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# ROGER HARRISON'S AUSTRALIAN ELECTRONICS

*Monthly*



## Guide to MARINE ELECTRONICS

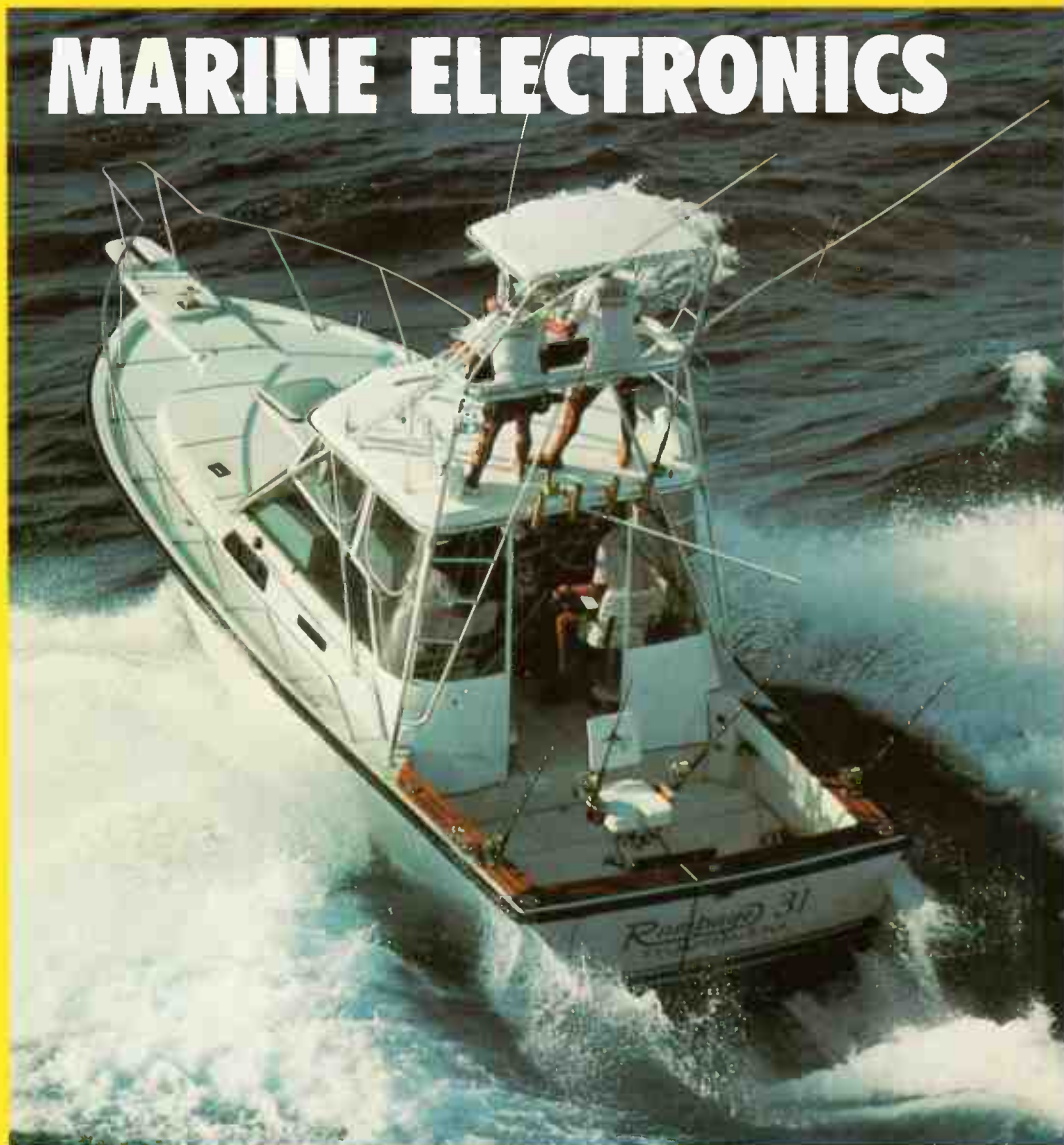
**FILTER DESIGN  
— part 2**

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World Radio History

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## COOPERATION FOR COMPETITION

THE HEADS of ten local companies in the electronic/computing industry are planning to get together next month in a bid to bolster their chances against overseas competition, widen their markets and lift standards.

The Managing Director of a Melbourne-based computer components distributor, Philip Jackson, of JIT (Australia) is behind the move to form a group with the aim of pooling ideas and jointly developing products and markets. At this stage, some ten companies have responded to Jackson's approach: Pulsar Electronics, Earth Computer Systems, Micro Byte Systems, Electronic Micros, Barson Computers, Mica Computers, Labtam International, Computer Corp, President Computers and Computer Networks.

Jackson believes a united approach to the Federal Government would improve their chances of getting longer-term loans at lower interest rates than is available to such companies at present.

The idea is not new, by any means, but it hasn't flourished here, and particularly not in this industry. It's been a successful strategy for mankind ever since we climbed down out of the trees and formed social groups. One can only applaud the move and wish the participants every success. Don't get bogged down in the politics, fellas, or you'll lose sight of the goal.

**Roger Harrison**  
Editor

**Published by:** Kedhorn Holdings P/L (Inc. in NSW), Fox Valley Centre, Cnr Fox Valley Rd & Kiogle St, Wahroonga 2076 NSW. **Typeset by:** Authotype Photosetters P/L, 397 Riley St, Surry Hills NSW, and Tuldin, 19 Princes St, McMahon's Point NSW. **Printed in 1987 by:** Offset Alpine, Cnr Derby & Wetherill Sts, Silverwater NSW. **Distributed by:** Network Distributing, 52-54 Park St, Sydney NSW. \*Cover Price \$4.75 (maximum and recommended Australian retail price only; recommended New Zealand price NZ\$6.50). Registered by Australia Post, Publication No: NBP 7435. ISSN No. 0815-5046.

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\$49.95 Australia,  
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## ADVERTISERS INDEX

### COVERS

Elmeasco ..... IFC  
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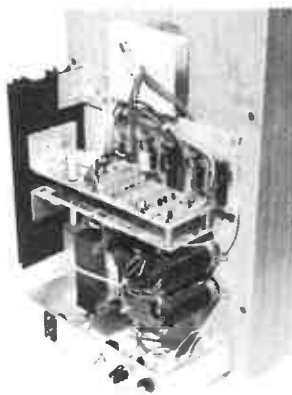
### INSIDE

Arista ..... 17  
 Benelec ..... 7  
 Datacom ..... 9  
 David Reid Electronics ..... 9  
 Dick Smith Electronics ..... 61-67  
 Geoff Wood ..... 95  
 Hi-Comm Unitronics ..... 52  
 IPS Radio & Space Services ..... 87  
 Jaycar ..... 22-23  
 Kenwood ..... 86  
 Maestro ..... 77  
 Micro-Educational ..... 44  
 Parameters ..... 18  
 Powersonic ..... 85  
 Switchmode Power Supplies ..... 49

### COVER

Summertime is boating time!  
 Picture courtesy Datamarine  
 International Australia Pty  
 Ltd. Design by Val Harrison.

