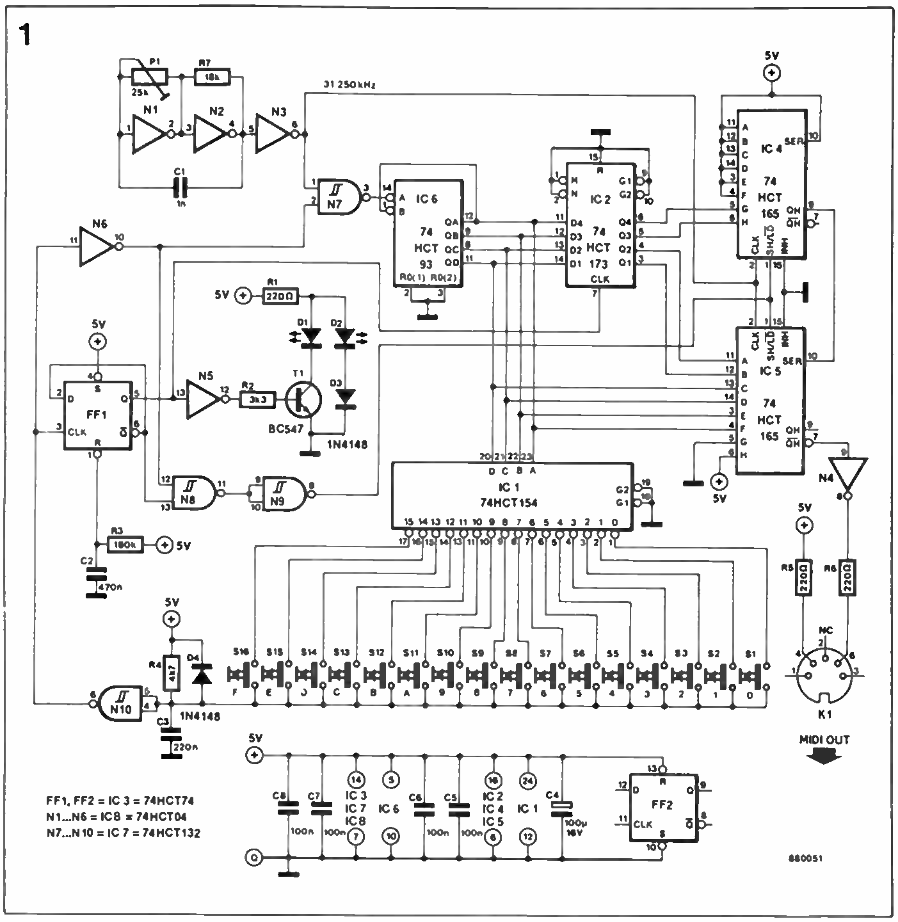


Fig. 1. Circuit diagram of the MIDI code generator.

inputs A...F incl. (these are the 6 nonused bits of the 16-bit shift register formed by IC_4-IC_5). The shifting out of bits applied to the parallel inputs is followed by that of the bit applied to SER, so that IC_4 supplies a series of logic high pulses after the 4 databits. After a few clock pulses, these bits are also present on the serial output of IC_5. Together with input bit H of IC_5 (a permanent logic "1"), these form a series of stop bits. The start bit is loaded into IC_1 as the logic low level permanently applied to input G. The complete MIDI command is, therefore, defined by the parallel data received via inputs G, F...A (IC_5), G, H, F...A and SER (IC_4) in that order.

Finally, preset P_1 enables accurately setting the serial bit rate on the MIDI OUT line to 31.250 Kbit/s.

Construction and use in practice

A prototype of the MIDI code generator was constructed on a piece of veroboard as shown in the accompanying photograph. The wiring was made in thin enamelled copper wire, fitted at the rear side of the board. The DIN socket and the 16 Digitast keys are conveniently mounted direct onto the component side of the board. The circuit is best fitted in a sturdy enclosure if portable operation

Parts list

Resistors (±5%):
R_1;R_5;R_6 = 220R
R_2 = 3K3
R_3 = 180K
R_4 = 4K7
R_7 = 18K
P_1 = 25K or 22K preset

Capacitors:
C_1 = 1n0
C_2 = 470n
C_3 = 220n
C_4 = 100μ; 16 V
C_5...C_8 incl. = 100n

Semiconductors:
D_1;D_2 = LED
D_3 = 1N4148
IC_1 = 74HCT154
IC_2 = 74HCT173
IC_3 = 74HCT74
IC_4;IC_5 = 74HCT165
IC_6 = 74HCT93
IC_7 = 74HCT132
IC_8 = 74HCT04
T_1 = BC547

Miscellaneous:
K_1 = 5-way DIN socket for PCB mounting.
S_1...S_{16} incl. = Digitast key (ITT Schadow).
Veroboard as required.
Note: it regretted that a ready-made PCB for this project is not available.

MIDI - frequently used codes

Note: all codes are given in hexadecimal notation

Channel Voice Messages

STATUS	DATA	DATA	
80...8F	00...7F	00...7F	NOTE OFF (+ channel number) + note number + VELOCITY
90...9F	00...7F	00...7F	NOTE ON (+ channel number) + note number + VELOCITY
A0...AF	00...7F	00...7F	POLYPHONIC KEY PRESSURE/AFTER TOUCH (+ channel number) + note number + PRESSURE VALUE
B0...BF	00...79	00...7F	CONTROL CHANGE (+ channel number) + CONTROL + VALUE
C0...CF	00...7F		PROGRAM CHANGE (+ channel number) + PROGRAM
D0...DF	00...7F		CHANNEL PRESSURE/AFTER TOUCH (+ channel number) + VALUE
E0...EF	00...7F	00...7F	PITCH WHEEL CHANGE (+ channel number) + CHANGE LSB + CHANGE MSB

In each message, the four least significant bits designate the channel number (1...16 incl.; 0=channel 1; F=channel 16). Example: 97=NOTE ON for channel 8. The status words given below are always followed by one or two databytes (<80) as required.

Note numbers:

6C (108): DOH high (88 keys)
60 (96) : DOH high (61 or 73 keys)
45 (69) : LAH 440 Hz
3C (60) : DOH from keyboard centre
24 (36) : DOH low (61 keys)
18 (24) : DOH low (73 keys)
15 (21) : LAH low (88 keys)

VELOCITY:

0 : NOTE OFF (do not use 0 as default value)
1 : ppp (pianissimo)
40: mp-mf (mezzo-forte); default value
7F: fff (fortissimo)

System Messages

F0	SYSTEM EXCLUSIVE (consult documentation supplied with equipment)
F1...F7	SYSTEM COMMON
F1	not defined
F2	POSITION POINTER (+ 2 databytes)
F3	SONG SELECT (+ 1 databyte)
F4...F5	not defined
F6	TUNE REQUEST
F7	EOX (marks the end of message SYSTEM EXCLUSIVE)
F8...FF	REAL TIME
F8	TIMING CLOCK
F9	not defined
FA	START
FB	CONTINUE
FC	STOP
FD	not defined
FE	ACTIVE SENSING
FF	SYSTEM RESET

Channel Mode Messages

B0...BF	7A...7F	0...7F	CHANNEL MODE (+ channel number) + MODE + MODE
B0...BF	7A	0	CHANNEL MODE (+ channel number) + LOCAL CONTROL OFF
B0...BF	7A	7F	CHANNEL MODE (+ channel number) + LOCAL CONTROL ON
B0...BF	7B	0	CHANNEL MODE (+ channel number) + ALL NOTES OFF
B0...BF	7C	0	CHANNEL MODE (+ channel number) + OMNI MODE OFF (ALL NOTES OFF)
B0...BF	7D	0	CHANNEL MODE (+ channel number) + OMNI MODE ON (ALL NOTES OFF)
B0...BF	7E	0...F	CHANNEL MODE (+ channel number) + MONO MODE ON (POLY MODE OFF) (ALL NOTES OFF) + NUMBER OF CHANNELS (0=all receiver channels)
B0...BF	7F	0	CHANNEL MODE (+ channel number) + POLY MODE ON (MONO MODE OFF) (ALL NOTES OFF)

is envisaged. The supply voltage for the circuit is obtained from a NiCd battery or a suitable mains adapter.
Set P_1 to the centre of its travel, and the code generator is ready for testing in a MIDI environment. The MIDI output on the generator corresponds to a standard MIDI OUT connection, and can be used for feeding otherwise unavailable codes to certain equipment. Similarly, the code generator can be used in conjunction with an expander for realizing MIDI functions not supported by a standard MIDI keyboard.

Use a standard MIDI cable for connecting the code generator to an instrument that is known to respond to, say, the NOTE ON/NOTE OFF command. Program this instrument to listen to MIDI channel 1, and send the following code sequence:
90 3C 40.
The function of these three bytes is as follows (also consult the accompanying overview of frequently used MIDI codes):
90 selects the NOTE ON mode on channel 1;
3C is the note number ("doh" from the centre of the keyboard);
40 is a commonly used velocity code.
Carefully adjust the oscillator clock frequency if this does not work. If necessary, use a frequency meter connected to the output of N_3 to set the clock oscillator to 31,250 Hz.
End the played note by typing:
80 3C 40. *R*

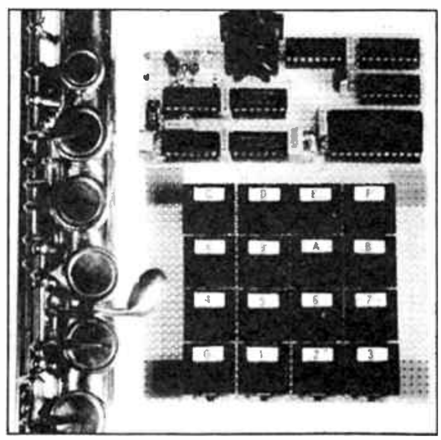


FIGURE 8.1 continuance from p. 83.

```
1760 J=J+1:IF J<2 THEN 1740
1790 P=I-1:FMIN(P)=FM:AMIN(P)=AM:DMIN(P)=DM
1800 RETURN
1810 N1=V+1:C1=LOG(10)/40:I1=1
1820 ZZ=(1-FBB/FMIN(I1)^2):Z=SQR(ZZ)
1830 FOR I2=1 TO V:G(I1,I2)=ZZ/Z(I2)/(ZZ-Z(I2)^2):NEXT I2
1840 I1=I1+1:IF I1<N1+1 THEN 1820
1850 FOR I1=1 TO N1:G(I1,N1)=-C1:C(I1)=-C1*DMIN(I1):NEXT I1
1860 R=1:J1=1:J2=N1
1870 J=R+1
1880 FOR K=1 TO R-1:G(R,J)=G(R,J)-G(R,K)*G(K,J):NEXT K
1890 G(R,J)=G(R,J)/G(R,R):J=J+1:IF J<N1+1 THEN 1880
1900 C=R+1
1910 FOR I=C TO N1:FOR K=1 TO C-1:G(I,C)=G(I,C)-G(I,K)*G(K,C):NEXT K:NEXT I
1920 R=R+1:IF R<V+1 THEN 1870
1930 FOR K=1 TO J1-1:C(J1)=C(J1)-G(J1,K)*C(K):NEXT K
1940 C(J1)=C(J1)/G(J1,J1):J1=J1+1:IF J1<N1+1 THEN 1930
1950 X(J2)=C(J2):FOR K=J2+1 TO N1:X(J2)=X(J2)-G(J2,K)*X(K):NEXT K
1960 J2=J2-1:IF J2>0 THEN 1950
1970 FOR I=1 TO V:GOSUB 1980:NEXT I:GOTO 1410:RETURN
1980 Z(I)=Z(I)+X(I):ZZ=Z(I)*Z(I):F(I)=SQR(FBB/(1-ZZ)):RETURN
1990 REM ____________________ STATE VARIABLE FILTER BLOCKS _________________
2000 PRINT:FOR I=1 TO V:NUM=I:PRINT USING "Filter block number #";NUM:PRINT
2010 GOSUB 2080:J=V+1-I:K=J
2020 IF P1(J)>5000 OR F1(K)>5000 THEN RIN=10000:R1=20000:R2=2000:R3=10000:RG=RIN
:C1=2.2E-10:C2=C1:GOSUB 2230 ELSE GOSUB 2130
2030 GOSUB 2390:RG=RIN:NEXT I:GOTO 1190
2040 REM ___________________ SWITCH FOR FREQUENCIES ABOVE 5 kHz _________________
2050 IF P1(J)>5000 OR F1(K)>5000 THEN RIN=10000:R1=20000:R2=2000:R3=20000:C1=2.2
E-10:C2=C1:RG=RIN:GOSUB 2320 ELSE GOSUB 2210
2060 RETURN
2070 REM _______________________ INITIAL VALUES OF Rs & Cs ______________________
2080 RIN=100000!:R1=RIN:R2=10000:R3=RIN:RG=RIN:C1=.0000001:C2=C1
2090 IF FC>500 THEN C1=1E-09:C2=C1:GOTO 2110
2100 IF FC>50 THEN C1=1E-08:C2=C1
2110 RETURN
2120 REM ____________ CALCULATE REAL POLE FOR LOW FREQUENCIES _______________
2130 IF ODD=0 OR I>1 THEN 2210
2140 CC=.0000033/P1(V+1):CL=.0000022
2150 FOR I1=14 TO 1 STEP -1 :IF CS(I1)>CC THEN CL=CS(I1):GOTO 2170
2160 NEXT I1
2170 IF X=1 THEN RG=.5/PI/P1(V+1)/CL ELSE CL=C1:RR=.5/PI/P1(V+1)/CL:GOSUB 2210
2180 RQ=100000!/(3.46*Q(J)-1-100000!/RIN):QQ=0:IF Q(J)<QMIN THEN QQ=1:RQ=10000!/
(.3162*(1+100000!/RIN)/Q(J)-1.1)
2190 GOSUB 2350:RETURN
2200 REM ___________ CALCULATE COMPLEX POLE FOR LOW FREQUENCIES ________
2210 RQ=100000!/(3.46*Q(J)-1-100000!/RIN):QQ=0:IF Q(J)<QMIN THEN QQ=1:RQ=10000!/
(.3162*(1+100000!/RIN)/Q(J)-1.1)
2220 GOSUB 2350:RETURN
2230 REM ___________ CALCULATE REAL POLE FOR HIGH FREQUENCIES _________________
2240 IF ODD=0 OR I>1 THEN 2320
2250 CC=.0000033/P1(V+1):CL=.0000022
2260 FOR I1=14 TO 1 STEP -1 :IF CS(I1)>CC THEN CL=CS(I1):GOTO 2280
2270 NEXT I1
2280 IF X=1 THEN RG=.5/PI/P1(V+1)/CL ELSE CL=C1:RR=.5/PI/P1(V+1)/CL:GOSUB 2320
2290 RQ=10000!/(3.46*Q(J)-1-10000!/RIN):QQ=0:IF Q(J)<QMIN THEN QQ=1:RQ=2000!/(.3
162*(1+10000!/RIN)/Q(J)-1.1)
2300 GOSUB 2350:RETURN
2310 REM _________ CALCULATE COMPLEX POLE FOR HIGH FREQUENCIES _________________
2320 RQ=10000!/(3.46*Q(J)-1-10000!/RIN):QQ=0:IF Q(J)<QMIN THEN QQ=1:RQ=2000!/(.3
162*(1+10000!/RIN)/Q(J)-1.1)
2330 GOSUB 2350:RETURN
2340 REM _______________________ CALCULATE Rf, Rhp, & Rlp _______________________
2350 RF=.05033/P1(J)/C1:RLP=11*RG/(2+RIN/RQ):RHP=.1*RLP*(F1(K)/P1(J))^2
2360 IF X=3 AND I=0 THEN 2380
2370 IF RHP<2200 OR RLP<2200 THEN RHP=RHP*2:RLP=RLP*2:RG=BG*2:GOTO 2370
2380 RETURN
2390 REM ____________________________ DISPLAY ______________________________
2400 FQ=P1(J)*Q(J):PRINT USING "The FQ product of this block is ######";FQ:PRINT
2410 IF FQ>200000! THEN PRINT "This is too high for an active filter.":GOTO 120
2420 R=RIN:GOSUB 2780
2430 PRINT USING "Rin=###.###\    \";R,R$
2440 R=R1:GOSUB 2780
2450 PRINT USING "R1 =###.###\    \";R,R$
2460 R=R2:GOSUB 2780
2470 PRINT USING "R2 =###.###\    \";R,R$
2480 R=R3:GOSUB 2780
2490 PRINT USING "R3 =###.###\    \";R,R$
2500 R=RF:GOSUB 2780
2510 PRINT USING "Rf =###.###\    \";R,R$
2520 R=RQ:GOSUB 2780
2530 PRINT USING "RQ =###.###\    \";R,R$
2540 IF QQ=1 THEN PRINT "Use circuit for low Q."
2550 IF X=3 AND I=0 THEN 2580
2560 R=RHP:GOSUB 2780:
2570 PRINT USING "Rhp=###.###\    \";R,R$
2580 R=RLP:GOSUB 2780:
2590 PRINT USING "Rlp=###.###\    \";R,R$
2600 R=RG:GOSUB 2780:
2610 PRINT USING "Rg =###.###\    \";R,R$
2620 C=C1:GOSUB 2820
2630 PRINT USING "C1 =###.###\ \";C,C$
2640 C=C2:GOSUB 2820
2650 PRINT USING "C2 =###.###\ \";C,C$
2660 IF X=1 AND ODD=1 AND NUM=1 THEN 2670 ELSE 2700
2670 C=CL:GOSUB 2820
2680 PRINT USING "CL =###.###\ \";C,C$
2690 PRINT "CL is in parallel with Rg."
2700 IF ODD=1 AND X=2 AND I=1 THEN PRINT "CR circuit needed at input of filter."
:C=CL:GOSUB 2830:R=RR:GOSUB 2780:PRINT USING "C  =###.###\ \      R  =###.###\
 \";C,C$,R,R$
2710 W=P1(J):GOSUB 1070:PRINT USING "Tuning frequency  =###.###\  \";W,A6$
2720 QW=P1(J)*(.5/Q(J)+SQR(1+(.5/Q(J))^2))
2730 W=QW:GOSUB 1070:PRINT USING "Q tuning frequency=###.###\  \";W,A6$
2740 W=F1(K):GOSUB 1070:PRINT USING "Notch frequency   =###.###\  \";W,A6$
2750 PRINT:INPUT "To continue, press ENTER.",SS$:PRINT
2760 RETURN
2770 REM ____________________ SUBROUTINE FOR RESISTOR UNITS ____________________
2780 IF R>=1000000! THEN R=R/1000000!:R$=" MOhms ":GOTO 2810
2790 IF R>=1000! THEN R=R/1000!:R$=" kOhms ":GOTO 2810
2800 R$=" Ohms  "
2810 RETURN
2820 REM ____________________ SUBROUTINE FOR CAPACITOR UNITS ____________________
2830 IF C>=1 THEN C$="  F":GOTO 2880
2840 IF C>=.001 THEN C=C*1000:C$=" mF":GOTO 2880
2850 IF C>=.000001 THEN C=C*1000000!:C$=" uF" :GOTO 2880
2860 IF C>=1E-09 THEN C=C*1E+09:C$=" nF" :GOTO 2880
2870 C=C*1E+12:C$=" pF"
2880 RETURN
2890 PRINT "End of programme.":END
2900 IF X=1 THEN:S=1:FOR I=1 TO V:W(I)=2*PI*P1(I):NEXT I:IF ODD=1 THEN W(V+1)=2*
PI*P1(V+1)
2910 IF X=2 THEN:S=-1:FOR I=1 TO V:W(I)=2*PI*FC*FC/P1(I):NEXT I:IF ODD=1 THEN W(
V+1)=2*PI*FC*FC/P1(V+1)
2920 INPUT "At what frequency [ Hz ] would you like the attenuation, phase, and
delay ?",F:W=2!*PI*F:FF=F/FC:S=0:IF X=2 THEN FF=FC/F:S=N*PI/2
2930 IF FF<.01 THEN ATTEN=0:GOTO 2980 ELSE ZZ=1-1/FF/FF
2940 FOR I=1 TO V:ZZ(I)=1-1/F(I)/F(I):IF ZZ(I)=ZZ THEN PRINT "The attenuation at
 this frequency is infinite.":ATTEN=999.99:GOTO 2980
2950 NEXT I:QQZ=(ZZ-1)^NIN:FOR I=1 TO V:QQZ=QQZ*(ZZ-ZZ(I))^2:NEXT I
2960 FFZ=EP2:FOR I=1 TO V:FFZ=FFZ*ZZ(I)^2:NEXT I
2970 ATTEN=4.343*LOG(1+ABS(FFZ/QQZ))
2980 PHASE=0:FOR I=1 TO V:P=ATN(W*W(I)/Q(I)/(W(I)*W(I)-W*W)):IF P<0 THEN P=PI+P-
2990 PHASE=PHASE+P:NEXT I
3000 IF ODD=1 THEN P=ATN(W/W(V+1)):PHASE=PHASE+P
3010 D=0:FOR I=1 TO V:D=D+W(I)*(W(I)^2+W^2)/Q(I)/((W(I)^2-W^2)^2+(W(I)*W/Q(I))^2
):NEXT I:IF ODD=1 THEN D=D+W(V+1)/(W(V+1)^2+W^2)
3020 GOSUB 3040:PRINT USING "Atten=###.## dB   Phase=####.## degrees    Delay=##
#.##\    \":ATTEN,(S-PHASE)*180/PI,D,DD$
3030 INPUT "Would you like to try another frequency [ Y or N ] ?",ANS$:IF ANS$="
Y" OR ANS$="y" THEN 2920 ELSE 1190
3040 IF D>=1 THEN DD$=" sec  ":GOTO 3070
3050 IF D>=.001 THEN D=D*1000!:DD$=" msec ":GOTO 3070
3060 D=D*1000000!:DD$=" usec "
3070 RETURN
```

Comprehensive range of sprays for electronic applications

Arista Electronics has revised their original range of ten electronics sprays, rationalising them to a new set of six of the most popular aerosols.

The new range includes: Dust remover – which supplies a powerful jet of compressed air; Safety Cleaner – for removing flux etc from pc boards; Contact Lubricant – for pots, switches and relays; Graphite – which will make any surface conductive (don't confuse this one with the cleaner!); Hyper Refrigerant – to help in the detection of heat-sensitive faults; and Lubricant Cleaner – which combines Safety Cleaner and Contact Lubricant. The cans are all 300g net capacity.

Certainly no service workshop would be worthy of the name without them, and some would prove very useful in the home workshop or professional development laboratory. Check them out with your nearest Arista distributor.

For more information, contact **Arista Electronics Pty Ltd, 57 Vore Street, Silverwater NSW 2141, (02) 648 3488.**

Photus interruptus

Looking for an opto interrupter? – that little gadget consisting of a LED and a phototransistor separated by a small gap, where anything interrupting the light from the LED switches the phototransistor off.

Well, Geoff Wood Electronics currently has such in stock. The gadget comprises a small, rectangular plastic fitting with a LED (60 mA max. forward current) and a 30 V, fast switching (5 us) phototransistor separated by a 3 x 7 mm gap. There are two countersunk screw holes in the fitting for mounting it.

The gadget's just great for robotics, position sensing, tacho applications, etc. At just $4.00, it's a steal. Contact **Geoff Wood Electronics, 229 Burns Bay Rd, Lane Cove West 2066 NSW. (02) 427 1676.**

Getting all hot and sticky!

Hot-melt glue has heaps of advantages. It's clean, requires no mixing, has no solvent to attack plastics etc, will bond almost anything to anything and you only need apply exactly the amount needed.

Dick Smith stores currently have hot melt glue guns at the bargain basement price of $14.95, a saving of five dollars on the normal price.

Apart from a myriad of uses in any electronics workshop, a hot melt glue gun finds heaps of applications in the service shop or around the home. See your nearest Dick Smith store.

Turn me on, I'm alarmed!

A keyswitch installed in an alarm system is the sensible way to restrict necessary access to the area protected by the alarm.

Apart from alarms, keyswitches are great for restricting access to anything that's electrically operated. Install one on your computer, or your model railway controller, for example!

Ritronics has sturdy keyswitches for a special price at the moment – just $4.95 instead of the usual $7.95.

Check them out at your nearest Ritronics store, or contact them at **PO Box 620, Clayton 3168 Vic. (03) 543 2648.**

D-type adaptors

With the proliferation of 9-pin D-type connectors on computer serial ports and interfaces these days, it has become something of a problem hooking up the 'older' standard 25-pin D-connectors on existing peripherals when you get new computer gear having the 9-pin connectors.

"No problem", says Des Bain of David Reid Electronics, echoing a famous Melmacian TV character. "We've got 9-pin to 25-pin D-type adaptors in our wide range of computer connectors".

Apart from D connectors, David Reid stocks a range of Centronics connectors, both solder-on and IDC type. The have a comprehensive selection of IDC type flat ribbon and double-sided edge connectors, too.

David Reid Electronics is located conveniently in Sydney's "Silicon Alley", at **127 York St, Sydney,** opposite the Queen Victoria Building. **(02) 267 1385.**

PROJECT BUYERS GUIDE

Scan Audio's new **Vifa SA-50 miniature bookshelf Star Project loudspeakers** are economical, easy to build and perform well. They will be available in kit form from a wide range of retailers Australia-wide – see the list in the article.

Datacom's **M1200 V21/V23 Star Project modem** should prove a winner. It's economically priced, may be interfaced to any computer as it features a constant speed interface, and operates on the widely popular 300 baud and 1200/75 baud modes. Enquire with Datacom, Private Bag 39, Bayswater 3153 Vic., or you can "pledge your plastic" by phone on (03)890 1661.

The **AEM5507 Mains Socket Safety Checker** proved it's worth here at the magazine recently, showing up a dangerous fault in the wiring to a power point in the basement – a problem of which nobody had previously been aware! It's an easy project to put together and the parts are readily available. Jaycar supply the Atco plug pack case if you're assembling your own bits and pieces, but they'll also be selling kits.

Components for the **Tuneable VHF and UHF TV preamps** in the Elektor section this month – or suitable substitutes for some – may be obtained through Stewart Electronic Components in Melbourne. Parts for the **Fuzz Unit** are widely stocked, with the exception of the AA119 diodes – a gold-bonded, low reverse leakage type. Common 1N1418/1N914s may be tried, with perhaps some variation in circuit behaviour. The common OA202 may substitute quite well, however. The 74HCT series devices specified in the **Midi Code generator** are not widely stocked, so check your favourite semiconductor supply house, like Geoff Wood Electronics in Sydney, Protronics in Adelaide and any number of places in Melbourne.

Build these high quality miniature speakers

Tom Manning
Scan Audio

Despite their tiny size – just 260 mm high by 170 mm wide by 195 mm deep – these loudspeakers deliver BIG performance! A new design employing quality Vifa drivers, they're ideal as 'bookshelf' loudspeakers where you only have limited space, better still, they have been designed to team with the Vifa SW-1 Band Pass Subwoofer we described last year.

IN SEPTEMBER 1987, we published a design for a passive bandpass subwoofer based on the latest research into bass system performance using some unconventional loading techniques. This subwoofer, the Vifa SW-1, employs two 250 mm bass drivers mounted face to face inside a 62 litre enclosure. Partitioned inside, one woofer fires rearward into a sealed chamber whilst the other unit is vented to the outside world through a large port. The beauty of this principle is that it combines the best virtues of both vented and sealed designs – the bass extension of the vented box with the transient performance and accuracy of a good sealed system.

The design was so well received that it inspired us to design a "satellite" speaker, ideally matched to the SW-1 in terms of transient response (in the writer's opinion, one of the most important and most often neglected aspects of speaker design) and efficiency, allowing painless matching of levels which can often be problematic when attempting to mate different manufacturer's designs.

Additionally, we required that the speaker possess the flexibility to be used alone, catering to the requirements of many people whose domestic environments do not permit the use of large speakers. This brings us to the first important design consideration.

Bass driver enclosure design

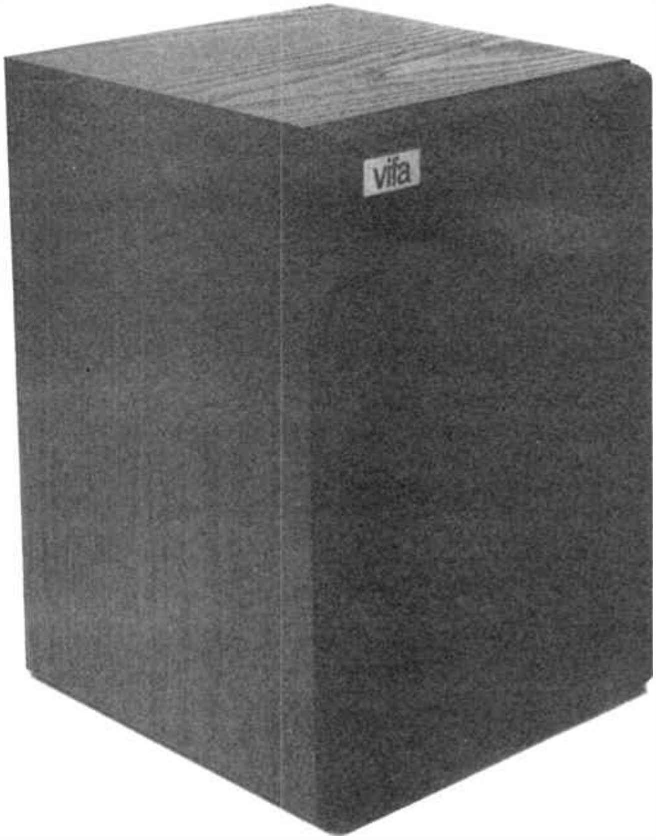
The appointed driver for the SA-50 is an interesting new woofer from Vifa. A 125 mm (5") unit, the C13-WG bass/mid-range driver is constructed with some features which, up until as recently as five years ago, were found only on drivers several times its cost. It features a paper pulp cone, impregnated with 'plasticising' compound, providing the moving assembly with a high degree of self-damping.

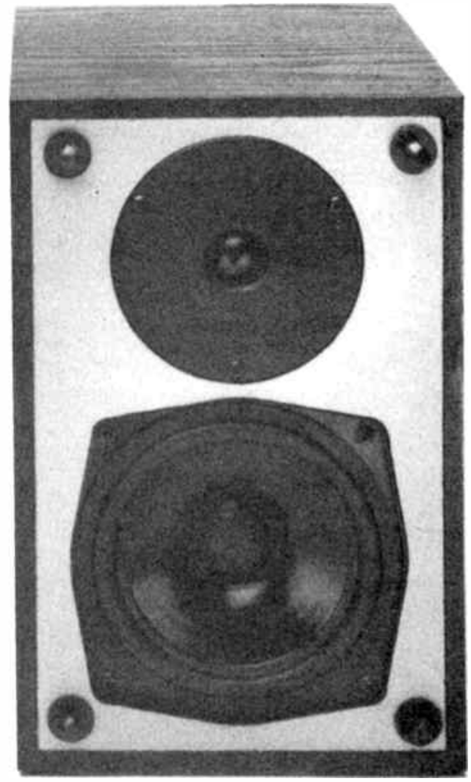
Paper cones, in any form, have generally been out of favour with speaker designers since the introduction of polypropylene and other plastic derivative cone materials, but in our opinion, correctly designed coated paper cones are generally far superior to cheap plastic types, particularly in the area of midrange resolution and overall clarity. Here, a precise amount of damping compound is applied, ensuring good dynamic cone balance and symmetrical transfer of wave oscillations, critical for good dispersion at higher frequencies.

SPECIFICATIONS

System: two-way, bass reflex
Woofer/mid-range: Vifa C13WG-08-08
Tweeter: Vifa D19TD-05
Crossover: 6 dB/octave
Crossover frequency: 3500 Hz
Frequency response: 72 Hz to 18 kHz (±3 dB)
Power handling: 30 watts RMS (IEC), 50 watts peak
Sensitivity (1 W at 1 m): 87 dB
Impedance: 8 Ohms minimum
Internal volume: 5.3 litres
Overall dimensions: 260 x 170 x 195 mm
Weight: 4 kg

The two Vifa drivers used. At left is the 125 mm C13WG bass/mid-range unit which features a long-throw voice coil and very wide frequency response. At right is the D19TD tweeter featuring a ferro-fluid cooled and damped voice coil.





The new SA-50s are small, beautiful, top performers and very economically priced at $319 for a kit. The cabinets are finished in black wood grain veneer, with the front panel finished in dove grey vinyl.

The C-13 is fitted with a rubber roll outer suspension surround, ideal for small woofers since it maintains good linear action at high excursions. It's also useful for damping cone-induced resonances since it acts as an effective edge termination for break up modes which travel outwards, not unlike ripples on calm water.

Most audio enthusiasts are aware of the pioneering research in the early 1970's by two Australian scientists – Neville Thiele and Richard Small – who transformed enclosure design from guesswork into that of a highly predictable nature. It's no surprise then, that modern bass drivers are designed with this in mind, having electrical and mechanical parameters dictating their suitability for particular "alignments".

The key factors are:

1) Their free air resonance (Fo), the frequency when both the driver's impedance is highest, and it exhibits the maximum amount of mechanical excursion for the minimum applied voltage.

2) The total Q factor of the driver (Qt), which is the quality factor at resonance and which indicates the combined effects of the driver's electrical and mechanical damping of the moving system and its free air resonance.

3) The VAS, which is the volume of air in litres needing to obtain the same restoring force to the cone as does the suspension. Expressed more generally, an indication of the "springiness" of the suspension system.

The 'numbers' for the C-13 are: Fo-47 Hz, Qt – 0.35, VAS – 17 litres. Consultation of Thiele's formulae indicates a box volume of between five and six litres with a system resonance of 70 Hz will be ideal. This will provide good bass performance (for this size cabinet) with the best possible transient qualities matching the SW-1 subwoofer both in frequency response and overall sonic character.

Treble considerations

The choice of a suitable tweeter can often present designers with many problems – fortunately the inherent qualities of our bass driver made this process fairly painless. The response of the C-13 stays within a 4 dB envelope from 200 Hz up to 4 kHz (see Figure 1). Such good high frequency performance allows the use of a 19 mm diameter dome tweeter, ▷

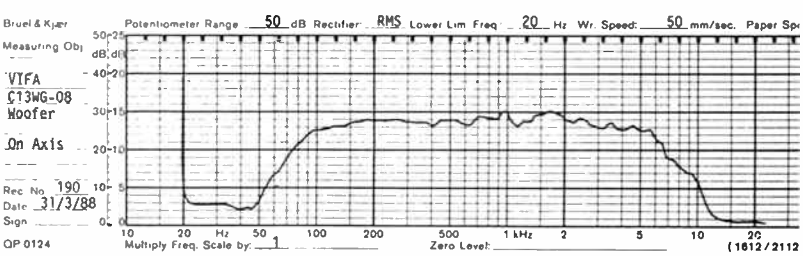


Figure 1. Frequency response of the C13WG woofer. The response stays within a 4 dB envelope from below 200 Hz to about 4 kHz. Bass end roll off is a touch below 100 Hz.

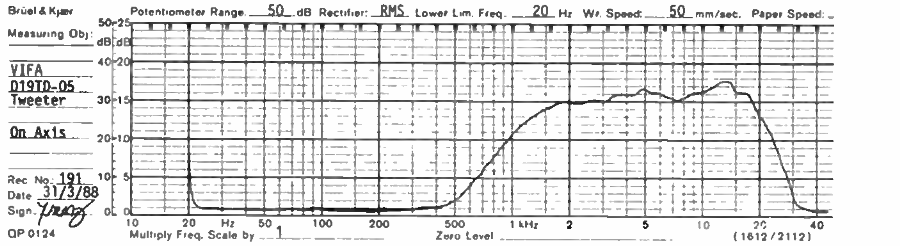


Figure 2. The D19TD tweeter has a response extending from below 2 kHz to around 20 kHz, overlapping the C13's response by a good octave.

which, due to its limited excursion capabilities cannot perform reliably at frequencies much below this. Particularly if first order filters are to be used, (more on this later) crossover frequency is of prime importance.

The Vifa D19TD tweeter, a polyamide dome design, was found to satisfy all these requirements as well as providing response out to 20 kHz and excellent distribution off-axis, an important consideration as many well known acousticians have demonstrated. This driver's frequency response is shown in Figure 2. Other noteworthy features include a ferrofluid damped and cooled voice coil, and a close tolerance magnetic circuit which ensures low flux leakage and high efficiency.

Crossover design

Having determined our driver complement and box design, we are now faced with the most interesting, and possibly the most important consideration involved in designing a speaker using off-the-shelf drivers, the crossover.

Thoughts on network design vary widely amongst different manufacturers, and it is unlikely that any sort of general consensus will ever be reached on the "correct" approach. The crossover has an enormous effect on the system's amplitude and phase behaviour, as well as determining the radiation pattern of the speaker in both the horizontal and vertical planes. The design of dividing networks would be easy if loudspeaker drivers were resistors – behaviour of different networks would follow classic filter theory with predictable results and a wide range of different responses would be available.

In a two-way system, involving a woofer and a tweeter, a low pass filter and a high pass filter are combined to divide-up the signal energy to each driver. The simplest low pass section comprises an inductor, the simplest high pass section, a capacitor. This is illustrated in Figure 3 (a) and (b), respectively. Here, the drivers are shown as resistive loads (a theoretical woofer and tweeter).

Now, let us say we have a crossover frequency of 2500 Hz – an arbitrary figure, but in the real world an important consideration. In order to obtain an overall flat frequency response, we require each driver's output to be half power (-3 dB) at this frequency. The values of the reactive components in the crossover must be such that their reactances equals the load resistance in each case at 2500 Hz. The signal *voltage* across the load is then 50% (–6 dB) of the voltage applied. The *power* delivered to each load will be half the signal power. This should provide a flat frequency response when the outputs are added together.

But, a loudspeaker is a complex device. As well as being inductive, resistive and occasionally capacitive, the mechanical and acoustical behaviour of drive units makes the task of building crossovers less than easy. If we applied the results of the above example to our speaker, the frequency response would exhibit an excessive amount of output in the crossover region. This is largely due to the proximity of the drivers on the front baffle, causing an *acoustical* summing due to the decrease in radiation resistance when any two sound sources are operating in close proximity at the same frequency. This occurs as long as the distance between both drivers is less than half a wavelength of the frequency being radiated, rolling off at 3 dB per octave as the frequency increases.

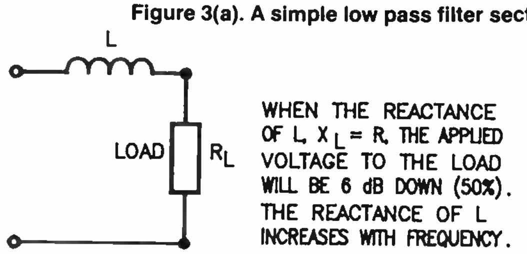
Other factors involved include the inductive nature of the woofer's voice coil (providing a certain counterbalancing effect) and the narrowing of the sound distribution (or radiation) pattern in the mid-range with increasing frequency. The solution is to stagger the crossover points so that both drivers contribute over a fairly wide bandwidth. If this is done carefully, an overall smooth response can be obtained.

This is the simplest type of crossover – it's a first order type, providing a roll off of 6 dB per octave beyond the crossover frequency. This means that, above the crossover frequency, the low pass section of Figure 3(a) provides a 50% decrease in signal voltage across the load with each *doubling* (an octave) in frequency. For the high pass section of Figure 3(b), the signal voltage across the load drops 50% for each *halving* in frequency. This is why they are sometimes referred to as a "6 dB/octave" filter.

However, this type of network can be used only when the selected drivers have smooth roll off characteristics outside the passband, and when the crossover frequency is high enough to prevent excessive excursion with many small tweeters where the applied voltage at its natural resonance may not be low enough to ensure reliable operation.

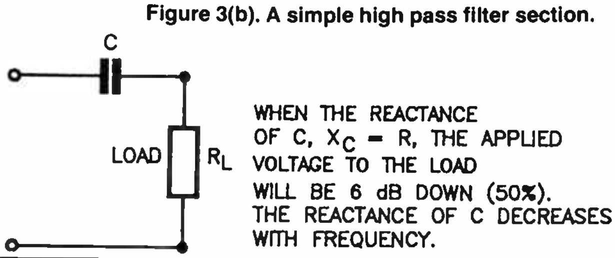
Fortunately, both drivers in this system are suitable for use with a first order filter, providing the crossover frequency is kept reasonably high. The greatest advantage of a first order (6 dB/octave) network is that it contributes the least amount of "ringing" to the system – a well known aspect of general filter design. Correctly designed passive first order crossovers have audibly better transient response than any other network configuration.