## PROJECTS TO BUILD



### AEM6112 Active Two-Way Loudspeaker ..... 55

*An electronic loudspeaker system offers unique advantages, with its predictable and carefully controlled active crossover and power amps driving the speakers directly. And home construction offers considerable savings.*

### AEM4601 Baud Rate Converter for Modems ..... 70

*Some computers can only 'talk' to a modem at a fixed Tx/Rx baud rate, C64s and PCs/compsats being common examples. This prevents 1200/75 bps (V23) operation. Here's a simple project to get your computer and dumb modem operating on 1200/75 bps.*

### AEM3014 Multi-band HF Trap Dipoles ..... 88

*Here's a simple economical antenna system that provides coverage of four or five of the HF amateur bands, features coax feed and does not require an antenna tuner.*

## CIRCUITS & TECHNICAL

### Filter Design – without fears or tears, Part 2 ..... 20

*This month: Butterworth filters.*



### Semiconductor Scene ..... 29

*Keep in touch with developments in semis.*

### Making-up Non-standard Resistor & Capacitor Values ..... 68

*Here's how to use your computer to select standard value components to make-up non-standard value components.*

### DATA SHEET ..... 74

*The AY-3-1015D UART, featured in our Baud Rate Converter this month.*

## ELEKTOR IN AEM

### IEC-Centronics Interface ..... 34

*Drive a Centronics compatible peripheral from an IEC/IEEE port.*



### Low Noise Mic Preamp ..... 38

*Here's a high performance mic preamp for on-stage use.*

## PRACTICAL COMPUTING



### Add-on Baud Rate Converter for Your Modem ..... 70

*If your computer can't handle the split baud rate of 1200/75 bps for V23 operation, just add this project to your modem. Fits to any modem using the 7910 World Chip.*

### Commodore Codex ..... 78

*'Octobyte 64', a simple monitor program for Commodore 64 owners.*

### Dial Up ..... 80

*Roy Hill talks about public domain data comms software packages.*

### BeeBuzz ..... 84

*Using the Microbee in your amateur shack.*

### SPECIAL OFFER ..... 82

*Here's a very special offer on modem kits and a comms package.*

## COMMUNICATIONS SCENE



### Review of the Tokyo Hy-Power HT-180 80m Mono-band Rig ..... 92

*This new low-cost rig is ideal for Novices, those just getting back on the bands or those who want a mobile for their favourite band.*



### Build a Multi-band HF Trap Dipole ..... 88

*Build yourself a four- or five-band trap dipole for the HF bands. Simple and economical.*

## FEATURE



## CONSUMER ELECTRONICS



### Guide to Marine Electronics – Part 1 ..... 10

*Electronics brings more pleasure and safety to leisure boating. Dave Jeans gives a rundown on the latest marine electronics equipment.*

### Guide to Marine Electronics – Part 1 ..... 10

*Electronics brings more pleasure and safety to leisure boating. Dave Jeans gives a rundown on the latest marine electronics equipment.*

## NEWS & GENERAL

### News Review ..... 6 *Aust. Laserdisc first.*

### Consumer Electronics ..... 8 *New NAD power amp.*

### Professional Products ..... 19 *Audio analyser debut.*

### Retail Roundup ..... 54 *The comrades' CRO!*

### Bytewide ..... 77 *Microbee Impacted.*

### Spectrum ..... 87 *UoSAT news.*

### Letters ..... 16

### Literature Review ..... 60 *Two new books.*

### Benchbook ..... 96 *Workshop hints and tips.*

### The Last Laugh ..... 98

## NEXT MONTH!

**ONE-OCTAVE EQUALISER**  
This project is ideal for a wide variety of audio work, from domestic sound equipment, to PA and sound reinforcement applications. As it's built in modular form, it can be readily adapted to your application.

**TELEPRINTER-COMPUTER INTERFACE**  
Want to get really cheap hard copy output from your computer? This simple, low-cost project will interface your computer to a teleprinter, which can be bought quite cheaply on the "surplus" market. Some quite snazzy software is included for Commodore 64 and Apple owners.

**"STOP-MOTION" VIDEO: INSIDE NATIONAL'S M5 CAMCORDER**  
National's M5 camcorder offers a unique feature – "stop-motion" recording. Malcolm Goldfinch takes us over the functions and features of this top-line machine.



**MARINE ELECTRONICS – PART 2**  
Dave Jeans continues with coverage of marine communications gear, performance equipment, entertainment electronics and some unusual accessories.

**NOTE:**  
*Owing to an oversight, the pc board artwork for the AEM4510 RS-True-32er projects was omitted from the article in our September issue. They're on page 97.*

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



# An Australian Laserdisc first

The future of an historic photographic collection dating back to 1869 has been assured by its transfer to laserdisc. This is the first time an Australian collection has been catalogued, conserved and presented in this way.

The archive project, the largest of its kind in Australia to date, covers more than 40 000 fragile glass plate negatives belonging to the NSW Government printing office. The company selected for the preparation of a laserdisc master is Digital Imaging Australia Pty Ltd, a Melbourne based video facility house specialising in the transfer of still images.

DIA is currently laying down the laserdisc master from 35 mm archive film positives of the original negatives. Joint Managing Director of DIA, Ian Large, said he expected to complete the one-inch edit master by the end of October. "This has been made possible, he said, "by DIA's unique facilities, which enables the images to be transferred to master video tape at an average rate of one every two seconds. Where necessary, we have also colour corrected or graded photographs to maintain the highest possible standards of reproduction".

From the edit master, a first pressing of 50 laserdiscs will be made for sale to professional photographers, researchers, libraries, etc, around Australia and overseas.

Digital Imaging Australia are located at 55 Wellington Street, Windsor 3181 Vic. (03)525 1488.

## Electronic enchanted forest at World Expo 88

An enchanted, computerised forest of animals to delight children and adults alike will be just one of the innovative and exciting features of Technoplaza Japan at Brisbane's World Expo 88, we're confidently told.

The enchanted forest will be presented by Hitachi, one of the six exhibitors in the \$9.8 million Technoplaza Japan. There will also be exhibits from Brisbane's sister city of Kobe, Queensland's sister state of

Saitama Prefecture, the Japan External Trade Organisation (JETRO), Idemitsu Kosan Company Ltd and Leisure Development Centre.

Several of the exhibits will feature presentations of traditional Japanese art and culture and visitors to the Leisure Development Centre exhibit will be offered a number of unique experiences in a series of rooms. One room will feature a sensor-scanning device, automatically advising people of their body temperature, blood pressure, height and weight.

World Expo 88 will be one of the major highlights of Australia's Bicentennial celebrations and will run from 30th April until 30th October next year.

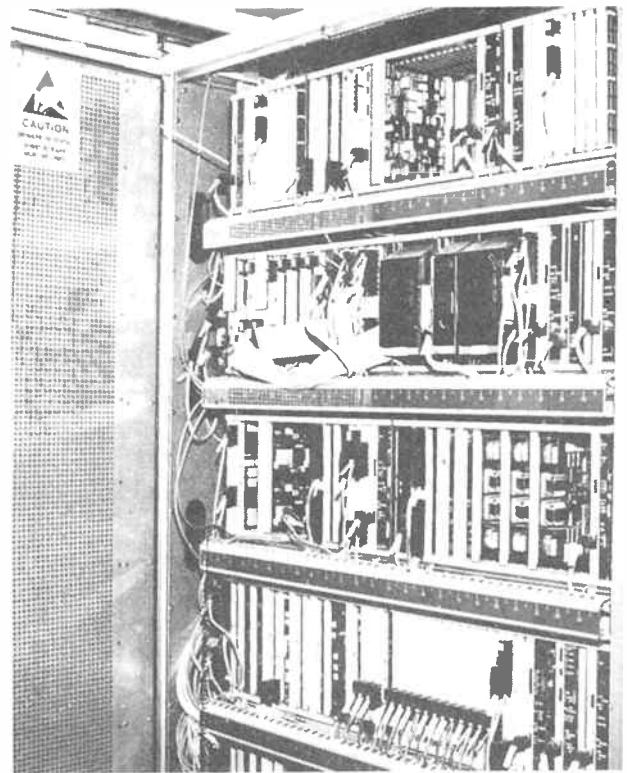
## Aussat launch good news for amateurs

The launch of the AMSAT Phase 3C amateur communications satellite is scheduled for January 1987 according to the manifest released by Arianespace in May of this year. In light of recent problems with the European Space Agency Ariane launch vehicles, some doubt existed as to whether this launch schedule would be met.

With the successful September launch of the V-19 mission carrying Aussat K3, things now look very hopeful for the launch of Phase 3C in the early part of 1988.