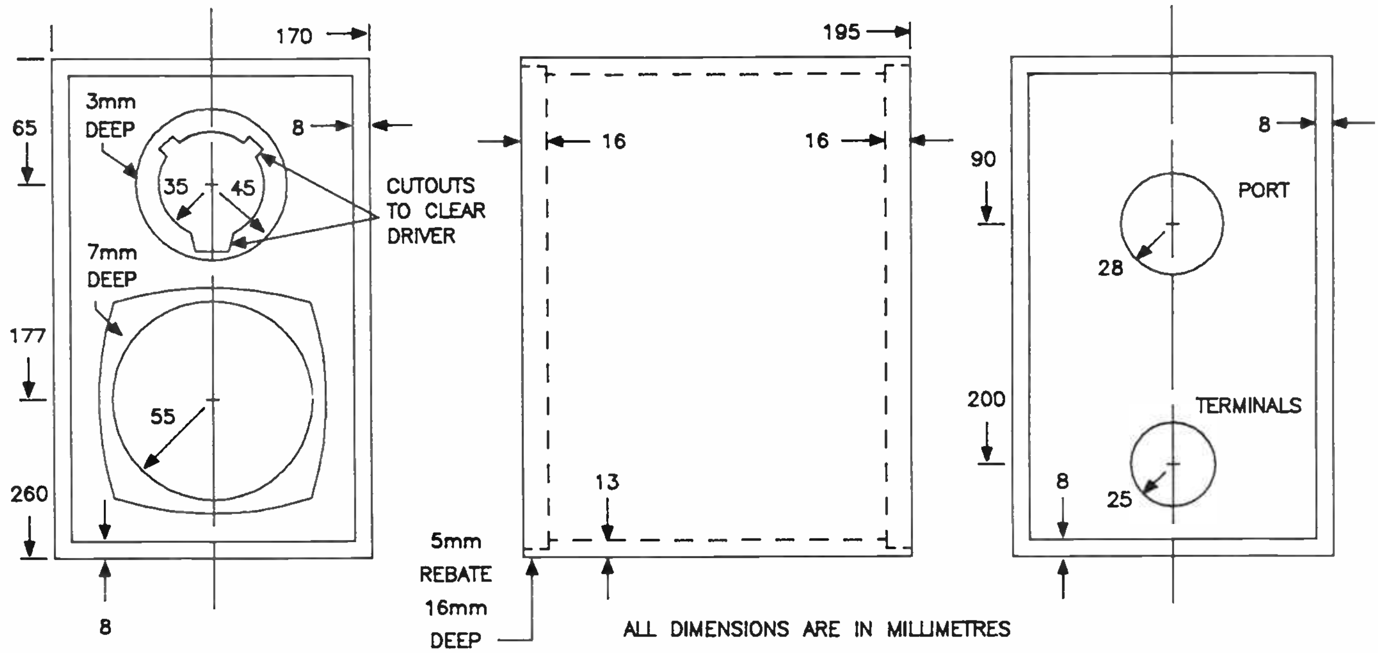
Figure 3(a). A simple low pass filter section.



In each case the roll off slope is 6 dB/octave.

Figure 3(b). A simple high pass filter section.





The circuit of the crossover network for the SA-50 is shown in Figure 4. L1 and C1 are the reactive components mentioned earlier, while R1 serves as a treble attenuator (about 3 dB) to match the sensitivities of both drivers. As you can see from Figures 1 and 2, which were taken with the same drive level and recorder sensitivity, the D19TD has about 3-4 dB more output and a slight rise in the response at about 12-14 kHz. The resistor brings the tweeter's output level in line with that of the woofer and effectively dampens the aforementioned peak, as can be seen from Figure 5, later.

Note the out-of-phase tweeter connection in the crossover which, as some readers will know, may at first seem unusual since each reactive component contributes only 45 degrees of phase shift to the overall response, the treble leading the input signal and the bass lagging by this amount. This combined effect should contribute only a 90 degrees phase error to the response, but examination of the driver's acoustical behaviour shows an additional roll off augmenting this problem, resulting in an overall error of about 140 degrees. Reversing the phase of the tweeter gives a much smoother response around the crossover region.

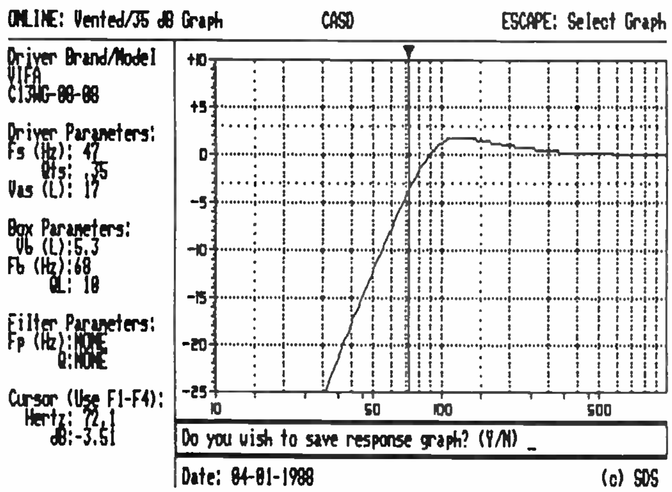
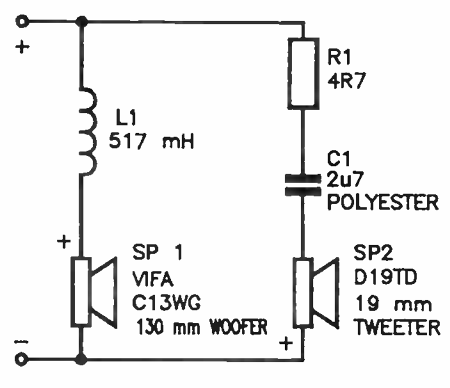


Figure 5. Plot from our computer design program showing how the C13WG driver behaves in a 5.3 litre cabinet with the port dimensions given.

Figure 4. Crossover network for the Vifa SA-50s. The reason for the out-of-phase tweeter connection is explained in the text.



The final design

Finally, we ended up with a box measuring just 260 mm high by 170 mm wide by 195 mm deep, giving an internal volume of 5.3 litres. The port is rear-mounted, opposite the tweeter hole. The port is cut from standard ABS plastic plumbing pipe, 32 mm inside diameter. It's mounted with a standard plastic pipe flange.

In this box, our computer design program shows the C13WG woofer gives a -3 dB roll off at 72 Hz, with a slight "lift" of 1.5 dB between 100-150 Hz. A printout, reproduced in Figure 5, clearly shows these results. The bass end roll off of the SA-50 matches reasonably well with the SW-1 subwoofer's top end roll off should you decide to team them.

The side and rear panels are made of black wood grain veneer chipboard, while the front baffle is 16 mm customwood covered in dove grey vinyl. The whole appearance is very smart and the speakers will blend with almost any decor. The front grille employs a clip-on frame with black ▷

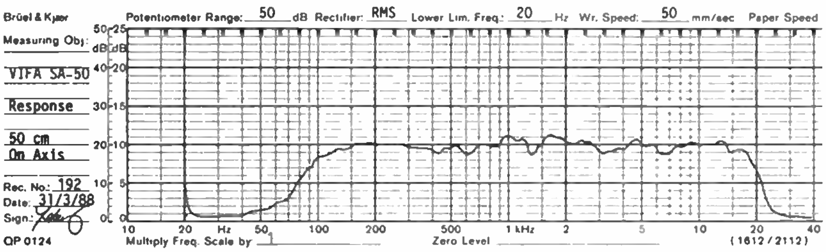


Figure 6. Overall frequency response of the SA-50s. The result is very good indeed for such a small enclosure!

grille cloth stretched over it. There are four male grille clips on the front panel which mate with holes in the grille frame.

The speaker connections are terminated to a spring clip assembly mounted in a hole in the rear panel opposite the woofer hole. A quantity of Dacron stuffing material is used for internal damping.

Performance

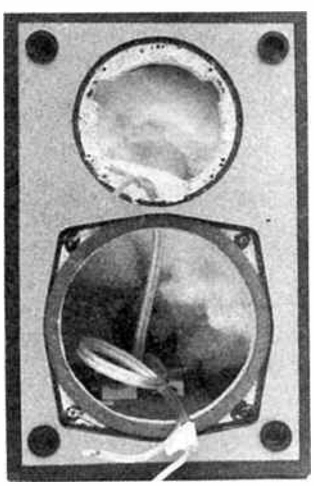
The measured frequency response of the SA-50 is shown in Figure 6. The response is within a ±3 dB envelope from 100 Hz to 18 kHz, although the early roll off at the bass end is partly an artifact of the manner in which the measurement was made. Nevertheless, that is a creditable performance, indeed! It compares very favourably with many similar commercial loudspeakers that cost a great deal more.

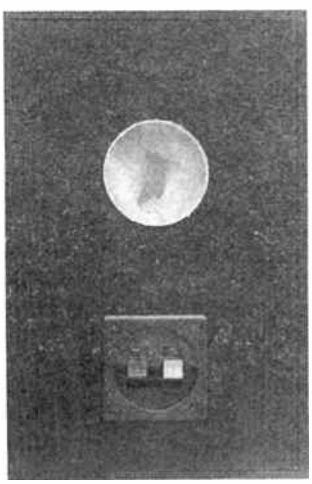
The impedance versus frequency response (Figure 7) shows a very smooth response, with a minimum of close to eight Ohms in the 200-500 Hz region and a maximum of a little over 11 Ohms in the deep bass (typical of bass reflex designs) and again at around 3 kHz near the crossover frequency. These speakers could be safely connected in parallel with an existing speaker system where good quality extension speakers were required and your amplifier could cope with a four Ohm load. Happily, most amplifiers will readily accommodate these days.

To the ear

The subjective performance of the SA-50s is very good indeed. They can be used satisfactorily without the subwoofer – although the addition of this component breathes real life into the system.

Rear view of the box, showing the terminals and the hole for the flange that supports the port. ▼





▲ Front view of the box, just prior to installing the drivers. Note the wires that connect to the drivers. The crossover parts are glued to the inside bottom of the box.

As a result of their small size, separation and placement of instruments in the musical soundstage is excellent – so too is the the transient performance and overall clarity, thanks to the quality of the drivers and the simple crossover.

When teamed with the SW-1 subwoofer, the result can be quite extraordinary, particularly if you're partial to full symphony orchestras or organ music. You can impress your friends if you hide the subwoofer!

System construction

The SA-50 is supplied as a complete kit, with cabinet woodwork and all components, and will be widely available through a number of dealers (see the accompanying list). The cabinets come as a flat pack which is simply folded together and glued. Alternatively, you can purchase the hardware – drivers and crossover, etc – and build the cabinets yourself; the general cabinet details are given in the accompanying drawing. To make your own cabinets, if you want a "professional" finish, you will need reasonable woodworking facilities.

Assembling the SA-50 is quite straightforward. If you purchase a kit, no woodworking ability is necessary and you only need elementary tools – scissors, Philips head screwdriver, soldering iron, sidecutters, etc. However, you will need a roll of masking tape, a tube of PVA woodworking glue ("Aquadhere", or similar) and a roll of adhesive foam tape, such as that made for "draught exclusion" applications or for sealing cupboards. This will be used to seal the rims of the two drivers. You will also need a tube of silicone sealing compound (such as "Silastic") to seal around the cabinet joins, port hole and the spring terminals. The crossover components are to be glued in the base of each cabinet so you will need to have a suitable glue, such as two-part epoxy resin (E.G: "Araldite"), or hot-melt glue (which requires a suitable glue "gun"). These extras may be obtained from most hardware stores.

PARTS LIST VIFA SA-50

2 x Vifa C13WG-08-08 bass/mid-range drivers
2 x D19TD-05 tweeters
2 x 513 nH (0.513 mH) air-cored inductors, low dc resistance
2 x 4R7, 5 W resistors
2 x 2u7 polyester (MKT) capacitors (2u2 & 470n in parallel)
2 m of good quality, h.d. speaker cable for internal wiring
2 x spring terminal blocks or 4 x banana plug sockets
2 x pieces of PVC pipe, 36.5 mm o.d., 32 mm i.d., 140 mm long
2 x pipe flanges
8 x male plastic grille studs
8 x female plastic grille studs
2 x pieces grille cloth
2 x grille frames
small quantity of Dacron damping material
2 x flat pack cabinets
Kit price: $319.00
Built up: $399.00
Driver prices: C13WG – $96; D19TD – $55

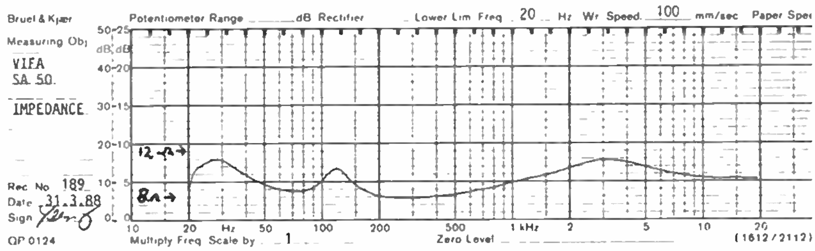


Figure 7. Impedance versus frequency plot of the SA-50s. The minimum impedance is close to 8 Ohms, while the peak impedance is less than 12 Ohms.

First, unpack and lay out all the various components – drivers, crossover parts and cabinets, and check everything. Only partly unpack the cabinets to avoid getting them scratched. Tackle the assembly of the cabinets first, one at a time.

Using each driver as a template, place them in their respective holes in the front baffles and mark the positions of the screw holes. Take care not to damage the drivers and see that the hole positions are not too close to the rims.

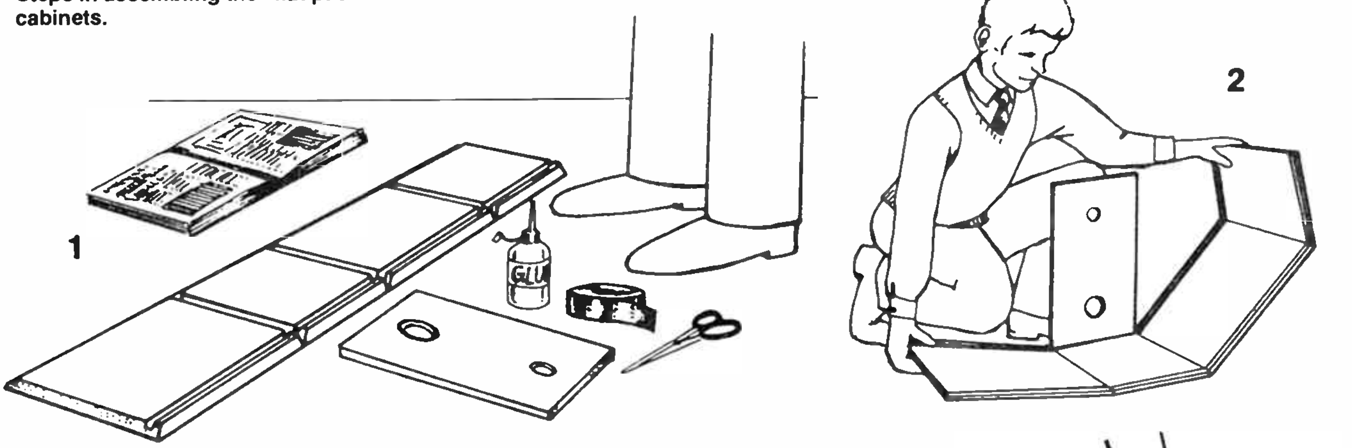
Now drill small 'pilot' holes for the screws. They ensure the screws penetrate in a straight line and prevent any possible splitting of the customwood baffle.

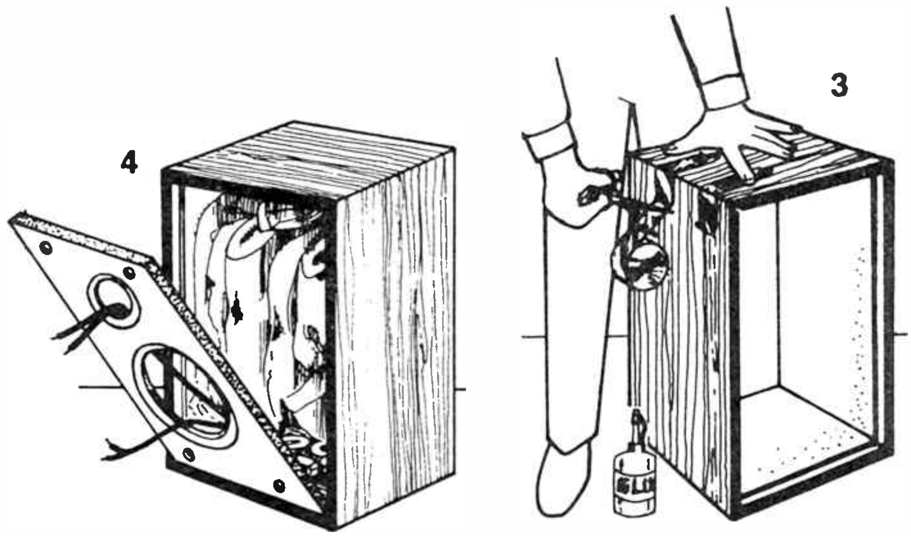
Now take the rear baffles and mark the hole positions for the port flanges and terminal blocks. Drill pilot holes for their securing screws, too. To prevent scratching the veneer, mark each hole centre with the point of a scriber, centre punch or other sharp-pointed tool before drilling.

That completed, the glueing comes next. You'll need a large, flat area to work – the kitchen table or loungeroom floor, for example. Put down newspaper to protect both the cabinet and your work area. The cabinet sides come as a continuous piece with the four panels separated by V-cut grooves. Lay one out and note which are the two side panels (the longer ones), and which is the top and bottom. The bottom is the short piece at one end so that, when the cabinet is folded up, the join is at the bottom.

Run a generous bead of PVA glue into each V-cut and the rear panel rebate channel, but not the front panel rebate. Run a bead of PVA glue over the end cuts, too. Place the rear panel, with the port hole downwards, onto the top panel – note that the rear panel sits flush with the side panel edges. Then carefully wrap the sides around the rear panel, taking care not to stress the corner joints. Press the final corner parts together and hold the corner in place with several strips of masking tape run from panel to panel. If a little PVA glue oozes out of the joints onto the veneer, you can wipe it away immediately with a dampened cloth or paper "wipe" (e.g: "Chux" wipes). ▷

Steps in assembling the "flat pack" cabinets.





1. Lay out the long continuous side piece and rear baffle on a flat surface and run PVA glue into the three V-cuts, the two ends and the rear baffle rebate channel.

2. Wrap the sides around the rear baffle. Terminal block hole uppermost, port hole downwards.

3. Hold the final corner together with masking tape.

4. Install the crossover and place the Dacron filling inside the box. Run glue around the front baffle rebate and install the ready-prepared front baffle.

Or, it is easily peeled off once the glue has dried. The cabinet should be left for up to an hour for the glue to set.

Meanwhile, you can tackle the grilles. You will have two grille frames and two pieces of grille cloth. In each case, tack the grille cloth along the long side of the frame, stretching it as you do so. Then stretch the cloth across the frame and tack it in place on the other side, stretching it keep it smooth. Then tack the two ends down, making sure the grille cloth is smooth across the front. Cut off the excess cloth. Insert the female plastic grille studs into the four holes on each frame. You may need to gently tap them in with a hammer. The "vifa" emblem is glued in the top left hand corner.

When the cabinets are ready, make sure that all the joints are airtight by running a line of silicone sealant around all inside corners before mounting the drivers. Then mount the crossover components on the base of each cabinet using hot-melt glue, Araldite or similar. Note that the capacitor actually comprises two capacitors wired in parallel – a 2u2 and a 470n (0.47u). It is a wise idea to solder leads to the crossover components before glueing them in place. Heavy duty figure-8 flex is used for this, having a "trace" marker on one wire. The marked wire should be used for the "+" connection from each driver and the "+" connection to the terminal block.

The resistor and (composite) capacitor should be connected in series by soldering one lead of each together. Then solder a marked wire to the remaining lead of the resistor and an unmarked wire to the remaining end of the capacitor. Solder marked wires to each end of the coil. All these wires should have sufficient length to reach outside the holes where they will be terminated to the other components – the two drivers and the terminal block. Lengths of about 300-350 mm should be adequate. Cut a sticky address label or something similar into strips and write the termination point of each wire on them, then attach them to the end of each flying lead so you will later know which wire's which.

Now turn your attention to the front panels. Press or gently tap the male plastic grille studs into place. Put the foam sealant tape around the rebate where the driver rims will be seated. Mark the screw hole positions by pressing a sharp point through the tape. Put the Dacron filling material inside the box now. Run a generous river of glue around the front panel rebate channel of each box. This has to provide a good, air tight seal, so be generous. Then press each panel carefully into place, making sure the tweeter hole goes to the top of the cabinet.

Pull out the wires now and terminate them to their respective components. The tweeter leads should be pulled through the tweeter hole, woofer leads through the woofer hole, and so on. Carefully solder the lead ends where each should go, making sure you get the driver and terminal block connections the right way round else your loudspeakers will sound decidedly "off"!

One marked lead from the coil and the marked lead from the resistor should terminate to the red (positive) terminal of the terminal block. The other marked lead from the coil connects to the positive terminal of the woofer (marked with a spot), while the unmarked lead from the composite capacitor goes to the negative terminal of the tweeter. Run an unmarked lead from the negative terminal of the woofer, and a marked lead from the positive terminal of the tweeter (marked with a "+") to the black terminal (negative) of the terminal block. Check your wiring once it's finished, then screw the two drivers and the terminal block in place. Put sealing compound around the inner rim of the terminal block as well as the inside of its hole in the rear panel. Remember, these places must have an airtight seal.

Now you can screw the port assembly in place. Sealing compound should also be placed around the inside and rim of the port hole to seal it, too.

Do a final check. When you're sure everything is together correctly, hook them up, select some music – sit back and enjoy your new speakers. We're sure you'll be impressed.

In use

The potential applications for the SA-50 are enormous – as well as a "main pair" in the home, they could be used for extension speakers, suspended from the ceiling, in bookshelf applications, surround sound speakers, automobile and marine installations – or anywhere you need music!

The SA-50s are ideal for use with power amplifiers with output power rated at between 15 and 50 watts. With unit rated towards the higher powers, it is advisable to use a speaker protector, or at least an amplifier clipping/fault indicator (e.g: the AEM6508, published in the June 1987 issue). Any amplifier which is run into clipping for a short period is capable of damaging the tweeter voice coil of any loudspeaker, so the latter unit is a wise precaution, at the least.

If the SA-50s will not be located on a bookshelf, then it is essential they be accommodated on stands to raise the tweeters so that they're at ear level at your usual listening position. A variety of speaker stands are available on the market and you should obtain a pair to suit.

WHERE TO GET THE VIFA SA-50 KIT

ACT
Brashs
168 Melrose Drive
Phillip 2606
(062)81 5255

NSW
Jaycar Electronics
Cnr Carlingford & Pennant Hills Rds
Carlingford 2118
(02)872 4444

115-117 Parramatta Rd
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St Peters 5069
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Eagle Electronics
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West Melbourne 3003
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Melbourne 3000
(03)663 6151

Ritronics
425 High St
Northcote 3070
(03)489 8866

Jaycar Electronics
45 A'Beckett St
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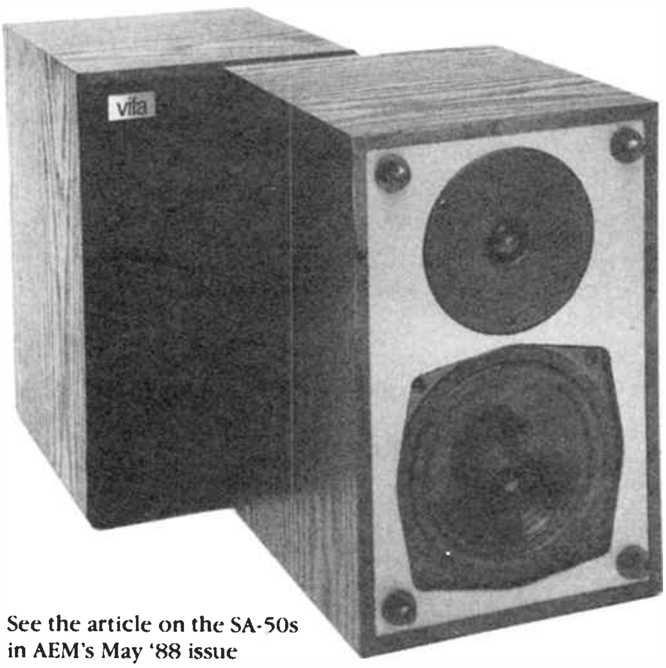

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For safety's sake, build this mains socket checker

Jonathan Scott
Brereton Samuel Research Pty Ltd

Plug this unit into any mains socket and it will tell you, unambiguously, whether power is available, whether it's correctly or incorrectly wired, and the existence of Earth line faults.

Our Mains Socket Checker will test if a mains outlet is working and if it's safe. Just plug it in and throw the switch! Four LEDs indicate the various conditions. The prototype was housed in a locally available plug pack case made by Atco and sold through Jaycar stores.

DO YOU *KNOW* if the mains outlet sockets in your house are correctly wired? If you're the lucky owner of a caravan or campervan, do you *know* if its mains outlets are correctly wired? Even if they are, how about the mains outlet you plug into at the campsite, is *that* correctly wired (– see the panel here)? A number of potentially hazardous situations may arise if a mains outlet socket is incorrectly wired or a fault condition is present.

Commercially available mains outlet checkers for domestic use comprise three neon indicators mounted on the front of a round plastic housing with the prongs of a three-pin mains plug protruding from the rear. The idea behind a mains socket checker is that, by plugging it into any mains socket and throwing the switch, it will indicate if the outlet is operational and safe. The indications provided by these neon checkers requires some interpretation, and they do not detect all the possible faults which can arise.

This novel project will detect all the conditions of any significance and it presents the results quite unambiguously using four LEDs. It is housed in a plug pack case made by Atco and sold through Jaycar stores (cat. no. HB-5950). The circuit uses only one cheap IC and a few resistors, diodes and capacitors. Further, it can be made very sensitive to Earth-Neutral voltages if desired, so that it will pick up even minute Earth return line voltages, which are caused by faults.

Consider the problem: In a correctly wired power point in a properly functioning building there will be full mains voltage between the "Active" and "Neutral" connections and a low impedance path from the "Neutral" line to the "Earth" line, across which a little, but not much, voltage is dropped. However, a number of fault conditions can arise. The significant ones being:

An Active-Neutral swap. This is perhaps the most common fault encountered. Fortunately it is not usually dangerous in itself, though it can mean that somebody who does not know what he is doing or does not abide by the Australian standards has wired the socket, so something else might be dodgy as well.

An A-N swap merely means, at the appliance, that there is a voltage from the so-called "Neutral" connection to Earth as well as to Active. Since the Neutral connection should be as well isolated from the person using the appliance as the Active, there ought to be no danger. (But see the story in the panel!)

There is often an A-N swap introduced by an elderly double adapter or an incorrectly wired extension cord (which may be a relatively common problem if hand wired).

An open circuit (high impedance) Earth connection. This situation will not affect operation of a correctly wired

TWO WRONGS MAKE A. . .

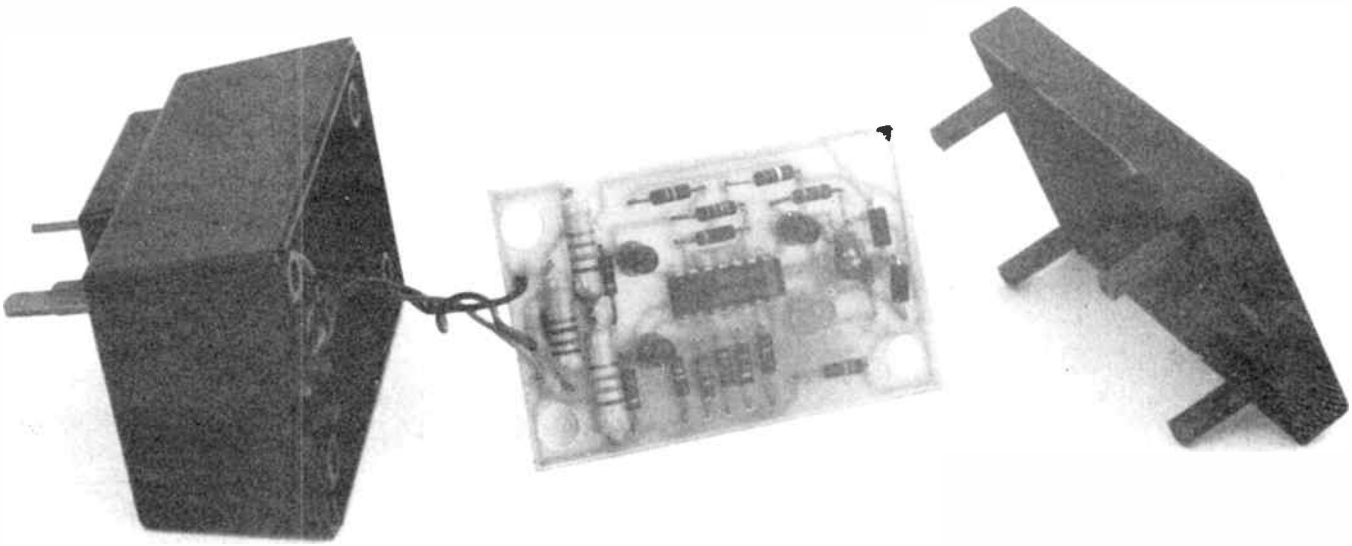
In the Wireless Institute of Australia journal, *Amateur Radio*, Roy Hartkopf tells the story of how an incorrectly wired electric griller and the transposition of Active and Neutral in the power outlet of a caravan park led to a potentially lethal situation.

A family took a holiday in their caravan, taking the aforementioned griller with them. The griller had worked for as long as all could remember. But, at a certain caravan park it refused to work. It seemed the element had gone open circuit. As a multimeter was on-hand, a check was made. All OK. As the griller had worked at a caravan park where they'd stayed earlier, what could be wrong? Checks showed that the Neutral lead from the griller's power cord was actually connected to the frame, not the Earth lead, which was connected to one end of the element.

The caravan park's mains outlet had the Active and Neutral lines swapped, thus connecting the Active directly to the griller's frame; the switch – which should have isolated the appliance – now being in the Neutral line. A toaster, also used in the caravan and adjacent to the griller, was correctly wired.

There was thus **live 240 Vac present between the frame of the griller and the frame of the toaster!** – confirmed by connecting a 240 V test lamp between them. A lucky escape.

– A.R., April '88, p.10.



All the components are mounted to the single printed circuit board which fits behind the 'top' of the case with the LEDs protruding through holes drilled for them. The board is held in position by the securing shafts which protrude from the case top (right).

appliance at all, but it totally cancels any safety measures which rely on the Earth system. This is very dangerous.

Many newer appliances are "double insulated", which merely means that they have two bits of insulation (plastic, usually) between you and the Active. Such appliances often have no Earth pin at all.

On the whole, the appliances which fall into the category of not having any Earth connection are small robust devices in a sturdy plastic housing. All other appliances have the Earth connection purely for your benefit. If the socket does not provide it, then you have less protection than with a double insulated appliance. (And we're not all that crazy about them anyway).

An open Active or Neutral line. The immediate upshot of this is that something plugged into the socket won't work. An appliance which did work would be wired wrongly, as it would have to be using the Active-Earth potential to operate (a no-no; see below).

Excessive voltage dropped across the Neutral-Earth impedance; usually due to excessive loading elsewhere in the system. This is a very subtle and nasty possibility indeed.

Modern wiring practice calls for the main circuit board in a house to carry an Earth-Neutral link. This ensures that the house Earth circuit and the house Neutral circuit both actually represent the same (Earth) potential. However, this is the only place that they meet, so that one failing leaves the other intact. Older houses do not necessarily have this arrangement.

In old installations* an appliance with a leak to Earth can cause sufficient current to flow such that it will raise the Earth connection at the plug well up from true zero volts, especially if the Earthing is not effective or the ground is very dry. In all sorts of buildings, a heavy current being drawn through the Neutral cabling can drop a significant voltage across the wires alone. Either case raises the Neutral and Earth potential.

If the Earth voltage really is raised from true Earth, you could get a shock between true Earth (like a sink) and the appliance Earth (such as from the case of a toaster). If the Neutral line is raised above Earth it means that the Neutral wires are dissipating a lot of heat, vastly increasing the fire hazard. Either situation signals something wrong.

Low impedance from Earth to Active instead of Earth to Neutral. This is a very rare situation, thank goodness, because it is the most deadly. It can only arise if there has been a serious error, because the Earth terminal must be connected directly to the Active circuit, and not anywhere to the correct Earth circuit. Were it to occur, shock hazard of full mains potential exists between all Earthed equipment such as fridges, toasters, electronic gear, etc, and true Earth, such as floors, water pipes, etc.

The interesting thing is that this condition is indistinguishable to any socket checker from the A-N swap condition above. Imagine being inside a black box with all the test equipment you like, and having three connections labelled A, N and E. There is no test you can apply that will tell you what the real Earth potential is.

In the project described here, the confusion arises because the checker cannot know what the *real* Earth potential is unless it has a stake in the ground, which is a bit impractical. (We considered adding this for a while. If not a stake, we could have run a wire out of the plug pack to, say, an alligator clip. This would allow the two problems to be distinguished, but then we would rely on the checker to be properly built so that IT didn't represent a hazard, and the wire would mostly be a nuisance. On balance, the extreme rarity of the E-A short made the decision.)

So in a nutshell, the project is a simple plug pack case with four LEDs indicating:

a) Mains available and enough to operate the checker (should be on);

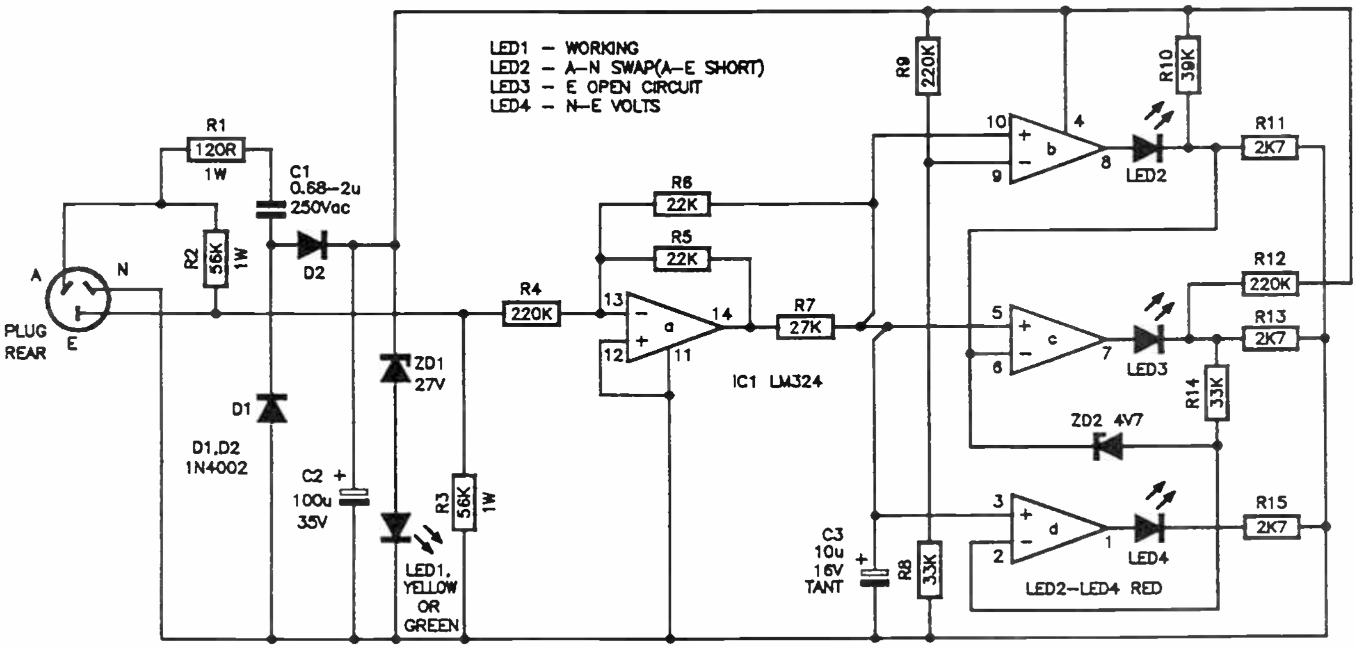
b) A-N swap;

c) Earth open circuit;
and

d) large N-E voltage;

the last three should all be *off*. ▷

*(*I have lived in a very beautiful house which was so old that it had a main circuit breaking switch that was designed for dc! The wiring was insulated with cloth and rubber, there was a very uncertain connection to the land below and, of course, no N-E link*).



Construction

What makes this project viable is the availability of (an Australian made) fully insulated plug pack case, and we suggest that you use it. This is because it provides a very safe way of building the project, and the finished item is safe to use, even if not built particularly expertly.

We also strongly recommend that you use the printed circuit board design presented here as this makes construction simple and virtually guarantees that if you can follow a wiring diagram, you can get a working result.

The pc board has four large pads to allow for the posts inside the case. Two of these are surrounded by the Earth connection, one by Active and one by Neutral. This fact is not of particular merit in the plastic case we suggest you use, but it may be useful for anyone planning to construct in their own way, as these are the three sole external connections required to the pc board. The LEDs are positioned squarely across the board, so they are in suitable positions to poke directly through the front face of the plug pack.

CIRCUIT OPERATION

The circuit is comprised of four functionally separate sections:

1) A power supply circuit which derives a 32 volt rail to run the electronics;

2) A network to 'load' the Earth line appropriately;

3) A full wave rectifier and op-amp averaging circuit which produces a dc voltage related to the prevailing Earth-Neutral voltage;

4) A set of comparators and decoding logic, employing a three op-amps, which indicate the condition implied by the resulting Earth-Neutral voltage.

I shall first describe the logic upon which the Checker operates, then discuss these sections of the circuit in turn.

Consider the problem: In a correctly wired power point in a properly functioning building there will be full mains voltage between the "Active" and "Neutral" connections and a low impedance path from the "Neutral" line to the "Earth" line, across which little voltage is dropped. However, a number of fault conditions, outlined in the main text of the article, can arise. These are:

1) An Active-Neutral swap;
2) An open circuit (high impedance) Earth connection;
3) An open Active or Neutral line;
4) Excessive Neutral-Earth voltage;
5) Low impedance from Earth to Active instead of Neutral.

As noted in the main text there is no way to separate (1) and (5) by measurements made without a guaranteed connection to Earth, but with the circuitry here all the others may be distinguished.

The Active-Neutral swap condition will result in the "Earth" line and the "Active" line being at the same potential (really, Neutral potential) and thus the circuit will see full line voltage on the "Earth" connection with respect to the "Neutral" one. In fact all it has is the Neutral line raised to Active potential.

If a network is provided to "pull" the Earth connection towards a potential half way from Active to Neutral, and it can do this, then the Earth connection is not securely connected (to either Active or Neutral), and the unit will see half line potential on the Earth connection with respect to the Neutral.

If the building Neutral return is dropping a voltage due to excessive loading, the "true Earth" will be a few volts away from the Neutral and we will see this small voltage (with low source impedance) at the terminals of the Checker.

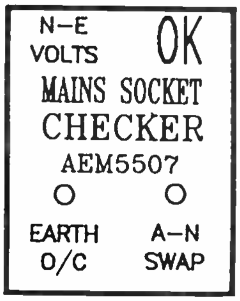
Finally, if either Active or Neutral is open, no power will reach the checker (or any other appliance), so we will not have the power to operate.

R1, C1, D1, D2, C2, ZD1 and LED1 form the power supply. When the Active line goes positive with respect to Neutral C1 charges, via D2 and C2, to the peak line potential. When the Active line goes negative, D1 allows C1 to be discharged and reverse charged in preparation for another cycle. When C2 reaches the desired operating voltage of about 32 volts, ZD1 conducts and shunts the extra charge away via LED1, which illuminates to indicated that the unit is receiving adequate energy to operate.

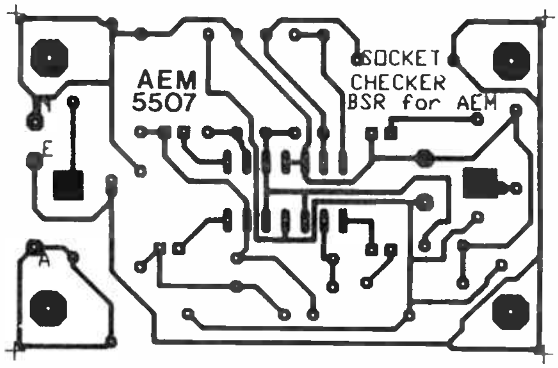
The values are chosen so that the unit will operate even with the low voltages which sometimes occur in country or beach properties some distance from the main distribution line. R1 is included to prevent large currents arising which could flow at the instant of connection, possibly damaging the circuit.

Resistors R2 and R3 together present an equivalent voltage of about 120 volts with an impedance of about 28k, to the Earth line. If the Earth connection is sound, the few milliamps this imposes on it will have no effect, but if the line is open, half rail voltage will appear on the Earth connection to the circuit, allowing the "Earth O/C" condition to be identified.