It appears that the European Space Agency has overcome the problems with the highly sophisticated third stage of the launch vehicle and the schedule now seems to be getting back on the rails.

The V-19 mission with Aussat K3 aboard was scheduled to fly in August 1987. This schedule seems to have slipped a little,



## AXE-man joins parties in venture

Telecom Australia and L.M. Ericsson Australia have officially launched a first-time joint development venture of new technology AXE-104 automatic telephone exchange equipment at Warragamba, NSW.

The exchange, designed to assist in upgrading a large proportion of the country network and supply those areas with the same level of facilities available to metropolitan networks, is the culmination of three years of development.

The Warragamba exchange is the first to be commissioned on the Australian mainland and there is a potential for exporting the technology, we're told.

The launch was hosted by

Telecom's New South Wales State Manager, Mr. Ken Douglas and the ceremony conducted by Chief General Manager, Mr. Bob McKinnon. Invitations to attend the launch were extended to the Minister for Communications, Senator Gareth Evans and Minister for Trade, Technology and Commerce, Senator John Button.

Invitations were also extended to local State and Federal members as well as representatives of the Local Government Authority responsible for the Warragamba area.

A feature of the launch was a telephone link between Warragamba and the King of Tonga, where a similar AXE exchange has been in operation since July 4th.

with the launch taking place on September 16th.

Assuming the V-20 mission, slated for an October launch and the V-21 mission scheduled for December, go ahead as planned, the possibility of Phase 3C being launched in the first quarter of 1988 looks very good.

The Phase 3C satellite is a sophisticated package along similar lines to the now ailing AMSAT OSCAR-10, but incorporating many improvements.

Good lessons have been learned from OSCAR-10, the first high elliptical (Molniya) orbit amateur satellite. Phase 3C will incorporate specially designed radiation hardened memory in the onboard computer, as well as communications packages which will allow amateurs access to reliable, long range communications in a variety of modes and on a variety of frequencies.

# PAUL YOUNG DOESN'T ENDORSE BEYER MICS.



*Paul Young shown using the Beyer MCE 81 Tourgroup Series mic.*

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**beyerdynamic** ))))

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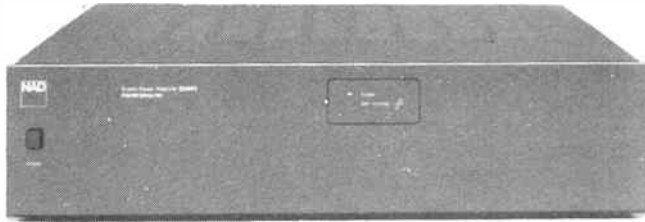
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Chatswood NSW 2067 (02) 417 7088.

World Radio History



## Champagne quality sound at a beer-budget price



**A** 40 watt stereo power amp with 160 watt peak output? That's what NAD claim for the newest addition to their range, the 2240PE. That's a headroom spec akin to a stretch limo with a rubber roof!

Headroom in an important parameter in an amplifier's performance as it's a measure of the equipment's peak transient (or dynamic) power output versus its continuous output rating. Typically it's 1-2 dB, in fact, 2 dB is considered good. Six dB is considered phenomenal!

But that's what NAD's new stereo amp, model 2240PE, delivers, according to the literature.

The 2240PE is rated at 40 W continuous output into 8 Ohms, but is capable of 160 W short term, 200 W into 4 Ohms, 240 W into 2 Ohms, NAD claim.

NAD achieve this through the use of their "power envelope" circuitry (hence the PE). It allows the economy of a medium power amp while delivering peak power sufficient to cope with the transients common in music.

The 2240PE also boasts NAD's "soft clipping" circuitry which gently limits the slew rate of the output when it approaches saturation, reducing the harsh distortion of hard clipping experienced with conventional output stages.

Another unique feature is the output impedance selector. This provides increased output voltage drive for the higher impedance loudspeakers of 8 Ohms or more, and higher output current capability needed to drive low impedance speakers or paralleled speakers.

And it's only \$499 rrp!

Further details from the distributors, **Falk ElectroSound, PO Box 234, Rockdale 2216 NSW. (02)597 1111.**



### New "digital" headphones

**A**rista Electronics has released a new series of headphones designed to cope with the dynamics of digital audio. There are four models in the range.

The CDS-16 is a lightweight set. Weighing-in at 95 grams they're designed for comfort, Arista say.

Next in the range is the MHD-12, boasting "clean, crisp" sound and "excellent separation". Individual left and right volume controls are fitted.

The Arista HD-1000 is a closed-back model, designed to totally cover the ears to keep out all extraneous background noise, making them "ideal" for both domestic and commercial use, according to Arista.

Top of the range is Arista's CDS-17. Combining "the ultimate in comfort" with a claimed frequency response of 20 Hz to 23 kHz and low distortion should endear them to the most discerning CD listener, Arista say.

Prices range from \$39.95 to \$56.95. You can audition them at your nearest Arista stockist. Further details from **Arista Electronics Pty. Ltd. 57 Vore St., Silverwater 2141 NSW. (02) 648 3488.**

### 10-year warranty from Philips

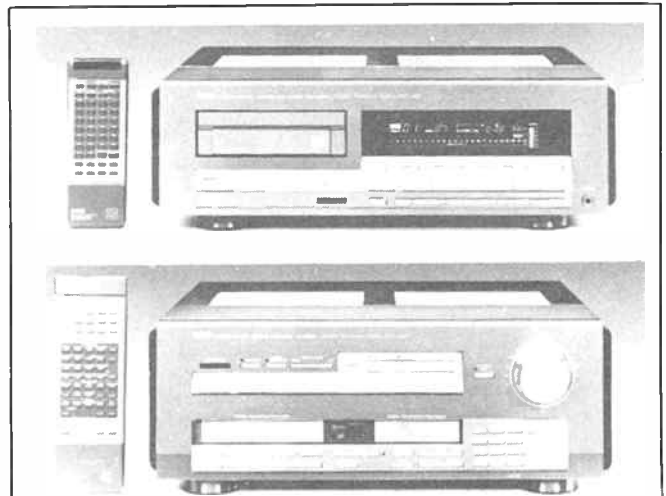
**F**or a once-only payment of just \$49.95, buyers of Philips major products like TV, video or audio systems, can extend the manufacturer's parts warranty to ten years.

This new extended parts warranty is available from October 1st 1987, by paying the \$49.95 fee to the Philips retailer within 30 days of purchasing the product.

Divisional Manager of Philips Consumer Service, Mr Roger Smith, explained that the extended warranty covers the supply of a replacement for any defective functional component, provided the repair is carried out by Philips Service or a Philips authorised service centre.

The extended warranty does not cover the labour cost of a repair outside the normal manufacturer's warranty period, nor does it cover damage caused by accident or misuse.

Full information on the extended parts warranty is detailed in a brochure available from Philips Service centres. 🐘



### "BI" CENTENNIAL

These two components are part of Yamaha's "Limited Centennial Edition 10000 Series" equipment, released as part of Yamaha's hundredth anniversary celebration.

At top is the CDX-10000 compact disc player - \$5000 worth - featuring Yamaha's high-bit quadruple oversampling digital filter, claimably the world's fastest access track access time, both digital (optical) and analogue output terminals, double floating suspension system and a 44-key remote control.

Beneath it is the CX-10000 control preamp. Yamaha proudly claim it's the first control amp in the world to include major digital innovations, such as their quad-oversample 18-bit DSP processing, digital equalization and direct digital inputs. The digital signal processing (DSP) circuitry can be used with analog sources for equalization and noise reduction. It comes with a 57-key remote and a \$15 000 price tag.

A 250 W/ch. Class A power amp (43 kg and \$12 000) and a pair of three-way loudspeakers (\$13 000) are included in this series. It was launched at the Perth Electronics Show and then at individual releases in each state later. We saw/experienced it at a release held at Len Wallis Audio in Lane Cove, Sydney. In a word? - impressive.