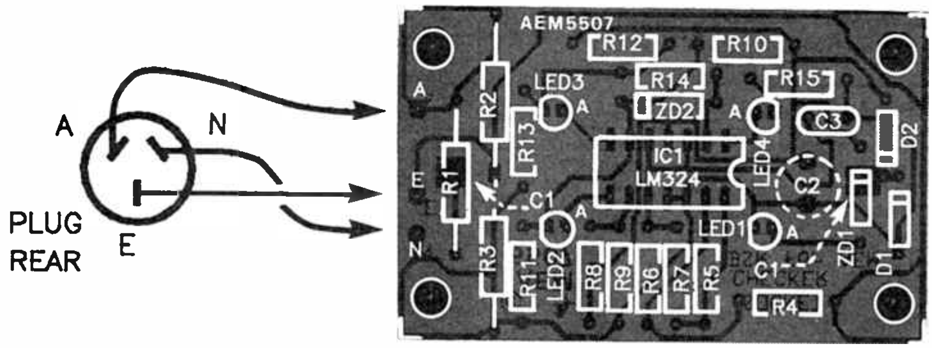
Resistors R4 to R7, together with C3 and IC1a, form a full wave rectifier and averaging circuit. When a positive voltage appears on the Earth line, the output of the op-amp clamps to "0 volts" (which is actually the "Neutral" connection). Charge flows via R6 to C3,



Full-size reproduction of the 'front panel' label.



Full-size reproduction of the pc board artwork.



Component overlay, showing the placement of the components on the printed circuit board. Note how the board is wired to the three-pin plug disc from the plug pack case.

AEM5507 PARTS LIST

Semiconductors

D1, D2	1N4002, 1N4004 etc
IC1	LM324
LED1	Yellow or green 5 mm LED
LED2-4	Red 5 mm LED
ZD1	27V, zener 400 mW or 1 W
ZD2	4V7, zener 400 mW or 1 W

Resistors all ¼ 5%, unless noted.

R1	120R, 1W
R2	56k, 1W
R3	56k, 1W
R4	220k
R5	22k
R6	22k
R7	27k
R8	33k
R9	220k
R10	39k
R11	2k7
R12	220k
R13	2k7
R14	33k
R15	2k7

Capacitors

C1	0.68-2u/250 Vac
C2	100u/25 V electro.
C3	10u/10 V tant.

Miscellaneous

AEM5507 pc board; hookup wire in red or brown, blue or black and green or green-&-yellow; Atco plug pack case (Jaycar cat. no. HB-5950); Scotchcal label.

Estimated cost: $27-$32

charging it positively. When the input (Earth line) goes negative, the op-amp output goes positive forcing a virtual Earth at its inverting input, again charging C3 positively, this time via R7. Values are chosen so that about 7 V results for full mains input.

The op-amp driving LED2 (IC1b) compares the averaged voltage with a fixed fraction of the supply provided by R8 and R9. If the Earth voltage is more than about 180 volts with respect to the Neutral line, the condition indicated is that of A-N swap (or possibly E-to-A linking) and LED2 lights.

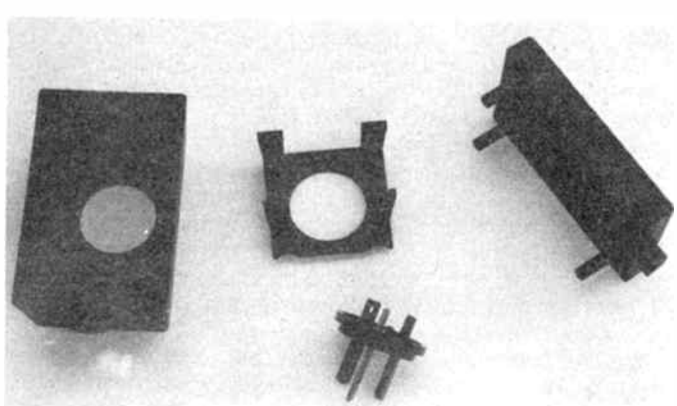
If LED2 is not illuminated, it is reverse biassed. In this case, R10 and R11 set the comparison level for the op-amp associated with LED3. This op-amp will turn LED3 on if the input potential exceeds that level which indicates that about half rail is present on the Earth connection, which is what we said represented an open circuit Earth line condition. Thus, LED3 illuminates if the Earth line is open circuit. If LED2 is turned on, then the inverting input of this op-amp is pulled up towards full rail. This causes LED3 to be turned forcibly off if LED2 comes on. Likewise, ZD2 will shortly be seen to shut of LED4 if LED2 comes on, so that the display is never ambiguous.

If LED3 is off, R12 and R13 set a comparison level at which the IC1d will turn on LED4. If LED2 is also off, this level is carried to the inverting input of IC1d via R14. A small but significant input voltage between Neutral and Earth will turn on LED4, warning of the N-E voltage condition. Should either LED2 or LED3 be turned on by its respective op-amp, The comparison level of IC1d is pulled high, guaranteeing that it will not turn on as well.

The value of R12 sets the voltage at which the E-N voltage warning is issued. I have chosen a warning value (about 10 volts) which is small enough to guarantee that such will not cause harm, and which represents a tolerable dissipation in a Neutral return. If you wish to be informed of a smaller level, doubling or quadrupling R12 will halve or quarter the sense level. The E-N voltage in a domestic installation should not really exceed a couple of volts in normal circumstances.

The first thing to do is prepare the pc board. It probably comes with only small holes in the four corner pads. These will have to be drilled out to about 6 mm diameter so that smaller diameter posts that hang down from the the case's 'top' will pass through, but not the shafts that rise from inside the main body of the case.

When you open the plug pack case you will see that the top is held on by four screws which will live at the bottom of deep holes in the main body of the case. The holes are inside wide shafts rising from the base of this part of the case. These ▷



The four pieces of the Atco plug pack case. The main body, or bottom, of the case is at left and the top piece at the right. Between them are the three-pin plug disc (front) and securing bracket (rear). A three-way screw terminal and a piece of insulation are also supplied, but are not needed in this project.

shafts slip over the narrower shafts protruding from the case's top. The pc board will be held in position by the four narrower shafts from the case top passing through the four holes drilled in the corners of the board. Once drilled, check that the board slides over these shafts.

The second step in construction is to drill the four holes for the LEDs in the top of the plug pack case. The blank pc board can be used as a marking template. Slip the board over the lid shafts and up flush against the case top. Locate the LED mounting holes (they are pairs of square pads) and, with a scribe or pin, mark the lid *through* the LED mount holes. Then remove the pc board and drill the lid to take the four (5 mm diameter) LEDs. We did not use LED bezels on the prototype as they are unnecessary.

At this stage, it would be wise to check the pc board, whether you have a "bought one" or have made your own, to see that all holes are drilled and of the correct diameter. Note that several pads on the board are there to permit mounting capacitors C1 and C2 on the rear (track) side. Check that there are no small breaks in tracks or "fingers" of copper likely to short to adjacent tracks or pads, particularly around the IC.

Now turn your attention to the bottom of the case. Remove the plastic retaining bracket clip and the plug disk. Solder wires of about 150 mm length (6") to the three terminal prongs of the plug. Use red or brown for Active, blue or black for Neutral, and green or yellow-green for Earth, to adhere to the standard colour coding. Note that the *Active* connection is the *top left* one when you are facing a wall socket with the radially aligned *Earth* prong at the *bottom*.

The case is designed so as to allow the prongs of the plug to move through 180 degrees, so that the case can swivel once in the socket. The prongs are fixed in a disk, but the disk is free to rotate in a track in the case. The problem with this is that the springy plastic clip which is designed to hold the disk in place, can slip out allowing the plug part to fall back inside the case.

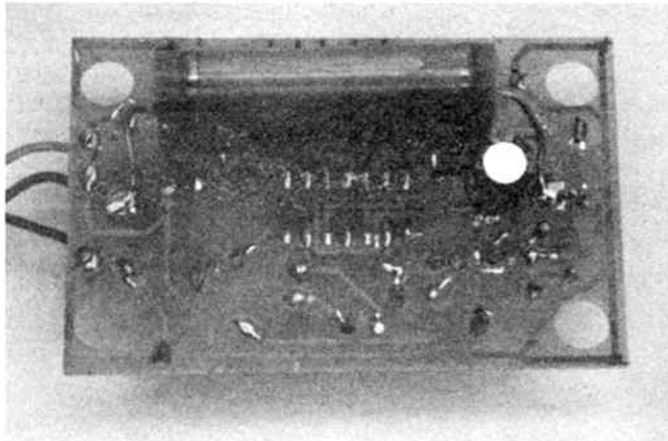
Either the plastic bracket, or the disk, must be secured with glue. We suggest that you use Superglue, Locktite or similar. We glued the disk in place, and this has proved quite OK. You might like to glue in the clip as well, or if you want to be able to swivel the plug, just glue the clip, leaving the disk free. In any case the consequences of losing the plug into the case is unlikely to be catastrophic, just a nuisance.

Now return to the pc board. Fit first the four LEDs, taking care to see that they are inserted the right way around. The 5 mm LEDs we used had spacer lugs on the leads, so that they sat spaced correctly from the board when inserted as far as they would go. The spacing must be such that the LEDs are visible but not crushed when the pc board is pushed towards the lid by the wider shafts of the case bottom, and spaced away from the lid by IC1. Once the LEDs are in place check that they pop through the holes in the case top when the board is pressed up against it by the closing of the case.

Next, fit all the components except C1 and C2. Be sure to get the diodes, C3 and IC1 the right way round.

Because C1 is likely to be as large as all the other components put together, it is meant to be soldered to the copper side of the board. C2 will not fit on the 'top' side of the board either, so it was also slung off the back of the pc board. Fit these two components last. Ensure that C2 is oriented correctly as it's polarised. Remember that there will be plenty of room inside the case. Slip "spaghetti" insulation over the exposed leads of C1 and C2 before soldering them in place.

Connect the three leads from the plug to the pc board. Be careful to get these the correct way, too, or you will get the wrong answers! Close the case, and screw it shut with the self-tapping screws supplied.



Capacitors C1 and C2 are mounted on the rear of the pc board. It's a good idea to slip spaghetti insulation over the leads of at least C1. Note that C1 may take various forms – with axial leads (as the one here has), or radial leads. Two capacitors of lower value, such as two 470n (0.47u) capacitors may be used in parallel to obtain a suitable value within the range 680n (0.68u) to 2u.

A label should be used on the front panel and full-size artwork that may be used to make a Scotchcal label is reproduced here. Kit suppliers may supply a Scotchcal. This should be fitted to the case top after it has been drilled. You'll find it easier to align in position if you first soak it in a little water, and wet the case before applying it. Once in place, the LED holes may be cut out with a scalpel or other sharp, narrow-pointed knife.

Make a last check of everything.

Using your Mains Socket Checker

The Mains Socket Checker could not be simpler to use: Plug it into the socket, and turn on. If the non-red (yellow or green) LED comes on, there is power available. If anything else comes on, don't avail yourself of the power! Call a licensed electrician and get the problem fixed.

If you want to be picky about it, you could take note which warning you are getting. An A-N swap (which is almost certainly going to be the case if that LED comes on) is really not very harmful (in itself, but note the warning in the panel earlier), so you could carry on until you can have the problem seen to – *EXCEPT* if you have your project plugged into the socket on the end of an extension lead. The fault may be either an A-N swap OR an E-N swap, which is potentially dangerous.

If it is the E-N volts LED that lights, then you ought to know to direct your complaint in that direction, because although the particular socket you are testing shows the symptom, it may be elsewhere in the house that the actual problem lies. (Like in your teenager's room where there are six floodlights, three radiators, two radios and a Christmas tree plugged into the one power point.)

It is not the place in this article to begin describing what to do about a problem if you have one. If you do not already and officially know what you are doing, get someone who does. The National grid has a swift if messy habit of pruning the number of amateur electricians – go check the death statistics at the government statisticians office if you don't believe us.

Be content you have found a problem, and get it fixed – swiftly.

Build the Datamodem M1200

Nigel Kukulka
Datacom Computers

Here's a straightforward direct-connect modem that's ideal for "starters" in the data communications stakes.

THERE'S NO DOUBT about the popularity of modems and data communications. Witness the proliferation of dial-up data services ranging from the privately-run bulletin board systems (now numbering over 100 Australia-wide) and networks, to the professional services such as that offered by Elders and Telecom's Viatel.

If you're wondering what the fuss over data communications is all about, then you've clearly never had the opportunity to sample the delights and advantages available. Telecom's Viatel remains the most popular public videotex service in the world, offering a huge range of services to both personal and business users too numerous to list here. Check it out at your nearest Telecom business office.

But for enthusiasts, it's the private bulletin boards and networks that offer the most scope. You can call up a bulletin board and "tap into" a huge (that word's inadequate – *ginormous!*) range and variety of information and software. You can get technical advice and assistance, useful "utility" programs, games and other software. You can buy and sell things via a network of linked bulletin boards, exchange messages with other enthusiasts etc.

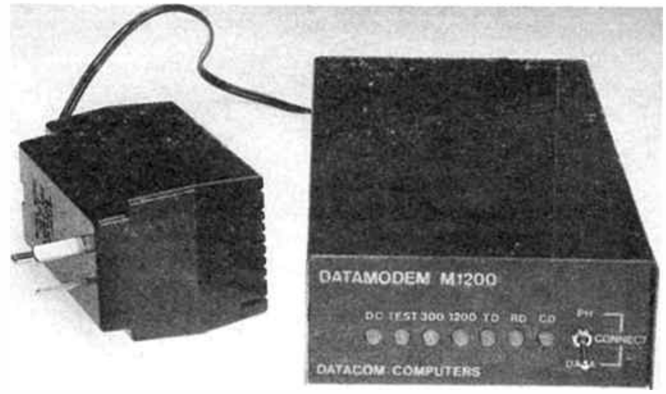
All this flows from the use of a set of data (or computer) communications standards (or "protocols") which specify how data is transferred from one system to another via a two-wire audio (voice frequency) link such as the public telephone network. These standards specify the use of various tones that represent the binary "on" and "off" signals used by computer systems, as well as speeds of data transfer.

The most popular data communications standards are known as "V.21" and V.23". These were set down many years ago by an international committee known as the "CCITT". Boiling it down, the V.21 standard applies to data transferred at 300 bits per second (or baud) to and fro between two systems. The V.23 standard is for systems where data is transferred in one direction at 1200 bits per second (bps) and 75 bps in the other direction.

The V.23 communications standard is used by Telecom's Viatel service. As subscribers predominantly *take*information ("download" is the jargon) from this service, the higher speed of 1200 bps is used to transfer the data from the Viatel computer system to the subscriber, while communications from the subscriber to the Viatel system is at 75 bps.

The private bulletin boards offer a range of communications standards, but by far the most widely used are V.21 and V.23. In the latter case, where a user may be downloading information, communications between the BBS (bulletin board system) and the user will be at 1200 bps, and between the user and BBS, at 75 bps. Where a user wants to send material to a BBS ("upload"), user-to-BBS communications is at 1200 bps and from BBS-to-user, it's at 75 bps.

But the BBS network and subscriber data services aren't the only uses for a modem. You can communicate with family, friends and acquaintances who also have a computer system and a modem. The beauty is, you don't have to have the same computer system at each end. Thus, a Commodore 64 and modem can "talk" to an Apple, a Microbee can talk to an IBM clone, etc.



FEATURES

- 300/300 and 1200/75 baud operation
- Constant speed, 1200 bps serial interface to computer
- Works with computers that don't run split speeds
- Ideal for videotex (e.g: Viatel) operation
- Full internal test facilities
- Complies with Telecom approval requirements
- "RJ"-type line connection sockets
- Seven status LED indicators on front panel
- Single printed circuit board construction
- Housed in sturdy metal case

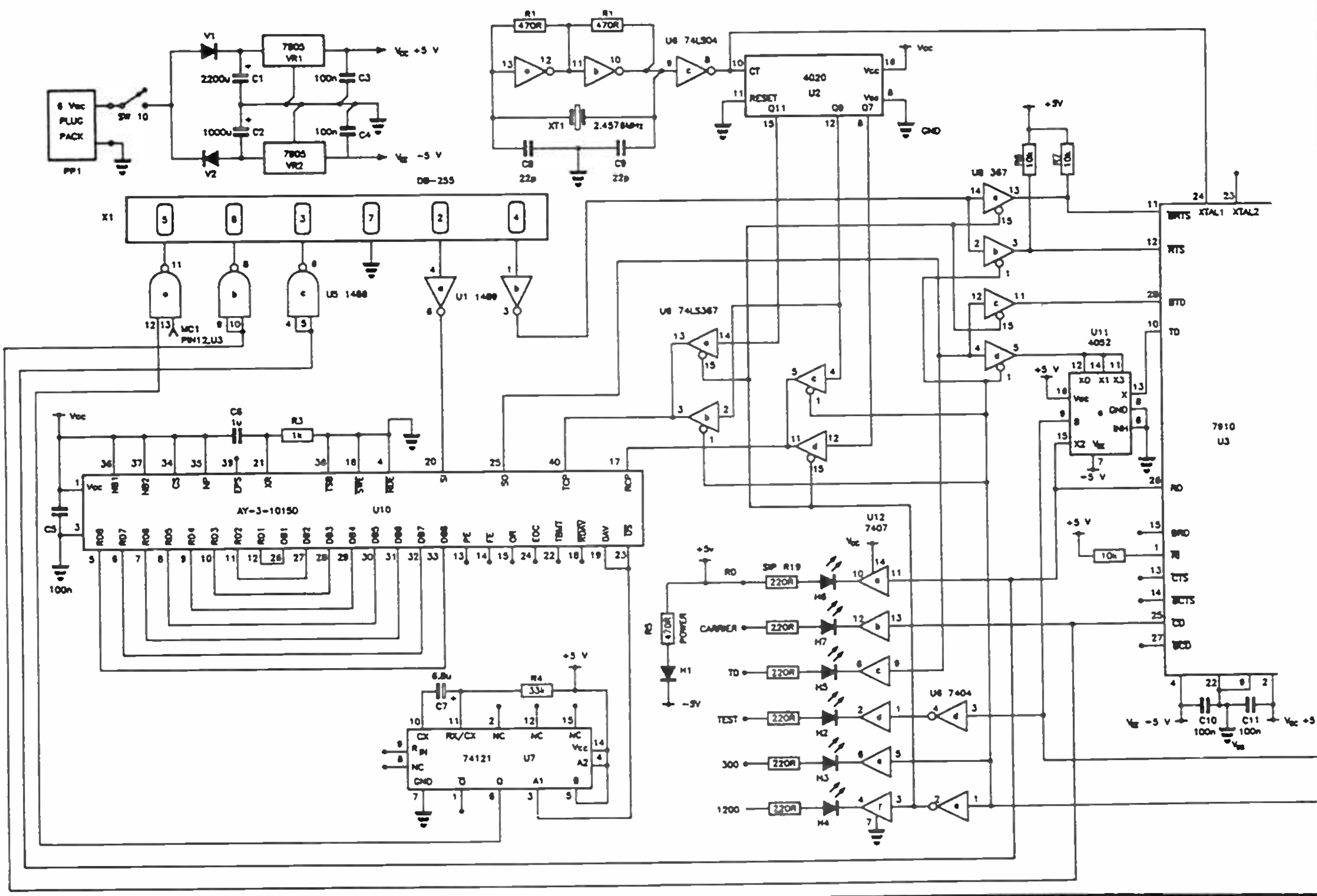
The snag

There's always a snag, and it's this. To send and receive data via a modem, the modem must be hooked into ("interfaced") with the computer via a serial link, or "port". Most computers either have one or it can be purchased as an add-on. The serial interface permits communications to and from the computer at set rates, which may be determined by software (the hardware does come into it, but let's not get complicated here). Some computers, particularly some very popular models like the Commodore 64 and the IBM PC and its many clones, have their serial port transmit and receive rates fixed at the same rate. That is, if you set the transmit rate at 1200 bps, the receive rate will be the same. Or, if you set it at some other rate, the transmit and receive rates are the same.

That's all fine and dandy until you want to connect a modem and use the V.23 protocol. If the computer can't "split" its serial port transmit and receive, rates you're up a well-known creek without paddle, modem, computer or data service.

The solution is to have the modem do the splitting of the transmit and receive data rates for you, providing a "constant speed" serial interface between the modem and the computer. ▷

This Star Project is from Datacom Computers of Bayswater in Melbourne. Complete kits are available for $199 tax paid, $179 ex. tax. Contact Datacom Computers, Private Bag 39, Bayswater 3153 Vic. (03)890 1661 ('phone orders only).



CIRCUIT DESCRIPTION

The modem design is based on the use of the now-famous '7910 "World Modem" chip.

A 2.4576 MHz crystal provides the main clock signals for the '7910 operation and is also sent to the binary counter U2 to provide the respective clocks for the UART.

The mode selection inputs to the '7910 are selected by the DIP Switch SW1-8, which is accessible from the bottom of the case. The PHONE/DATA switch, SW9, provides a ground to the input of the comparator IC4b which provides buffering to transistor V4 which drives the line relay, RLA2. SW4 also activates the DTR input, of the '7910, pin 16.

The analogue output to line from the '7910 TC (pin 8) is fed to a multiplexing IC, U11b, and is also capacitively fed to the duplexer circuit comprising op-amp, U4a with R8, R9 and R10.

A 125 mA pico-fuse, F1, protects the lines from any possible high voltage surges that may occur due to failure of the modem power supply.

Zener diodes V5 and V6 ensure that the signal peak transmitted to the line is no greater than 3.3 volts peak-to-peak.

Transformer T1 provides the necessary isolation barrier, between the modem and the telephone line. It also ensure that proper termination of the (nominal) 600 Ohm line impedance exists. RJ sockets X2 and X3 are wired for flexibility in connecting the line and and a handset.

RLA-2 is a DPDT relay, rated to meet Telecom specifications. The line is required to be switched on both sides, so that the handset or modem is completely disconnected from the line while the other is connected to the line.

Returning to the main circuit of the modem, U11 is a multiplexing IC that is used to switch the analogue and digital signals during loopback test modes.

During analogue test mode the transmitted data passes through the modem out the TC output (pin 8) through the multiplexer (U11b) and back into the modem chip, via RC pin 5 and back into your terminal/computer.

During digital loopback, the received carrier signal from the telephone line passes through the modem IC, out RD pin 26, through the multiplexing U11 and back into the modem chip, via RC pin 5 and back into your terminal/computer.

During digital loopback, the received carrier signal from the telephone line passes through the modem IC, out RD (pin 26), through the multiplexing IC (U11) and back into the '7910 via TD (pin 10) then back out to line via the duplexer circuit.

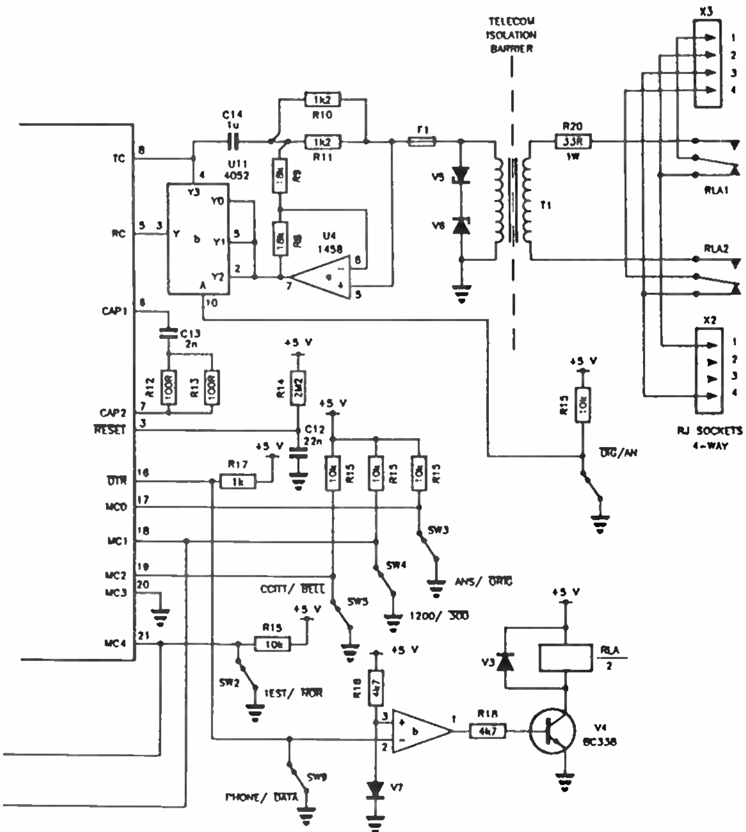
During test mode, the PHONE/DATA switch should be set to data, to enable the line relay and the modem's internal circuits.

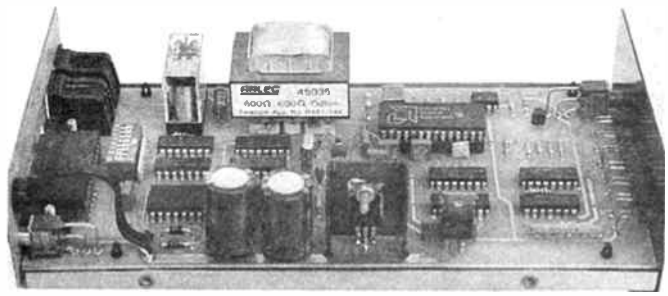
U1 and U5 provide two-way level conversion between the RS-232 connector, X1, and the TTL levels required by the '7910 and associated circuitry.

U1 pin 4 is the RTS signal from the terminal/computer. When this signal is asserted, a low is placed on the RTS input to the '7910 on pin 11, turning on the transmitter. Assuming a call is established, with DTR pin 16 low and TD pin 10 clamped high, a constant carrier will be transmitted to line. Data entering the modem via U1 pin 1 will pass through the baud rate converter and digital switch to the '7910 TD input (pin 10). As this TTL signal changes state, the carrier switch will change also, depending upon the mode switch settings.

The received signal from line is fed via pin 26 of the '7910 to pins 4/5 of the 1488 RS232 line driver (U5) to the terminal. The data does not pass through the baud rate converter circuitry. Pin 25 of the '7910 provides the carrier detect signal which is passed directly to the RS232 connector via the 1488 line driver. This signal may be used by the terminal if required.

Finally, U5 pin 12 has a signal derived from the baud rate converter (U10) and output onto pin 5 of the RS232 connector as Clear-to-Send CTS). This signal should be used by the terminal during opera-





Inside view of the M1200. This is the prototype; pc boards supplied with the kits are solder-masked both sides and have a silk-screened component overlay on the top side.

tion in the 1200/75 mode.

Now we come to the baud rate converter, consisting of the UART, U10 (an AY-3-1015D UART), a one-shot (U7) and the frequency divider U2. The UART is strapped for 8 data bits, no parity and 1 stop bit. This is the common protocol used.

Serial data from the 1489 line receiver is fed into the UART's serial input, pin 20. When a full character is receiving the DAV output of the UART triggers the one-shot, U7. The output of the one-shot, pin 6, is fed to the AND gate of U5 line driver pin 12. If the gate is enabled by a high on U5 pin 13, the CTS line to the RS232 connector and terminal will be disabled indicating to the terminal to cease transmission. Remember, when in the 1200/75 mode the terminal is transmitting to the modem at a speed of 1200 bps. Thus, with respect to 75 bps, a relatively long time delay is required. However, when using CCITT V.21, i.e: 300 bps, the CTS signal from U5 is disabled by SW1 and thus can be ignored; the serial data still passes through the bit rate converter U10, but it is effectively transparent to the signal.

The output of the UART, pin 25, is fed to the electronic switch comprised of U9. Here, the serial data is fed to either the TD or BTD input depending on the mode of transmission.

Different clock speeds for the UART are selected from the frequency divider U2. The outputs providing 1200, 300 and 75 bps are fed to the electronic switch U8, which in turn feeds the selected clock speed for the UART's transmit and receive clock inputs.

The 74LS07, U12, provides current sinking for the display LEDS. The respective signals are fed to the 74LS07 to the LEDS which make up the front panel display and are quite self explanatory.

Power is supplied from an ac plug pack rated at 6 Vac at about one amp. SW10 allows power to the modem to be turned off when not in use. V1 and V2 half-wave rectify the ac supply, C1 and C2 provide smoothing of the supply and VR1 and VR2 regulate the to ±5 V, respectively. Capacitors C3 and C4 provide some decoupling of the regulated output before being fed to the circuit.

The M1200

While many low-cost build-it-yourself modems have been described in recent years, there were none which overcame this basic problem, I noticed. Being keenly interested in data communications, I set about rectifying the problem and this modem is the result.

The M1200 is based on the deservedly popular and widely used '7910 "World Modem" chip which provides for the CCITT V.21 and V.23 communications protocols, among others which are little used in Australia, if at all. I teamed it with a low-cost, readily available "universal asynchronous receiver-transmitter" (UART) IC, the AY-3-1015D, which does the work of handling the serial interface baud rates, maintaining a constant speed of 1200 bps to and from the computer, but splitting the rates into 1200/75 bps, as required, to and from the '7910.

The table here lists the main features. The popular V.21 and V.23 protocols head-up the list, along with the constant speed serial interface. A full complement of modem "status" indicators are provided by seven LEDs on the front panel that show:

DC – supply on, modem operating

TEST – internal test mode actuated

300 – 300/300 bps operation

1200 – 1200 bps operation

TD – data being transmitted

RD – data being received

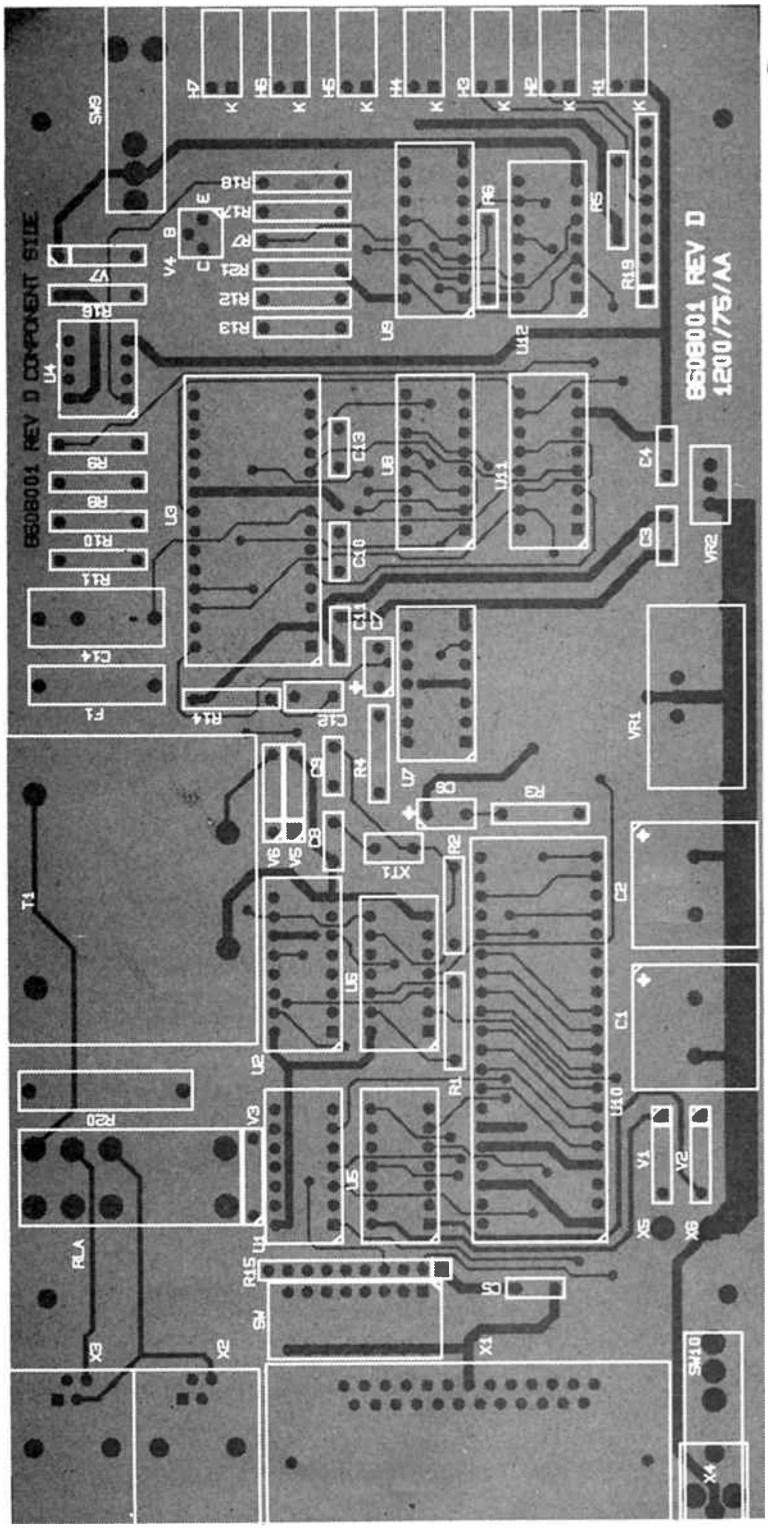
CD – "carrier detect" (communications established)

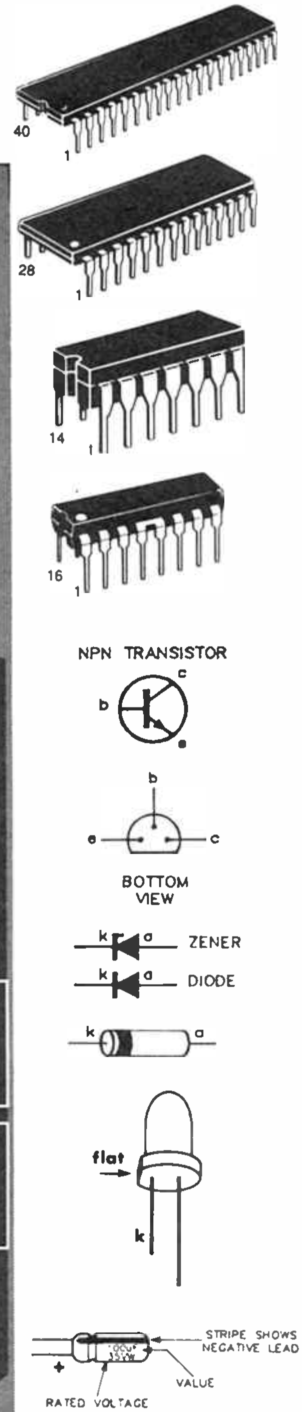
A switch, seen at the right hand side of the front panel in the picture, permits switching the modem on and off the line.

Two "RJ"-type sockets are provided on the rear panel to provide a simple, flexible arrangement for connecting the modem on-line. They can be seen on the left hand side of the panel in the rear-panel photograph. Two sockets are provided so that you can plug-in a pushbutton dial-type telephone handset for convenience, otherwise the modem is linked-in via a 'piggyback' double adaptor line connector. The line cable plugs into the socket on the far left of the rear panel, and the 'phone handset can be plugged into the socket next to this.

I designed the project so that all components would be mounted on a single printed circuit board as this greatly simplifies, obviates any external wiring and the possibility of wiring errors and complies with Telecom construction standards. The printed circuit board is double-sided with plated-through holes and is supplied with a solder mask on both sides and silk-screened annotation on the component side. All these features greatly ease construction, contributing to successful completion of the project with the least hassles. ▷

The serial interface provides for the use of a "straight through" RS232 cable between the modem and the computer. This means you can employ a low-cost ribbon cable with crimp-on DB25 insulation displacement connectors (IDC). This arrangement should suit the vast majority of serial interface requirements. With any modem, there are some functions which are used the majority of the time, and others which are used rarely, but convenient or necessary to have available. Rather than clutter up the front panel, and to keep its "normal" operation as simple as





M1200 PARTS LIST

Semiconductors	
V1-3	1N4002 diode
V4	BC338
V5, V6	3V3/500 mW zener
V7	1N4002 diode
VR1	7805
VR2	7905
H1	5 mm Red LED
H2	5 mm Yellow LED
H3-6	5 mm Red LED
H7	5 mm Yellow LED
U1	1489
U2	4020
U3	7910
U4	1458
U5	1488
U6	74LS04
U7	74121
U8, V9	74LS367
U10	AY-3-1015D
U11	4052
U12	7407
Resistors	all ¼ W, 5%
R1, R2	470R
R3	1k
R4	33k
R5	470R
R6, R7	10k
R8, R9	18k
R10, R11	1k2
R12	100R
R13	NOT USED
R14	2M2
R15	10K 6-pin SIP
R16	4k7
R17	1k
R18	4k7
R19	220R
R20	39R, 1W
R21	10k
Miscellaneous	
X1	25-pin DB socket
X2	NOT USED
X3	RJ socket, 6-pin
SW1-8	DIP switch 8-way
SW9	C&K 7101 PCB-mount
SW10	C&K 7101 PCB-mount
RLA	DPDT 5 V relay
T1	600/600 ohm line trans.
F1	125 mA picofuse
XT1	2.4576 MHz crystal
M1200	PCB Rev. D
M1200	Metal case and screws
PP1	6 Vac plug pack
G1	strain relief
HS1	TO-220 heatsink
PS1	4 x push-on feet
Capacitors	
C1	2200u/16 V electro.
C2	1000u/16 V electro.
C3	100n poly
C4	100n poly
C5	100n poly
C6	1u0/16 V electro.
C7	6u8/16 V N.P.O.
C8, C9	22p disc ceramic
C10	100n poly
C11	100n poly
C12	22n greencap
C13	2n2 greencap
C14	1u0 poly N.P.O.

Kit price: $199 inc. tax.

possible, I have provided selection of the lesser-used functions on a DIP switch mounted on-board and accessed through a cutout in the underside of the case. The accompanying table on "DIP Switch Settings" indicates their use. The modem will most often be used in the "originate" mode on "normal" operation, CCITT standards.

The unit is powered from a 6 Vac plugpack, supplied with kits. RS232 and line cables to suit your requirements are available as separate items as individual needs will vary.

Construction

Construction of the modem is relatively straightforward as long as you remember a few simple rules. Don't apply too much heat to the components as permanent damage to them is likely to occur and you will probably go off looking for a construction mistake during testing.

Check all the parts against the parts list provided as there may be substituted parts, especially if a different source of supply was used to obtain the parts. Don't worry about capacitor voltage ratings as long as they are above 16 volts, then its OK.

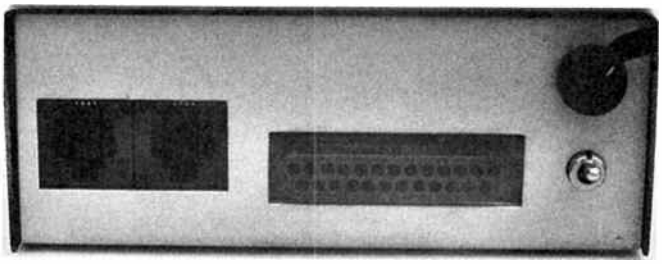
Start by populating the board with resistors and diodes, making sure of the orientation of the diodes; the little notch on the silk screened layout atop the board refers to the band around the diode cathode).

Next, put the DIP switch on the board – it goes on the rear (non-component) side – making sure that you place SW1 at the same end as the "pin 1" notch on the silk screened overlay. Now put the rest of the switches and plugs onto the PCB, the power switch has the shorter toggle shaft of the two switches.

Bolt the heatsink to the positive regulator (7805), using a little heatsink compound smeared on the meeting faces of the regulator's metal tab and the heatsink. Solder it onto the pc board then bend over the tabs under the board to secure the regulator. Now solder on the negative regulator; this one does not need a heatsink as it supplies very little current to the circuit compared to the positive regulator. Just make sure that, with both regulators, the manufacturer's writing on the case faces outwards from the board as this will ensure their correct orientation.

Next, solder the crystal in place, followed by all the capacitors, making sure that the electrolytic capacitors are positioned correctly. If power is applied and they have been inserted back to front, they make an awful smell when they explode, not to mention the mess!

The ICs can be soldered-in next, except for the modem chip. Note that all the ICs are orientated with pin 1 facing the REAR PANEL end of the board. Follow by placing all the LEDs on the board, taking note of their polarity. The shorter lead is the *cathode* and is marked on the silk screen with a "K". Before soldering them down, place a twenty cent coin on the top side of the board along the front edge, in front of each LED in turn, and bend the legs under them to lift them off the board so that the body of each LED is in line with the PH/DATA toggle switch's shaft.



Rear view of the M1200 modem, showing the two RJ sockets at the left, the DB25 RS232 interface socket, the power on/off switch and the cable to the plug pack supply.

M1200 DIP SWITCH SETTINGS

SW1	ON	Digital Loop test
	OFF	Analogue Loop test
SW2	ON	Normal operation
	OFF	Test mode, as per SW1
SW3	ON	300 bps Originate Mode
SW4	ON	
SW3	OFF	300 bps Answer Mode
SW4	ON	
SW3	ON	1200 bps Originate Mode, Half Duplex
SW4	OFF	
SW3	OFF	1200 BPS Originate Mode, with equalizer on
SW4	OFF	
SW5	ON	Bell (USA) Standards
	OFF	CCITT Standards
SW6,7,8	OFF	RESERVED for future use.

***NOTE: The modem MUST have Phone/Data switch set to Data when using Test mode. Disconnect the modem from the line in analogue loopback test.**

The relay, line isolation transformer and fuse can now be mounted and soldered down, in turn. The DB25 socket and the two RJ sockets can be soldered in last of all. Put each in place and then bolt them down before soldering the pins.

First tests

You can test the project before mounting it in the case. The plug pack leads can be temporarily connected to the points marked X5 and X6 on the board. After checking the board for solder dags across tracks etc, switch on the power. The LED marked "H1" should come on and a quick check of the power rails on the appropriate IC pins should indicate whether or not you have done everything properly.

Assuming that all has gone well up to now, turn off the power and desolder the plug pack leads.

Now solder in the modem chip taking extreme care not to apply too much heat. Make sure your soldering iron is hot and the tip is clean and tinned! You cannot be too careful when thirty dollars of semiconductor is at stake.

Once this is done, fit the plastic feet onto the base of the metal case. In some instances, you may need about 1 mm cut-off the front-most portion of the feet as it may interfere with the location of the front panel. Put the plug pack lead through the hole on the rear of the metal box and solder the leads back onto the pads at X5 and X6. Clamp the anchor grommet onto the lead and fit it to the case. It's a tight fit and may need a little coaxing with a pair of pliers. If it's still not going to fit the hole without distorting the box out of shape, then arm yourself with a small file and slightly elongate the hole (in a vertical direction), then try fitting the grommet again. A little patience is required here because if the hole is too big, then the grommet will have no clamping effect, and you may damage the paint job on the case.

We now come to the final piece. Secure the front panel with the screws provided and that should be just about it. Before securing the top cover, go through the check-out and test routines described here and then put the cover on.

As noted earlier, the modem requires a one-to-one RS232 cable with a male connector on both ends. Make sure that the

to p. 73. ▷

Will a viper beat a virus?

Scientists from Britain's Royal Signals and Radar Establishment (RSRE) have launched what is claimed to be the world's first "perfect", or "no-fault" commercial computer. The 32-bit computer, now to be marketed by the Marconi electronic group, is called a Verifiable Integrated Processor for Enhanced Reliability – which means it's a VIPER!

Work on the VIPER was started at the RSRE because of doubts about the ability of low-cost, mass produced microcomputers to offer the high standards of protection needed in nuclear reactor control systems and aircraft autopilots. (A "virus" bug in such systems doesn't bear thinking about!)

The result is a complete package of verifiable hardware and software able to guard against system failure in a range of critical situations, we're told.

A Marconi spokesman adds: "It is the first commercially available microprocessor to be specified in formal mathematical terms. Use of VIPER leads to systems whose every condition and state can be predicted "

Optimistic fellow!

For the past six months 15 British organisations, including GEC Avionics, the United Kingdom Atomic Energy Authority, Westland Helicopters and the British Rail research centre, have been assessing the new computer and are expected to give their verdict soon. NASA has recently taken delivery of a VIPER for evaluation.

VIPER could form the basis for a new world standard that will be needed in the 1990s to combat the prediction that computer design and program errors will lead to fatal accidents.

A bunch of fives

Datacraft has released its new "Craft" series of modems; five models with a top-line unit featuring 9600 baud operation. The range includes models with data compression and error correction.

The "MAILCRAFT" modem is intended for videotex operation, and offers speeds of 300, 1200/75 and 1200 baud.

The "INFOCRAFT" is a 1200 baud Hayes/Concord compatible autodial autoanswer modem, for general use.

The "QUADCRAFT" operates up to 2400 baud and features error correction. The "SPEEDCRAFT" adds data compression, which allows operation at 4800 baud asynchronous.

The top-of-the-range "PROCRAFT" is a V32 modem offering 9600 baud operation and many user-friendly features, says Datacraft.

Recommended retail prices (inc. tax) are: Mailcraft – $488; Infocraft – $750; Quadcraft – $959; Speedcraft – $1,439; Procraft – $4,995.

Datacraft are located at: **Maroondah Highway, P.O. Box 353, Croydon 3136 Vic. (03)727 9111.**

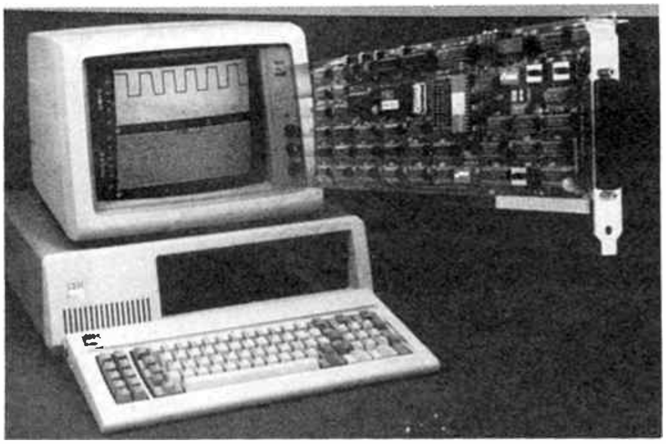
EGA card price plummets

Electronic Solutions' EGA display card for IBM PCs and clones, dubbed the "PEGA", described in *Bytewide* Dec. 1987, has had a significant price reduction.

The PEGA card, which can emulate CGA, Hercules and other modes, has been dropped in price from $499 to $299. Who said – you reap the benefit!?

Don't delay, call today. **Electronic Solutions, PO Box 426, Gladesville 2111 NSW. (02)427 4422.**

High speed A/D converter for PCs



Novatech Controls has released a new high-speed analogue interface board for the IBM PC/XT/AT/RT or compatible computers from Metrabyte.

Dubbed the DASH-16F, it allows 12-bit A/D conversions at greater than 100 kHz, Metrabyte say. It can sample up to 16 single-ended or eight differential inputs, and provides two 12-bit analogue outputs, eight digital I/O bits and a programmable counter/timer.

High-speed data transfers use Direct Memory Access, and the board may be used with any of the IBM or compatible range (PC, XT, AT or RT.)

An assembly level software driver is supplied with the board for simple interfacing using BASIC. Calibration and example software is also supplied. Drivers for Turbo Pascal, Fortran and C are available.

The DASH-16F is compatible with the most of the major data acquisition packages including: Labtech Notebook, Asyst, Asystant, Q.E.D., Snapshot Storage Scope and UnkelScope.

Applications include audio digitisation, transient analysis or spectrum analysis. For further information, contact: **Novatech Controls (Aust) Pty Ltd, Melbourne 3000 Vic.(03)645 2377;** or Sydney **(02)758 1122.**

PC interfacing book

A new volume on interfacing techniques for the IBM PC is available from Brumby Technologies of Lakemba. It is "Microprocessor Interfacing – 10 Projects using LAB 40 on the IBM PC", and was written with the intention of assisting educators and engineers in getting their applications up and running quickly.

The book describes a simplified method of creating high speed data acquisition and control peripherals using the LAB 40 bus. Projects include a digital oscilloscope, voice record/playback and a numeric display.

The introductory projects use BASIC, while the later ones use machine code which is intended to be accessed from BASIC. Use of interrupts and Direct Memory Access (DMA) are described in detail.

A workstation kit with the LAB 40 bus generator, protoboard, cables and chips is available.

For more information, contact: **Brumby Technologies Pty Ltd, 25 McCallum St, Lakemba NSW 2195. (02)759 1638**

New printed circuit CAD software

Intergraph has released a new software package, "PCB Engineer," which they say is an advanced aid in designing printed circuit boards.

PCB Engineer has provision for single layer, two-sided and multilayer boards, which can incorporate analogue, digital and high-speed logic along with surface mount devices.

Components can be placed visually, automatically or by a combination of both methods. Following placement, traces can be routed at any angle on one or more layers of the board. The standard editing functions – notch, stretch, rip-up and two-point routing are available.

The optional TIGER router can provide automatic routing functions with multiple algorithms to simplify the most difficult routing tasks.

Two dimensional layouts can be converted to 3-D models using Intergraph's mechanical design software. The software can also assist in the design of housings for boards by enabling interference checking and the verification of wiring connections.

For more information, contact: **Intergraph Corporation Pty Ltd, 55-61 Talavera Rd, North Ryde 2113 NSW. (02)816 2311**

A Real Time Clock for your Computer for Under $50?

YOU'RE KIDDING!

This nifty little device resides under an existing EPROM or ROM in you IBM/PC or compatible and adds the convenience of a real time, battery backed clock, cheaply.

Simple to install, just like installing an IC, the Smartwatch does not use up an expansion card slot in your PC, allowing you to use it for other equipment. The device is housed in a standard 28-pin DIP, piggy-back socket, fits under any standard BIOS ROM or other EPROM in the computer and is totally transparent to any other devices. It comes complete with a floppy disk containing installation software,

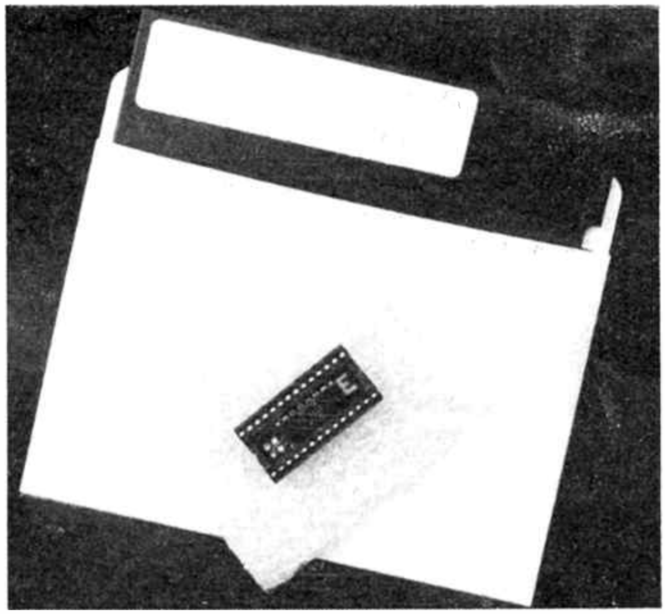
Full details are available in the February 1988 edition of AEM, giving complete installation and operational details.

Offer extended till 30th JUNE 1988, but HURRY!

Send mail orders to:

AEM Smartwatch Offer,
1st Floor, 347 Darling St,
BALMAIN 2041 NSW.

or phone (02)555 1677 and "pledge your plastic".



THE XE1216E "SMARTWATCH" BY XECOM
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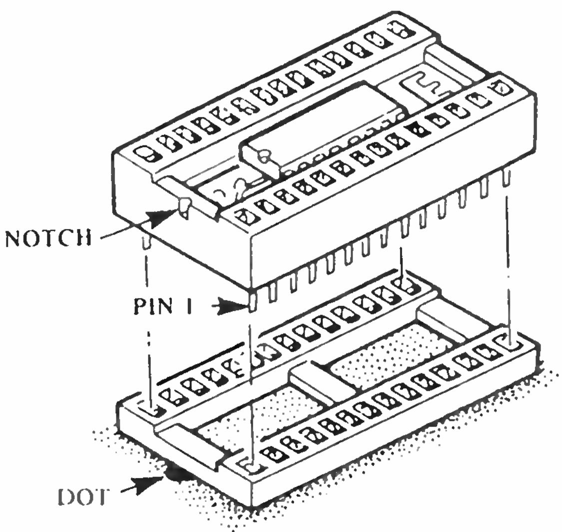
(Not suitable for use in compatibles where an RTC is already included on the motherboard. e.g: Amstrad PC1640).



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Do you do circuit design? Put a little SPICE in your life!

Jonathan Scott

SPICE is easily the single most powerful and popular program available to help electronic design. Ten years ago it was found only on mainframe computers in universities and large corporations. Now growth in personal computer power and the pressure of its popularity have combined to make a full version of SPICE available to small businesses and even dedicated enthusiasts. This article describes the beast, and reviews a version available locally.

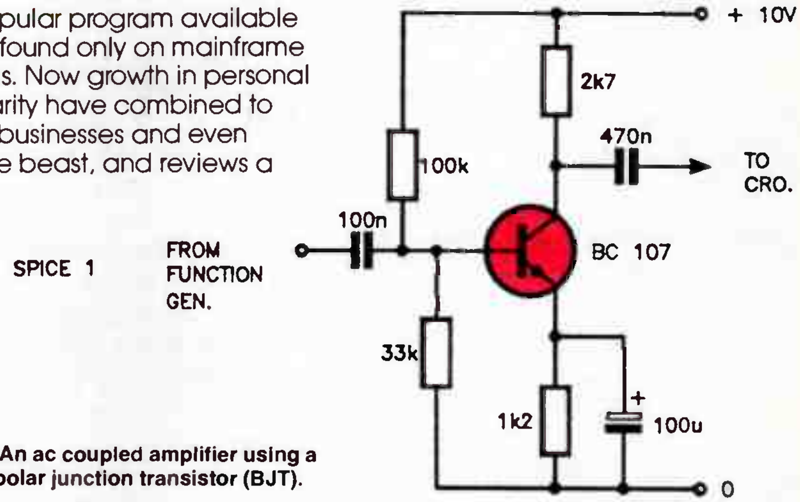


Figure 1. An ac coupled amplifier using a single bipolar junction transistor (BJT).

SPICE is an acronym for Simulation Program with Integrated Circuit Emphasis. It was born in the late 1960s at the University of California, Berkeley ("UCB"), as a result of the work of a gentleman by the name of Nagel, who wrote the first version as part of his PhD thesis.

The idea was to tell a computer about electronic components such as resistors and capacitors and transistors and so forth, and to get the computer to predict numerically what the circuit would do if and when it was built. This was (and remains) especially important when you are designing an IC for the simple reason that it costs a bundle to make one and you can't change a connection here and there once you've made it, to get it going. You have to be right first time, or maybe the second.

"Testing" a circuit by simulation on a computer can be faster and much cheaper than building it, but you can also do things you would not dream of, using any other means.

The whole idea caught on remarkably, and UCB continue to develop and expand the SPICE program. Other companies produce their own versions, but thank goodness they all manage to adhere to the basic idea pretty closely, and there is good standardisation.

Desktop SPICEing

These days it is possible to get SPICE on a personal computer, to have libraries of standard components on disk, and to learn to SPICE-simulate circuits reliably in only a few days. The result is that if you do any amount of electronic work, SPICE can save you time and money even on plain circuits – like many of the projects published in this magazine – by correcting errors before the circuit is even prototyped.

So good has SPICE become that the cost of IC fabrication is no longer needed as a justification for moving to computer simulation. If you have the computer already, and many people do, the effective cost is remarkably low.

An example

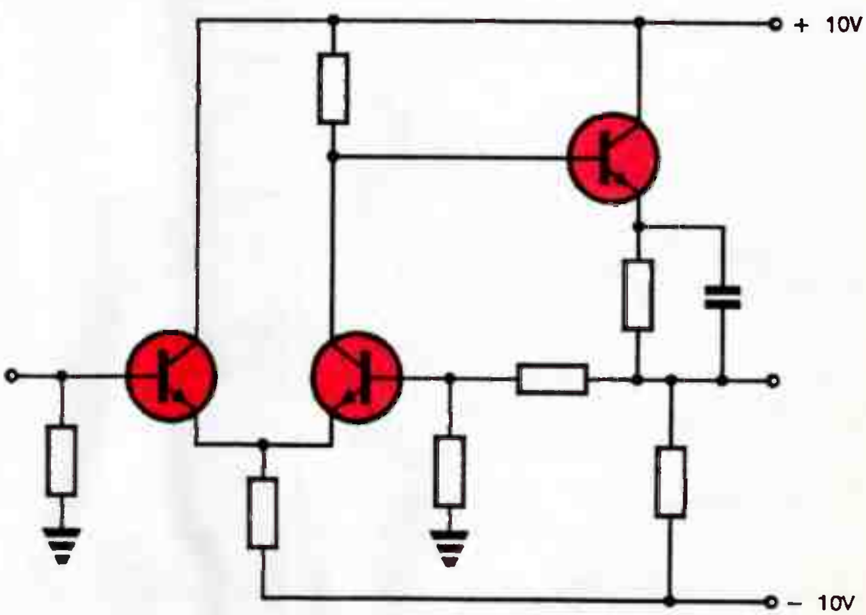
To give you some idea how SPICE works, let us describe a simple example. (For those already familiar with SPICE, I suggest you skip to the next section.) Consider the circuit of Figure 1. The circuit is that of a classic one transistor ac coupled amplifier.

Of course one would not resort to SPICE for a circuit of this simplicity under normal circumstances. However, the effort for this circuit is not a lot less than that for something much more complicated. You could probably figure out in a couple of minutes what the collector current for this circuit ought to be. If you are experienced, you could estimate the gain and the sort of frequency response to be expected.

However, can you estimate what the harmonic distortion will be for an input signal of 40 mV peak-to-peak? Could you find the collector currents, frequency response, gain and so forth for the circuit of Figure 2? With almost the same effort as for the one transistor case, SPICE will find base, collector and total consumed currents, gain, input and output impedances, frequency response (magnitude and phase), distortion, step response, clipping levels and much more for the more complicated circuit and even circuits of a complexity far beyond that one, too.

However, let us return to the original exam- ▷

Figure 2. A more complicated amplifier.



ple. To tell SPICE about the circuit, first number the "nodes", as shown in Figure 3. Note that the signal generator feeding the circuit and the CRO attached to the output are both represented by their equivalent circuits. Then create a file with a title line, one line per component, one line per test to be performed, one line per result to be printed, and one line explaining each different kind of transistor used. The result is shown in Figure 4. This shows the input file corresponding to the numbered circuit of Figure 3. Just how did I arrive at each line?

- The first line is the title line, and is the only piece of compulsory documentation. It is reproduced on each page of the output to identify the source.

- The second line is the "card" (1) which informs SPICE about the capacitor labelled "Cinput". We could have used any name, but that one is descriptive. The line says that the capacitor is connected between nodes 2 and 3, and that it has a value of 100 nanofarads (nF, or 10^{-9} F). Note that SPICE accepts numeric shorthand, n (nano) being 10^{-9}, f (femto) = 0^{-15}, p (pico) = 10^{-2}, etc and k (kilo) = 10^3, meg = 10^6 and so forth. Note also that the unit identifier, F for Farads, is not required, since SPICE assumes that all things starting with the letter C are capacitors, and thus will have a value in Farads. Any letters after the last valid numeric (including legal multipliers) are ignored, so you could put in the unit if you wanted to.

- Likewise, the next few cards (lines) can be similarly interpreted. All cards beginning with R are resistors.

- Line 7 starts with Q and is a bipolar junction transistor. The order of the nodes following the component label is important, and goes CBE. After that is the type of transistor. Wherever there are different types of something, like different types of BJT (bipolar junction transistor), there will be a card somewhere to define the model; in this case a BC107, which is used for Q1. It is worth noting at this point that, apart from the first and last lines, the order of lines is quite unimportant. SPICE will sort out what to do with each one, just as you would assemble a circuit with little attention to the order in which you were handed the parts.

```
SPICE simulation of 1 transistor amplifier
Cinput 2 3 100n
Rbias1 3 100 100k
Rbias2 3 0 33k
Re 5 0 1.2k
Cbypass 5 0 100u
Q1 4 3 5 BC107
Rc 4 100 2.7k
Cout 4 6 470n
* The function generator equivalent circuit
Vgen 1 0 AC 1 sin(0 .02 1k)
Rgen 1 2 500hms
* The CRO equivalent input impedance (X1 probe)
Rcro 6 0 1MEG
Ccro 6 0 100p
* The power supply
Vcc  100 0 10V
* The transistor model
.model BC107 NPN BF=250   VA=100 RE=1 RB=150  CJC=5p
+ CJE=6p   IS=3.16e-15
* list of commands
.op
.ac dec 20 20 2MEG
.plot ac vdb(6)
.tran 5u 8m 7m
.four 1k v(6)
*
.end
```

Figure 4. The SPICE input file for the one transistor example.

- Lines beginning with an asterisk (*) are comments, and are ignored by SPICE. They help to make the file easier to understand, just like comments in a computer program. The asterisk is the comment sign of the language in which SPICE was first written.

- Line 11 describes the input signals which are to be used in the tests of the circuit. Without going into tedious detail, the line says that the source is to be used for a small-signal frequency response test, and is to inject a sinewave of 40 mV peak-to-peak value at 1 kHz for a further test. This sort of signal generator card has the capacity to act pretty much like an ideal function generator, and there are numbers which can be included on it equivalent to most of the "knobs" you find on a real function generator.

- Note that on the Rgen card, I have exercised the option of putting text after the number.

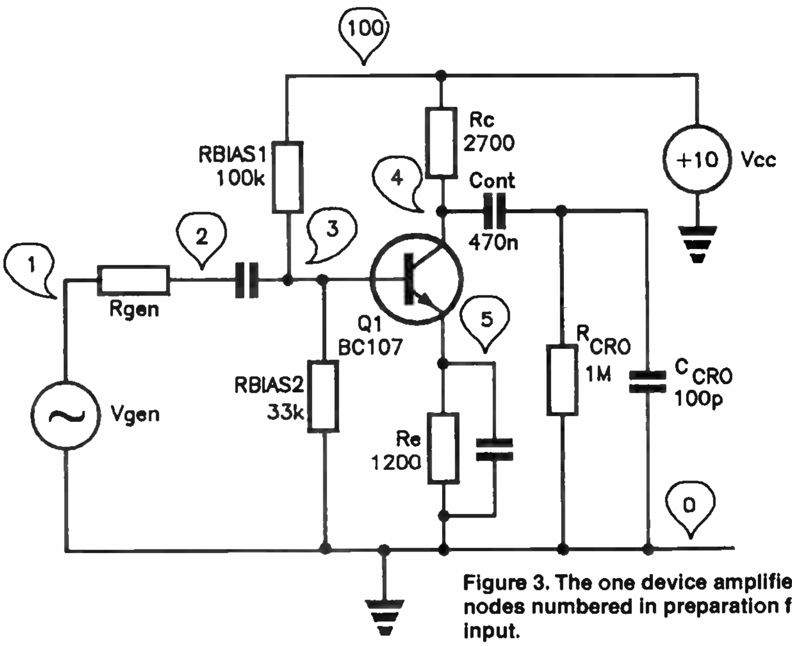


Figure 3. The one device amplifier with nodes numbered in preparation for SPICE input.

(1) The term "card" means line. The term arose in the early days of computing when all input lines to a computer occupied their own punched cardboard card.

(2) The rumour has it that UCB got so sick of people wanting copies they have given the job of distribution to someone who charges for the processing, just to reduce the headache.

(3) Applied to the model parameters supplied on the .MODEL card for the device.

The "O" (letter oh) is distinct from the "0" (zero), and SPICE sees only 50, not 500, even if your printer makes them look alike. This is a one of the first traps for the beginner.

- Rcro and Ccro model the input impedance of the oscilloscope I intend to actually use to measure the circuit operation.
- Vcc is an ideal battery which provides the supply.
- The ".model" card describes the BC107 BJT. The various parameters tell SPICE what is the forward current gain, the output resistance characteristic, etc, of the transistor. The line commencing with a + sign is a continuation card, supplying further information about the BJT which would not conveniently fit on the original line.
- The ".op" card says find the operating point, including all collector currents, power supply current, etc.
- The ".ac" card says do a frequency response analysis, with 20 samples per decade from 20 Hz to 2 MHz.
- The ".plot" card says that I want the results of the ac analysis plotted out, showing the voltage at node 6 in decibels.
- The ".tran" card instructs SPICE to apply the sinewave signal at 1kHz, and the ".four" card asks for a prediction of distortion.
- Finally, the ".end" card says that is all the input information.

Without reproducing the copious information SPICE generates from the input file, I find that it indicates that the circuit will have, amongst many other data,

- a voltage on the base of the transistor of 2.35 V and 6.28 V on the collector,
- a collector current in Q1 of 1.37 mA,
- a total circuit power supply current of 1.45 mA,
- a midband gain of 42 dB,
- a frequency response (–3 dB) from 445 Hz to 450 kHz, and
- a THD of around 1.67% (predominantly 2nd order – at about 1.2%).

Have you ever wondered what the voltage on a particular point in a circuit should be? If a circuit is suitable for use in a hi-fi system? Here is a way to find out.

Berkeley SPICE

SPICE is designed to be able to operate on any computer. Original Berkeley SPICE swallows a simple text file as input, and usually produces output on a line printer using no special graphics characters, etc. The graphs produced by a .plot command come out sideways from the printer, and use plain characters. They can be made 80 or 132 columns wide.

Berkeley SPICE is available for DEC computers and upward. You can get it on large IBMs, Control Data mainframes, etc. For this reason it is not really of much use to the small person. The most common and trusted version is 2, and it is now up to revision G or so. Version 3 is available, and this incorporates gallium arsenide (GaAs) devices as well as a number of later facilities such as the modelling of switches in circuits. Version 3 being new, it still has some bugs.

The good news is that it is basically "public domain software", that is, UCB don't charge royalties. A nominal fee for transfer of the program is made, but that is all (2).

Microsim's PSPICE

Given that SPICE is "free", it is hard to imagine that anyone could want to write their own version and try to sell it. Yet a lot of people do – there are a number of versions, including PSPICE, ISSPICE, IGSPICE and ZSPICE, of which I am aware. What do they offer?

Berkeley is presumably interested in SPICE as a research tool, not a slick commercial package. The commercial SPICES think they can get an edge by offering one or more of these attributes:

- Code that executes faster, and more efficiently, so it can operate faster or in the same time on a less powerful machine;
- Code ported to different or more popular machines, such as the IBM PC family;
- Associated programs to make using the software more rapid and convenient, e.g: to provide output on graphics devices such as colour monitors or plotters, etc;
- Associated libraries of components to save the user having to measure and calculate values for .MODEL cards or programs to develop models from data sheets;
- Fewer bugs and/or fewer problems of numerical convergence on complex circuits or circuits with feedback mechanisms;
- More up-to-date handling of newer devices, such as MOSFETs or gallium arsenide JFETs.

Elements and commands supported

PSPICE offers the following statements, most of which are SPICE2 standard:

B
GaAsFETs. I will have more to say about PSPICE's handling of the GaAsFET model in my final comments upon the package as a whole. For now, this card simply means that SPICE ought to be able to handle design of those tantalisingly low-noise RF amplifiers which have been available for the last few years. Radio Amateurs will particularly appreciate this facility, because they are the people who would presumably most like to design a circuit using a GaAsFET. Dick Smith sells (or once sold) a GaAsFET RF amplifier, and it was not cheap. The GaAsFET is still sufficiently rare and delicate that simulating before soldering could save a lot of money in devices blown up in the experimental stage.

C
Capacitors. Femtofarads to terafarads, you name it! Linear and quadratic voltage and temperature coefficients may be specified, allowing modelling of, say, drift of radio tuning with temperature or the introduction of distortion by non-linear capacitors. If the "Monte Carlo" option is available, capacitor models may be specified with tolerances and temperature coefficient tolerances.

D
Diodes. SPICE will model power, zener and signal, silicon and germanium, schottky and p-n diodes. A pleasing part of the PSPICE documentation is that both the equations used, and a suitable literature reference (book or papers) are given, so you can look up more about the device in question easily.

E
Things beginning E are voltage-controlled voltage sources, or VCVSs. This might seem a very silly component, since you can't walk in and buy one, especially with some odd polynomial transfer function. However, they are very useful for making a quick model of a buffer or opamp for investigating the ideal behaviour of a circuit without going to the length of loading an opamp model. In point of fact, they allow the demo version of PSPICE (see later) to handle circuits with several opamps!

F
Current-controlled current source (CCCS). Similar comments apply as for F

G
VCCS, comments as for VCVS.

H
CCVS, ditto.

I
Current source. This is an ideal current source, again useful for ideal modelling of circuits. It can be made to produce pulse, sinusoidal, FM and other common waveforms, and as such finds its best use along with Voltage sources (V...) as a source of signal such as a signal generator or an antenna, viewed as the input to a circuit.

J
JFETs. JFET parameter spreads have always been wide, and this has been a factor in their limited success. PSPICE not only models them, but with the Monte Carlo option (3), some assessment of the effects is possible. ▷

K
The K card allows the coupling between coils to be specified, turning two inductors into a transformer. This works for power transformers, so power supply sag and regulation can be modelled, and also for pot cores and even air wound transformers, so small signal circuits can be handled. PSPICE supports the standard SPICE notation in addition to Microsim's own, which is perhaps more suitable to the inclusion of standard core data, and which handles multitap windings more succinctly. PSPICE also allows modelling of hysteresis (Jiles-Atherton model).

L
Inductors are modelled with current and temperature dependence if required.

M
MOSFETs. The modelling of MOSFETs is a very complex procedure, and one whose fine points are still being ironed out in the literature (4). PSPICE provides the same three levels as SPICE2, based on the same references.

N
This is a new card, which allows the modelling in an analogue way of the input to a circuit from a digital logic IC. Apart from providing a quite adequate signal and source impedance, this card can act as a "port" to a digital simulation program interfacing with PSPICE.

O
This is the converse of N, allowing the modelling of an output from the circuit to the input of a logic gate.

Q
The BJT (circuit symbol Q) is the best modelled and best used device. PSPICE provides the full model as summed up by Getreu from the Tektronix company.

R
The resistor. PSPICE allows the standard SPICE resistor format, and can handle temperature coefficients and tolerances with the Monte Carlo option.

S
PSPICE offers the SPICE3 advance of modelling switches. These can provide simple models of SCRs and Triacs, as well as allowing apparent external intervention part way through a simulation.

T
Again of interest to the RF fraternity, SPICE models transmission lines. Baluns and matching sections are equally well handled. The modelling of transmission lines, particularly short ones, consumes computer time, so multi-hour runs are not hard to produce. The transmission line is ideal, so losses are handled by pads if necessary.

V
This is the equivalent of the I card, but providing a signal voltage rather than a current. It is most useful for providing a signal generator model for circuit testing.

W
This is another form of S, but is switched by a current rather than a voltage.

X
X is the card used by SPICE to signify a "subcircuit". A subcircuit is to SPICE what a subroutine is to a program. A subcircuit is a whole separate SPICE circuit which can be viewed as a block. It is usual to place op-amps in this form. The subcircuit, once defined, can be repeatedly called, and this is equivalent to having all the cards in the subcircuit copied with appropriate numbering into whatever places an X card is used. This is an exceedingly useful method of breaking up a large circuit into sensible sections.

The following cards, starting with a period, are *command* cards, which give SPICE instruction, rather than telling it about elements in the circuit.

.AC
This card tells SPICE to perform a *small signal* analysis of the circuit. The card produces a plot of magnitude and/or phase vs frequency. It is most usually used for finding the gain and frequency response of an amplifier of filter. The user must be aware that the analysis is carried out without checks for saturation and so forth, and that it can therefore get ridiculously large signals (megawatts from a small BJT). It is, however, much faster than trying to get the same results using a .TRAN card, which does a full analysis.

.DC
This card instructs SPICE to calculate a dc transfer curve for the circuit, varying a source (I or V card), temperature, or a device model parameter, such as the beta of a BJT. In conjunction with the Probe option, this command can draw families of curves, such as produced by curve tracers, etc.

.END
This card indicates that the input file is finished, and must be the last card in the input "deck". PSPICE allows the processing of several circuits from the one file, each one starting after the .END card. Thus, if the input file does not end after the .END card, PSPICE assumes another input deck is coming. This is rather necessary in some situations, because PSPICE on a PC is rather slower than SPICE on a mainframe, and it is convenient to leave the computer doing various runs overnight, in a sort of batch mode.

.ENDS
This is similar to a .END card, but ends a subcircuit, not a whole input deck.

.FOUR
This card instructs SPICE to perform a Fourier analysis. It is used to determine distortion. Note that there is a little more to getting a successful distortion analysis than merely specifying a .FOUR, since the data for it to use must be carefully extracted from a transient analysis.

.IC
This card is used to help the transient analysis if it has trouble in operating successfully or quickly. It has no specific circuit analysis use apart from this.

.INC
This is the SPICE "include" statement, which merely reads in a file as if you typed it in every time. It is useful if you have a number of input files all of which need to have some comment, explanation or block added to them. It is best not used for loading models and subcircuits, since the .LIB statement will take care of that much more efficiently.

.LIB
This card allows a file to be specified which contains many model cards and subcircuit definitions. The file is read, and *only* those models or subcircuits needed are read in. It differs from .INC in that it processes only models and subcircuits, but does not read in unnecessary definitions to take up RAM.

.MC
This card invokes the Monte Carlo analysis. See later.

.MODEL
This card allows all the model parameters for some sort of device to be specified. For instance, a .MODEL card is associated with every BJT, and gives the beta, junction capacitances, Early voltage, etc, of the device. Models may be given for:

capacitors
resistors
inductors
diodes
NPN BJTs
PNP BJTs
N-channel JFETs
P-channel JFETs
N-channel MOSFETs
P-channel MOSFETs
N-channel GaAs MESFETs (5)
magnetic cores
voltage controlled switches
current controlled switches
digital input devices (DAC)
digital output devices (ADC)

.NODESET
This card does for bias calculations what .IC does for transient analyses.

.NOISE
This card asks for a noise performance analysis. This is very important for assisting in the design of low noise audio and RF gear, and so is of particular interest to the audio and radio enthusiasts. It can quickly tell the designer what topology (circuit) will give better noise performance, and what sort of performance to expect of the whole circuit. This can ease the task of actually measuring the result by giving an idea of what sort of instrumentation will be necessary, too.

.OP
This calculates the dc operating point of a circuit.

.OPTIONS
This card controls trivial things like width of output plots, printing of diagnostic node check lists, etc.

---

(4) This accounts in part for the fact that MOSFET audio amplifier design has not yet settled into an optimised form, and designs boasting improvements are still appearing. An old story goes to the effect that the inventors of the bipolar junction transistor first wanted to make a FET, but couldn't figure out how to actually build one, so they settled for the bipolar transistor until manufacturing technology could address the more hairy field effect approach.

(5) There are no P-channel ones yet . . .

.PLOT
This card controls the production of a plot of values produced by .AC and .TRAN cards, etc.

.PRINT
Like .PLOT but for printed lists of data values.

.PROBE
This command is specific to PSPICE, and causes data to be prepared for the .PROBE option (see under "Probe" heading later).

.SENS
This is a very difficult card to describe briefly. It asks spice to determine what component and model parameter values affect the dc bias point, and by how much. It is used for finding components which are critical to the stability of the operating point, for instance which components in an amplifier affect the biassing most strongly.

.SUBCKT
This card names and starts a subcircuit definition.

.TEMP
This card instructs SPICE to run the circuit at different temperatures, to see the effect of it getting hot or cold (6).

.TF
This card calculates the small signal dc gain. Only useful for dc coupled amplifiers.

.TRAN
This is the most used and most powerful card. It instructs SPICE to perform a full predictive analysis of the circuit taking everything into account. It chews the most computer time by far.

.WIDTH
Tells SPICE how many columns you have in the output and input devices.

*
A comment card starts with an asterisk. (PSPICE allows in-line comments with the ";" symbol as well, after the fashion of assemblers.)

Options

PSPICE offers four associated "additive" packages, each of which offers a special capability.

Probe: This is the name of the package which allows graphic plotting of the output waveforms and graphs on monitors, plotters and printers with graphics capability. The program supports a wide range of plotters, PC graphics cards and printers. On a PC with a CGA or an EGA, it does an impressive job.

However, this is not by any means the limit of its offerings. It is capable of a number of things which cannot be achieved with standard SPICE at all. It can plot one variable against another, "CRO XY" fashion; it can calculate RMS, average, and other functions of variables; it can determine power dissipation as a function of time, or determine its average; it can perform a Fourier transform on a plot; it can display several graphs simultaneously; it can also overlay a number of plots. This last facility is very useful in conjunction with the Monte Carlo accessory described next. In fact, I would go so far as to say that PROBE is necessary to get the full utility of the Monte Carlo package.

To use PROBE, one merely inserts a .PROBE statement in the original SPICE input file, and then when SPICE has run, a datafile is left for the PROBE post-processor to read in later.

In using PROBE, I encountered some minor and some major facets which I found detracted from its appeal.

One minor problem is that it always presents a menu of options, but forces you to choose a number from the list, rather than also accepting a mnemonic letter or name of the function required. For instance, if you wish to rescale the X-axis, you have to press "3" or whatever, instead of "X". This means that you cannot effectively type-ahead, and have each time to convert what you want to do to a number. This gets annoying, especially in the light of the second complaint. I found this surprising, since it can accept commands from a file at initialisation in the form of the english words in the menus (a very useful facility in itself).

PROBE can get ridiculously slow. The apparent reason for the ability to execute commands from a file at initialisation is that PROBE can get so slow that it must be left to do its work in a batch job. I had some simple runs which produced datafiles but which took minutes to load into probe and plot. We could have printed the original SPICE output on a printer in the time it took PROBE to come up with a display.

PROBE can be crashed, without giving any error indication. Note that the crashing is not such a burden since it does not destroy anything in the crashing, mainly because it is not a program which produces any data, fortunately for it.

Overall, PROBE is a good thing, despite the grizzles above. Considering the quality of a lot of commercial software, which is execrable, it is pretty good.

Monte Carlo: This option allows tolerances, both individual and lot, to be associated with parameters in the input file. Then any specified number of repeat runs may be made (limited by time and data storage space on the disk) with the various tagged parameters being randomly changed on each run. By this method the expected spreads in production can be assessed. For those familiar with the difficulty of theoretical calculation of sensitivities of various operational properties to various component tolerances, particularly in the case of filter design, this will immediately offer a tremendous saving of effort.

To get an idea, say of the expected variation of response shape in a triple-notch canyon filter, using the Monte Carlo option PROBE can be used to superimpose the responses of 50 or 100 runs with varied component values. The result of this test appears in Figure 5.

The Monte Carlo option has most appeal only to potential manufacturers, of course. However, the potential for saving a designer serious algebra and time is enormous, and I can state unequivocally that if you perform electronic design for manufacturing production, this option gives you considerable power.

(6) A certain audio amplifier once described in these pages should have been checked with this card. It tends to produce extreme distortion as the temperature falls – tough if you have one and live in the mountains. Oops.

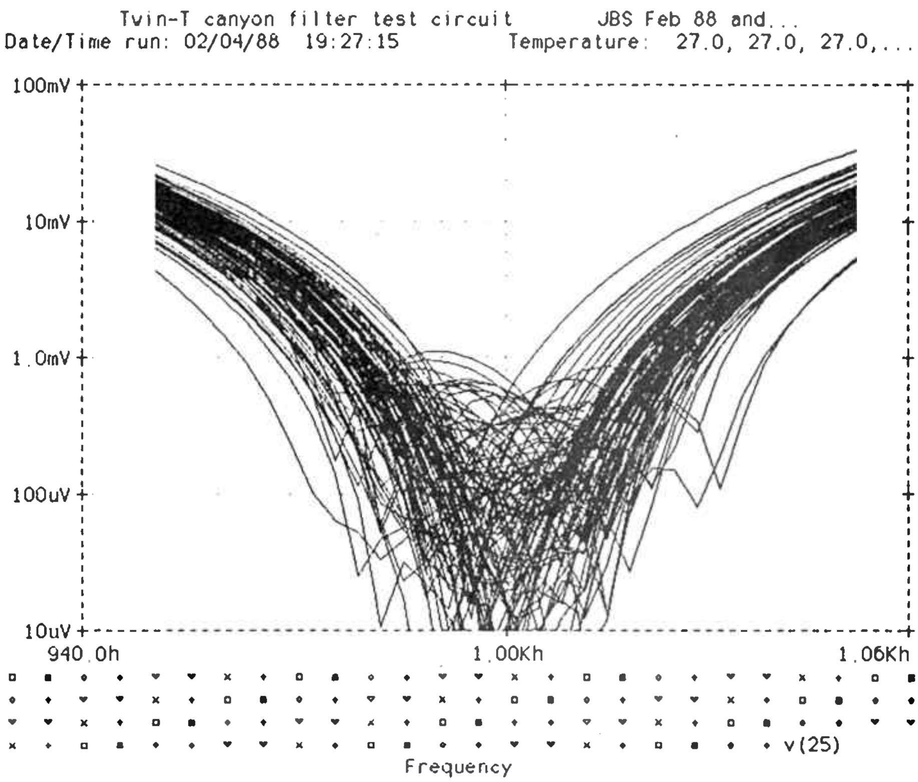


Figure 5. A prediction of response spreads for a triple- notch filter made with a Monte Carlo run and plotted with PROBE.

Library and Parts: The more astute reader will have already realised where the hard work and the potential for error in a SPICE simulation lies – in determining the .MODEL parameters of the special components. Where did the model in our example above come from? What would you put in for, say the Early voltage of a 2N3055? (There is no mention of it in the data sheets for any device I have seen. In fact it is easily calculable if your data sheet gives you the device's output conductance for a known collector current, or if there is a graph of Ic vs Vce, and provided you have a good text to tell you how.)

To assist in the determination of model parameters, PSPICE is accompanied by a library of standard things – some op-amps, diodes, MOSFETs, BJTs, etc – and can have an optional package called PARTS included.

The model library writers seem to think that only Motorola and Texas Instruments make bipolar junction transistors (BJTs). This "Americanocentric" view is rather common in the USA. We found the library rather useless in view of the local suppliers' ranges. Thus I turned to the Parts program to see if I could not build some sort of library useful for the devices I find common here. The program will produce models for diodes, BJTs and MOSFETS and op-amps, using data you feed in from the data sheets of the device you are trying to model.

Provided you have a good data book for the Part you are trying to model, the program is reasonably successful. We were able to crash it in several places by entering what I presume was silly data, which should not have been possible. Indeed, on several occasions it rejected ludicrous data or warned us that results were out of sensible bounds, but it did have obvious chinks in the armour. Overall, Parts does a good job, in the light of a severe limitation which is not the fault of the makers. This limitation is simply that it must use data from the device specifications.

The truth of the matter is that most components are terribly underspecified, and the program either does not attempt to implement the estimation of those parameters for which the manufacturer does not usually supply data, or it makes a crude guess from a few simple data.