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# Electronics brings more pleasure, more safety to leisure boating

Dave Jeans



The rapid development in electronic products has not bypassed the pleasure boating scene. In fact about all that has changed in pleasure craft during the past decade is the gear installed onboard. This change is exciting! Electronic equipment is doing things for the skipper that his dad would never have dreamed possible.

THE KEY to the upsurge in marine electronic equipment has been the development and subsequent low cost manufacture of dedicated, purpose designed micro-chips. These devices have enabled electronics companies to design and manufacture communications, navigation and boat performance equipment so powerful in capability that in most cases only a fraction of the inbuilt potential is used.

Does it matter though if a microprocessor capable of 47 different functions has only three or four of them utilised in its role in a depth sounder? Or that a SatNav receiver offers a 200 waypoint capability, when the user can't even think of how to use two of them? Or that an HF/SSB transceiver has 390 channels, when there are only 160 authorised frequencies world wide in the marine HF band?!

To the boat owner it doesn't matter a jot. In most cases pleasure craft are just a diversion for the owner. Something to take the mind away from the problems in the office, a counter to the pressures of city living, and a way to get down to basics with the family.

What has happened over the past few years is that, owing to the escalating cost of new boats, owners are sticking to their old boats ('old' might mean only two or three years since launching) and they are re-fitting with some of the exciting new electronic gadgets that crowd the chandlery shelves, beckoning.

So, hand in hand with the availability of sophisticated electronic gear, there has been a tremendous desire to fit-out the old tub, and spend a pleasant weekend reading through the radar set owner's manual. Timewise it has dovetailed together beautifully. The only thing that's moving at the dockside these days is electronic gear.

To get a broad picture of the way electronics has been adapted to marine tasks, equipment available for navigation, communications and entertainment will be examined in the following pages.

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## Navigation Equipment — SATNAV —

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A true child of the space age is the satellite navigation receiver, or SatNav. These marvellous black boxes are so accurate in determining position that new dangers now exist — islands are no longer where the chart says they are!

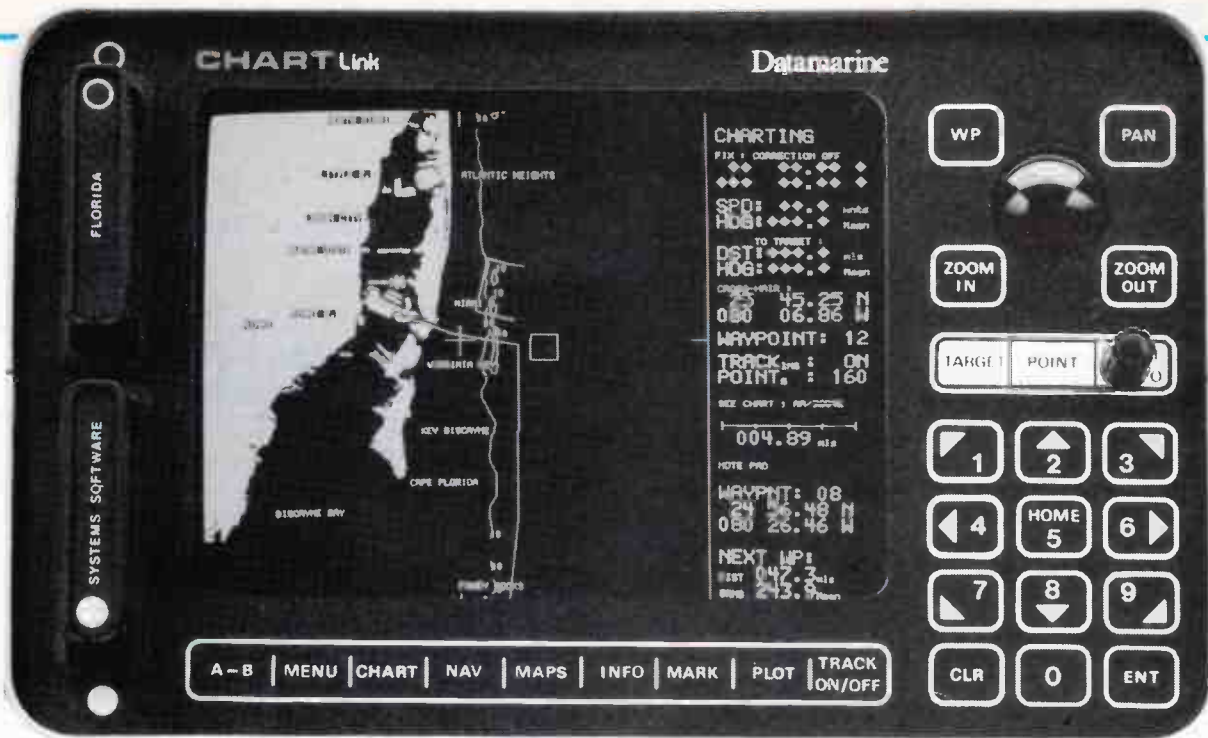
Yachtsmen cruising in remote Pacific areas have found supposedly up-to-date charts with errors of up to three nautical miles in the position shown for some islands and reefs.

The Transit Satellite Navigation System comprises six satellites orbiting in paths which take them over the poles, at an altitude of about 1075km. The orbits of the satellites are spaced rather unevenly around the 360 degrees of the globe, giving varying time intervals between the passes from successive satellites. The longest time between the useable pass of one satellite and the next is about two hours. The SatNav is a passive device, acting only as a receiver and processor of signals transmitted from the satellite.

### How they work

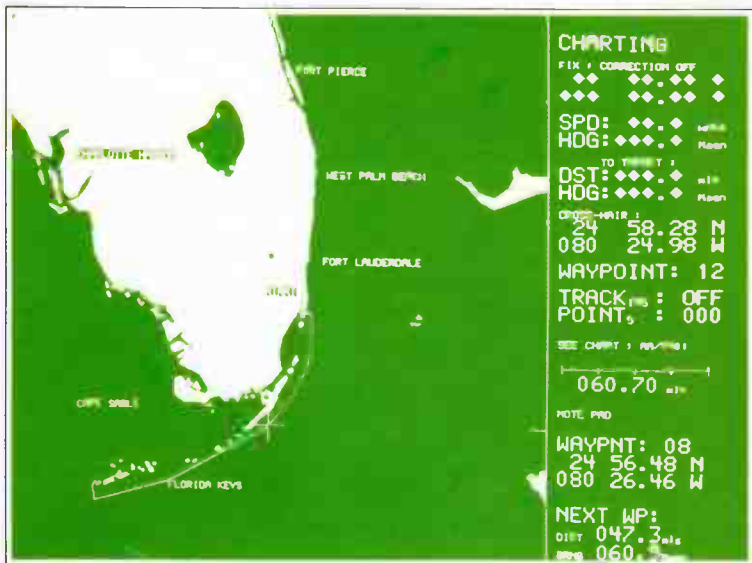
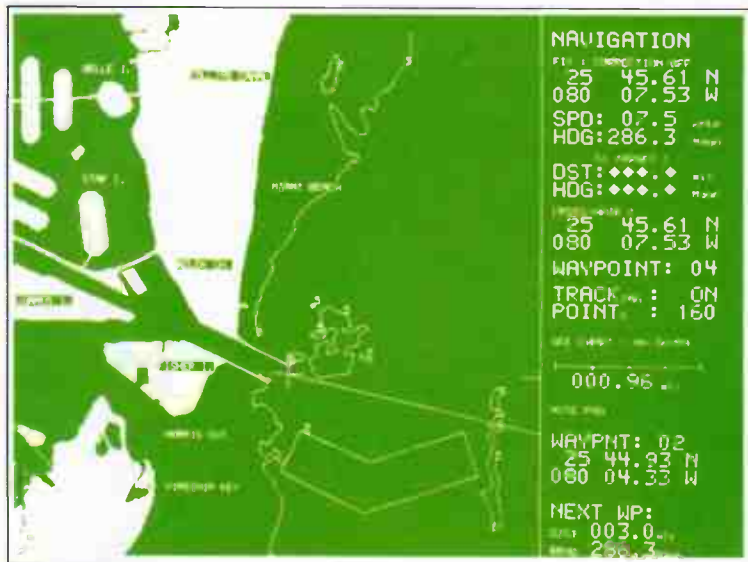
Each satellite transmits a primary carrier signal on 399.968 MHz. The SatNav receiver has a very stable inbuilt oscillator with output on 400.00 MHz, giving a resultant "beat note" ▶





Whilst satellite navigation systems are an enormous benefit when sailing in unfamiliar waters, it can be quite difficult at times to quickly assimilate all the various information from such systems. The Chartlink, from Datamarine, can translate vital Loran (or SatNav) information into an easily recognizable electronic plot of your position, track of where you've been and course to new waypoints.