I was able to get it to tell us that a 2N3055 had a [beta] of about 16 000, and yet to produce a plot that resembled what I knew to be correct for *hFE* by adjusting other parameters to equally ridiculous values. This resulted from a combination of:

- willful ignorance on our part,
- underspecification on the manufacturer's part, and
- resignation on the part of the Parts program to the underspecification of the manufacturers.

One must take into account that *precise* specification is not necessary, as Microsim point out, because devices will differ from batch to batch. Nevertheless, I felt that I would have preferred the program to offer to take the results of some measurements made on an actual device and then to give a better model, rather than saying (as it does) that "such-and-such a parameter is not so important anyway . . .".

I feel that it would be foolish to expect anyone to be able to use Parts successfully without first knowing the significance of many of the device parameters. In short, Parts assumes a lot of knowledge on the part of the user, and an hour or two in a lab with a curve tracer and some measuring gear followed by a few minutes with a calculator and a textbook on device models will provide a better model of a device than Parts and a data book will ever do. This criticism is less true of op-amps, which are significantly harder to measure and usually better specified, but even in their case, I think that you need to know what you are doing.

Device Equations: This option is only for the serious research establishment, and is of no interest to the small designer. It basically consists of supplying the program in partly compiled form so that changes to the basic equations can be simply implemented. For the reader in such a situation, the following comments will be of interest.

We took the trouble of consulting a designer involved closely with GaAs MESFET IC design to assess the model PSPICE offered. The model of a MESFET is still a matter of contemporary publication, and Microsim are continuously updating their model in response to published research from the major institutions. Indeed, an update arrived during the course of this review. The design equations implemented were, even in the case of the update, rather behind state of the art. The temperature compensation equations had in fact been transferred directly from the silicon case (*wrong!*) and thus, to be of any use, the equations option would have been necessary.

We applaud Microsim for making this option available, even though it will have limited custom!

Summary

PSPICE executed significantly slower on a PC (even with fast hard disk, fast memory, a 10 MHz CPU, 8 MHz coprocessor and a full expanded EGA) than SPICE does on a VAX 11/780, but it was nevertheless quite fast enough for jobs likely to be encountered by enthusiasts and small businesses. I was even satisfied with its speed on an XT with 760K floppy drives. No complaints here.

I consider that it is very up-to-date in comparison with other software, and revisions were coming out as I conducted this review. Shortcomings were felt, but only at the very leading edge, and these will not bother any of the intended users of the package. Bugs were considerably fewer than those encountered in some other PC SPICES I have used, and also fewer than those in Berkely SPICE version 3.

PSPICE offered a very good graphics post-processor in Probe, which lives up to its adage as a "software CRO", and more again. Initially I felt it unnecessary, but the more I used it, the more I found it could do. A recommended purchase for anyone who is paying for the time of the person using PSPICE, or anyone with the Monte Carlo accessory. The Monte Carlo accessory itself is very highly recommended for anyone contemplating manufacture (or publication for lots of people to build!) of circuits.

My first criticism arises with the copy protection. PSPICE demands that the "key" disk be in the A: drive every time you use it, or any of the accessories. This is a pain in the posterior. I can understand that this is the sort of software that lots of people would like to pilfer, and that it is a large and relatively costly package, given away virtually free to anyone who has a mainframe, so there is temptation to copy it. The copy protection, nevertheless, forces 360K on one drive, and precludes the use of machines without 5.25" drives. Other (USA) reviewers have said as much elsewhere.

The second criticism is that the full package will not run at all without a coprocessor. If anything, this is more serious, and there can be little justification for it. These ICs cost about $500 plus here, and much software does not demand them. This prevented us testing the software on some machines, particularly laptops, etc, with no 8087 provision. I must assume that they do not want to receive criticism for the slowness which would result. I figure they deserve criticism more for the omission.

The cost of the package, at $1295 ex. tax, is relatively high. It is higher than any of the other SPICE programs for PCs of which I have heard. It seems to be better, than most I admit – some PC SPICES have been very poor, though some have been comparable. The accessories are all around the $500 mark, again exclusive of sales tax.

There is one strong redeeming factor. Microsim has a
demonstrator package, copying of which is "welcomed". This package allows the full range of functions, including Probe, but is limited to small circuits. This smaller package runs without a coprocessor, off any disk. I was able to test filters of considerable complexity using half a dozen E cards as op-amps, test models of transistors and MOSFETs, design RF front end amplifiers and generally exercise all the facilities of the larger program on it. I absolutely recommend this to anyone thinking of buying the package, as well as anyone who just wants to learn about SPICE.

One day, manufacturer's will publish the SPICE models of their op-amps and components in their data books. Who knows what will happen? AEM might be induced to publish models of the devices it uses in its projects or SPICE input files for projects. It is certainly on the cards that this magazine's projects will be increasingly tested using SPICE in one form or another.

PSPICE was supplied for review by MTI Engineering Software Company, 432-434 Chapel Rd, Bankstown 2200 NSW. Their service has been excellent, and I wish to thank them for the loan of the package for review. May SPICE flourish.

▷ from page 63

handshake signals are hooked up correctly according to what your computer requires and supplies. Check the line circuits as there are a few different ways that you may hook into it.

Testing

Once constructed and checked-out, the modem can be quickly tested before use as follows.

The modem should not be connected in-line. Power off. Set the DIP switch to select 300 BPS (SW4, on), originate mode (SW3, on), CCITT (SW5, off), test mode (SW2,on), analogue loopback (SW1, off).

Before hooking up the modem to your computer or terminal, check that the handshake and data lines are correctly wired. Under normal circumstances a one-to-one cable will be sufficient. Set your computer or terminal so that the serial interface communicates at 300 bps (baud), with a protocol of eight data bits, one stop bit and no parity.

Switch on the power and see that the following LEDs are lit: "DC", "TEST" and "300". Now hit a key on the keyboard. The "TD" LED should flash to the typing. If all is OK, switch SW9 (on the right of the front panel) to DATA. The line relay should operate and the "CD" LED should come on. Hit a few keys again. This time the "TD" and "RD" LEDs should flash in harmony and letters should appear on the screen of your computer or terminal. If the letters are not correct, check the speed setting of your computer's or terminal's serial interface. It should be 300 bps and the protocol should be eight data bits, one stop bit and no parity, as noted earlier.

Once this is accomplished, try switching SW5. This will change you over to Bell standard and there should be no change in what you type on the terminal. Now switch SW3 to off again. Typing on the terminal should make no difference and characters should be received OK.

If you're experiencing problems, check the cable connection with the circuit diagrams and the serial port of your computer. Also check the orientation of the DIP switch with the pc board layout.

Once you've got that going, you might like to try the other test modes, and/or linking up with a friends modem and computer.

When using the modem in 1200/75 mode, analogue loopback is not connected, but will operate when in digital loopback with the remote modem.

After the modem has been tested and checked out OK reset the DIP switches to the desired setting and you're ready to communicate!

Interfacing notes

The modem is designed to interface to the host computer via a one-to-one RS232 cable, as noted earlier. Some programs do not require or use carrier detect on pin 8 so it is optional unless you require it. Clear to Send (CTS) on pin 5 is required when using 1200/75, and should be wired into the cable. However, if you are a slow typist then you may get away without using it. Try it, it may work OK.

Request to Send (RTS) on pin 4 is required. If your computer does not supply this signal, then try using DTR on pin 20 instead. The modem has been tried on various cable configurations. The best thing to do is to try a one-to-one cable and then go from there.

You'll find your modem will open up undiscovered worlds. Have fun!

Introducing the "SUPERbis" modem

Roy Hill

Welcome to Part 1 of a three-part article detailing the technology and construction of the new "Superbis" Modem. It features many 'automatic' functions and full software control using the popular Hayes command set widely used in 'smart' modems, and all of the popular baud rates that a hobbyist could wish for – 300, 1200, 1200/75 (Viatel) and 2400 – all at an incredibly low cost, **without** compromising performance.

THIS PROJECT was developed in response to the many requests from readers for a 2400 bits per second (bps) full duplex facility (known as "V.22bis") in a modem. In a way, this project is the successor to the very popular AEM4610 Supermodem which we published two years ago. Like the Supermodem, this new modem has been designed by Chris and Dan Darling of Maestro Distributors and provides 2400 bps operation along with the popular "older" speed standards of 300, 1200 and 1200/75 bps. Also like the Supermodem, it is a 'smart' modem – its entire operation can be configured and controlled from the keyboard of your computer using the popular and widely used set of commands developed by the US modem maker, Hayes, which is now virtually an industry "standard". Current AEM4610 Supermodem owners should not despair that they are being neglected. An upgrade project to provide 2400 bps operation that installs on the Supermodem's expansion connector is under development. The upgrade should appear as a construction article in this magazine about mid- year (please be patient – there are only three of us!).

In this first article, I will give an overview of the project and describe the major components used and how they operate. The second part will cover the construction details and troubleshooting and the final part will cover the software and the manner in which the Hayes command set is implemented.

Our new Superbis modem incorporates some of the features that readers have written to us and requested. For example, it employs a set of LEDs on the front panel that provide indication of the TxD, RxD, CTS, DCD and DTR signals and the OFF-HOOK status. This, above all, was one of the most commonly requested features that readers wanted to see on the Supermodem. A 50-pin expansion bus is also provided for the more adventurous constructor, although we suggest that this be forgotten about until such a time as you are totally conversant with the features and operation of the modem.

FEATURES

- CCITT 300/300, 1200/75, 1200/1200 and 2400/2400 bps operation
- Bell 212A (300/300 and 1200/1200 bps) operation
- Supports Hayes 2400 command set (full software control)
- Auto-answer
- Auto-dial (pulse and tone)
- Call progress monitoring
- Line condition monitoring
- LEDs to monitor – TxD, RxD, CTS, DCD, DTR and OFF-HOOK
- Expansion bus on-board
- Low cost – $319 as a kit, $399 fully built

Now for the goodies! The Superbis is designed around two new and exceedingly powerful sets of components. The first of these is the microprocessor that controls the operation of the modem. This is the Zilog Z0880020PSC, more simply known as the "Super8." The other is the XR-2400 chip set (two chips) which is used to provide the V.22bis facility. Partial Data Sheets for both of these components will be found included elsewhere in this issue. However, I will now describe the manner in which these chips are used in the project. The familiar Thomson 7910 World Modem chip is used for the lower speeds – 1200/75, 75/1200 (CCITT V.23) and 300 bps (CCITT V.21). The XR chip set is used to provide the V.22 and V.22bis, as well as the Bell 212A (1200/300) protocols.

With the XR chip set the Superbis will run at 2400 bps full duplex and provide a better signal-to-noise ratio on the line than the most commonly used chip set employed in current commercially produced modems. As the price for the kit is just $319 and the fully-built modem (Telecom approval pending) is only $399, the Superbis represents extraordinarily good value for money. This price is *less than half* (in fact, closer to a third) the cost of modems offering similar performance, *and* the Superbis offers better performance characteristics in the 2400 bps mode. In fact, by measurement, the improvement in performance is a FULL 3db (See Table 1).

As we have done in the past, the Superbis project will be available as a kit or fully-built by ordering through the magazine. In addition, a "Sorry Maestro – It doesn't work" offer is available, for those who experience problems in getting the kit to work. For the tiny sum of $35, Maestro will examine your inoperable modem and determine the cause/s of the problem. You will then have the option of effecting the repairs yourself, or negotiating with Maestro to carry out the repairs for you. Also, as usual, the offer depends upon Maestro's assessment of the kit. If they feel that it has been too badly constructed to be effectively repaired, they reserve the right to refuse to repair it (fortunately, from past experience this is extremely rare). So, you should be totally confident of your ability to construct a project of this magnitude and complexity. Anyone with a modicum of experience in electronics construction should be able to successfully complete the project.

The Super8

The Super8 is a 48-pin DIP package that contains an enhanced Z8 instruction set. These enhancements include such features as multiply and divide instructions, Boolean and BCD operations and instructions to provide the implementation of "threaded-code" languages such as Forth. The latter feature is particularly useful, as Maestro now do all of their software development in Forth. Such features as the "Enter" and "Exit" routines provided are vital to the implementation of a language such as Forth, as they provide the necessary support for the Forth 'primitive' command NEXT. This, in turn, controls the manner in which calls to and returns from *words*, are handled. The Super8 also has:-

(a) Two x 16-bit counter timers,

(b) 272 general purpose registers and 53 mode and control registers,

(c) The capacity to address 128 kbytes of memory,

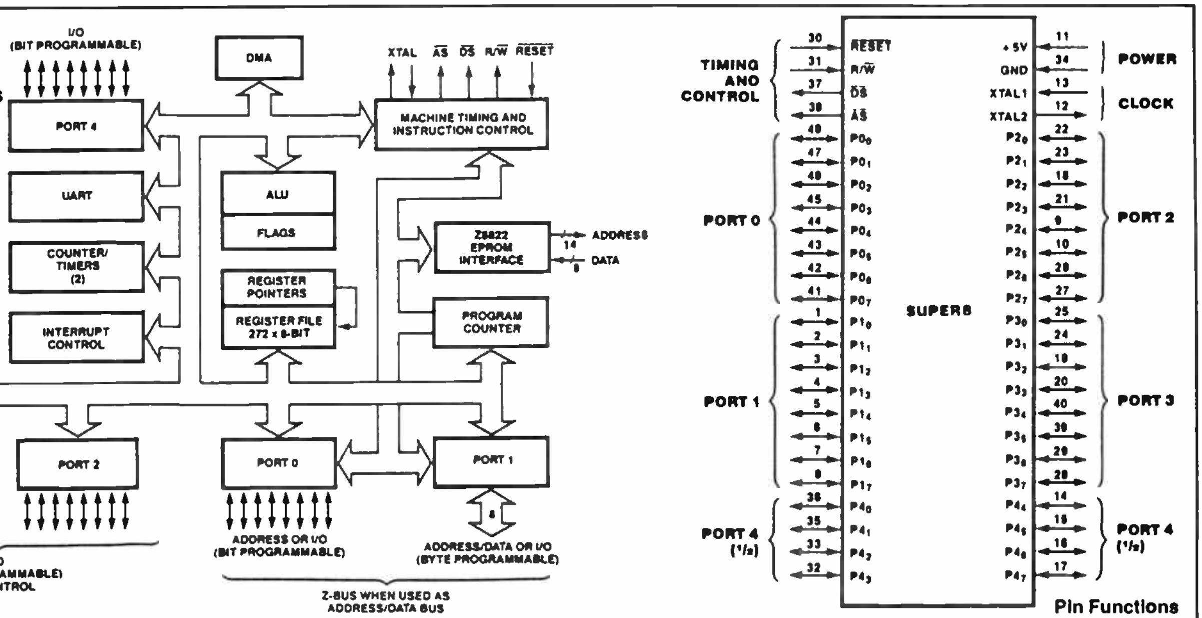
(d) A DMA controller,

(e) Four 8-bit programmable I/O ports,

(f) An on-board clock oscillator (this makes the design of a clock circuit fairly trivial).

In addition, the Super8 can be driven by a 20 MHz clock (a 19.6608 MHz crystal here), which means that it is running at an equivalent speed to an IBM AT with a 6 MHz clock. In the ▷

Block diagram and pin functions of the Super8.



Superbis Modem, all 32 I/O lines are fully utilised – one 8-bit port is used to control the 7910 chip, one port is used for the XR chip set and the other two are used to generate address lines for the EPROM and RAM. Anyone wishing to use the modem as a controller will need to map additional I/O chips into the address space, using the expansion connector.

The Super8 uses a 27256 (32k x 8 bits) EPROM as both its operating system and Hayes Command Set store. Forth, in the form of F83 (a public domain version of Forth by Laxen and Perry) is also provided in the EPROM. Details on how this may be adapted for use by the constructor will be provided in part three. RAM is provided by either a 43256 (32K x 8 bits) or a 6264 (8K x 8 bits). The selection of either type is made by the provision of a shorting lug on the motherboard (SW2). Note that the standard kit will only be provided with a 6264. A 13-input NAND gate (U15) and a 74HC138 (U18) are provided for address decoding, to allow you to drive further expansion facilities. These additional lines (seven of them) are also provided on the expansion bus. Further details on the software operation of the Super8 will be provided in part three.

The XR2400 chip set

The chip set comprises two chips, both of which are CMOS devices. Normal CMOS handling precautions must be taken with these chips, as they are not cheap (about $130 retail). The XR2401DSP is a Digital Signal Processor chip which provides the baud rates, scrambling/descrambling facility, adaptive equaliser, carrier detect and DTMF (tone dialling) tone generator. The baud rates provided for by the 2401 are 300 bps FSK (frequency shift keying), 1200 bps DPSK (differential phase shift keying) and 2400 bps QAM (quadrature amplitude modulation). For an explanation of any of these terms, readers are referred to my *Dial-Up* column over the past year in this magazine. Back issues or article photostats (where back issues are unavailable) cost $4.00, post paid.

The XR chip set has been tested against the leading supplier of two-chip modem sets, using a fairly impressive test circuit. This consists of a BERT (Bit Error Rate Tester), a line simulator, a line impairment simulator and a reference modem (in this case a Hayes 2400). The results of this test are shown in Table 1.

The XR2402 is used to provide all of the interface functions required by the 2401. These include such features as the A/D and D/A conversions, band splitting filters, PGA (Programmable Gain Amplifier – Not the "GWS" Great White Shark version of PGA – the Professional Golfers Association!), asynchronous to synchronous conversion, synchronous to asynchronous conversion and guard tone generation for CCITT applications. The XR2400 chip set is specifically designed to operate with the Super8 processor, so that it is indeed a fortuitous combination. It's almost as if Zilog and Exar combined forces just to produce a modem set for Maestro!

The Super8 communicates only with the XR2402. This chip is also known as an AFE (Analogue Front End) chip, as it provides the front end to the DSP chip. Readers of my Dial-Up column will remember that I discussed the topic of DSP's in the July '87 issue. The particular chip being discussed at that time was Texas Instrument's TMS32020DSP. A feature on the TMS320x0 DSP in modem applications also featured in the April '86 issue. Note that the TMX32020 is being used as the DSP in the "Trailblazer" modem, which retails for around $3000.

The 2400 chip set appears to the Super8 as a memory mapped I/O channel (this means that the chip set occupies a small amount of the Super8's memory space and appears to the Super8 exactly the same way that RAM may appear). The 2402 acts as a bridge between the 2401 and the Super8.

One of the most helpful features of the 2400 is the ability to "retrain." If the signal coming from a remote modem becomes degraded, due to line hits (or other causes), the 2400 re-adjusts its operating parameters to improve the S/N ratio and to re-lock itself onto the carrier.

Nearly all of the essential circuitry is provided for by the three main chips. The only additional components required are those to drive the line interface (transceivers), the Telecom Isolation circuit, two amplifier circuits (one for the 7910 and one for the 2402), the crystals and the power supply.

LINE SPEED (BPS)	S/N RATIO (ORIGINATE MODE) (dB) Rockwell 2400	XR2400
2400	19.0	17
1200	8.3	11
300	10.4	8

TABLE 1. Bit error rate S/N ratios.

CIRCUIT DESCRIPTION

The heart of the circuit is the Super8 (U2). This provides all of the control functions required by the modem chips, as well as the address lines to support the ROM and RAM. The operating system and the Hayes 2400 command set are contained in the 27256 EPROM. The Super8 also controls the various dialling functions and the communication with the host computer and the modem chips.

The IC, U1 (a 74LS373), provides a buffered latch for the address lines to support the EPROM (U3) and the RAM (U4). Chip select for the EPROM is derived from U20C, whilst chip select for the RAM is derived from the 13-input NAND gate (U15) and U20A & B. Data lines D0 through D7 from the Super8 to the EPROM and RAM chip are used to generate the multiplexed Address/Data lines required by the 2402. U14 (a 74LS153 multiplexer) is used to select the appropriate path (to and from the Super8, the 7910 or the 2402) for connection to the host computer. This is because there are several possible paths for data to take as it comes from the host or the remote. It may go DIRECT to the host computer (the Super8 only looks at it as it comes through, but doesn't process it), it may go to the 2402 (via the Super8) or it may go to the 7910 (again via the Super8). (For a more detailed explanation, see Figures 1a, 1b and 1c).

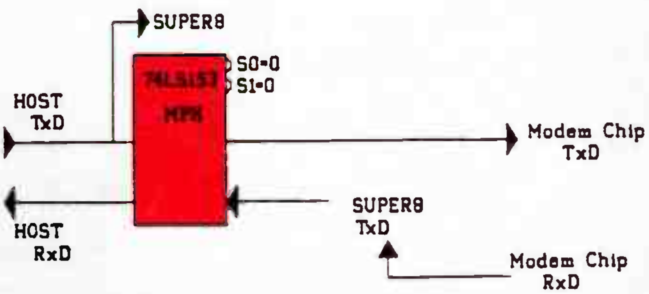


Figure 1(a). Remote RxD routed through Super8 host TxD to Super8 and modem chip (Super8 monitors line for '+++').

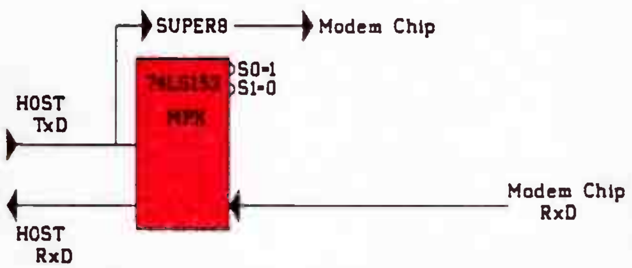


Figure 1(b). Host TxD routed to modem chip through Super8 remote RxD straight to host RxD via modem chip.

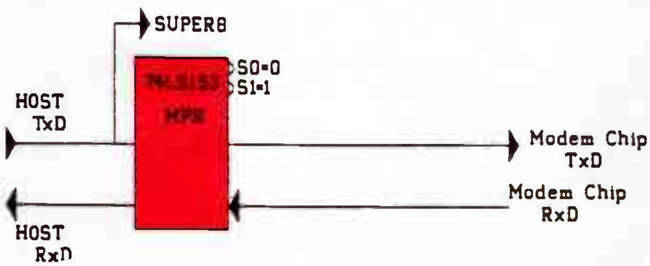


Figure 1(c). Super8 once again only monitors host TxD for '+++' remote RxS routed directly to host RxD via modem chip.

1488 and 1489 line drivers/receivers are used for the RS232 side of the circuit. However, to allow for synchronous operation, three additional lines to the host computer are required. These are identified on the circuit diagram as "- TXCLK" and "-RXCLK", which indicate inverted logic clocks. The other line is "-EXTCLK" which is used to provide a source of synchronisation.

The 7910 part of the circuit is a fairly standard configuration. The clock for the 7910 is provided by XTL1, a 2.45 MHz crystal. An analogue amplifier is provided for by U11, a TL081 op-amp, and its associated circuitry. This provides for amplification of the incoming (RxD) signal and also provides for the automatic nulling of its own carrier signal. The hex inverter (U19B), is used to provide the correct logic signal for the 7910's BCTS. This is the CTS signal for the Back Channel (75 bps) as used by Viatel.

A similar amplifier – a 1458 (U10A and B), is used to amplify the incoming and outgoing signals from the 2402. Note that the trace running from pin 1 of U10 (the analogue in) to pin 46 of the XR2402 is not a track on the PCB. This is a link of shielded coax, to prevent any interference from the digital section that it passes close to.

A speaker amplifier (two selectable volumes – loud and soft!) is provided on the board. The circuit for this comprises Q2, Q3 and U21 (an LM386 op-amp). Q2 is used to turn the speaker on and off, and Q3 is used to provide the two volume levels.

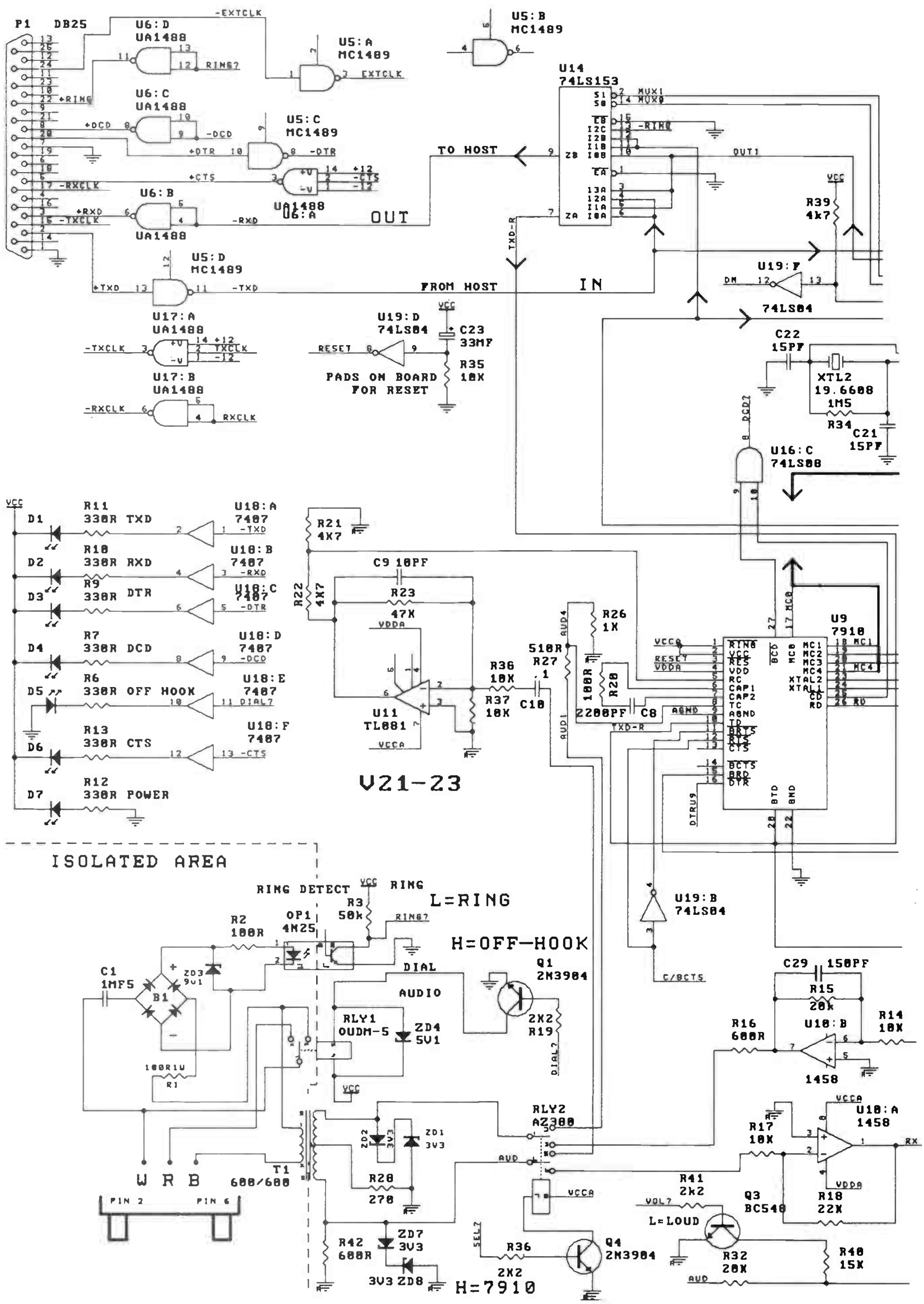
The power supply for the board is completely different to the old Supermodem power supply. A 10 volt ac plugpack is used to provide the power to the board. This is then half wave rectified using D8 and D9, and the output of these two diodes is centre-tapped to provide a false earth. 7805 (U12) and 7905 (U13) three terminal regulators are used to provide the plus and minus 5 V required by the modem chips. The Super8 is a single supply chip and only requires +5 volts.

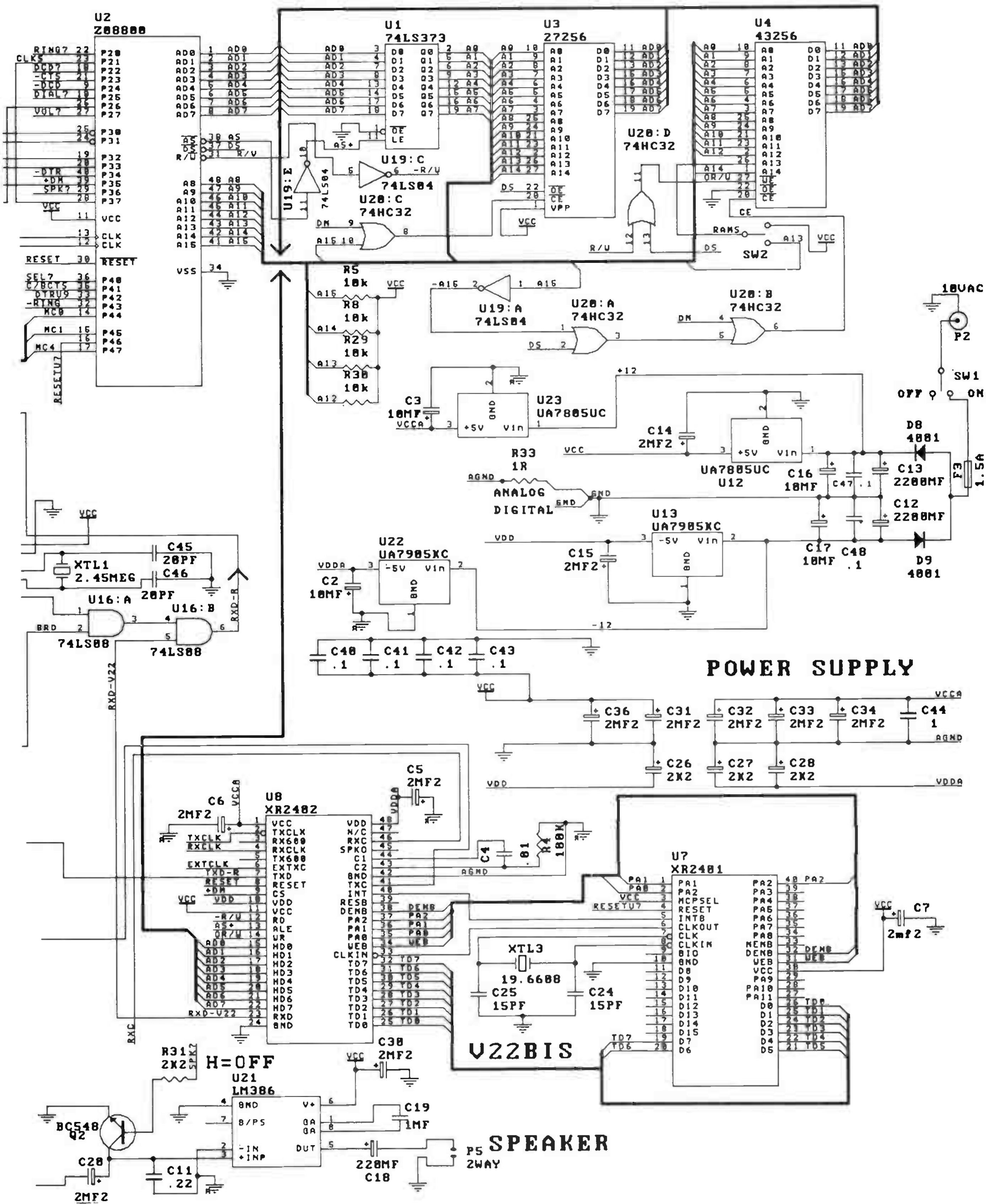
The voltages required by the line drivers/receivers (plus and minus 12 volts) are provided by two zener diodes (ZD5 and ZD6), which are tapped from the rectified input to the regulators. The output from each of the regulators is split into two separate power rails – a digital rail and an analogue rail. The analogue rails (positive and negative) pass through chokes L1 and L2 in order to remove any high frequency noise that is generated by the digital circuit.

In order to keep digital switching spikes away from the analogue side of the circuit, a lot of 2u2 tag tantalum and 100n (0.1 uF) "blue chip" monolithic ceramic capacitors have been used for bypassing at various points. It is absolutely vital that these capacitors be installed as per the instructions, as any stray noise will cripple the 2400 part of the circuit. The analogue section also has its own ground completely separated from the digital ground via a 1R resistor to the main bypass capacitors.

The Telecom side of the circuit has been extensively revised to keep stray noise to a minimum. Ring detect is provide by the bridge rectifier (B1) and the 1u5 isolation capacitor, feeding the opto-isolator (OP1) via a 9.1 volt zener diode (ZD3). This, in turn, drives the base of TR1 (a BC548) and provides the RING? signal via the collector of TR1. A 100 ohm 1 Watt resistor (R1) is used to prevent line overload on the Telecom side of the circuit. The analogue I/O to the Telecom line is isolated by a 4 pole two position relay (RLY1) and by a centre-tapped transformer (T1), through two fuses (F1 and F2 – Note: No longer a Telcom requirement) to provide the Receive In and Transmit Out signals.

The dial signal is applied to the base of Q1 (a 2N3904). A second relay (RLY2 – a DIP relay) is used to route the I/O to either the 7910 or the XR2402, so as to provide optimum performance from either chip.


P1 DB25
U6:D UA1488
U5:A MC1489
U5:B MC1489
U14 74LS153
-EXTCLK
EXTCLK
RING?
+RING
U6:C UA1488
+DCD
-DCD
U5:C MC1489
+DTR
-DTR
+CTS
-CTS
-RXCLK
-TXCLK
U6:B UA1488
+RXD
-RXD
UA1488 U6:A
OUT
TO HOST
MUX1
MUX0
-RING
OUT1
U5:D MC1489
+TXD
-TXD
FROM HOST
IN
TXD-R
VCC
R39 4k7
U19:F 74LS04
U17:A UA1488
TXCLK
U19:D 74LS04
RESET
C23 33MF
R35 10K
PADS ON BOARD FOR RESET
U17:B UA1488
RXCLK
C22 15PF
XTL2 19.6608
1M5
R34
C21 15PF
DCD?
U16:C 74LS08
D1 R11 330R TXD U18:A 7407
D2 R10 330R RXD U18:B 7407
D3 R9 330R DTR U18:C 7407
D4 R7 330R DCD U18:D 7407
D5 R6 330R OFF HOOK U18:E 7407 DIAL?
D6 R13 330R CTS U18:F 7407
D7 R12 330R POWER
R21 4K7
R22 4K7
C9 10PF
R23 47K
VDDA
U11 TL081
VCCA
R36 10K
R37 10K
510R R27
.1 C10
R26 1K
100R
R20
2200PF C8
AGND
AUD4
AUD1
U9 7910
V21-23
DTRU9
U19:B 74LS04
C/BCTS
ISOLATED AREA
RING DETECT
RING
L=RING
R3 50k
R2 100R
OP1 4N25
H=OFF-HOOK
Q1 2N3904
DIAL
AUDIO
C1 1MF5
B1
ZD3 9V1
RLY1 OUDM-5
ZD4 5V1
2K2 R19
100R1W R1
C29 150PF
R15 20K
R16 600R
U10:B 1458
R14 10K
U10:A 1458
R17 10K
RX
RLY2 AZ300
AUD
ZD2 3V3
ZD1 3V3
T1 600/600
W R B
PIN 2 PIN 6
R28 270
R41 2K2
VOL?
L=LOUD
Q3 BC548
R18 22K
R42 600R
ZD7 3V3
3V3 ZD8
SEL?
R36 2K2
Q4 2N3904
H=7910
R32 20K
R40 15K


U2
Z80000
U1
74LS373
U3
27256
U4
43256
U19:C
74LS04
U19:E
74LS04
U20:C
74HC32
U20:D
74HC32
U19:A
74LS04
U20:A
74HC32
U20:B
74HC32
SW2
R5
10k
R8
10k
R29
10k
R30
10k
U23
UA7805UC
C3
10MF
C14
2MF2
U12
UA7805UC
R33
1R
ANALOG
DIGITAL
C16
10MF
C47
.1
C13
2200MF
C12
2200MF
10VAC
P2
SW1
OFF
ON
D8
4001
D9
4001
F3
1.5A
U13
UA7905XC
C15
2MF2
C17
10MF
C48
.1
U22
UA7905XC
C2
10MF
XTL1
2.45MEG
C45
20PF
C46
20PF
U16:A
74LS00
U16:B
74LS00
C40
.1
C41
.1
C42
.1
C43
.1
POWER SUPPLY
C36
2MF2
C31
2MF2
C32
2MF2
C33
2MF2
C34
2MF2
C44
1
C26
2X2
C27
2X2
C28
2X2
U8
XR2402
C6
2MF2
C5
2MF2
C4
.01
R4
100K
U7
XR2401
C7
2mf2
XTL3
19.6608
C25
15PF
C24
15PF
V22BIS
R31
2X2
H=OFF
U21
LM386
C30
2MF2
C19
1MF
BC548
Q2
C20
2MF2
C11
.22
220MF
C18
P5
2WAY
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The well spoken Tannoys

Tannoy Professional speakers have recently been enjoying considerable success, with major contracts for the Darling Harbour complex and the Sydney Opera House, as well as several leading studios.

The conference facilities at Darling Harbour will be equipped with 14 Little Gold Monitors (LGMs). The LGM is a compact system using the latest 305 mm (12") dual concentric drive unit and is intended as a reference monitor with multiple applications.

The Little Gold Monitors succeed Tannoys's very successful Little Red Monitors.

The University of Technology Sydney (ex-Institute of Technology), TV Channel 9, Palm Studios film production facilities, EMI's Studio 301 and CBS Studios have all purchased Tannoy Professional loudspeakers recently through Hi-Phon Tannoy's Australian distributor.

Studio 301 are said to be "raving" over their pair of Tannoy DTM-8 desktop monitors which they are using as near field monitors. CBS Studios recently purchased two pairs of SGM 10B's to be used as the main monitors in their film cutting rooms.

The Sydney Opera House purchased five pairs of DTM-8s to be used in the control rooms for each of the concert halls. Channel 9 use DTM-8s in their control rooms.

We'll be reviewing the LGMs in an upcoming issue. Watch for it. For further information, contact: **Mike Wilson, Hi-Phon Distributors Pty Ltd. (02)417 7088.**

New range of panel lamps

Novatech has released a new range of neon and incandescent lamps for industrial control panels, electronic and electrical appliances featuring low power consumption, low heat output, long operating life, wide range of operating voltages, rugged construction, choice of three colours and clear lenses.

Sizes include 10 and 25 mm diameter, and they come with stripped leads, solder terminal or screw lugs.

The lamps are clearly visible from all angles, Novatech claim, and are designed to operate reliably in harsh environments.

For more information, contact **Novatech Controls (Aust) Pty Ltd, Sydney (02)758 1122, or Melbourne (03)645 2377.**

PCB faults and shorts locator

Emona Instruments has released the Polar 850 Shorts Locator which allows the pin-pointing of short circuits on printed circuit boards in a fraction of the time it would normally take.

By locating solder bridges, etching defects, faulty ICs or faulty decoupling capacitors, the 850 eliminates the need to cut tracks to isolate faults, Polar claim.

The instrument's two milliohm ranges (40 and 200 mohm) and the 2 mV range (with microvolt resolution) allows the tracing of faults by analysis of minimum resistance or of current flow.

In addition, a magnetic field sensing current probe allows the tracing of inaccessible current paths, such as those through ICs or within multilayer pc boards. A variable pitch tone and a digital display guide the user to the location of the short.

Emona Instruments are at **86 Parramatta Road Camperdown, (02)519 3933, or write to PO Box K720, Haymarket NSW 2000.**

Trewin catalogue

Multi-contact Australia has released a new catalogue covering its Australian-made Trewin Components range.

It contains photographs, technical drawings, dimensions and full specifications for the full range of Trewin binding posts, laboratory sockets and laboratory plugs.

The A4-sized catalogue describes newly-released products and features a colour cover illustrating the products.

Copies may be obtained from **Multi-Contact Australia Pty Ltd, Sydney (02)438 3600, Melbourne (03)383 3733, Brisbane (07)369 0544, Perth (09) 443 3944**

New Utilux D connectors

Utilux has released their second family of I/O connectors – a range of crimp type removable subminiature D connectors and accessories. Connectors are available for 9 to 50 conductors of 20 to 28 AWG.

Accessories include plastic and metallised hoods for use with screwlocks, cable back shells for clip and retainer attachment and a slide latch assembly.

For more information, contact **Utilux Electronic Division, 14 Commercial Road, Kingsgrove 2208 NSW. (02)50 0155.**

Practical filter design — without fears or tears

Part 8 — Special purpose filters

Jack Middlehurst

Imagine you're at a cocktail party. Here you'll be introduced to messrs Linkwitz, Lipshitz and Bessel, and see Chebychev stand on his head! You'll also learn about subtraction, delay equalization, notches and crossovers. Take it away, Jack!

IN THIS PART I'll gather together a number of "loose ends", some of which I deliberately left until now, plus some topics brought up by readers over the past few months.

The inverse Chebychev filter

So far we have looked at filters that are: (1) maximally flat in the passband and with continuing attenuation in the stopband (Butterworth), (2) equiripple in the passband and with continuing attenuation in the stopband (Chebychev), and (3) equiripple in the passband and equiripple in the stopband (elliptic). The fourth possible combination is maximally flat in the passband and equiripple in the stopband. The filter with these characteristics is called the *inverse Chebychev* filter.

By sacrificing the ultimate attenuation in the stopband, this filter permits you to have a maximally flat passband and a greater cutoff slope than the Butterworth filter. This means that the filter has the smooth phase shift and delay of the Butterworth but a cutoff slope similar to the Chebychev. Consequently its main use is in active crossover units and filters where smooth phase response is essential.

Figure 8.1 is a GWBASIC program that calculates the filter order, tuning frequencies, Qs, and notch frequencies for inverse Chebychev LP and HP filters. The main difference from the usual Chebychev program is that you need not have an attenuation of 3 dB at the cutoff frequency.

The notch frequencies are found by using a special program devised by R.W. Daniels. This program takes quite a while to run (10 sec on a 10 MHz AT) because it finds the notches by a successive approximation method which requires running the major subroutine, in which there are many loops, four times. When you run the program you will notice that the Qs needed for the inverse Chebychev filter are considerably less than those for the ordinary Chebychev filter, which is an added bonus.

Even though it is theoretically possible to build BP and BR filters using the inverse Chebychev filter, it is not usual to do so; the elliptic filter is preferred for these, although a BP design was presented on page 36 of the Elektor section of AEM Sept. 1987.

In a similar way to the elliptic filter, it is possible to arrange the position of at least one of the notches to your liking by changing the frequency of the stopband edge. Since these filters are usually used for audio frequencies, the best way to build them is by using state variable filter blocks. Consequently, once the filter is designed to your satisfaction, the program proceeds to display the component values for the necessary number of state variable blocks.

The construction and alignment of these filters is similar to that of state variable elliptic filters, the only difference is in the actual values of the Qs, tuning and notch frequencies. The program of Figure 8.1 displays all the necessary information for tuning and adjustment. The only adjustment that you

Figure 8.1. GWBASIC program to calculate the order, tuning and notch frequencies, Qs, attenuation, phase shift, and delay of inverse Chebychev LP and HP filters.

```
10 PRINT "                State Variable Filter Components"
20 PRINT "            for Inverse Chebychev LP & HP filters."
30 PRINT "            Copyright Aguila Holdings Pty Ltd 1987 ":PRINT
40 DIM A(25),B(25),C(25),CS(15),D(25),F1(25),K(25),P(25),Q(25),S(50),X(50),Z(50)
50 DIM G(10,10)
60 REM ___________________ TEXT ARRAYS FOR DISPLAY ___________________________
70 A1$="  Cutoff frequency=":A2$="Stopband frequency=":A3$="    Atten at Fstop="
:A4$=" dB":A5$="                 Ripple=":A7$="  Centre frequency=":A8$="       Ban
dwidth="
80 REM_________________________ CONSTANTS & DATA ____________________________
90 PI=3.141592654#: CSW=0 :G1=1 : G2=0:RFACTOR=4700:QMIN=.5747
100 FOR I=1 TO 14:READ CS(I):NEXT I
110 DATA 1E-6,.47E-6,.33E-6,.22E-6,.1E-7,.47E-7,.33E-7,.22E-7,1E-8,.47E-8,.33E-8
,.22E-8,1E-9,.47E-9
120 DEF FNCOSH(X)=(EXP(X)+EXP(-X))/2:DEF FNACOSH(X)=LOG(X+SQR(X*X-1))
130 DEF FNSINH(X)=(EXP(X)-EXP(-X))/2:DEF FNASINH(X)=LOG(X+SQR(X*X+1))
140 PRINT "What type of filter would you like to design "
150 PRINT "1. Low pass"
160 PRINT "2. High pass"
170 INPUT "Would you please enter the appropriate integer ?",X:IF X<1 OR X>2 THE
N 140
180 PRINT "What is the cutoff frequency [ Hz ] ? ":INPUT FC:IF FC<=0 THEN 180
190 IF CSW=1 THEN 1190
200 INPUT "What is the attenuation [ dB ] at the cutoff frequency ? ",A1:IF A1<=
0 OR A1>3 THEN 200
210 IF CSW=1 THEN 1190
220 INPUT "At what frequency [ Hz ] in the stopband is the attenuation known ? "
,FS:IF FS<=0 THEN 220
230 IF CSW=1 THEN 1190
240 IF (X=1 AND FS<=FC) OR (X=2 AND FS>=FC) THEN PRINT "That frequency is not in
 the stopband.":GOTO 220
250 IF CSW=1 THEN 1190
260 INPUT "What attenuation would you like at that frequency ? ",ASTOP:IF ASTOP<
=0 THEN 260
270 IF ASTOP<=3 THEN PRINT "The attenuation in the stopband must be greater than
 3 dB.":GOTO 260
280 IF CSW=1 THEN 1190
290 FRATIO=FS/FC:IF X=2 THEN FRATIO=FC/FS
300 EP1=10^(.1*ASTOP)-1:EP2=10^(.1*A1)-1
310 N=INT(FNACOSH(SQR(EP1/EP2))/FNACOSH(FRATIO))+1
320 PRINT:PRINT "Filter order is ";N
330 COUNTER=0:PRINT "These calculations are rather lengthy, please wait ..."
340 REM __________________ EQUIVALENT NORMALIZED LP FILTER ____________________
350 V=INT(N/2) : EVEN=0 : ODD=1 : IF N MOD 2=0 THEN EVEN=1 :ODD=0
360 GOTO 1330
370 FOR I=1 TO V:F(I)=F(I)/FC:NEXT I:GOSUB 390:GOTO 830
380 REM ______________________ GENERALIZED POLES & Qs __________________________
390 E0=SQR(EP2) : M=ODD+2*V : M0=2*INT(M/2) : R=0 : T=M
400 FOR I=1 TO V : Z(I)=SQR(1-1/F(I)/F(I)) : NEXT I
410 GOSUB 490:GOSUB 520
420 IF M>M0 THEN C(2*M)=0
430 FOR I=0 TO 2*M STEP 2 : A(M-I/2)=C(I)+D(I) : NEXT I : GOSUB 840
440 R=R+1 : D=1+P(R)+Q(R) : B(R)=(1+P(R)/2)/D
450 P(R)=1/D^.25 : Q(R)=1/SQR(2*(1-B(R)/P(R)^2)):IF R<M0/2 THEN 440
460 IF M>M0 THEN F(R+1)=SQR(1/(A-1))
470 RETURN
480 REM ___________COEFFTs OF F(Z)^2=C(0)+C(2)*Z^2+C(4)*Z^4+ &c _________________
490 ZZ0=1:FOR I=1 TO V:ZZ0=ZZ0*Z(I)^4:NEXT I
500 C(0)=EP2*ZZ0:FOR I=2 TO 2*V STEP 2:C(I)=0:NEXT I:RETURN
510 REM ___________COEFFTs OF Q(Z)^2=D(0)+D(2)*Z^2+D(4)*Z^4+ &c ______________
520 FOR I=1 TO ODD : S(I)=-1 : NEXT I
530 FOR I=ODD+1 TO ODD+V : S(I)=-Z(I-ODD)^2 : NEXT I
```

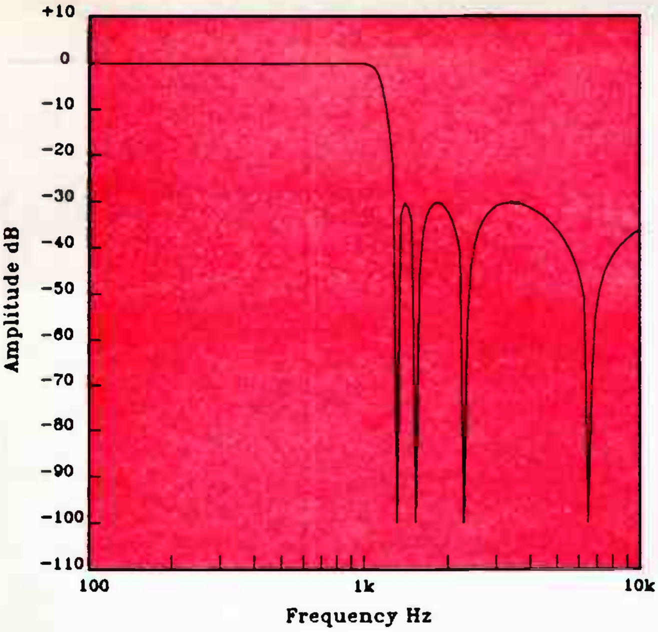


Figure 8.2. Frequency response of an Inverse Chebychev LP filter. Attenuation 0.1 dB at Fc = 1 kHz, and 30 dB at Fs = 1.3 kHz. Order = 8.

are likely to need is the frequency of the notch nearest the cutoff frequency.

The program of Figure 8.1 also enables you to calculate the attenuation, phase shift, and time delay of these filters at any frequency. A typical frequency response for an 8th order filter having Fc(0.1dB) = 1 kHz and 30 dB attenuation at 1.3 kHz is shown in Figure 8.2. You can see the resemblance to the Butterworth shape in the passband and the typical elliptic type of response in the stopband. Actually the response in the passband is even flatter than that of a Butterworth, since this filter does not require the cutoff attenuation to be 3 dB. In the example in the graph, the attenuation up to the cutoff frequency of 1 kHz does not exceed 0.1 dB, so this particular passband response is really flat.

Delay equalization – the all-pass filter

Rather than think in terms of phase shift, many filter engineers concentrate on the time delays introduced by filters. In many ways this is more logical since a filter with a delay that is independent of frequency will pass a waveform without distorting it. This is a very simple criterion to have for a filter. Since most filters introduce delay distortion, i.e: their delay is a function of frequency, various tricks are used to cancel, at least in part, this time-dependent delay. We will look at some solutions to this problem.

The all-pass filter is the answer to the question "when is a filter not a filter?" In audio frequency work, it often happens that a filter is used that has precisely the required frequency response but introduces a delay that is frequency dependent. To correct this we need a 'filter' that has a flat frequency response together with a counteracting delay. It is not possible to cancel out a delay, since that would involve going backwards in time. The idea is to add to an existing delay so that the overall delay is independent of frequency. This is the purpose of the all-pass filter.

Cancelling the delay of a filter is an art rather than a science. Indeed this part of filter design, if it becomes necessary, can take longer than the rest of the design since it has to be done by trial and (lots of!) error. Most of the filters we have discussed so far have had a program associated with them ▷

```
540 FOR I=ODD+V+1 TO ODD+2*V : S(I)=S(I-V) : NEXT I
550 SO=M : GOSUB 560 : D0=(-1)^ODD
560 FOR I=0 TO 2*M STEP 2 : D(I)=D0*B(I/2) : NEXT I : RETURN
570 REM ________________PRODUCT(X+S(I))=B(0)+B(1)*X+B(2)*X^2+ &c ____________
580 B(0)=S(1) : B(1)=1 : J=1
590 J=J+1 : A(0)=S(J)*B(0)
600 FOR I=1 TO J-1 : A(I)=B(I-1)+S(J)*B(I) : NEXT I
610 FOR I=0 TO J-1 : B(I)=A(I) : NEXT I : B(J)=1 : IF J<SO THEN 590
620 RETURN
630 REM ____________________ FACTOR FINDER ______________________
640 FOR I=1 TO T : A(I)=A(I)/A(0) : NEXT I
650 A(0)=1 : B(0)=1 : C(0)=1 : I1=0
660 IF T=2 THEN 790
670 P=0 : Q=0 : I1=I1+1
680 B(1)=A(1)-P : C(1)=B(1)-P
690 FOR I=2 TO T : B(I)=A(I)-P*B(I-1)-Q*B(I-2) : NEXT I
700 FOR I=2 TO T-1 : C(I)=B(I)-P*C(I-1)-Q*C(I-2) : NEXT I
710 X1=T-1 : X2=T-2 : X3=T-3 : X4=C(X2)^2+C(X3)*(B(X1)-C(X1))
720 IF X4=0 THEN X4=.001
730 D1=(B(X1)*C(X2)-B(T)*C(X3))/X4 : P=P+D1
740 D2=(B(T)*C(X2)-B(X1)*(C(X1)-B(X1)))/X4 : Q=Q+D2
750 IF ABS(D1)+ABS(D2)>.00001 THEN 680
760 P(I1)=P :Q(I1)=Q : A(1)=A(1)-P : T=T-2
770 FOR I=2 TO T : A(I)=A(I)-P*A(I-1)-Q*A(I-2) : NEXT I
780 IF T>2 THEN 670
790 IF T=2 THEN I1=I1+1 : P(I1)=A(1) : Q(I1)=A(2)
800 IF T=1 THEN A=-A(1)
810 RETURN
820 REM ______________ DENORMALIZE FREQUENCIES & Qs ____________________
830 ON X GOTO 850,880
840 REM _______________ CALCULATE VALUES FOR LP FILTERS _______________
850 FOR I=1 TO V:RE(I)=P(I)/2/Q(I):IM(I)=P(I)*SQR(1-1/4/Q(I)^2):F1(I)=FC*F(I):P1
(I)=FC*P(I):NEXT I:IF ODD=1 THEN P1(V+1)=FC*F(V+1):Q(V+1)=.5
860 GOTO 910
870 REM _______________ CALCULATE VALUES FOR HP FILTERS _______________
880 FOR I=1 TO V:RE(I)=P(I)/2/Q(I):IM(I)=P(I)*SQR(1-1/4/Q(I)^2):F1(I)=FC/F(I):P1
(I)=FC/P(I):NEXT I:IF ODD=1 THEN P1(V+1)=FC/F(V+1):Q(V+1)=.5
890 GOTO 910
900 REM __________________ DISPLAY RESULTS ______________________
910 PRINT "              Tuning Frequency          Q":PRINT
920 ON X GOTO 940,1000
930 REM ______________ DISPLAY RESULTS FOR LP FILTERS________________
940 IF EVEN=0 THEN W=P1(V+1):GOSUB 1080:PRINT USING "\              \###.###\  \\
     \###.##";Z$,W,A6$,Z$,Q(V+1)
950 FOR I=V TO 1 STEP -1
960 W=P1(I):GOSUB 1080:PRINT USING "\            \###.###\  \\           \##.##";Z
$,W,A6$,Z$,Q(I):NEXT I
970 PRINT:PRINT "              Notch Frequency":PRINT
980 FOR I=V TO 1 STEP -1 :W=F1(I):GOSUB 1080:PRINT USING "\             \###.###"
;Z$,W.A6$:NEXT I
990 PRINT:GOTO 1130
1000 REM _______________ DISPLAY RESULTS FOR HP FILTERS__________________
1010 FOR I=1 TO V
1020 W=P1(I):GOSUB 1080:PRINT USING "\            \###.###\  \\           \##.##";
Z$,W,A6$.Z$,Q(I):NEXT I
1030 IF EVEN=0 THEN W=P1(V+1):GOSUB 1080:PRINT USING "\             \###.###\  \\
      \###.##";Z$,W,A6$,Z$,Q(V+1)
1040 PRINT:PRINT "              Notch Frequency":PRINT
1050 FOR I=1 TO V :W=F1(I):GOSUB 1080:PRINT USING "\             \###.###";Z$,W,A
6$:NEXT I
1060 PRINT:GOTO 1130
1070 REM ___________ SUBROUTINE FOR CONVENIENT FREQUENCY UNITS ____________
1080 IF W>=1000000! THEN W=W/1000000!:A6$=" MHz":GOTO 1110
1090 IF W>=1000! THEN W=W/1000!:A6$=" kHz":GOTO 1110
1100 A6$=" Hz"
1110 RETURN
1120 REM ________________ DISPLAY CURRENT VALUES OF FC, BW, &C_______________
1130 INPUT "To go to the next part of the programme press ENTER.",SS$:PRINT
1140 W=FC:GOSUB 1080:PRINT USING "\                        \###.###\  \";A1$,W,A6$
1150 W=FS:GOSUB 1080:PRINT USING "\                        \###.###\  \";A2$,W,A6$
1160 PRINT USING "\                   \###.###\ \";A3$,ASTOP,A4$
1170 PRINT USING "\                   \###.###\ \";A5$,A1,A4$:GOTO 1190
1180 REM ______________________ WHAT NEXT ? ______________________
1190 CSW=1 :PRINT: PRINT "Would you like to :"
1200 PRINT "1. Quit ?"
1210 PRINT "2. Calculate component values for state variable blocks ? "
1220 PRINT "3. Calculate the notch & tuning frequencies & Qs ?"
1230 PRINT "4. Alter the value of the passband ripple ?"
1240 PRINT "5. Alter the value of the stopband attenuation ?"
1250 PRINT "6. Alter the value of the stopband frequency ?"
1260 PRINT "7. Alter the value of the cutoff frequency ?"
1270 PRINT "8. Calculate attenuation, phase, & delay ?"
1280 INPUT "Please enter the appropriate integer.",XX
1290 IF XX<1 OR XX>8 THEN 1300 ELSE 1310
1300 PRINT "That is not an appropriate integer.":GOTO 1330
1310 ON XX GOTO 1320,1990,290,200,260,220,180,2900
1320 PRINT:PRINT "End of programme.":END
1330 REM ___________________ LP POLE LOCATOR (RW DANIELS) _______________
1340 NIN=ODD:IF X=2 THEN FS=FC*FC/FS
1350 IF V=1 THEN F(1)=1.1*FS:GOTO 1390
1360 IF V=2 THEN F(1)=1.05*FS:F(2)=125*FS:GOTO 1390
1370 IF V=3 THEN F(1)=1.02*FS:F(2)=1.25*FS:F(3)=3!*FS:GOTO 1390
1380 IF V=4 THEN F(1)=1.015*FS:F(2)=1.2*FS:F(3)=2.5*FS:F(4)=4.5*FS
1390 FS(1)=FS:FBB=FC*FC:FH=FS(1):A(0)=0:A(1)=ASTOP
1400 FOR I=1 TO V:Z(I)=SQR(1-FBB/F(I)/F(I)):NEXT I
1410 F=FH:GOSUB 1520:AH=A:FM=FH:AM=AH:DM=AH-A(1):FX=FH:FY=F(1):I=2:GOSUB 1730
1420 IF V=1 THEN 1460
1430 ZA=Z(I-1):ZB=Z(I):GOSUB 1580
1440 FX=F(I-1):FY=F(I):I=I+1:GOSUB 1730
1450 IF I<V+1 THEN 1430
1460 ZA=Z(V):ZB=1
1470 IF NIN>0 THEN GOSUB 1580
1480 IF NIN=0 THEN Z=.999999:GOSUB 1530
1490 IF NIN=0 THEN FM=1E+18:AM=A:DM=A-A(1)
1500 FX=F(V):FY=10*FS(1):I=V+2:GOSUB 1730
1510 COUNTER=COUNTER+1:IF COUNTER >4 THEN GOTO 370 ELSE GOSUB 1810
1520 Z=SQR(1-FBB/F/F)
1530 ZZ=Z*Z:QQZ=(ZZ-1)^NIN
1540 FOR I3=1 TO V:QQZ=QQZ*(ZZ-Z(I3)^2)^2:NEXT I3
1550 FFZ=EP1:FOR I3=1 TO V:FFZ=FFZ*Z(I3)^4:NEXT I3
1560 A=4.343*LOG(1+ABS(FFZ/QQZ))
1570 RETURN
1580 ZZ0=(ZA*ZA+ZB*ZB)/2:I1=1:ZZA=ZA*ZA:ZZB=ZB*ZB
1590 IF ZB=1 THEN ZZ0=(NIN/2*ZA*ZA+1)/(NIN/2+1)
1600 ZZ=ZZ0:GOSUB 1700:D0=D:ZZ1=ZZ0-.000001
1610 ZZ=ZZ1:GOSUB 1700
1620 D1=D:ZZ2=(ZZ0*D1-ZZ1*D0)/(D1-D0)
1630 IF ZZ2<ZZA THEN ZZ2=ZZA+.001
1640 IF ZZ2>ZZB THEN ZZ2=ZZB-.001
1650 D0=D1:ZZ0=ZZ1:ZZ1=ZZ2:IF ABS(ZZ1-ZZ0)>.0000001 THEN 1610
1660 F=SQR(FBB/(1-ZZ1)):Z=SQR(ZZ1):GOSUB 1530
1670 IF FS(I1)<F THEN AR=A(I1)
1680 FM=F:AM=A:DM=A-AR:I1=I1+1:IF I1<2 THEN 1670
1690 GOSUB 1700:RETURN
1700 D=NIN/2/(1-ZZ)
1710 FOR I2=1 TO V:D=D+1/(Z(I2)*Z(I2)-ZZ):NEXT I2
1720 RETURN
1730 J=1
1740 IF FS(J)<FX OR FS(J)>FY THEN 1780
1750 IF A(J-1)>A(J) THEN AR=A(J-1) ELSE AR=A(J)
1760 F=FS(J):GOSUB 1520
1770 FM=F:AM=A:IF DM>A-AR THEN DM=A-AR
```

Sorry about this, but 8.1 continues on page 44 ▷

that calculates the time delay as a function of frequency. If you want to get serious about smoothing the time delays of filters, it would be worth your while to write your own graphics program that plots the curve of delay-vs-frequency for the filter of interest.

Two circuit blocks are used for delay equalization, first order and second order. The first order circuit is shown in Figure 8.3. The circuit at (a) produces a phase shift that is –180° at 0 Hz and increases to 0° at high frequencies.

The phase shift of the circuit of (b) starts at 0 and increases with frequency to 180°. The GWBASIC program of Figure 8.4 allows you to calculate the delay as a function of frequency after you choose either the resistor R or the capacitor C together with the delay at zero frequency. First order all-pass blocks have their maximum delay at zero frequency.

The second order circuit block can be realised using the circuit of Figure 8.5 or with the state variable block as shown in Figure 8.6. In each case the output is obtained by summing the input signal and the signal after it has passed through a BP filter. The delay response of this filter resembles the frequency response of a BP filter in that it has a peak in it. This peak permits you to fill in a 'hole' in the delay response of a filter. As you would expect, the height and width of the delay peak are controlled by the Q of the all-pass circuit.

The program of Figure 8.7 asks for the frequency at which you would like a peak, and the Q, and then displays the delay at any frequency that you select. Once you have chosen the frequency and Q, the magnitude of the delay at any frequency is fixed; it is not possible, for example, to halve the delay at all frequencies, much as this may be desirable. Again it is worthwhile adding a graphics package that will plot the delay-vs-frequency response of both the 1st and 2nd order delay equalizers so that you can easily see the effect of changing the frequency and Q.

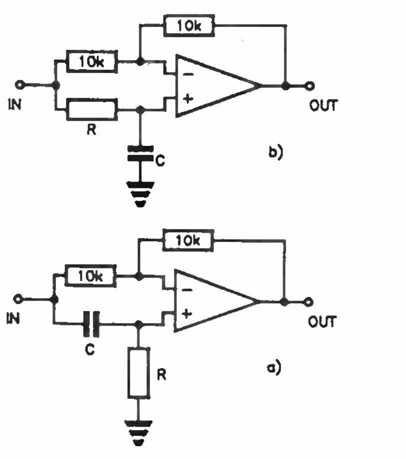
Figure 8.8 shows the way in which the delay response of a 2nd order all-pass delay filter alters with Q. For Qs less than about 0.7, the delay is similar to that of a 1st order delay circuit. For Qs less than about two, the peak in the delay occurs at a lower frequency than the resonant frequency of the BP filter within the all-pass filter. For the curves of Figure 8.8, the all-pass tuning frequency was 1 kHz.

So the procedure in delay equalization is to look at the delay response of your filter, choose a 1st or 2nd order all-pass delay compensating stage, add its delay response to that of your filter, inspect the result, modify the Q or peak frequency, or perhaps add another delay section, and keep this up until you are satisfied with the shape of the overall delay-vs-frequency curve. You can have a lot of fun doing this on a computer and then breadboarding your choice before you ever commit anything to a printed circuit board. After you have decided on the shape of delay curve you like, the program of Figure 8.7 displays the component values for the circuits of Figure 8.5 or Figure 8.6.

Figure 8.4. GWBASIC program to design 1st order delay circuits.

```
10 PRINT "                    First Order All Pass Time Delays"
20 PRINT "                 Copyright Aguila Holdings Pty Ltd 1987":PRINT
30 INPUT "Would you like to choose the R [ Enter R ] or C [ Enter C ] ? ",A$
40 IF A$<>"R" AND A$<>"r" AND A$<>"C" AND A$<>"c" THEN 30
50 IF A$="R" OR A$="r" THEN INPUT "What value [ Ohms ] would you like for R ? ",
R:IF R<=0 THEN 50 ELSE R$=R
60 IF A$="C" OR A$="c" THEN INPUT "What value [ uF ] would you like for C ? ",C:
IF C<=0 THEN ELSE CC=C
70 INPUT "What time delay [ ms ] would you like at zero frequency ? ",D0:IF D0<=
0 THEN 70
80 D0=D0/1000:IF A$="R" OR A$="r" THEN CC=D0/2/R ELSE RR=1000000!*D0/2/C
90 IF A$="R" OR A$="r" THEN C=CC:GOSUB 240:PRINT USING "C=###.###\ \";C,C$ ELSE
R=RR:GOSUB 200:PRINT USING "R=###.###\    \";R,R$
100 INPUT "At what frequency [ Hz ] would you like to know the delay ? ",F:IF F<
=0 THEN 100 ELSE W=2*3.141527#*F
110 D=2*RR*CC/(W*W*RR*RR*CC*CC+1):GOSUB 140:PRINT USING "The delay at that frequ
ency is ###.###\  \";D,D$
120 INPUT "Would you like to choose another frequency [ Y or N ] ? ",A$
130 IF A$="Y" OR A$="y" THEN 100 ELSE PRINT "End of programme.":END
140 IF D>=1 THEN D$=" sec":GOTO 190
150 IF D>=.001 THEN D=D*1000!:D$=" ms ":GOTO 190
160 IF D>=.000001 THEN D=D*1000000!:D$=" us ":GOTO 190
170 IF D>=1E-09 THEN D=D*1E+09:D$=" ns ":GOTO 190
180 D=D*1E+12:D$=" ps "
190 RETURN
200 IF R>=1000000! THEN R=R/1000000!:R$=" MOhms":GOTO 230
210 IF R>=1000! THEN R=R/1000!:R$=" kOhms":GOTO 230
220 R$=" Ohms "
230 RETURN
240 IF C>=1 THEN C$=" F":GOTO 290
250 IF C>=.001 THEN C=C*1000!:C$=" mF":GOTO 290
260 IF C>=.000001 THEN C=C*1000000!:C$=" uF":GOTO 290
270 IF C>=1E-09 THEN C=C*1E+09:C$=" nF":GOTO 290
280 C=C*1E+12:C$=" pF"
290 RETURN
```

Figure 8.3. 1st order all-pass delay filters. (a) lagging phase; (b) leading phase.



Active crossovers

Active crossover networks for audio systems have been discussed in AEM on several occasions. The AEM6503 project design by David Tilbrook (Feb. '86) is an excellent example of what can be achieved. The reasons for using an active crossover are simple. Any LC filter represents a reactive load on whatever is driving it. Also, LC filters only work properly when terminated with the correct load. Since a loudspeaker is a load whose properties vary with frequency, the LC filter is set an impossible task, and the amplifier is presented with a complex load, neither of which is likely to lead to optimum conditions for accurate audio reproduction. The active crossover removes both of these problems since each speaker is driven directly by its own power amplifier.

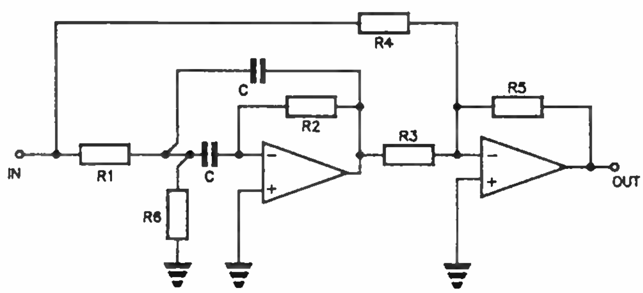


Figure 8.5. Multiple feedback 2nd order all-pass delay filter.

The next layer of problems appears when you actually try to use two or more loudspeakers to cover the audio spectrum. There will always be a range of frequencies over which both loudspeakers are contributing to the sound. If we use extremely sharp filters to reduce this range of frequencies, we know that there will be serious phase distortion, whereas if

Figure 8.6. State Variable 2nd order all-pass delay filter.

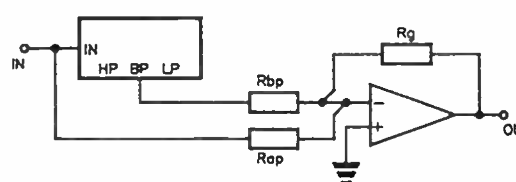


Figure 8.7. GWBASIC program to design MFB or State Variable 2nd order all-pass delay circuits.

```
10 PRINT "                    Second Order All Pass Time Delays"
20 PRINT "                 Copyright Aguila Holdings Pty Ltd 1987":PRINT
30 INPUT "At what frequency [ Hz ] would you like the peak ? ",FR:IF FR<=0 THEN
30 ELSE WR=2*3.1415927#*FR
40 INPUT "What value would you like for the Q ? ",Q:IF Q<=0 THEN 40
50 IF Q<2 THEN PRINT "For Qs less than about 2 the peak does not occur at the ch
osen frequency.":PRINT "For example a Q of 1 produces a peak at 74% of the chose
n frequency.":PRINT "For a Q of 2 the peak is at 97% of the chosen frequency ."
60 INPUT "At what frequency [ Hz ] would you like to know the delay ? ",F:IF F<=
0 THEN 60 ELSE W=2*3.1415927#*F
70 D=2*Q*WR*(W*W+WR*WR)/(Q*Q*(W*W-WR*WR)^2+W*W*WR*WR):GOSUB 740:PRINT USING "The
 delay at that frequency is ###.###\  \";D,D$
80 PRINT:PRINT "Would you like to "
90 PRINT "1. calculate the delay at another frequency "
100 PRINT "2. design a state variable all-pass block ( Q>0.56 ) "
110 PRINT "3. design a multiple feedback all-pass block "
120 PRINT "4. start again "
130 PRINT "5. quit."
140 INPUT "Please enter the appropriate integer . ",X:IF X<1 OR X>5 THEN 80
150 ON X GOTO 60,270,160,30,660
160 R0=20000:GOSUB 810:R2=2*Q/WR/C:PRINT
170 IF Q<=SQR(2) THEN R1=R2/4/Q/Q:R3=Q*Q*R0 ELSE R1=R2/2:R6=R1/(2*Q*Q-1):R3=R0/2
190 R=R1:GOSUB 620:PRINT USING "R1=###.###\    \";R,R$
210 R=R2:GOSUB 620:PRINT USING "R2=###.###\    \";R,R$
220 R=R3:GOSUB 620:PRINT USING "R3=###.###\    \";R,R$
230 R=R0:GOSUB 620:PRINT USING "R4=###.###\    \";R,R$
240 R=R0:GOSUB 620:PRINT USING "R5=###.###\    \";R,R$
245 IF Q<=SQR(2) THEN PRINT "There is no R6" ELSE R=R6:GOSUB 620:PRINT USING "R6
=###.###\    \";R,R$
250 GOSUB 670:PRINT USING "C  =###.###\ \";C,C$:PRINT:GOTO 80
260 REM ________________ SWITCH FOR FREQUENCIES ABOVE 5 kHz ________________
270 IF F>5000 THEN RIN=10000:R1=20000:R2=2000:R3=20000:RG=2*RIN:RLP=RIN:RHP=2*RI
N:C1=2.2E-10:C2=C1:GOTO 320
280 REM ______________________ INITIAL VALUES OF Rs & Cs ____________________
290 RIN=100000!:R1=RIN:R2=10000:R3=RIN:RG=2*RIN:RLP=RIN:RHP=2*RIN:GOSUB 810:C1=C
:C2=C1
300 REM ___________ CALCULATE REAL POLE FOR LOW FREQUENCIES ______________
310 RQ=100000!/(1.1*Q/SQR(.1)-2):RF=SQR(.1)/WR/C1:GOTO 340
320 RQ=10000!/(1.1*Q/SQR(.1)-2):RF=SQR(.1)/WR/C1:GOTO 340
330 REM __________________________ DISPLAY ______________________________
340 IF Q<.56 THEN PRINT "The Q is too low for a state variable design.":GOTO 80
350 FQ=F*Q:PRINT:PRINT USING "The FQ product is ######";FQ:PRINT
360 IF FQ>200000! THEN PRINT "This is too high for an active filter.":GOTO 180
370 R=RIN:GOSUB 620
380 PRINT USING "Rin=###.###\    \";R,R$
390 R=R1:GOSUB 620
400 PRINT USING "R1 =###.###\    \";R,R$
410 R=R2:GOSUB 620
420 PRINT USING "R2 =###.###\    \";R,R$
430 R=R3:GOSUB 620
440 PRINT USING "R3 =###.###\    \";R,R$
450 R=RF:GOSUB 620
460 PRINT USING "Rf =###.###\    \";R,R$
470 R=RQ:GOSUB 620
480 PRINT USING "RQ =###.###\    \";R,R$
490 R=RHP:GOSUB 620:
500 PRINT USING "Rap=###.###\    \";R,R$
510 R=RLP:GOSUB 620:
520 PRINT USING "Rlp=###.###\    \";R,R$
530 R=RG:GOSUB 620:
540 PRINT USING "Rg =###.###\    \";R,R$
550 C=C1:GOSUB 680
560 PRINT USING "C1 =###.###\ \";C,C$
570 C=C2:GOSUB 680
580 PRINT USING "C2 =###.###\ \";C,C$
590 PRINT:GOTO 80
600 PRINT:PRINT "End of programme.":END
610 REM ____________________ SUBROUTINE FOR RESISTOR UNITS __________________
620 IF R>=1000000! THEN R=R/1000000!:R$=" MOhms ":GOTO 650
630 IF R>=1000! THEN R=R/1000!:R$=" kOhms ":GOTO 650
640 R$=" Ohms  "
650 RETURN
660 REM ____________________ SUBROUTINE FOR CAPACITOR UNITS __________________
670 IF C>=1 THEN C$="  F":GOTO 720
680 IF C>=.001 THEN C=C*1000:C$=" mF":GOTO 720
690 IF C>=.000001 THEN C=C*1000000!:C$=" uF" :GOTO 720
700 IF C>=1E-09 THEN C=C*1E+09:C$=" nF" :GOTO 720
710 C=C*1E+12:C$=" pF"
720 RETURN
730 REM ____________________ SUBROUTINE FOR DELAY UNITS ______________________
740 IF D>=1 THEN D$=" sec":GOTO 790
750 IF D>=.001 THEN D=D*1000!:D$=" ms ":GOTO 790
760 IF D>=.000001 THEN D=D*1000000!:D$=" us ":GOTO 790
770 IF D>=1E-09 THEN D=D*1E+09:D$=" ns ":GOTO 790
780 D=D*1E+12:D$=" ps "
790 RETURN
800 REM ____________________ SUBROUTINE TO CHOOSE C __________________________
810 IF FR>=5000 THEN C=1E-09:GOTO 850
820 IF FR>=500 THEN C=1E-08:GOTO 850
830 IF FR>=50 THEN C=.0000001:GOTO 850
840 C=.000001
850 RETURN
860 PRINT:PRINT "End of programme.":END
```

we use filters with a shallow cutoff slope, the range of overlap can be excessive.

The main controversy is whether to use second, third, or fourth order filters. There are good arguments for and against each, so the debate will continue. One approach is to try each and see which one best suits your acoustic environment. Start by using Sallen and Key Butterworth filters. Simply put an LP filter before the amplifier driving the Woofer and an HP filter before the amplifier driving the high frequency speaker. You can try the effect of not tuning the two filters to the same cutoff frequency if you feel a bit adventurous.

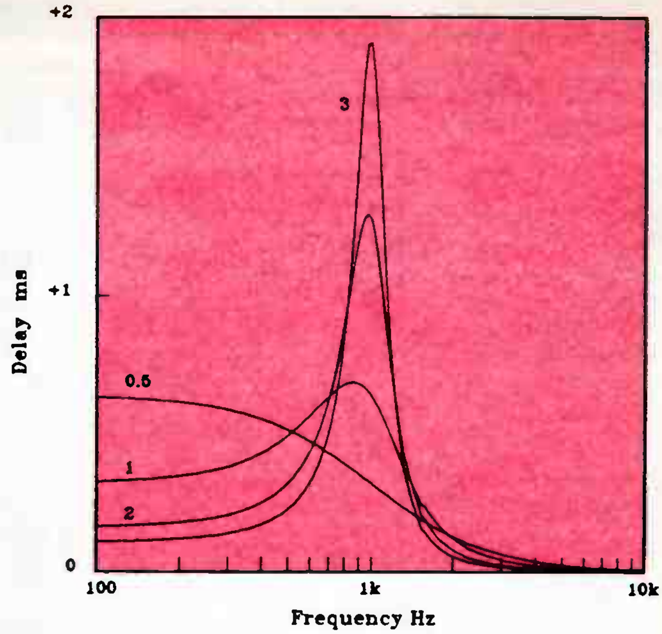


Figure 8.8. Delay of 2nd order all-pass filter, tuned to 1 kHz for the values of Q shown on the curves.

Linkwitz filters

No matter what you do, there is always some phase and amplitude distortion at the crossover frequency with Butterworth filters. Since the cutoff frequency is where the frequency response is 3 dB down, i.e: the output power is down to 70.7% of maximum, when you add the outputs of the two filters at the crossover frequency you get 141% or 3 dB up on maximum power. So there is a bump in the frequency response.

If you separate the cutoff frequencies of the LP and HP filters so that they cross over at their –6 dB points, you end up with a dip in the response each side of the crossover. In an attempt to overcome this, Linkwitz designed a filter with a cutoff shape slightly different from that of the Butterworth and put the crossover frequency where the loss was 6 dB. i.e: 50% down. This eliminates the bump.

To get a 24 dB per octave cutoff slope, he used two 12 dB per octave Butterworth filters in series. The frequency response of such a 4th order filter is obtained by taking the square of the response of the 2nd order filter. This is not the same as the frequency response of a normal 4th order Butterworth filter.