With Chartlink, you can simply look at the screen and immediately determine where your are and where you want to go. The instrument's visual presentation of charted information also makes it an extremely useful tool for preliminary cruise planning, without the necessity of thumbing through a pile of charts.



By moving a track-ball or pushing a button, it is possible to call up various charts and zoom in or out to three or more levels of magnification. Without the need for dividers, parallel rules and guesswork, it is possible to instantly determine the latitude and longitude of waypoints and the range and bearing to them. Charts are stored on cartridges that are available for most parts of the world and each cartridge can hold an average of ten charts. Accuracy of the boat's position on the screen will depend upon the accuracy of the Loran or SatNav instrument feeding the Chartlink, but the electronic charts are believed to be accurate and reliable.

The Chartlink can be powered from any dc source between approximately 10 V and 40 V dc with a current drain of around one amp. Battery backup is provided for waypoints, tracking and marks. The display uses a 200 mm (8") CRT with a resolution of 512 x 672 pixels. Chartlink is distributed by Datamarine International, 7-9 George Place, Artarmon 2064 NSW. (02)427 0666.

(difference between the two frequencies) of 32 kHz if both equipments were stationary.

As the satellite approaches the SatNav's position, the Doppler effect causes the received frequency to increase, reducing the beat note frequency. After passing overhead, the Doppler effect decreases the frequency of the satellite signal, increasing the frequency of the beat note. If the satellite passes to the west or east of the observer rather than overhead, the closing and departing speeds are reduced, and the Doppler effect is lessened.

Back in the days of Sputnik, scientists became aware of the pronounced Doppler shift in signals received from those early satellites. Knowing their own exact position, the scientists used routine mathematics to calculate the position of Sputnik at any moment by measuring the Doppler shift. It was a natural step to devise a captive satellite system, whereby the position of a receiver could be calculated from the known position of the satellite.

Giving birth to the Transit Satellite System meant devising a means of knowing accurately the position of each satellite in the system at any moment, and in passing this information to the SatNav receiver. To achieve this end, ground stations in the USA track each satellite as it passes over their position, and transmit correction data, applicable for the next 12 hours, regarding the satellite's drift away from true orbit. This correction data is stored in the satellite's memory and retransmitted for reception by the SatNav receiver, which acts on this correction data when calculating its own position.

### Obtaining a position

To obtain a position from a SatNav after initial powering up, you enter simple data such as GMT date and time, accurate to within 15 minutes, the vessel's DR position to within 60 nm, and the height of the antenna above sea level. During the next useable pass of a satellite (when its elevation is between 15 and 75 degrees above the horizon) the SatNav receives the incoming signals for a period of from 8 to 15 minutes.

From the DR position stored in the SatNav computer, a Doppler shift curve is produced and compared with shift curves being received from the satellite transmission. Comparison goes on until two curves coincide. This process takes only a few seconds. The SatNav computer continues to obtain this matched curve/position line information for several minutes, before establishing a fix. The computer then provides a readout of the vessel's position on the screen in latitude and longitude.

Various factors cause errors in the resultant fix, the major one being the vessel's movement during the lengthy period the fix is being obtained. Low cost installations rely on the user entering the vessel's course and speed. Elaborate installations have continuous inputs from speed log and compass or directional gyro. This latter setup also allows accurate DR positions to be obtained between satellite fixes. An accuracy of better than one nautical mile is routine with SatNav operation.

The inbuilt SatNav computer finds position fixing a breeze. Its great power potential is also used to predict the time of subsequent 'good' satellite passes, to calculate future vessel positions, called 'waypoints', where a course change or some other action is necessary, and to warn ahead of an impending waypoint by sounding a buzzer. Some receivers can be interfaced with TV monitors to provide data additional to that which can be displayed on its own small screen.

SatNav antennas can be active or passive. The active pre-amplifier can be an option on some of the less costly units. The antennas are small, often encased in a plastic housing, and appear to be vertical quarter wave sections. The more efficient have ground plane rods, either open or mounted within a circular plastic shield.

Current drain at 12 volts varies between 0.5 amp up to 1.5 amps depending on model. Some SatNavs have a 'sleep' mode (current drain about 200 mA) which enables the frequency generator circuits to operate continuously, but switches off the computer and display electronics between satellite passes.

Retail price for SatNavs ranges from \$1685 for the NavStar 2000S to \$5610 for the sophisticated Raystat 200 by Raytheon.

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## Navigation Equipment — RADAR —

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The history of marine radar goes back to World War II. Thirty years after the initial development, vacuum tubes were still being used by some of the more conservative manufacturers. The sets were bulky, with no virtue seen in miniaturisation. After all, there was no lack of space on the bridge of a merchant ship.

Even when transistors found their way into the circuitry, no attempt was made to reduce size. The display unit needed to be big, to allow several deck officers to view the picture together, inside surrounding blackout curtains. Power consumption was incidental, with several hundred kilowatts of ac power on hand.

Nonetheless the need to miniaturise is endemic in electronic engineers, and mini radar sets started to come on the market. They were shrunken copies of their merchant ship ancestors; tiny look-alikes, with 150 mm CRT tubes, straight out of the workshop CRO.

Because the radar picture faded during the period of the antenna sweep, light defying hoods were fitted over the screen when viewing in daylight. Attempting to keep your head still against the viewing hood in rough seas was difficult and often brought on attacks of mal de mer.

When the radar antenna was reduced in size the performance suffered in two ways. Firstly the beamwidth increased from the narrow one degree, common in the three metre wide big ship scanners, to around five degrees for a 750 mm antenna suitable for installation on a small cruiser or yacht. This wider beamwidth gave far less target resolution. The picture was fuzzy and lacked fine detail.

The second problem of the wide beam antenna was reduced range in transmission and reception. To some extent this was offset by mounting the transmitter and receiver pre-amplifier right in the antenna housing. This technique overcame the long runs of lossy waveguide used in big ship systems, where the electronics were housed below the antenna mast, in the bridge deck.

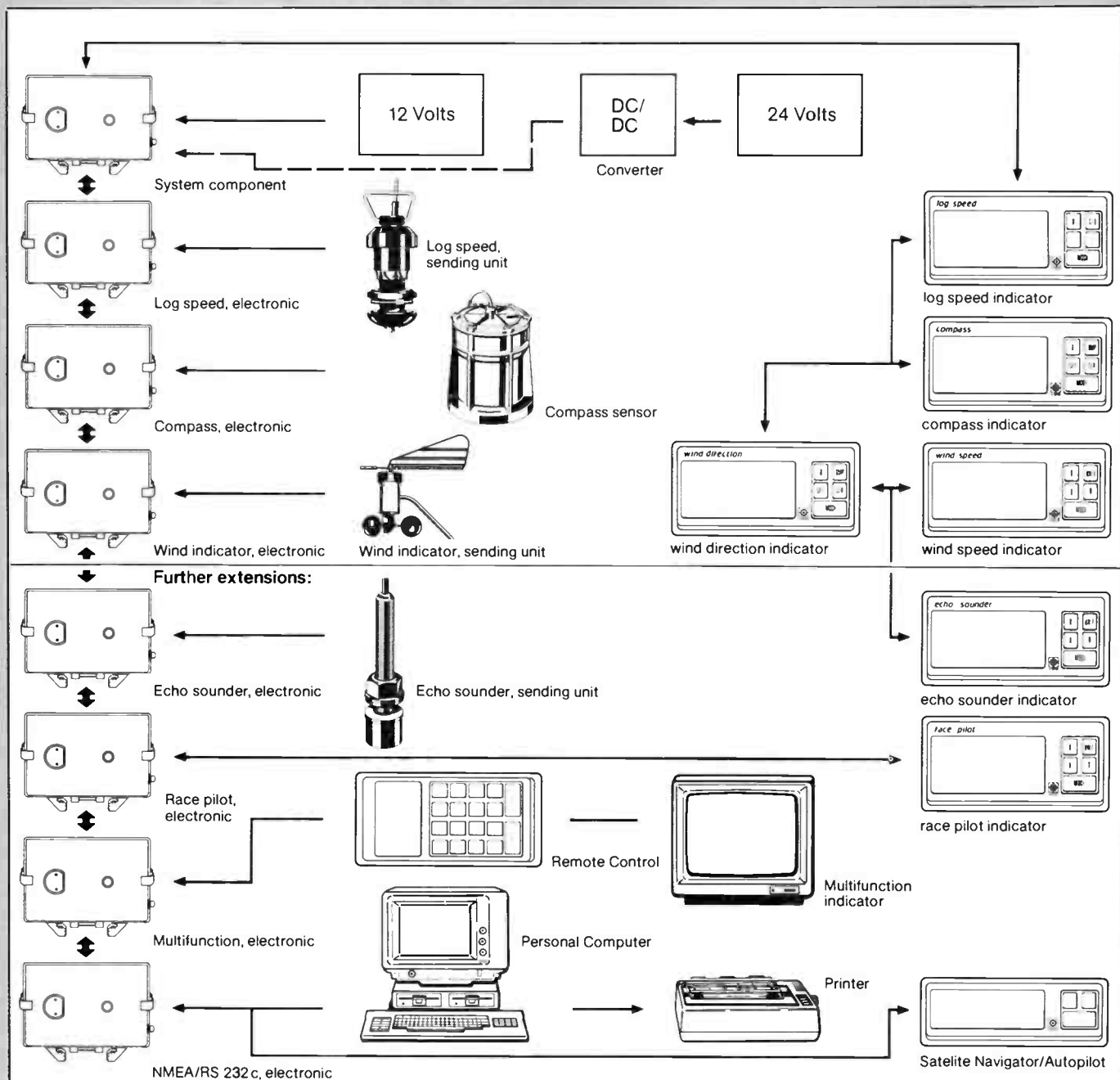
### The breakthrough

Three quite remarkable developments have been incorporated in small ship radar during the past five or six years. The first was the invention of extremely sensitive and noise-free receiver pre-amplifiers, and to a lesser extent a gradual improvement in small antenna design. This has meant longer range operation and better picture definition.

The second development was in the manufacture of daylight viewing radar screens. This was achieved by using memory circuits to store the target information from one complete sweep of the antenna, and then display it on a raster scan, monochrome TV set type presentation.

This technique meant the radar picture remained on the screen for the whole period of the antenna sweep (about 2.5 seconds) instead of gradually fading out. Once each sweep the picture was updated, instantly, from the memory circuits. Picture brightness was great enough to allow full daylight





The illustration here shows the modular concept behind the VDO Navpac system. Each component in the system uses a separate microprocessor, which can interchange information with other system units and calculate and display the information on digital indicators. A major advantage of the separate processor technique is that each instrument will continue to perform its basic function even if there is a system failure.

Below deck, separate electronic components plug together and are easily interchangeable. A single data link connects these components to the display units on deck. Due to this configuration there is a very high computing speed and a data output rate of 0.2 seconds. Via an interface unit, NMEA/RS232C, all system data is available for navigational and racing purposes and can be used with personal computers

and advanced performance systems.

The on-deck displays are LCD types with 20 mm high figures and symbols for easy readability. Night illumination is provided by means of the latest electro-luminescence techniques and any selected display can be highlighted as desired. The display damping factor can be selected at will, overcoming any difficulties associated with rapidly changing data.

Navpac's modular design overcomes the traditional wiring "jungle" and lends itself to simple expansion. Any combination of instruments can be added, one or more at a time and in any order required. The system is distributed by VDO Instruments Australia Pty Ltd, 115 Northern Rd, Heidelberg West 3084 Vic.(03)450 3209.

viewing for several people simultaneously. At night the brightness could be turned down, as in a domestic TV set.

The third development was a natural. With the target information in memory, all sorts of data could be introduced and displayed on the screen with the stored receiver signals. Such refinements as moveable electronic bearing lines, with digital readout of the bearing in degrees. The distance from the vessel to a target of interest could also be represented by variable range markers with digital readout in nautical miles. Some mini radars provide guard zones, which can be moved around the screen, to warn if a target enters the protected area.

All of these quite dramatic improvements were capped by the introduction of colour radar into the small ship field. Signal strength could now be portrayed in a range of up to eight colours. Digital readout information was displayed in a contrasting colour, as were the range and bearing lines.

Manufacturers are now vying with each other to improve picture detail by the use of even smaller picture elements (pixels). Antennas are now made using printed circuit board etching techniques. Interfacing between other marine navigation equipment is now possible, with the newly developed NMEA standards from USA.

Having regard to the modest antenna height possible in small craft, useful operating ranges of up to 10 to 12 nautical miles are routinely achieved for large targets such as distant merchant ships. Peak pulse power hovers around the 3 kW mark, and current drain at 12 volts is about 5 A. Prices are down too, with a good monochrome set selling for around \$4000 retail.



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### Navigation Equipment — DEPTH SOUNDERS —

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The 3000 series instruments from Datamarine are designed for offshore applications in yachts. The International Offshore 3000 depth sounder shown here can read depths to 1000 feet, 300 metres or 160 fathoms. In depths of less than 10 units, it reads in tenths.

As supplied, the instrument reads depths from the transducer, but a rear panel adjustment allows depths to be read from the water surface or from the lowest point of the keel or prop. To help prevent unpleasant surprises and to aid in establishing position, the International Offshore 3000 has eight depth alarm settings. For more details, contact Datamarine on (02)427 0666.

No piece of marine equipment has offered such a happy hunting ground for the electronics design engineer as the depth sounder. Currently this device is offered in five different modes of presentation, i.e: flasher, digital, chart, liquid crystal display (LCD) and video.

Depth sounders can be divided into two broad categories, navigation and fish finding. The first two presentation modes mentioned above lend themselves to navigation, with the remainder firm favourites with fishermen, both sport and commercial.

#### The basic depth sounder

The flasher sounder is the simplest, most reliable and cheapest available. It will sound efficiently down to about 100 metres, and can give some indication of the presence of fish under the boat. Most low cost sounders operate on an ultrasonic frequency of 200 kHz. They transmit short pulses of energy (typical pulse length one millisecond) and listen for echoes between transmissions.

Based on the travel speed of sound through sea water of 1500 metres per second, the flasher sounder measures the time interval between the transmission of the pulse from the transducer under the boat, and the reception of the echo reflected from the sea bottom.

The visual presentation comprises a rotating disc driven by a small electric motor. An LED or neon bulb fastened to the disc is energised by the transmission pulse as it passes the 12 o'clock position, and is again energised by the amplified returning echo signal.

The outside scale around the disc has the depth marked in metres. The distance to the sea bottom below the boat is indicated on the depth scale by the flash from the echo signal. If the disc is slowed to half speed, the sounder will indicate to twice the depth, providing a useful means of switching depth scales.