Linkwitz filters can only be even order filters. The program of Figure 8.9 calculates the values of the resistors and capacitors to be used in Linkwitz 2nd and 4th order LP and HP active filters. These values are then used in the LP or HP Sallen and Key circuit. Using this filter gives a considerable reduction in the bumps in the overall frequency response, which is why it has become popular in active crossover systems. The program of Figure 8.9 also calculates the attenuation, phase shift, and delay of 2nd and 4th order Linkwitz LP and HP filters. ▷

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1A	S-4461	35A	S-4487

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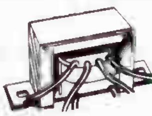

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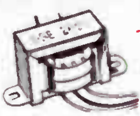

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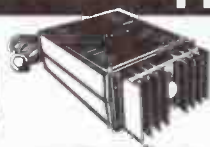

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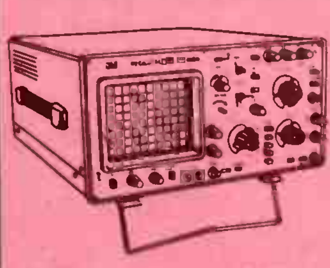

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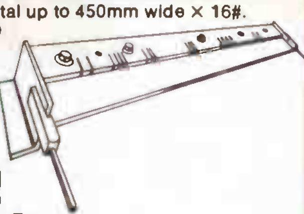

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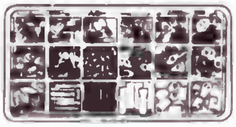

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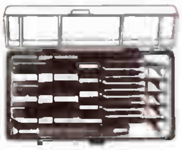

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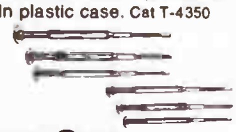

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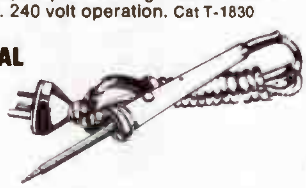

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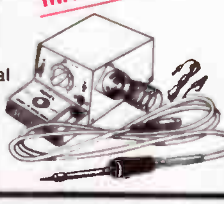

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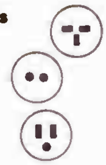

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Figure 8.9. GWBASIC program to design 2nd and 4th order Linkwitz LP and HP filters.

```
10 PRINT "                Active Linkwitz Filter Design":PRINT
20 PRINT "Would you like to design "
30 PRINT "1. a 12 dB/octave LP filter."
40 PRINT "2. a 12 dB/octave HP filter."
50 PRINT "3. a 24 dB/octave LP filter."
60 PRINT "4. a 24 dB/octave HP filter."
70 PI=3.1415927#
80 INPUT "Please enter the appropriate integer.",X:IF X<1 OR X>4 THEN 20
90 INPUT "What is the cross-over frequency ( Hz ) ? ",FC:IF FC<=0 THEN 90 ELSE W
=2*PI*FC
100 ON X GOTO 110,110,150,150
110 INPUT "Would you like to choose the resistance value ( Enter R ) or the capa
citance ( Enter C ) ? ",V$
120 IF V$="R" OR V$="r" THEN INPUT "What value resistance ( Ohms ) would you lik
e ? ",R:IF R<=0 THEN 120 ELSE C=1/W/R
130 IF V$="C" OR V$="c" THEN INPUT "What value capacitance ( uF ) would you like
 ? ",C:IF C<=0 THEN 130 ELSE R=1000000!/W/C
140 GOTO 180
150 INPUT "Would you like to choose the resistance value ( Enter R ) or the capa
citance ( Enter C ) ? ",V$
160 IF V$="R" OR V$="r" THEN INPUT "What value resistance ( Ohms ) would you lik
e ? ",R:IF R<=0 THEN 120 ELSE C=1/W/R/SQR(2)
170 IF V$="C" OR V$="c" THEN INPUT "What value capacitance ( uF ) would you like
 ? ",C:IF C<=0 THEN 130 ELSE R=1000000!/W/C/SQR(2)
180 RR=R:GOSUB 290:PRINT USING "R1=###.###\    \";RR,R$
190 IF X=4 THEN RR=2*R:GOSUB 290:PRINT USING "R2=###.###\    \";RR,R$ ELSE PRINT
 USING "R2=###.###\    \";RR,R$
200 IF X=3 THEN CC=2*C:GOSUB 330:PRINT USING "C1=###.###\ \";CC,C$ ELSE CC=C:GOS
UB 330:PRINT USING "C1=###.###\ \";CC,C$
210 CC=C:GOSUB 330:PRINT USING "C2=###.###\ \";CC,C$
220 IF X<3 THEN 270
230 RR=R:GOSUB 290:PRINT USING "R3=###.###\    \";RR,R$
240 IF X=4 THEN RR=2*R:GOSUB 290:PRINT USING "R4=###.###\    \";RR,R$ ELSE PRINT
 USING "R4=###.###\    \";RR,R$
250 IF X=3 THEN CC=2*C:GOSUB 330:PRINT USING "C3=###.###\ \";CC,C$ ELSE CC=C:GOS
UB 330:PRINT USING "C3=###.###\ \";CC,C$
260 CC=C:GOSUB 330:PRINT USING "C4=###.###\ \";CC,C$
270 INPUT "Would you like to calculate the attenuation, phase, & delay ( Y or N
) ? ",A$
280 IF A$<>"Y" AND A$<>"y" THEN 390 ELSE 400
290 IF RR>=1000000! THEN RR=RR/1000000!:R$=" MOhms":GOTO 320
300 IF RR>=1000! THEN RR=RR/1000!:R$=" kOhms":GOTO 320
310 R$=" Ohms "
320 RETURN
330 IF CC>=1 THEN C$=" F ":GOTO 380
340 IF CC>=.001 THEN CC=CC*1000!:C$=" mF":GOTO 380
350 IF CC>=.000001 THEN CC=CC*1000000!:C$=" uF":GOTO 380
360 IF CC>=1E-09 THEN CC=CC*1E+09:C$=" nF":GOTO 380
370 CC=CC*1E+12:C$=" pF"
380 RETURN
390 PRINT:PRINT "End of programme.":END
400 IF X=1 OR X=2 THEN N=1 ELSE N=2
410 INPUT "At what frequency ( Hz ) would you like the attenuation, phase, & del
ay ? ",F:IF F<=0 THEN 410 ELSE W=2*PI*F
420 IF X=1 OR X=3 THEN Z=F/FC:S=0 ELSE Z=FC/F:S=N*PI
430 FOR I=1 TO N:W(I)=2*PI*FC:Q(I)=.5*SQR(N):NEXT I
440 ATTEN=8.686*LOG(1+Z^(2*N))
450 PHASE=0:FOR I=1 TO N:IF W=W(I) THEN P=PI/2:GOTO 470
460 P=ATN(W*W(I)/Q(I)/(W(I)*W(I)-W*W)):IF P<0 THEN P=PI+P
470 PHASE=PHASE+P:NEXT I:PHASE=S-PHASE
480 D=0:FOR I=1 TO N:D=D+W(I)*(W(I)^2+W^2)/Q(I)/((W(I)^2-W^2)^2+(W(I)*W/Q(I))^2)
:NEXT I
490 GOSUB 510:PRINT USING "Atten=###.## dB   Phase=####.## degrees    Delay=###.
##\    \";ATTEN,PHASE*180/PI,D,DD$
500 INPUT "Would you like to try another frequency ( Y or N ) ?",ANS$:IF ANS$="Y
" OR ANS$="y" THEN 410 ELSE 390
510 IF D>=1 THEN DD$=" sec  ":GOTO 540
520 IF D>=.001 THEN D=D*1000!:DD$=" msec ":GOTO 540
530 D=D*1000000!:DD$=" usec "
540 RETURN
```

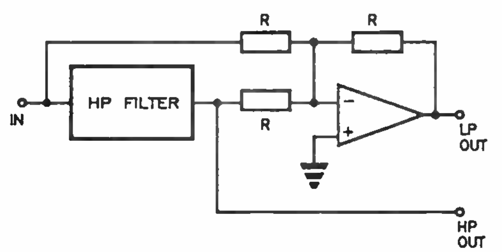


Figure 8.10. Subtraction circuit to get LP and HP outputs using only an HP filter.

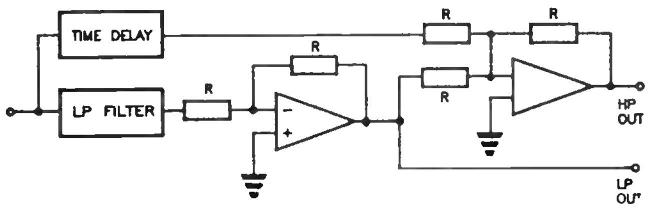


Figure 8.11. Circuit for a Lipshitz constant phase crossover filter.

Subtraction circuits

Rather than use an LP and an HP filter, it is possible to use only an HP filter and derive the LP signal by subtraction. The circuit of Figure 8.10 shows how this is done for an odd order HP filter. For an even order filter an amplifier with a gain of –1 is inserted between the filter and the subtraction amplifier. By subtracting the output of the HP filter from the original signal, what is left is a signal that looks as if it has gone through an LP filter, since the high frequencies are now missing. Neat and simple.

Unfortunately, there is a catch. If the cutoff slope of the HP filter is 18 dB per octave (3rd order), the slope on the difference signal is only 6 dB per octave. Also, there is a 4 dB bump in the frequency response of the 'LP' output just below the crossover frequency. Still, for many applications this system is cheap and entirely adequate.

Lipshitz filters

In an attempt to make a high fidelity version of the subtraction system, Lipshitz and Vanderkooy investigated in detail a related system in which the main filter was an LP, and a finite delay was introduced into the original signal before the LP signal was subtracted from it. This was designed to compensate for the delay introduced by the LP filter. The circuit is shown in Figure 8.11.

The introduction of this delay gave a considerable improvement in the flatness of both the frequency response and the phase response around the crossover frequency and also increased the slope of the cutoff of the 'HP' signal. They investigated many different types of LP filters and found that the best was the Linkwitz. The delay could be introduced using all-pass filters or Bessel filters.

A circuit for such a filter system was presented in the Elektor section in AEM of October 1987 on page 46. This uses the standard all-pass circuit of Figure 8.5, to introduce the necessary delay but it is easy to substitute a state variable all-pass or Bessel filter if you wish. The amount of time delay to add is the same as the time delay of the LP filter at very low frequencies. To find out what this delay is, simply enter a frequency of 1 Hz in the appropriate phase and delay program for the LP filter that you choose. The time delay depends not only on the type of filter that you choose but also on its cutoff frequency.

Bessel filters

The design of the Bessel or Thomson filter is based on the mathematical properties of the Bessel polynomial. These filters are mainly used in their active LP form and are usually implemented using Sallen and Key circuits. Their sole, but important, claim to fame is that they have a phase shift that is

Figure 8.12. GWBASIC program to design Bessel LP filters.

```
10 PRINT "              Design of Bessel LP Active Filters"
20 PRINT "          Copyright Aguila Holdings Pty Ltd 1987":PRINT
30 DIM FACTOR(9),C(44)
40 PI=3.1415927#
50 FOR I=2 TO 9:READ D0(I):NEXT I
60 DATA 1.359,1.753,2.111,2.424,2.699,2.947,3.174,3.388
70 FOR I=1 TO 44:READ C(I):NEXT I
80 DATA .9066,.68,1.423,.988,.2538,.7351,.6746,1.012,.39,1.01,.8712,.3095,1.041,
.31,.6352,.61,.7225,.4835,1.073,.2561,.8532,.7792,.3027,.725,.4151,1.1,.2164
90 DATA .5673,.554,.609,.4861,.7257,.359,1.116,.1857,.7564,.707,.2861,.6046,.435
2,.7307,.3157,1.137,.1628
100 INPUT "What cutoff frequency ( Hz ) would you like ? ",FC:IF FC<=0 THEN 100
110 INPUT "At what frequency ( Hz ) in the stopband is the attenuation known ? "
,FS:IF FS<=0 THEN 110
120 INPUT "What is the attenuation at that frequency ? ",A
130 FOR N=2 TO 9:EVEN=0:IF N MOD 2=0 THEN EVEN=1
140 W=FS/FC
150 FOR I=0 TO N:B(I)=1:NEXT I
160 FOR K=3 TO 2*N-1 STEP 2:B(0)=B(0)*K:NEXT K:I=1:I1=1
170 FOR K=N-I+1 TO 2*N-I:B(I)=B(I)*K:NEXT K
180 I1=I*I1:B(I)=B(I)/2^(N-I)/I1
190 I=I+1:IF I<N THEN 170
200 FOR I=0 TO N:H(I)=B(I)*D0(N)^I/B(0):NEXT I
210 GOSUB 910:IF ATTEN>A THEN 240
220 NEXT N
230 PRINT "The required order is greater than 9. Please try different input date
.":GOTO 100
240 PRINT USING "The minimum order is #";N
250 PRINT:PRINT "Would you like to "
260 PRINT "1. Calculate the delay at a chosen frequency  "
270 PRINT "2. Proceed with the circuit design "
280 PRINT "3. Quit "
290 INPUT "Please enter the appropriate integer ",X:IF X<1 OR X>3 THEN 250
300 ON X GOTO 310,330,690
310 INPUT "At what frequency ( Hz ) would you like the delay caloulated ? ",F:IF
 F<=0 THEN 310 ELSE W=F/FC
320 GOSUB 910:D=D/2/PI/FC:GOSUB 990:PRINT USING "The delay at this frequency is
###.###\   \";D,D$ :GOTO 250
330 INPUT "What value resistance ( Ohms ) would you like ? ",R:IF R<=0 THEN 330
340 Z=2*PI*FC*R:START=0:FOR 1=1 TO N:START=START+I-1:NEXT I
350 PRINT:IF EVEN=0 THEN 520
360 C1=C(START):C2=C(START+1):GOSUB 800
370 CC=C1/Z:GOSUB 700:PRINT USING "C1(1)=###.###\ \";CC,C$
380 CC=C2/Z:GOSUB 700:PRINT USING "C1(2)=###.###\ \";CC,C$
390 IF N=2 THEN 680 ELSE PRINT
400 C1=C(START+2):C2=C(START+3):GOSUB 800
410 CC=C1/Z:GOSUB 700:PRINT USING "C2(1)=###.###\ \";CC,C$
420 CC=C2/Z:GOSUB 700:PRINT USING "C2(2)=###.###\ \";CC,C$
430 IF N=4 THEN 680 ELSE PRINT
440 C1=C(START+4):C2=C(START+5):GOSUB 800
450 CC=C1/Z:GOSUB 700:PRINT USING "C3(1)=###.###\ \";CC,C$
460 CC=C2/Z:GOSUB 700:PRINT USING "C3(2)=###.###\ \";CC,C$
470 IF N=6 THEN 680 ELSE PRINT
480 C1=C(START+6):C2=C(START+7):GOSUB 800
```

Figure 8.13. Tuned T notch filter.

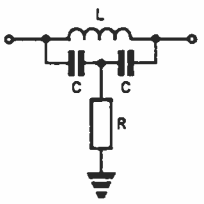


Figure 8.14. GWBASIC program to design tuned T notch filters.

```
10 PRINT "                 Design of LCR notch filter"
20 PRINT "      Copyright Aguila Holdings Pty Ltd 1987"
30 PRINT
40 PI=3.1415927#
50 REM ______________________ READ & CHECK INPUT DATA ______________________
60 INPUT "What is the required resonant frequency ( Hz ) ?",FC:IF FC<=0 THEN 60
ELSE W1=2*PI*FC:W2=W1*W1
70 INPUT "Do you know the value of L ( Enter L ) or C ( Enter C ) ?",A$
80 IF A$<>"L" AND A$<>"l" AND A$<>"C" AND A$<>"c" THEN PRINT "The answer must be
 L or C.":GOTO 70
90 IF A$="L" OR A$="l" THEN INPUT "What is the value of the inductance ( Henries
 ) of L ?",L:IF L<=0 THEN 90
100 IF A$="C" OR A$="c" THEN INPUT "What is the value ( uF ) of C ?",C:IF C<=0 T
HEN 100 ELSE C=C*.000001
110 IF A$="L" OR A$="l" THEN C=2/W2/L ELSE L=2/W2/C
120 GOSUB 420:PRINT USING "The inductance is ###.###\ \";LL,L$
130 GOSUB 350:PRINT USING "Each capacitor is ###.###\ \";CC,C$
140 INPUT "What is the resistance ( Ohms ) of L ?",RL:IF RL<=0 THEN 140
150 INPUT "What is the value ( Ohms ) of the load resistor ?",RLOAD:IF RLOAD<=0
THEN 150
160 ROPT=1/RL/C/C/W2
170 GOSUB 300:PRINT USING "The optimum resistance is ###.###\      \";RR,A$
180 INPUT "What value resistor ( Ohms ) would you like to use ?",RTRY:IF RTRY<=0
 THEN 180
190 INPUT "At what frequency ( Hz ) would you like to calculate the attenuation
?",F:IF F<=0 THEN 190 ELSE W=2*PI*F:WSQ=W*W
200 REM ______________________ CALCULATE ATTENDATION ______________________
210 A=1-RL*RTRY*C*C*WSQ:B=RTRY*C*W*(2-L*C*WSQ):C1=RL-2*RTRY*L*C*WSQ+RLOAD*(1-RL*
RTRY*C*C*WSQ-L*C*WSQ)
220 D=L*W+2*RL*RTRY*C*W+2*RLOAD*RTRY*C*W+RLOAD*RL*C*W-RLOAD*RTRY*L*C*C*W*WSQ
230 Y=RLOAD*SQR((A*C1+B*D)^2+(B*C1-A*D)^2)/(C1*C1+D*D)
240 AT=-8.686*LOG(Y):PRINT USING "Attenuation=###.## dB";AT
250 INPUT "Would you like to try another frequency ?",ANS$
260 IF ANS$="Y" OR ANS$="y" THEN 190
270 INPUT "Would you like to try another value resistor ?",ANS$
280 IF ANS$="Y" OR ANB$="y" THEN 180 ELSE 460
290 REM _______________ SUBROUTINE FOR RESISTANCE UNITS _______________
300 IF ROPT>=1000000! THEN RR=ROPT/1000000!:A$=" Mohms":GOTO 330
310 IF ROPT>1000! THEN RR=ROPT/1000!:A$=" kOhms":GOTO 330
320 A$=" Ohms "
330 RETURN
340 REM _______________ SUBROUTINE FOR CAPACITANCE UNITS _______________
350 IF C>=1 THEN CC=C:C$=" F":GOTO 400
360 IF C>=.001 THEN CC=C*1000!:C$=" mF":GOTO 400
370 IF C>=.000001 THEN CC=C*1000000!:C$=" uF":GOTO 400
380 IF C>=1E-09 THEN CC=C*1E+09:C$=" nF":GOTO 400
390 C=C*1E+12:C$=" pF"
400 RETURN
410 REM _______________ SUBROUTINE FOR INDUCTANCE UNITS _______________
420 IF L>=1 THEN LL=L:L$=" H":GOTO 450
430 IF L>=.001 THEN LL=L*1000!:L$=" mH":GOTO 450
440 LL=L*1000000!:L$=" uH"
450 RETURN
460 PRINT "End of programme.":END
```

```
490 CC=C1/Z:GOSUB 700:PRINT USING "C4(1)=###.###\ \";CC,C$
500 CC=C2/Z:GOSUB 700:PRINT USING "C4(2)=###.###\ \";CC,C$
510 GOTO 680
520 C1=C(START+1):C2=C(START):C3=C(START+2):GOSUB 830
530 CC=C2/Z:GOSUB 700:PRINT USING "C1(1)=###.###\ \";CC,C$
540 CC=C3/Z:GOSUB 700:PRINT USING "C1(2)=###.###\ \";CC,C$
550 CC=C1/Z:GOSUB 700:PRINT USING "C1(3)=###.###\ \";CC,C$
560 IF N=3 THEN 680 ELSE PRINT
570 C1=C(START+3):C2=C(START+4):GOSUB 800
580 CC=C1/Z:GOSUB 700:PRINT USING "C2(1)=###.###\ \";CC,C$
590 CC=C2/Z:GOSUB 700:PRINT USING "C2(2)=###.###\ \";CC,C$
600 IF N=5 THEN 680 ELSE PRINT
610 C1=C(START+5):C2=C(START+6):GOSUB 800
620 CC=C1/Z:GOSUB 700:PRINT USING "C3(1)=###.###\ \";CC,C$
630 CC=C2/Z:GOSUB 700:PRINT USING "C3(2)=###.###\ \";CC,C$
640 IF N=7 THEN 680 ELSE PRINT
650 C1=C(START+7):C2=C(START+8):GOSUB 800
660 CC=C1/Z:GOSUB 700:PRINT USING "C4(1)=###.###\ \";CC,C$
670 CC=C2/Z:GOSUB 700:PRINT USING "C4(2)=###.###\ \";CC,C$
680 GOTO 250
690 PRINT:PRINT "End of programme.":END
700 IF CC>=1 THEN C$=" F ":GOTO 750
710 IF CC>=.001 THEN CC=CC*1000!:C$=" mF":GOTO 750
720 IF CC>=.000001 THEN CC=CC*1000000!:C$=" uF":GOTO 750
730 IF CC>=1E-09 THEN CC=CC*1E+09:C$=" nF":GOTO 750
740 CC=CC*1E+12:C$=" pF"
750 RETURN
760 IF F>=1000000! THEN F=F/1000000!:F$=" MHz":GOTO 790
770 IF F>=1000! THEN F=F/1000!:F$=" kHz":GOTO 790
780 F$=" Hz "
790 RETURN
800 F=FC/SQR(C1*C2):Q=SQR(C1/4/C2)
810 GOSUB 760:PRINT USING "Tuning frequency=###.###\  \    Q=#.##";F,F$,Q
820 RETURN
830 AA=C1+3*C3:BB=2*C3*(C1+C2):CC=C1*C2*C3
840 P=-AA/CC:Q=BB/CC/CC:R=-1/CC/CC
850 A=(3*Q-P*P)/9:B=(P*(9*Q-2*P*P)/27-R)/2
860 ROOT=B+SQR(B*B+A*A*A):IF ROOT<0 THEN W1=-(-ROOT)^(1/3) ELSE W1=ROOT^(1/3)
870 ROOT=B-SQR(B*B+A*A*A):IF ROOT<0 THEN W2=-(-ROOT)^(1/3) ELSE W2=ROOT^(1/3)
880 W=W1+W2-P/3:W=SQR(W):TAU=CC*W*W:Q=1/W/(AA-TAU):F=FC*W:GOSUB 810
890 F=FC/TAU:Q=.5:GOSUB 810
900 RETURN
910 K1=N\2:K2=(N-1)\2:IF EVEN=0 THEN K2=K1
920 X1=0:FOR K=0 TO K1:Y1=2*K:X1=X1+(-1)^K*H(Y1)*W^Y1:NEXT K
930 X2=0:FOR K=0 TO K2:Y1=2*K:Y2=Y1+1:X2=X2+(-1)^K*Y2*H(Y2)*W^Y1:NEXT K
940 X3=0:FOR K=1 TO K1:Y1=2*K:Y2=Y1-1:X3=X3+(-1)^K*Y1*H(Y1)*W^Y2:NEXT K
950 X4=0:FOR K=0 TO K2:Y1=2*K+1:X4=X4+(-1)^K*H(Y1)*W^Y1:NEXT K
960 ATTEN=4.343*LOG(X1*X1+X4*X4)
970 D=(X1*X2-X3*X4)/(X1*X1+X4*X4)
980 RETURN
990 IF D>=1 THEN D$=" sec ":GOTO 1040
1000 IF D>.001 THEN D=D*1000!:D$=" msec":GOTO 1040
1010 IF D>=.000001 THEN D=D*1000000!:D$=" usec":GOTO 1040
1020 IF D>=1E-09 THE D=D*1E+09:D$=" nsec":GOTO 1040
1030 D=D*1E+12:D$=" psec"
1040 RETURN
```

precisely proportional to frequency, consequently their time delay is independent of frequency in the passband. The considerable price paid for this is an extremely poor cutoff rate in the stopband.

For example, a 5th order LP Butterworth filter has 55 dB attenuation at three times the cutoff frequency whereas the 5th order Bessel has only 30 dB. Nonetheless there can be occasions, such as those discussed in the previous section, where you really have to have a constant delay, in which case this is the filter to use. The program of Figure 8.12 allows you to design Bessel filters from order 2 to 9.

You will notice that the Qs of the circuits are all low, even a 9th order filter uses filter blocks with Qs less than 2, which means that the chance of overloading the filter is low. Indeed this is the one filter in which the order of the filter blocks is not particularly critical. The program of Figure 8.12 also enables you to calculate the filter delay at any frequency. You will find that high order filters have flat delays well beyond their cutoff frequency, so you can alter the delay of the filter within reasonable limits simply by altering the cutoff frequency.

Notch filters

There are many occasions where a notch filter is handy. The obvious one is when there is an unwanted signal having a single steady frequency. Another, possibly not so obvious, one is to remove the effects of a single resonance that can dominate the acoustic environment in a room, by reducing the amplifier output at that frequency.

a) LC notch filters

We have already mentioned the simplest forms of LC notch filter in part 4 of the series and have looked at their operation in detail. The main limitation on simple notch filters is the attainable Q of the circuit, since this sets both the width and the depth of the notch.

For audio work a special version of the notch filter called the tuned T filter is often preferred. Its circuit is shown in Figure 8.13. Because of the way in which the currents flow in this circuit, the current flowing in R can be made to cancel the current associated with the resistance of L. In this way the Q of the circuit can be made very high indeed. The circuit needs to be fed from a low impedance and to have a high value of load resistor to operate properly.

If you enter the values of the inductance of L, its resistance, the load resistor and the desired resonant frequency into the GWBASIC program of Figure 8.14, the value of C and the optimum value of R are both displayed. Since the true value of the resistance of L should include the effects of all losses, the measured dc resistance will always be somewhat lower than the actual series loss resistance.

So, once the optimum value is suggested by the program, use a fixed resistor of about 75% of that value with a variable resistor of about 50% of the suggested value in series with it. With the unwanted signal being fed into the filter, simply adjust the variable resistor for minimum output. The adjustment can be surprisingly critical if you want a really deep notch.

b) RC notch filters

The classical RC notch filter is the parallel T, also known as the twin T, shown in Figure 8.15. In almost all descriptions of ▷

Figure 8.15. Parallel T notch filter.

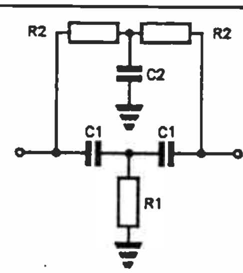


Figure 8.16. GWBASIC program to design parallel T filters.

```
10 PRINT "                    Design of Parallel T Notch filter."
20 PRINT "                 Copyright Aguila Holdings Pty Ltd 1987":PRINT
30 INPUT "At what frequency ( Hz ) would you like the notch ? ",FC:IF FC<=0 THEN
 30 ELSE W=2*3.1415927#*FC
40 INPUT "What ratio of R2 to R1 would you like ? ",RATIO:IF RATIO<=0 THEN 40 EL
SE K=SQR(2/RATIO)
50 PRINT "Only 1 component need be specified, using a capital letter plus number
"
60 INPUT "Please enter the component name [ R1, or R2, or C1, or C2 ]. ",A$
70 IF A$<>"R1"AND A$<>"R2"AND A$<>"C1" AND A$<>"C2" THEN 60
80 IF A$="R1" THEN INPUT "What is the value [ Ohms ] of R1 ? ",R1:GOTO 120
90 IF A$="R2" THEN INPUT "What is the value [ Ohms ] of R2 ? ",R2:GOTO 140
100 IF A$="C1" THEN INPUT "What is the value [ uF ] of C1 ? ",C1:GOTO 160 ELSE C
1=C1/1000000!
110 IF A$="C2" THEN INPUT "What is the value [ uF ] of C2 ? ",C2:GOTO 180 ELSE C
2=C2/1000000!
120 IF R1<=0 THEN 60
130 R2=RATIO*R1:C1=1/K/R2/W:C2=4!*C1/RATIO:GOTO 200
140 IF R2<=0 THEN 90
150 R1=R2/RATIO:C1=1/K/R2/W:C2=4!*C1/RATIO:GOTO 200
160 IF C1<=0 THEN 100
170 C2=4!*C1/RATIO:R2=1/K/C1/W:R1=R2/RATIO:GOTO 200
180 IF C2<=0 THEN 110
190 C1=C2*RATIO/4!:R2=1/K/C1/W:R1=R2/RATIO
200 R=R1:GOSUB 250:PRINT USING "R1=###.###\    \";R,R$
210 R=R2:GOSUB 250:PRINT USING "R2=###.###\    \";R,R$
220 C=C1:GOSUB 290:PRINT USING "C1=###.###\ \";C,C$
230 C=C2:GOSUB 290:PRINT USING "C2=###.###\ \";C,C$
240 PRINT "End of programme.":END
250 IF R>=1000000! THEN R=R/1000000!:R$=" MOhms":GOTO 280
260 IF R>=1000! THEN R=R/1000!:R$=" kOhms":GOTO 280
270 R$=" Ohms "
280 RETURN
290 IF C>=1 THEN C$=" F ":GOTO 340
300 IF C>=.001 THEN C=C*1000!:C$=" mF":GOTO 340
310 IF C>=.000001 THEN C=C*1000000!:C$=" uF":GOTO 340
320 IF C>=1E-09 THEN C=C*1E+09:C$=" nF":GOTO 340
330 C=C*1E+12:C$=" pF"
340 RETURN
```

this circuit the ratios R2/R1 = 2 and C2/C1 = 2 are used. There is nothing in the theory of this circuit that restricts you to these values. Indeed, it is often preferable to use different ratios for the resistors to arrive at more practical values for the capacitors.

The program of Figure 8.16 allows you to choose any value for R2/R1 and then displays the values of the other components. By running the program a few times you can choose whichever ratio best suits your purpose. You will find that resistor ratios of 1, 2, 4, and 8 produce simple capacitor ratios. This circuit also must be fed from a low impedance and terminated with a high impedance to work properly.

The Q of this circuit is 0.25, which is not particularly impressive. For a notch frequency of 1 kHz, the 3 dB points are at 236 Hz and 4.236 kHz so the notch is altogether too wide even though in principle it is infinitely deep. To increase the Q to a usable value, this circuit is used in the Q enhancement feedback system that we have met before.

The circuit is given in Figure 8.17. If the tapping on Rl is at P% of Rl, then the Q becomes 25/(100 – P), so, if the tap is at 99% of Rl, the Q is 25. Depending on the IC that you use, attempting to push the Q beyond about 100 can lead to oscillation. Use two fixed resistors rather than a trimpot for Rl, and stick to a ratio of R2/R1 of 2 or less.

Always build this circuit on a small piece of printed circuit board to test it if you need a high Q notch, then, if it doesn't oscillate, faithfully copy the layout onto the final pc board and re-use the same components. It is worthwhile trying several ICs of the same type to make sure that the lack of oscillation was not caused by a lucky combination of properties of the particular IC you used to test the circuit.

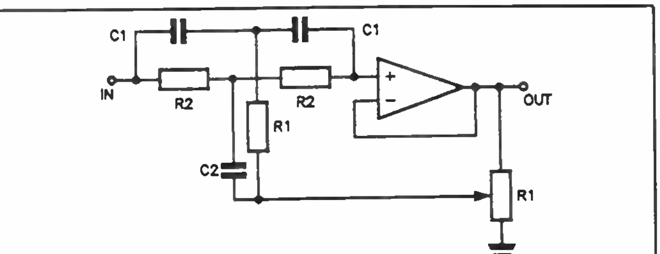


Figure 8.17. Positive feedback circuit to increase the Q of the parallel T notch filter.

To get the deepest possible notch, it is essential to use components that are as accurate as possible. Using 1% components will only give about 50 dB attenuation in the notch if you are unlucky with the tolerances. It is best to match the two R2s and the two C1s and to make 5% of R1 adjustable and to use a C2 that is a few percent low. Then you can trim R1 and put low value capacitors in parallel with C2 until you get the best possible notch depth at the frequency that you want. You will find that optimizing this circuit is only possible if you have considerable patience.

c) Tuning notch filters

The limitation on measuring notch depth may well be your test equipment. It is not easy to measure a 120 dB notch, nor, incidentally, is such a notch likely to be stable in frequency.

In testing any notch filter, the quality of the signal generator is of first importance. Many audio oscillators have about 1% harmonic distortion and this is quite adequate for general use. When such an oscillator is applied to a notch filter, that filter only removes the fundamental frequency, any harmonics being passed to the output. This means that, no matter how good your notch actually is, with a high Q filter the measured depth can never be better than 40 dB if the oscillator distortion is 1%.

Those lucky enough to have access to an oscilloscope will be able to see that the output contains harmonics, and will be able to judge the real depth of the notch. Since the notch filter only works at one frequency, the obvious solution is to put the output of your oscillator through a sharp LP filter to remove the harmonics of that frequency. A 6th order elliptic or 8th order Chebychev will reduce second harmonic by 60 dB. So, by using such a filter, you can test a notch that is 100 dB deep. By now you should certainly be able to design that filter!

FURTHER READING

Chapter 8 of R.W.Daniels' book *Approximation Methods for Electronic Filter Design*, McGraw-Hill NY 1974, was the source of the LP pole locator program used in Figure 8.1. This excellent (but high powered) book is now out of print but is available through any large library.

Linkwitz filters are described in the paper *Active Crossover Networks for Noncoincident Drivers*, J. Audio Eng. Soc., Vol. 24, pp 2-8 (Jan/Feb 1976) by S.H.Linkwitz.

S.P. Lipshitz and J. Vanderkooy have published three major papers on their modified subtraction filter: *A Family of Linear-Phase Crossover Networks of High Slope Derived by Time Delay*, J. Audio Eng. Soc., Vol. 31 pp 2-19 (Jan/Feb 1983); *Is Phase Linearization of Loudspeaker Crossover Networks Possible by Time Offset and Equalization?*, J.Audio Eng. Soc., Vol. 32 pp 946-955 (Dec 1984); and *Use of Frequency Overlap and Equalization to Produce High-Slope Linear-Phase Loudspeaker Crossover Networks*. J. Audio Eng. Soc., Vol. 33 pp 114-125 (Mar 1985).

EXAR

V.22 bis Modem

GENERAL DESCRIPTION

The XR-2400 Chip Set is designed to provide the complete modem function for V.22 bis (2400 BPS) type modems. The chip set consists of the XR-2401 DSP Modem Signal Processor and the XR-2402 DSP Interface. The XR-2400 set also provides Bell 212A (1200/300 BPS) and CCITT V.22 (1200 BPS) modes for a Bell/ CCITT compatible system.

The XR-2401 is the heart of the system. It is a digital signal processor (DSP) based chip providing 300 BPS FSK, 1200 BPS DPSK, and 2400 BPS QAM modulation and demodulation for the system. Other functions included are scrambler/descrambler, adaptive equalizer, carrier detection, and DTMF tone generator.

The XR-2402 provides the interface functions for the XR-2401, such as A/D and D/A converters for getting into and out of the DSP chip. Also provided are band splitting filters (SCF type), programmable gain amplifier (PGA), asynchronous to synchronous and synchronous to asynchronous conversion, and guard tone generation for CCITT applications.

Both XR-2401 and XR-2402 are constructed with the Si-gate CMOS technology for low power operation. The XR-2401 is available in a 40 pin and XR-2402 in a 48 pin package. The XR-2401 operates for a single 5 volt and XR-2402 from ±5 volt power supplies.

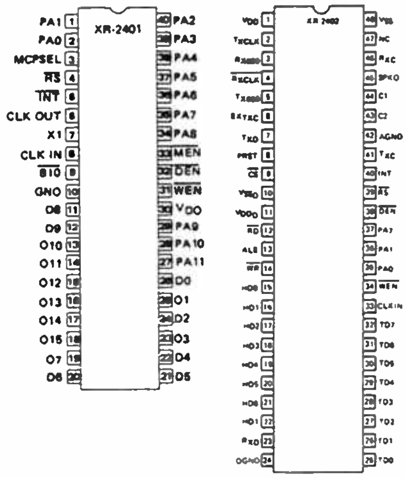
FEATURES

2400 BPS (QAM), 1200 BPS (DPSK), 300 BPS (FSK) Operation
V.22 bis, V.22, 212A, 103 Compatible
DSP Based (XR-2401)
Bus Structured Control
No Adjustments
DTMF Dialing
Low Power CMOS (450 mw max.)
Adaptive Equalization
Asynchronous/Synchronous Operation
550 Hz/1800 Hz Guard Generation
Automatic Call Progress Monitoring

APPLICATIONS

Stand Alone Modems
Internal Modems
Smart Modems

FUNCTIONAL BLOCK DIAGRAMS



ABSOLUTE MAXIMUM RATINGS

Power Supply	
XR-2401	−0.3 to +7 V
XR-2402	−7 to +7 V
Input Voltage	−0.7 to (V_{DD} +0.3) V
DC Input Current (Any Input)	±10 mA
Power Dissipation (package limitation)	1 Watt
Storage Temperature Range	−65°C to +125°C

ORDERING INFORMATION

Part No.	Package	Operating Temperature
XR-2401CP	Plastic	0°C to 70°C
XR-2401CN	Ceramic	0°C to 70°C
XR-2402CP	Plastic	0°C to 70°C

Consult factory for surface mount package availability.

SYSTEM DESCRIPTION

The XR-2401 / XR-2402 Modem Chip Set is designed to interface directly to popular μcs, such as 8051 or Z-8 types. The μc provides such functions as handshake control, smart functions such as "AT" commands, and dialing control.

The only other circuitry necessary is a line interface circuit (DAA) and RS-232 interface.

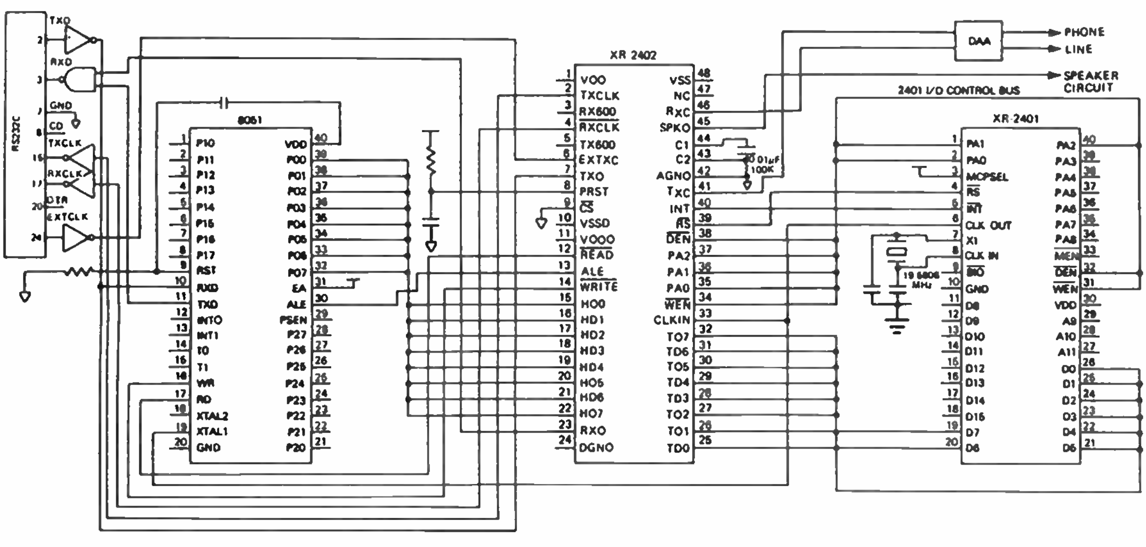
PIN DESCRIPTIONS/FUNCTIONS

The XR-2401 and XR-2402 provide the heart of a V.22 bis modem system and when connected to a microcontroller such as the 8051 type, a complete system is formed. The XR-2402 provides the analog front end (AFE) function as well as the bridge, or interface, between the XR-2401 digital signal processor (DSP) and microcontroller.

The pin functions of the XR-2401 are as follows.

Name	I/O	Pin	Description
VDD	I	30	Positive supply voltage +5V ±5%
GND	I	10	Ground connection - digital
$\overline{RS}$	I	4	Reset to initialize chip
X1	I	7	Crystal input 19.6608 MHz ±0.01%
CLK IN	I	8	Crystal input or external clock
CLK OUT	O	6	¼ crystal/CLK IN frequency
PA0-PA11	OUT	1,2, 27-29, 34-40	External address bus. I/O port address multiplexed over PA0-PA2
$\overline{BIO}$	I	9	External polling input for bit test and jump operations.
D0-D15	I/O	11-26	16 bit data bus
$\overline{DEN}$	O	32	Data enable indicates the XR-2401 accepting input data on D0-D15.
$\overline{INT}$	I	5	Interrupt input
MCPSEL	I	3	Mode select. 1 = microcomputer mode, 0 = microprocessor mode.
$\overline{MEN}$	O	33	Memory enable indicates that D0-D15 will accept memory instruction.
$\overline{WEN}$	O	31	Write enable indicates valid data on D0-D15.

▷



XR-2400 V. 22 bis MODEM

The pin functions of the XR-2402 are as follows:

Name	I/O	Pin	Description
V_{DD}	I	1	Positive analog supply +5V ±5%
V_{SS}	I	48	Negative analog supply −5V ±5%
V_{DDD}	I	11	Logic positive supply +5V ±5%
V_{SSD}	I	10	Logic negative supply −5V ±5%
DGND	I	24	Logic ground
AGND	I	42	Analog ground
PRST	I	8	Power on reset input

Microprocessor Interface

Name	I/O	Pin	Description
ALE	I	13	Address latch enable
HD0	I/O	15	Address/data bus bit 0
HD1	I/O	16	Address/data bus bit 1
HD2	I/O	17	Address/data bus bit 2
HD3	I/O	18	Address/data bus bit 3
HD4	I/O	19	Address/data bus bit 4
HD5	I/O	20	Address/data bus bit 5
HD6	I/O	21	Address/data bus bit 6
HD7	I/O	22	Address/data bus bit 7
$\overline{CS}$	I	9	Chip select
$\overline{WR}$	I	14	Write strobe
$\overline{RD}$	I	12	Read strobe

XR-2401 Interface

Name	I/O	Pin	Description
CLK IN	I	33	4.9152 MHz input from XR-2401
$\overline{INT}$	O	40	Interrupt flag for XR-2401
$\overline{RSB}$	O	39	Reset output for XR-2401
PA0	I	35	I/O port address bus bit 0
PA1	I	36	I/O port address bus bit 1
PA2	I	37	I/O port address bus bit 3
$\overline{DENB}$	I	38	Read enable strobe
$\overline{WEN}$	I	34	Write enable strobe
TD0	I/O	25	Data bus bit 0
TD1	I/O	26	Data bus bit 1
TD2	I/O	27	Data bus bit 2
TD3	I/O	28	Data bus bit 3
TD4	I/O	29	Data bus bit 4
TD5	I/O	30	Data bus bit 5
TD6	I/O	31	Data bus bit 6
TD7	I/O	32	Data bus bit 7

RS232C Interface

Name	I/O	Pin	Description
E_{XTXC}	I	6	External transmit clock
T_{XCLK}	O	2	Transmit clock output
T_{XD}	I	7	Transmit data input
$\overline{R_{XCLK}}$	O	4	Receive clock output
R_{XD}	O	23	Receive data output, with pull-up resistor

Special Functions

Name	I/O	Pin	Description
T_{X600}	O	5	Transmit 600 Hz output:
R_{X600}	O	3	Receive 600 Hz output
SPKO	O	45	Audio output to speaker

Analog Interface

Name	I/O	PIN	Description
T_{XC}	O	41	Transmit carrier output
R_{XC}	I	46	Receive carrier input
C1	O	44	Programmable gain stage output
C2	I	43	A/D input

SYSTEM OPERATION

The XR-2400 (XR-2401/2402) is designed to interface with a host controller by both hardware and software. The XR-2400 looks like a memory mapped peripheral to the host controller. The XR-2402 acts as a bridge or interface between the XR-2401 DSP and host controller and thus, all control/status information will pass through it. Figure 1 shows the general data/address bus connection of the XR-2400 to the host controller.

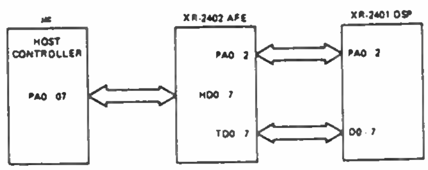


Figure 1. General Data/Address Bus Connection

The XR-2401 DSP performs all of the modem signal processing function. However, the controller functions are left to the host microcontroller for system flexibility.