## The chart recording depth sounder

One limitation of the flasher sounder is that no record is available for later perusal. The chart sounder provides an accurate display of the sea bottom and other echoes, by marking them on a roll of chart paper. The transport moves the paper horizontally while the stylus etches the echo signal on to the paper.

The stylus moves vertically down the paper, carried on a flexible belt running on rollers fitted at the top and bottom of the chart. The stylus burns a mark at the top of the paper, indicating the sea surface (transmission pulse), and again as it travels down the chart, to indicate reception of the echo.

Before the introduction of microprocessors, depth ranges were contrived by varying the speed of belt travel. In modern chart sounders the belt travels at a constant speed, with the electronics creating appropriate delays to mark the echo at the correct position on the chart.

This delay technique also allows the machine to scan intermediate depths, rather than from the surface downwards. Fishermen may be interested only in what is happening near the bottom, so the sounder can display that segment of depth bracketing the bottom.

Some chart sounders have a facility called 'bottom expansion' whereby the chart traces the bottom contour as a straight line, and all echoes to five or 10 metres above the bottom. This information is displayed on the lower portion of the chart, with the regular display compressed on the upper part of the chart. This way no wanted fish echoes are missed.

Upon all of this chart information can be printed depth scale lines, the depth range selected, the digital depth and whether in metres, fathoms or feet. With appropriate sensors, the boat speed and water temperature can also be displayed on the chart. Some chart sounders provide separate depth indication on an LCD readout, to conserve chart paper while running out to the fishing grounds.

## LCD display sounders

The development of large screen liquid crystal displays has given birth to the LCD sounder. These units provide quite sophisticated depth information, but suffer two major limitations.

The first is difficulty in viewing the display under some lighting conditions, and particularly when viewing off to one side. The second problem is in the coarseness of the display, due to a limited number of picture elements making up the display. Both problems are being overcome and the potential for crisp, easily viewed displays is just around the corner.

## Video depth sounders

Using similar techniques to the daylight viewing radar, the video sounder circuitry stores echo signals and other screen detail in its memory, and then displays them on the raster scan screen, one strobe at a time. The video picture moves slowly from the right side of the screen to the left in minute movements, built up from vertical segments, each depicting one sounding of the transmitted pulse.

The exciting aspect of video sounders is that they use up no expensive chart paper, and the difficult task of changing paper rolls in rough seas is avoided. The first video sounders on the scene were colour, and only later did low cost monochrome video sounders appear. Even they were quickly updated, changing from black and white screens to highly visible amber, with up to four visible shades to indicate signal strength.

Video sounder manufacturers have included vast potential into their products. Some video sounders are capable of dis-



Shown here is the DM-1800 colour video depth sounder from Imark. The DM-1800 uses a 150 mm (6") CRT screen to display the sea bottom, reefs and fish beneath the vessel. Capable of operation to a depth of 160 metres, the depth sounder has five selectable ranges, as well as a "zoom" facility which allows the user to display any five metre section of the water over the entire screen.

The DM-1800 uses a seven-colour, 128 x 160 pixel CRT display for very high resolution and also has a "freeze frame" facility allowing the screen to be "frozen" for greater analysis. Adjustable alarms are provided which can be set to sound when the depth exceeds or becomes shallower than preset limits.

The control panel of the DM-1800 is backlit for night use and all switches are soft-touch waterproof types. Operating from a normal 12 Vdc supply, the depth sounder draws only 1.6 amps. The unit is 155 mm high, 239 mm wide and 230 mm deep and it weighs 4 kg. Details from Imark, 167 Roden St, West Melbourne 3003 Vic. (03)329 5433.

playing segments of depth in one metre increments (or two metres, or three metres, etc.), from zero depth down to 1000 metres. Automatic functions allow continuous bottom tracking, irrespective of depth changes. Fast, slow and freeze mode is commonplace.

The sets are also available for operation at several frequencies, from 33 kHz, for really deep water sounding, up to 200 kHz for shallow work. Some sets can operate on two frequencies simultaneously, portraying the results on a split screen.

The ability of the TV screen to portray additional data, whilst performing the normal depth sounding function, has been used by most manufacturers. Interfacing with other navigation systems means that positional data from Loran, SatNav and the ships log and compass can be displayed on the video sounder screen.

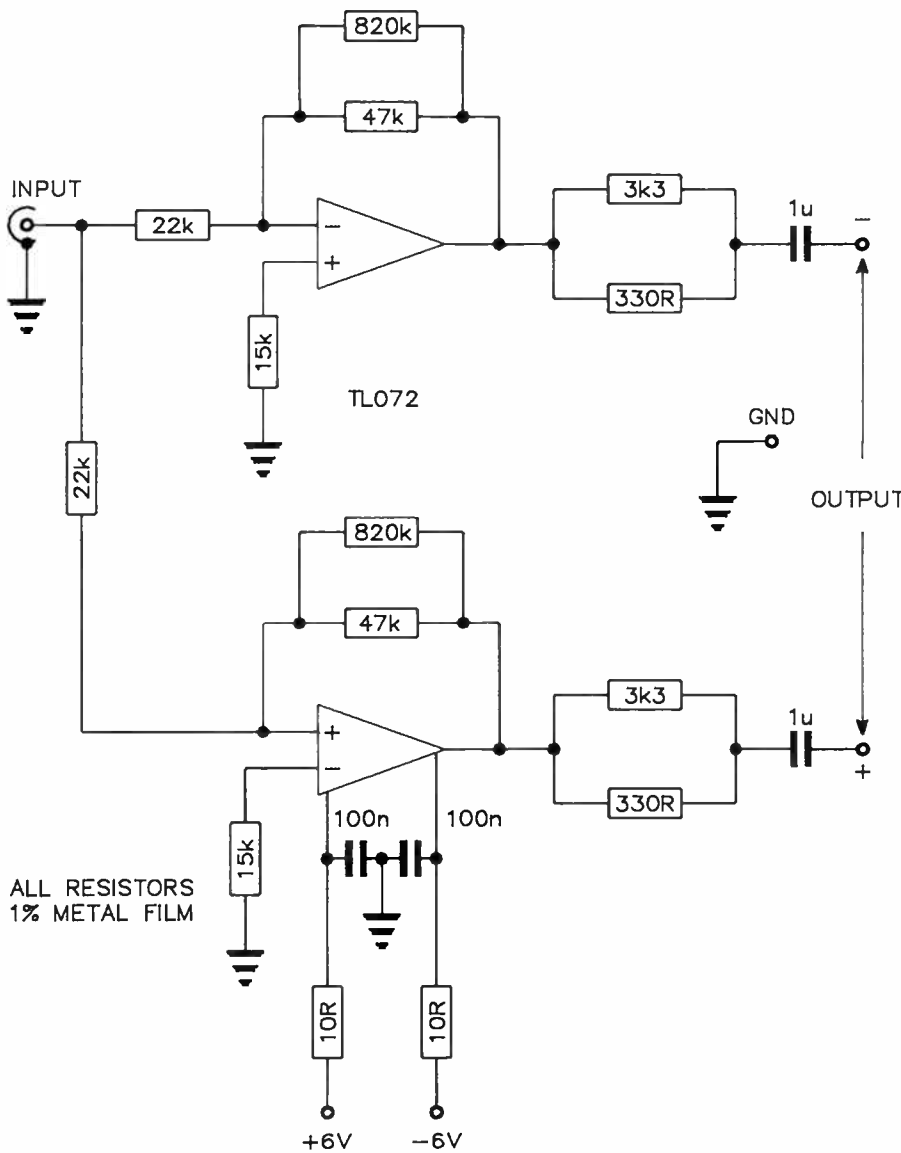
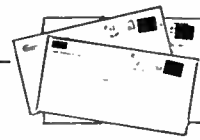
And yes, the video sounder display can be tape recorded and played back, using a split screen effect so that current depth sounding echoes are not missed.