There are two kinds of control/status registers for the host µc to access: one in the XR-2402 and one in the XR-2401 via the XR-2402 interface buffer. The XR-2402 register looks to the µc just like an external data memory. The XR-2401 data memory which must be accessed through the XR-2402. It needs a handshake procedure to access the memory map as shown in Table I.

Read	Write	Name
	0	Address register (8 bit latch)
	1	Write data register (8 bit latch)
2		Read data register (8 bit latch)
3		Status register in XR-2402
	3	Control register in XR-2402

Table I. Memory Map for Host

GENERAL MODE SETTING READING INFORMATION FROM XR-2400

A handshake procedure is necessary for communication with the host µc and XR-2401. All data (address, write data, read data) passes through a register in the XR-2402 with the procedure for controlling this register as follows:

Read Cycle

First, the host µc will write a target address to the XR-2402 address register. Simultaneously, the XR-2402 will poll interrupt for the XR-2401, which will branch to interrupt service routine and send data out to the XR-2402. This procedure takes 3 µs, thus, the host µc needs to ensure it waits at least 3 µs from target address and reading data.

Write Cycle

The write cycle is used for the host µc to write to the XR-2400. Data is written first to the XR-2402 then the target address to the address register. It will poll interrupt for the XR-2401 and after a 6 µs delay, the XR-2401 will take the data from the write register.

Read/Write Data Directly From the XR-2402

There are two data memory locations which the host µc can access immediately.

1. Status Register - Address 3

Bit 3 - Bit 0 are copied from Control Register 7 in the XR-2401. Bit 6 - Bit 4 are generated in the XR-2402.

- Bit 0 R_{XDATA}
- Bit 1 Unscrambled R_{XDATA}
- Bit 2 Energy Detect
- Bit 3 Signal Quality Indicator
- Bit 4 S1 Signal Detector With an S1 pattern coming in, Bit 4 will be continuously high allowing the user to access the coming S1 signal information.

2. Control Register

- Bit 0 Parallel T_{XD} Input – This allows the user to input T_{XD} through the parallel data bus.
- Bit 1 Software Reset for XR-2401 – Reset = "0"; Normal Operation = "1". For proper reset operation, a low must be present for at least 2 µS.

The following is an example of writing to the control register:

```
MOV    RO,#3   ;    Put #03 in RO
MOVX @ RO,A    ;    Move data from ACC
                    to external memory.
```

- Bit 5 Dotting Pattern Detect Indicator. With an incoming dotting pattern (alternating etc.), this indicator will be high allowing the user to detect digital loopback.
- Bit 6 R_{XD} after Buffer. The user may access parallel R_{XD} through the data bus.

The following is an instruction example for the status register:

```
MOV    RO,#3   ;    Put #03 in RO
MOVX   A,@ RO,      Move external memory #03
                    to ACC.
```

Modem Mode Selection Control

The XR-2401 data memory location #69 is used for mode selection as follows:

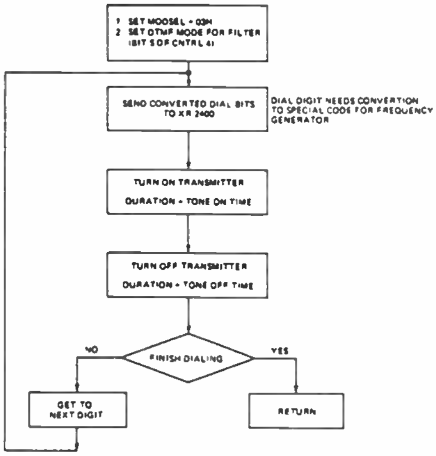
- 0 Idle Mode
- 1 FSK Mode
- 2 PSK Mode
- 3 DTMF Mode

Handshake Sequences

The XR-2400 chip set provides operating modes of 2400 BPS, 1200 BPS and 300 BPS to cover CCITT standards of V.22 bis and V.22 as well as Bell 212A and 103. The following figures illustrate the handshake sequences for automatic rate or speed selection. Figure 2 shows the sequence for 2400 BPS (V.22 bis) with V.25 automatic answering. The following figures, 3 through 6, show the remaining handshake sequences needed to support other CCITT/Bell operating modes.

DTMF Generation

The XR-2400 provides an onboard DTMF generator which is controlled by the host µc. The flow chart in Figure 7 illustrates the procedure for DTMF tone generation.



*TXEN BIT SHOULD BE DISABLED BEFORE SENDING DIALING DIGIT

Figure 7. DTMF Generation Flow

Figure 8 shows the digit/tone pairs for the DTMF generator.

Dial Digit	Encode D4	D3	D2	D1	Tone Pairs (Hz) Tone 1	Tone 2
0	0	1	1	1	941	1336
1	0	0	0	0	697	1209
2	0	1	0	0	697	1336
3	1	0	0	0	697	1477
4	0	0	0	1	770	1209
5	0	1	0	1	770	1336
6	1	0	0	1	852	1477
7	0	0	1	0	852	1209
8	0	1	1	0	852	1336
9	1	0	1	0	852	1477
*	0	0	1	1	941	1209
#	1	0	1	1	941	1477
(8)	1	1	0	0	697	1633
(C)	1	1	0	1	770	1633
(D)	1	1	1	0	852	1633
(F)	1	1	1	1	941	1633

Figure 8. DTMF Tone Pairs/Dial Digits

ELECTRICAL CHARACTERISTICS

Test Conditions: $T_A = 25°C$, $V_{DD} = 5\ V \pm 5\%$, $V_{SS} = -5\ V \pm 5\%$

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT	CONDITIONS
XR-2401 f_{CLKIN} = 19.6608 MHz ±0.01%						
I_{DD}	Positive Supply Current			50	mA	
V_{DD}	Positive Supply Voltage	4 5	5.0	5.5	V	
V_{IH}	High Level Input Voltage	2.0			V	Except CLKIN
V_{IHC}	CLK High Level Input Voltage	0 56 V_{DD}			V	
V_{IL}	Low Level Input Voltage			0.8	V	
I_{OH}	High Level Output Current			20 300	µA µA	$V_{OH} = V_{DD} - .4$ V V_{OH} = 2.4 V
I_{OL}	Low Level Output Current			2	mA	
V_{OH}	High Level Output Voltage	V_{DD} – 4 2 4			V V	I_{OH} = 20 µA I_{OH} = 300 µA
I_I	Input Current			50	µA	V_I = 0 to V_{DD}
XR-2402 f_{CLKIN} = 4.9152 MHz ±0.01%						
V_{DD}	Positive Supply Voltage	4.5	5.0	5.5	V	
V_{SS}	Negative Supply Voltage	–5.5	–5.0	–4.5	V	
I_{DD}	Positive Supply Current		15	20	mA	
I_{DDS}	Positive Supply Current, Standby Mode		3	5	mA	
I_{SS}	Negative Supply Current			20	mA	
I_{SSS}	Negative Supply Current, Standby Mode			5	mA	
V_{IH}	High Level Input Voltage	2.0			V	
V_{IL}	Low Level Input Voltage			0.8	V	
I_{OH}	High Level Output Current			300	µA	V_{OH} = 2 4 V
I_{OL}	Low Level Output Current			2	mA	
V_{OH}	High Level Output Voltage	2.4			V	I_{OL} = 700 µA
I_I	Input Current			50	µA	V_I = 0 to V_{DD}
R_{XC}	Receive Carrier Range	-6		-45	dBM	(Using 6/16 dB RCVG feature. Tip and Ring Pin 46 is 3 dB higher

TRANSMITTER SPECIFICATIONS

All values are measured at T_{XC} (Pin 41) of the XR-2402 with Bit 0-2 = 1 of CNTRL 0.

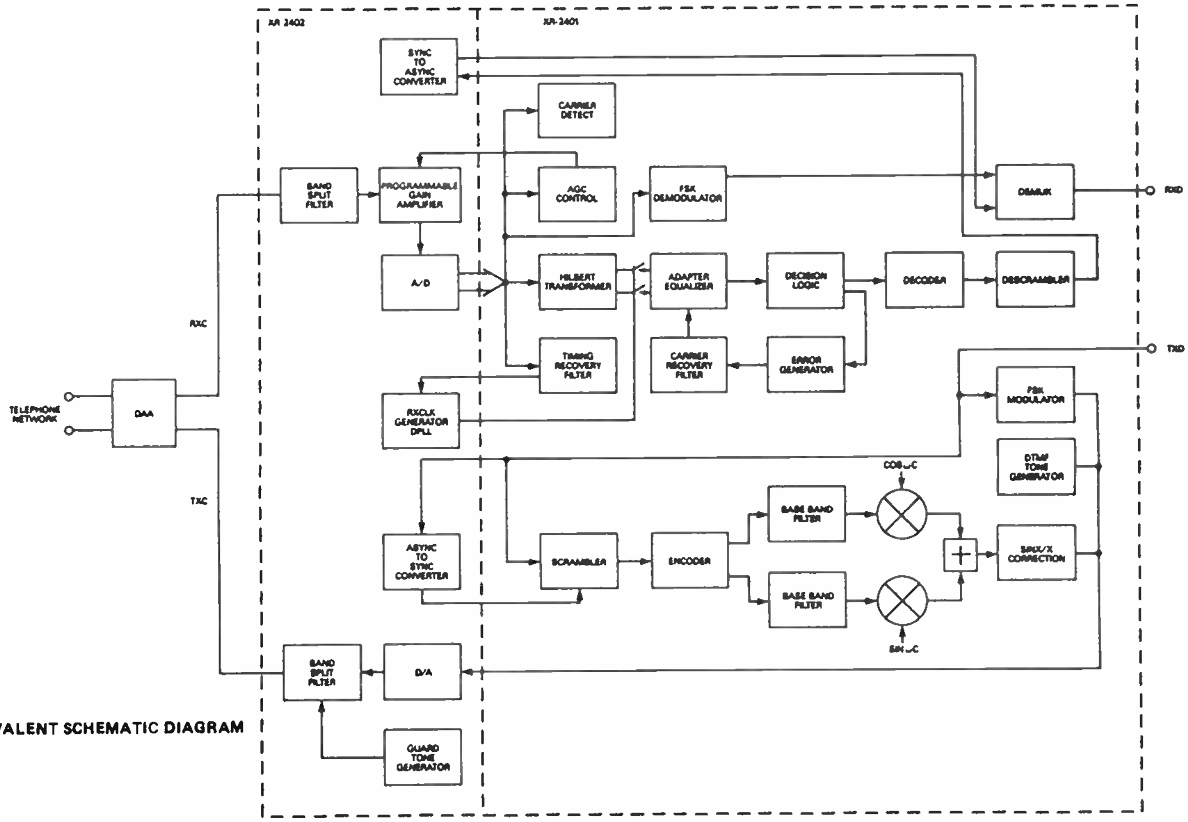
SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT	CONDITIONS
TRANSMITTER POWER						
T_{XC} QAM/PSK	QAM/PSK Transmitter Power		+2		dBM	
T_{XC} 550 T_{XC} 1800	CCITT Guard Tone Power	–2 –5		0 –7	dBM dBM	T_{XC} = 2 dBM T_{XC} = 2 dBM
T_{XC} QAM/PSK 550	QAM/PSK Transmitter Power With Guard Tone		+3.5		dBM	
T_{XC} QAM/PSK 1800			+3		dBM	
T_{XC} FSK	FSK Transmitter Power		+1		dBM	
T_{XC} AT	Answer Tone Power		+1		dBM	
T_{XC} DTMF C	DTMF Tone Power Column		–5		dBM	
T_{XC} DTMF R	DTMF Tone Power Row		–4		dBM	
T_{XC} DTMF T	DTMF Tone Power Twist		–1 5		dBM	

▷

SYSTEM PERFORMANCE

V_{RXD} = −40 dBM, Originate Mode, C2, 3002, B/B Line Conditions, T_{XC} = −10 dBM.

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT	CONDITIONS
S/N	Signal-to-Noise Ratio		17 9 12		dB dB dB	2400 BPS 1200 BPS 300 BPS
F_{OFF}	Frequency Offset		±10		Hz	2400/1200 BPS



EQUIVALENT SCHEMATIC DIAGRAM

Call Progress Tone Monitor Operation

The host μc uses the XR-2402 as a filter for call progress detection mode. When CPM = HIGH (enabled), the XR-2402 low band will be scaled down by a factor of 2.5 or 300-660 Hz. The ALB control bit provides the input for band connection to the carrier detect as shown in Figure 9.

CPM = 1

ALB	Carrier Detect (CD) Connected to
0	High Band (2400 Hz)
1	Low Band (Scaled low band 300-660 Hz)

Figure 9. CPM Frequency Band Assignments

The output of the CD circuit is monitored by the host μc for duration and repetition rate to determine line status. The CD information is available by reading Bit 2 of CNTRL 7. The CD status is as follows:

The MODSEL is set to FSK mode. After CPM mode, the μc needs to send a reset signal to the XR-2401.

CD = Energy Detect (direct access locations)

1 = Energy Detected

0 = No Energy

Figure 10 indicates the various CD selections.

CPM	ALB	A/O	CD
1	0	0	Received high band; monitor answer tone
1	1	0	Received low band filter scaled down by 2.5; monitoring dial tone, busy tone, and ring back tone.
0	0	0	Normal high band energy detect.
0	0	1	Normal low band energy detect.

Figure 10. CD Frequency Band Assignments

Signal Quality Indicator

The XR-2400 provides a signal quality indicator, SGQ, to indicate the quality of the received demodulated data. The state of this output is as follows:

SGQ Output:

0	Good Signal
1	Bad Signal

The XR-2401 signal quality detector utilizes least mean square error method for error detection.

The XR-2400 provides the SGQ indicator for the host μc. A counter is set up in the μc, and if the value in it exceeds a preset value in a predetermined time, a request for retrain requirement will be given.

Test Modes

ALB, Analog Loopback, is a test mode which is used for complete testing of the local modem. Figure 12 illustrates the basic signal flow.

The transmit carrier is looped back to the demodulator input, bypassing the receive filter. The demodulator is set to the transmit carrier frequency. Figure 13 illustrates ALB selection for answer and originate.

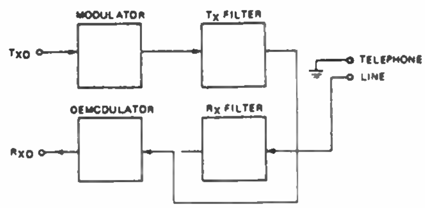


Figure 12. ALB Signal Flow

ALB = 1

MODE	T_X	R_X
ANS	Low Band	Low Band
ORIG	High Band	High Band

Figure 13. ALB Frequency Assignments

RDLT, Remote Digital Loopback, is used to test the far-end or remote modem. The start of this type of loopback is automatically initiated by the reception of an unscrambled/scrambled mark pattern, as seen in Figure 14. Also shown in Figure 14 is the carrier pattern for termination of RDLB.

IBM Quick off the mark, again!

IBM announced a number of breakthroughs recently in silicon technology, especially in the production and performance of high speed DRAM.

IBM scientists in New York have made and tested the world's fastest silicon circuits, they claim, using IBM's recently announced ability to make transistors from 10th-micron parts, one-thousand times smaller than a human hair.

The circuits, still in the experimental stages, are able to switch on or off 75 billion times a second. A 13- picosecond switching time is quoted by IBM, an improvement of more than 200% over speeds previously achieved by silicon transistors, they say.

Logic chips, and a whole host of other semiconductor technology will potentially benefit almost all devices using such technology. In fact, until last year when IBM made such devices, nobody was sure that these circuits, using elements only a few hundred atoms wide, were able to be made at all.

However, IBM caution that it will be a long while until entire chips can be made using the new transistor technology.

Experimental techniques were used to make and operate these devices in the laboratory. Advanced lithographic processes were used in writing the ultra-thin lines, and for cooling the circuits during operation to -196° C in liquid nitrogen.

These tenth-micron transistors belong to the NMOS, or n-channel, field-effect transistor (FETs) family. The next major development in this technology, IBM say, will be to produce these circuits using the more sophisticated complimentary-channel, or CMOS circuitry.

Of particular note is the advanced electron-beam tools IBM use to solve the problems of linewidth control and accurate pattern placement associated with such fine work on the silicon surfaces. The technology involved in using and making these tools is very complex and IBM has been considered world leaders in this field since the 1960s.

Solid state disk chip

NEC has announced the release of a new μPD42601 "Silicon File" chip, which is specially designed to form the basis of solid state disks for high-speed data access. It features very low power consumption to ease battery backup requirements.

Specifications for the μPD42601 include: capacity of 128Kb; self-refresh figure of 30 μA (max.) and a 512-bit page-mode cycle time of 200 ns (min.).

For further information, contact The George Brown Group, Marketing Division, 456 Spencer Street, West Melbourne 3003 Vic. (03)329 7500.

"Atomic" transistors

Experimental, single-electron transistors have been created by researchers in AT&T Bell's Laboratories. These devices are so sensitive that *a single electron* can produce a change in the current flowing through the device.

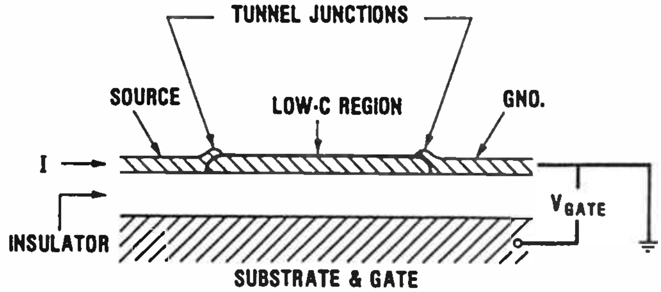
As they are still only experimental and operate only in very low temperatures. Scientists, however, are confident that the research and development of these devices will foreshadow generations of all-metal transistors that operate extremely fast and consume very little power.

Using superconducting materials to optimise their performance, it is envisaged that they could be used as electrometers in experiments to measure induced charges as small as 1% of an electron, AT&T say.

These devices are able to be made through the use of similar electron-beam lithography techniques that IBM scientists have been using as outlined in the item above.

The transistors consist of three microscopic parts, the first, a small "island" of metal, a mere few hundred atoms wide. Connected to this island are two tunnel-junction electrodes separated by an insulating barrier, only a few atoms thick. This substrate forms a gate junction that applies an electric field, creating a steady-state bias, thus a charge is produced across the junctions.

This charge controls the current passing through the central electrode via the tunnel junctions. Just as in a conventional FET, the current through these devices can be increased or decreased by altering the gate voltage.



The central "island" referred to in the text is referenced here as the 'Low-C Region' with the two tunnel junction electrodes marked 'Source' and 'Gnd'. The oxide barriers in the device occur where the electrodes touch the island.

Japanese semiconductor data manuals

Imark Pty Ltd has secured a limited quantity of the hard to obtain 1987 CQ Data Manuals, containing information on Japanese semiconductor devices.

The manuals cover the following topics: Transistors; FETs; monolithic op-amps; Hybrid op-amps; Industrial linear ICs; TTL ICs; CMOS ICs; Memory ICs; Power and industrial semiconductors; Interface IC devices; and A-D/D-A converter ICs.

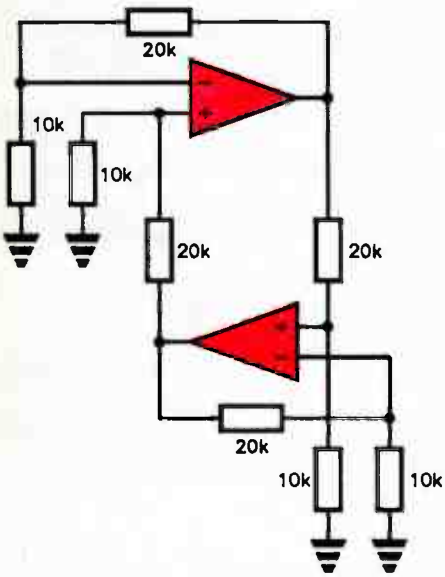
These are very handy books. We obtained a set of 1986 manuals for the office technical library and they have proved invaluable. Contact Imark Pty Ltd, 167 Roden Street, West Melbourne 3003 Vic. (03)329 5433.

Audio bal-to-unbal converter again

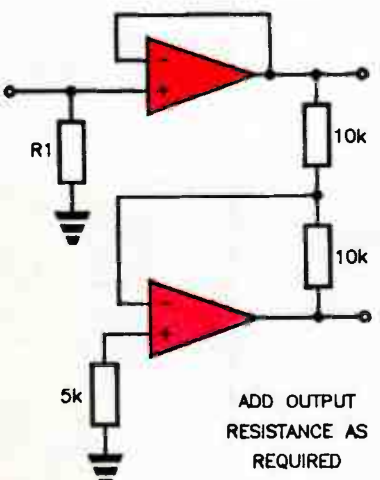
Dear Sir,

It is with some disappointment that I find myself writing to you, partly because I have to battle with the w.p. It concerns the "Audio bal-to-unbal converter" on page 32 of the March issue.

When I first saw your answer to the query by Ben Furby's letter *(Nov. '87)* I thought, "Erk. Another poor guy led astray by a silly mistake." I figured it was just a draughting error and thought nothing much more of it. But then I saw Chris Wendt's offering and I thought "Oh dear, oh dear me". I guess it might be a bit of an improvement but I would describe it as a bad circuit, one that does not live up to the claims made about its performance.



TRY THIS
INPUT IMPEDANCE = R1
IT WORKS, IT'S SIMPLE



If you redraw the circuit, with the input grounded, (see circuit here) you will notice that there is positive feedback around the two op-amps. This is (I presume) the "cross- coupling" that C.W. talks about in his letter. What this "cross-coupling" does is degrade the dc offset performance and unbalance the outputs. I did not just deduce this but actually tried the circuit because it looked so suspicious. Another point to consider is the source impedance. If the amp has no dc path to ground at the input, the output offsets get worse.

Chris Wendt also seems to display a lack of understanding of feedback theory. The 33 Ohm "build out" resistors have little or no impact on the output impedance of the amp because they are inside the feedback loops of the op-amps. At 10 kHz, with a 22 pF compensation capacitor the open loop gain of an NE5534 is about 20 000. With a closed loop gain of about three, the 33 Ohm resistors would contribute about 0.05 Ohms to the output impedance. At lower frequencies they would contribute even less.

I have some reservations about using polarised caps in the output too. If they were to be reverse biased some undesirable things can happen, the least nasty of which is probably distortion, and with the unpredictable dc behaviour of this circuit, this is a definite probability.

As for the problems caused by varying load impedances, anyone who knew basic circuit theory would tell you that you need lower output impedance. I cannot understand this preoccupation with matched sources and loads, especially at audio frequencies. It may reduce reflections on a long line but if the line and load are properly matched there will be no reflections, irrespective of the source impedance.

By all means add some output resistance to isolate capacitive loads and provide some protection for the output, but most op-amps should need no more than about 100 Ohms. Matching sources to loads is inefficient (you immediately halve your available voltage) and can degrade noise and interference performance.

As for C.W.'s claim that the circuit is "adapted from those used in several brands of professional recording equipment" I feel quite at home with that. I have seen some terrible "things" passed off as professional equipment for broadcast, recording, scientific and industrial use, and I would describe them as crap (putting it mildly) "designed" by incompetent people who knew a little electronics.

It is just possible I have overlooked something but my years of experience with op-amps tell me that the fault is with the circuit and besides, I checked the test circuit many times; I even considered the possibility of a drawing error and tried alternative ways of wiring the circuit, but I feel it is not really worth the paper it is printed on. The circuit kind of works but does not really live up to its claimed performance.

Phil Denniss,
Dept. of Plasma Physics,
University of Sydney

Thank you for your concern over this topic. I trust your information sets Ben Furby and other readers on the right path.

Roger Harrison

Electronic dog repeller

Dear Sir,

Would you please advise me if you have a circuit available for a high frequency device, which I could make, to repel dogs and possibly cats from the front yard of my home.

Whilst I am not an animal hater, I am fed up of them crapping on my lawn and digging holes in the garden. Believe me, the plastic water bottle theory doesn't work with the dogs in our district.

I am aware of the old dog whistle principle, in which a master blows on a special whistle to call his dog on a frequency beyond human hearing. What I need is a device which will blow their ears off when they walk into a beam.

Ideally, the device would need a range of 20 metres with an arc pattern similar to a microwave alarm detector.

I have been in touch with Dick Smith Electronics, but the best they can do is a mosquito repeller with a frequency of 21 to 23 kHz, and Jaycar Electronics only have a mouse repeller which they claim will not work on dogs.

I do hope you can help me and anxiously await your reply.

J. Mumford,
Roselands, NSW

We know of no such device for keeping dogs and cats away from a given area. Even if there were a suitable frequency to use, it is doubtful you could confine the beam sufficiently so that it did not "spill over" onto adjacent areas.

However, all is not lost. Enclosed find plans for a one metre high picket fence which we suggest you erect around your front yard. For a second line of defence, *we have also enclosed photostats of our Variable Output Electric Fence project, AEM9502 (November 1986).*

Roger Harrison

Choosing a modem

Dear Jamye,

After reading your article in the March edition of AEM (*Modems On Parade!*), I now know a little more about modems, but due to my lack of exposure to modems and computers in general, I have found it hard try and select a modem for my recently purchased Tandy 1000 (IBM compatible).

I have already increased the memory capacity from 128K to 640K by a 4N1 multi-function card from Micro Mainframe which has a clock and an RS-232C asynchronous communications port.

I am a teacher at the local TAFE college dealing in engineering subjects and three questions that I would like to ask you are:

1. What type of modem would you recommend that I purchase?

2. Is there literature or a directory dealing with the types of "communicate's" with which I could communicate.

3. What are types of software for the modem that you recommend?

Your assistance in this matter would be most appreciated.

Brett Hunter,
Leeton, NSW

I'm glad you found my article of interest. I trust the following answers prove useful in opening up the world of data communications for you.

In answer to your first question, perhaps you should first consider how much money you want to spend. This will bracket, then, the types and makes of modems you need to consider. It's impossible for me to recommend a particular modem here as so many personal factors enter into it.

For around $200 you can get a simple "manually operated" modem providing 300 and 1200/75 bps operation. Maestro Distributors has a 1200 bps only manual modem for $199. If you feel inclined to build your own, modem kits cost somewhat less and there are a variety on the market: our AEM4600 Dual-Speed Modem and AEM4605 Super Simple Modem being two examples. However, neither of these have a "constant baud rate" interface (the serial link between the modem and your computer), so to be able to use the 1200/75 bps mode, you will need a bit rate converter such as our project AEM4601 (Nov. '87). You might consider the Datacom M1200 modem, featured as a Star Project this issue, which incorporates a built-in bit rate converter.

"Smart" modems are by far the most versatile and convenient, but naturally cost more. Prices vary considerably, as you can see from the table in my article. Again, kits offer considerable savings if you're prepared to build your own.

As you live in the country, your phone calls will be predominantly STD so it makes sense to get a modem which offers a high speed full duplex mode at a price you feel you can afford – spending more on the equipment here will save you running costs in the end. Hence, if you can afford it, I would recommend a modem which offers V.22 operation (1200 bps full duplex) at the least, or preferably V.22bis (2400 bps). Quite a number of bulletin boards and other dial-up services now offer either or both V.22 and V.22bis operation. A few offer nothing less!

Among the commercial modems offering 2400 bps operation, you might consider the Netcomm range and the Nice Modem 4. You might also consider our new "Superbis" modem project (AEM4624), presented in conjunction with Maestro Distributors, the description of which commences in this issue. This features 300/300, 1200/75, 1200/1200 and 2400/2400 bps operation and is a "smart" modem employing the Hayes command set.

To answer your second question, many bulletin boards carry a directory of bulletin boards – but you need a modem and a number to call before you can access it! Catch 22. However, lists of bulletin boards and their details are regularly published in the local computer magazines, but the lists you'll find on a BBS are generally more up to date. For a first try, call up The First Nice Midiline (02)868 4347.

For both 'dumb' and 'smart' modems, there are a host of programs available, both commercial and public domain ("Shareware"). As the Tandy 1000 is IBM compatible, you might check out Cross-Talk or Mirror (reviewed in our July '87 issue). Public domain programs are found on bulletin boards – but you need one to dial up a bulletin board to get one in the first place! Catch 22, again.

Try and contact another teacher or student at your college who has a computer and modem and download something. Public domain comms programs were discussed in Roy Hills' "Dial-up" columns in our August through December 1987 issues. I would recommend you obtain perhaps, Procomm, Qmodem 3.0 SST or Telix 2.12A. They're available on the BBS mentioned above.

Good luck!

Jamye Harrison

Pitfalls of CRO manuals

Dear Sir,

Your article (March 1988) on how to evaluate and select a cathode ray oscilloscope was excellent.

The difficulty arises after one has purchased a suitable instrument. Most textbooks recommend that the owner: "Consult the technical manual for that particular equipment to determine the correct operating procedure and any limitations."

But that often proves disappointing as most of the manuals supplied are quite inadequate. They usually contain a bald statement of the specifications and brief instructions couched in such quaint English (obviously translated roughly from some foreign language) as to make the manual virtually useless.

What the new owner needs to know is how to connect the oscilloscope to the apparatus to be measured. Where does one connect the input leads of the oscilloscope and how is this done? For instance, of the owner wishes to measure the frequency of an ac mains supply, the output of a record- player, a radio set, an amplifier or a transmitter, where does one connect these devices with safety?

An article along these lines would, I am sure, be much appreciated.

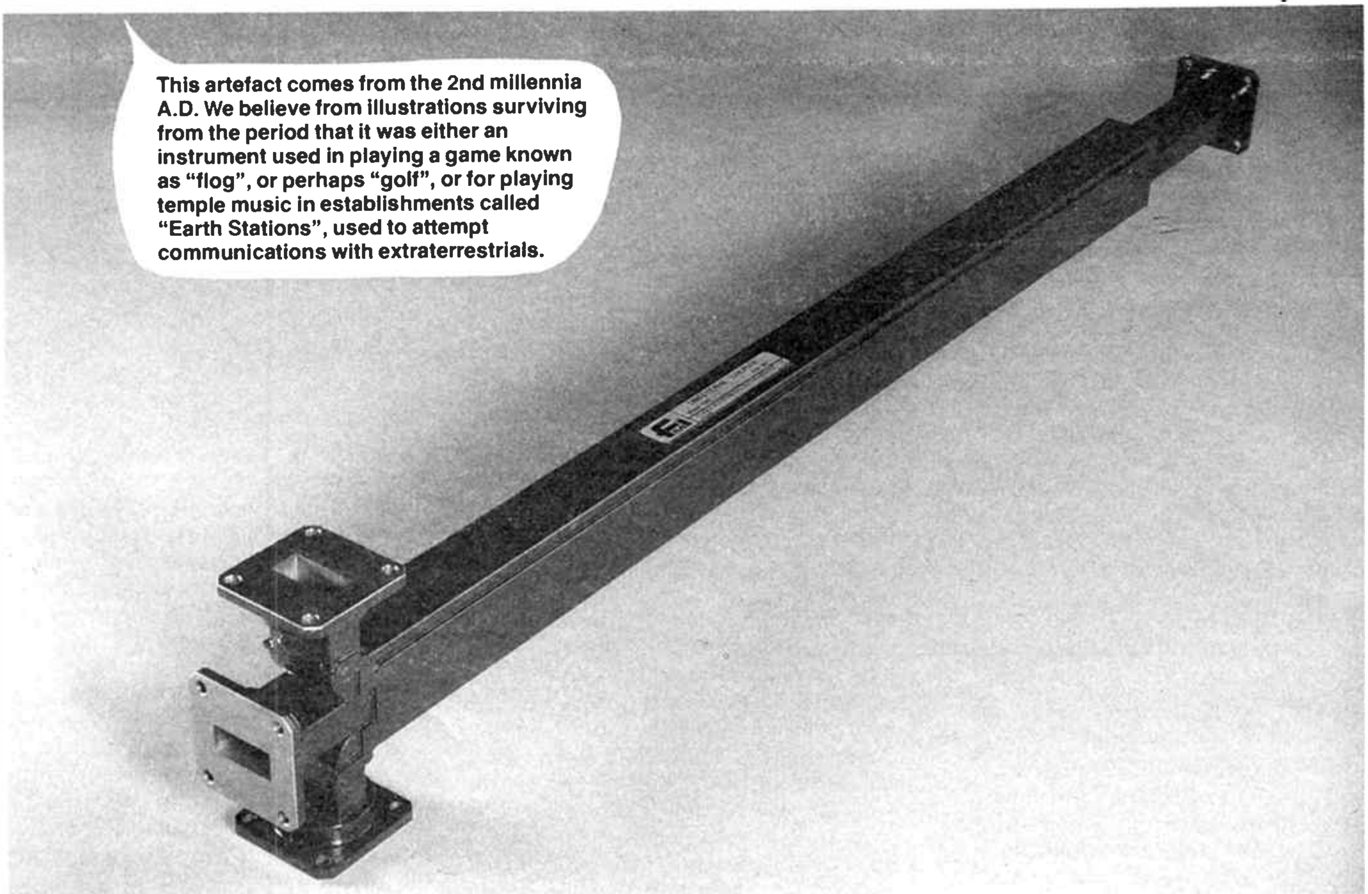
K. S. Jaffrey,
Nelly Bay, Qld.

We have, in fact, done an article much along those lines, called "Using the Modern Oscilloscope" – featured in our first and second issues: July-August 1985. The feature was compiled from a handbook produced by Philips Scientific and Industrial Division, Test and Measuring Instruments and is copiously illustrated. Back issues have sold out, unfortunately, but photostats of the articles can be obtained for $4.00, including postage.

Those articles notwithstanding, I guess it's time we looked at the subject afresh.

Roger Harrison

The Last Laugh



WE HAVE A WINNER! The Last Laugh "Silly Season" Competition was won by Eddy Kusilek (Pd.D. (failed)) of Sydney. He receives the copy of "Silicon Valley High Tech – a window to the future", and the Dick Smith Q-1512 handheld digital multimeter (with flat battery). Eddy was the only one to get Question 2 correct, or nearly correct, that is, his was the nearest correct entry – it was the only question to which the judges had an actual answer! He read our crack in March's Last Laugh about not including his address, and sent us a letter, which may yet be the subject of another Last Laugh.

So many of the answers were good fun. Thanks to all who entered. Perhaps we'll make it an annual event.

The electronic nose

We have just learned that Japanese scientists have constructed a robot that can distinguish the delicate differences between different whiskies, the nuances of the "noses" between numerous wines, and the subtle smells of so many sakes.

At the Tokyo Institute of Technology, Professor Toyosaka Moriizumi is responsible for this marvel of modern technology, and he claims it can distinguish 11 different alcoholic drinks. It doesn't "smell" the way we do – I don't mean B.O., I mean with our noses – because nobody is yet sure exactly how our nose works.

This robot analyses the aroma of each beverage and matches it with patterns stored in an on-board memory. It is not reported how it fared with our Rutherglen reds.

Off the air

The following item, we are assured, comes from the magazine *Worldradio* for October 1987, authored by one Ray B. Chipman, W6HQF. It has been doing the rounds on local packet radio bulletin boards.

'It must have been about 3:00 in the morning on that winter night, back in 1950. For some reason or other, I just couldn't sleep, so I decided to go out into my ham shack on the back porch to see if there was anything on 10 metres.

Before too long, I heard a weak signal and zeroed in on it. It was KX6AB on Kwajalein Island, calling "CQ". I had a transmitting crystal for my little 18 watt, Heising modulated AM rig, that was pretty close to his frequency. I slipped it in, called three times and listened.

He came back again, calling "CQ".I called him again.

About the third time, he finally found me and came back to me . . . . . . weakly. I had my earphones on so as not to disturb the rest of the family sleeping in nearby rooms, and I settled down for a good old ragchew (. . . . a chat, a chinwag – Ed.).

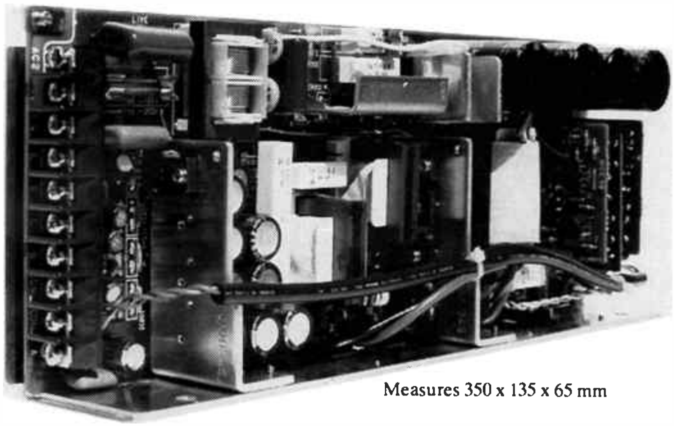
Now, there's one thing about that little "Globe Trotter" transmitter I was using. What it lacked in power could be made up for with its "Heising" modulation. The more power you needed, the louder you hollered into that little carbon microphone. And man, I was really generating "*modulation*" power.

I was screaming, but were were having a good QSO. Then I felt a tap on my shoulder and, turning around, I saw my wife standing there. I had not even heard her open the door to the shack. She was MAD. I had awakened her out of a nice, deep sleep.

I slipped the earphones off my head just as she said, "What the devil do you think you're doing?!" I said, "I'm talking to a guy on Kwajalein."

As she snorted and started to walk away, she turned and said, "*Well, why don't you use the radio?!!*"

. . . . PSST!



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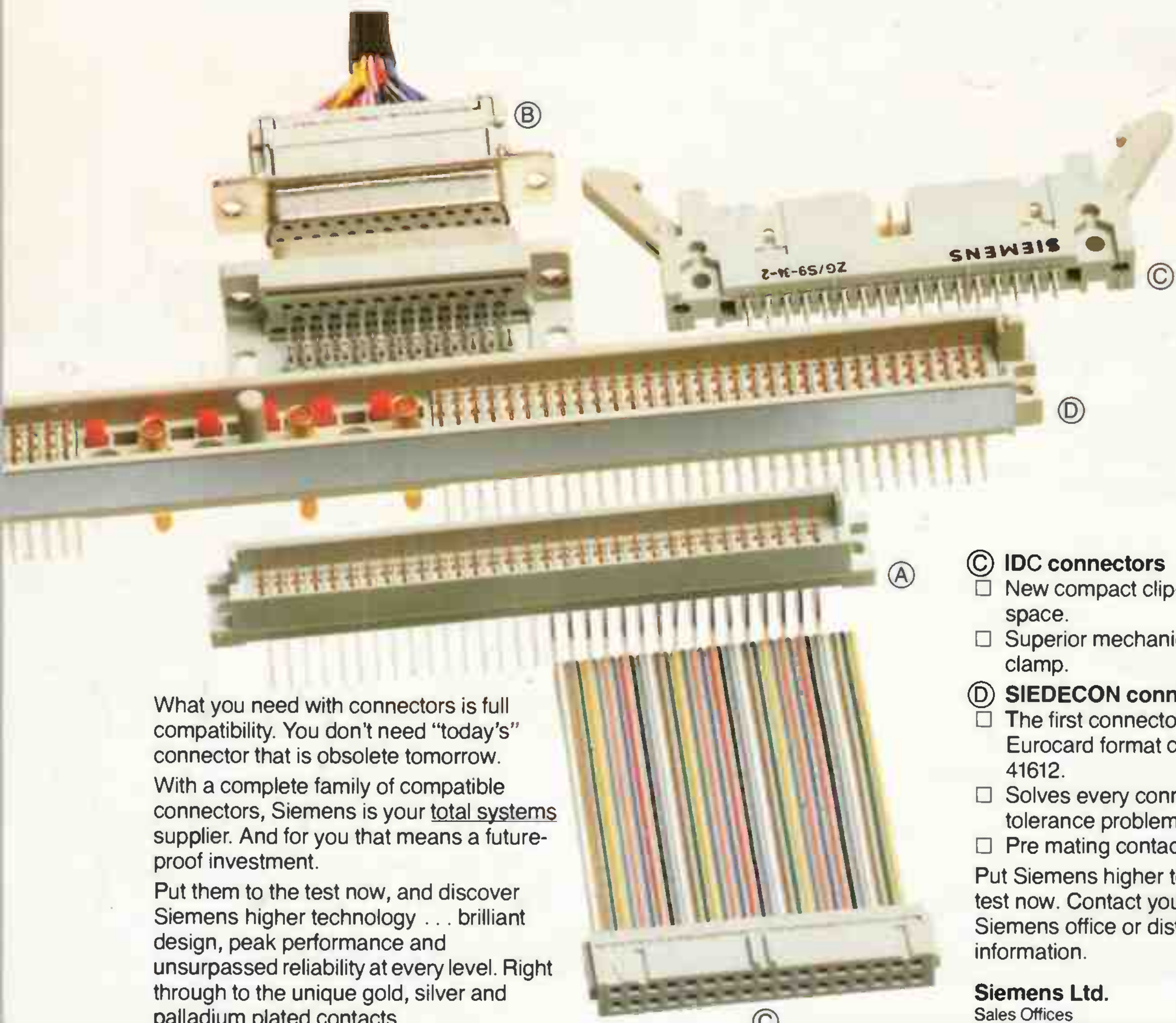

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