Colour video sounders operate from a 12-24 Volt DC supply, drawing about 2 A. Retail prices for colour sounders range from \$1500 up to \$5000. Monochrome video sounders operate from 12 or 12-24 Vdc, drawing 1.5 to 2.0 A. Retail prices start at about \$800.

Chart sounders operate from 12 or 12-24 Vdc, drawing about 1 A. Retail prices range from \$600 up to \$2000. Flasher depth sounders draw about 300 mA from 12 V, and cost from \$150 to \$300. Digital depth sounders draw similar power and are priced from \$300 to over \$600 for the top brands.

LCD sounders operate from 12 Vdc, draw minute current and cost from \$200 upwards.

— continued next month.



ALL RESISTORS  
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## Balanced output

Dear Roger,

I read your July issue with great interest, in particular the Spot Sinewave Generator in the Elektor section.

However, like all such audio generator projects I have seen over the past number of years, it lacks a balanced output.

I am involved as a technical volunteer with the community radio station, of which there are some 70 around the country at present. What I need, and the same goes for my colleagues in similar positions, is audio test gear with a balanced output, preferably of 600 Ohms impedance.

OK. It's just an idea . . . . .

Ben Furby VK2XNZ

It's a good idea! There are plenty of applications where 600 Ohm balanced circuits are used in audio work, aside from that you mention.

The circuit here will provide a 600 Ohm balanced output from a 600 ohm unbalanced input with an overall "gain" from input to output of one, allowing the metering on your generator to be used for output level monitoring. The capacitors should be MKT types, and all resistors 1% metal film, with the exception of the 10R supply decoupling resistors.

Roger Harrison

## Modem questions

Dear Sir,

I have just completed the construction of your excellent "Bit Stream Flyer"

modem, but have a few queries concerning the section in the instructions on completion and testing.

I have followed the procedure in setting up the trimpot using my oscilloscope connected between pin 1 of IC1 and ground. With the panel switches set as suggested, there is nothing but silence on the 'scope. There is no signal by which to adjust the trimpot. My interpretation of the flow chart suggests that this is what should happen in the "orig" mode.

In "ans" mode, I get what I think is the scrambler on the scope. Adjusting the pot in this mode still makes no noticeable difference to the level of the signals. If I shift the probe to pin 7 of the op-amp, the signal appearing there can be tuned to a minimum level. Is this correct?

I noticed in the revised parts list (supplied with the kit) that R17 and R18 have been marked "not used". Do I leave them out altogether?

M. A. Waite,  
Chelmer, Qld.

Thank you for your letter. I am glad you are pleased with the modem design which is proving to be a popular project.

As detailed on page 6 of our September issue, there are a few transpositions, omissions and typographical errors which crept into the article. I will repeat the information for you here.

Concerning the article in the June 1987 issue, on page 70 under "completion and testing", the first sentence of the third paragraph should read: Set SW3 to HANG UP (left), SW1 to ANS (left), SW2 to TEST LOOP (left). Connect the plug-pack, power up again and quickly check the supply rails. In the same paragraph, a few lines down, you attach the CRO or audio millivoltmeter between pin 7 of IC6 and ground.

In the parts list, ZD1 - a 12 V zener, was missed, R17 and R18 are 2k2 and should be fitted and R12 was omitted, it's 1k.

I hope this clears up the problems for you and we apologise for the confusion in the original article. These things happen!

Andy Keir

## More modem questions

Dear Sir,

I recently became interested in building a modem and having had experience with other "smart" modems at work, decided on your Supermodem project (AEM4610) published in the April to July issues last year.

While this unit would seem to fulfil



## letters

my requirements very well, you may be able to assist me with the answers to the queries listed below before I commit myself to building the project:

- 1) Have there been any errata published in subsequent issues?
- 2) Has the V.22 1200/1200 baud upgrade been published yet and if not, when might this be expected?
- 3) Is it possible to obtain the pc board and EPROM in Brisbane and if not, where are these currently available?
- 4) Where may I purchase the necessary Viatel software?
- 5) Are there any new modem projects or major changes to this project which may make it worth my while to hold off for a time?

Thank you for what promises to be an interesting and worthwhile unit. Hoping you can assist.

R. J. Hicks,  
Moggill, Qld.

Thanks for your interest in the AEM4610 project. There have indeed been some errata published and some queries answered concerning the unit and you will find these in the "Dial Up" column in the October 1986 to January 1987 issues.

The 1200/1200 baud upgrade was published in the February and March 1987 issues. The Viatel software can be obtained by writing to: Maestro Distributors, Calool Street, South Kincumber 2256, NSW.

Regarding your final question, there are no major changes planned for the immediate future for this design. Don't hold off!

Andy Keir

### Dummy load

Dear Roger,

Congratulations on your fine publication, you must be extremely pleased with its acceptance by readers, and I hope that sales are buoyant.

I have a small technical enquiry that I am sure you can assist me with as a fellow VK (- jargon for amateur radio operator - Ed.).

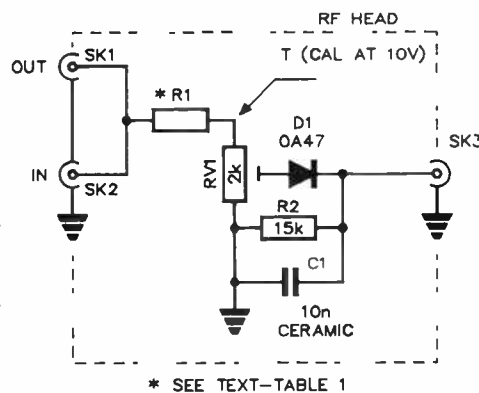
I have just built a fine high power RF dummy load to enable me to tune up an FL2100Z linear amplifier. It comprises a number of paralleled resistors mounted in a can and connected to an SO239 socket on the lid. I wish to build underneath the lid a little circuit to rectify the RF and, whilst operating the plate and load adjustments on the linear, to read from a multimeter attached to two terminals inserted in the lid, the maximum

dc voltage produced by the rectifier. At maximum voltage read, I will know the amplifier is tuned for maximum power output. As well, I can see that the power output is within the DOTC's requirements.

I can't quite get the circuit all together in my mind. I would probably need a pass-through capacitor inserted in the dummy load's lid, along with another terminal, to hook the multimeter probes onto, plus a few diodes as well.

Brian Pittman VK4ATQ,  
Brookfield, Qld

Obviously, you missed our April '86 issue. The AEM2600 Peak RF Power Meter/Monitor project featured in that issue can be readily adapted to your application. This comprised an "RF head unit" and a LED bargraph monitor "display unit".



The circuit of the RF head, given here, is a rectifier giving a dc output directly proportional to the voltage developed across the load (or antenna). This could be built as described in the April '86 article and mounted under the lid of your dummy load. Resistor R1 would connect between the centre pin of the SO239 socket on your dummy load and RV1. For R1, from Table 1 in the article, use a 20k/1 W resistor.

The rectifier output can be calibrated using the procedure outlined in the article and Table 2. A photostat of the AEM2600 project can be obtained for \$4.00, inc. postage.

The output socket (SK3) may be replaced with a 1000 pF (1n) feedthrough capacitor (All Electronic Components of 118 Lonsdale St, Melbourne have suitable bolt-on types, see "Retail Roundup" last month). Retain the 10n ceramic capacitor, though, as this is the rectifier's reservoir capacitor.

Roger Harrison

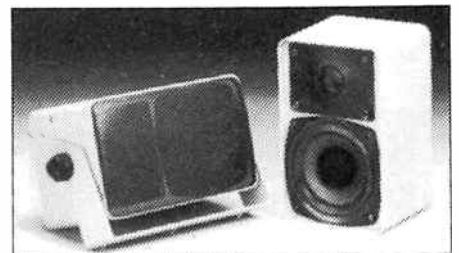
# Problem?

Your existing speakers were not designed to...

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- 3: put up with the salt spray on the boat...

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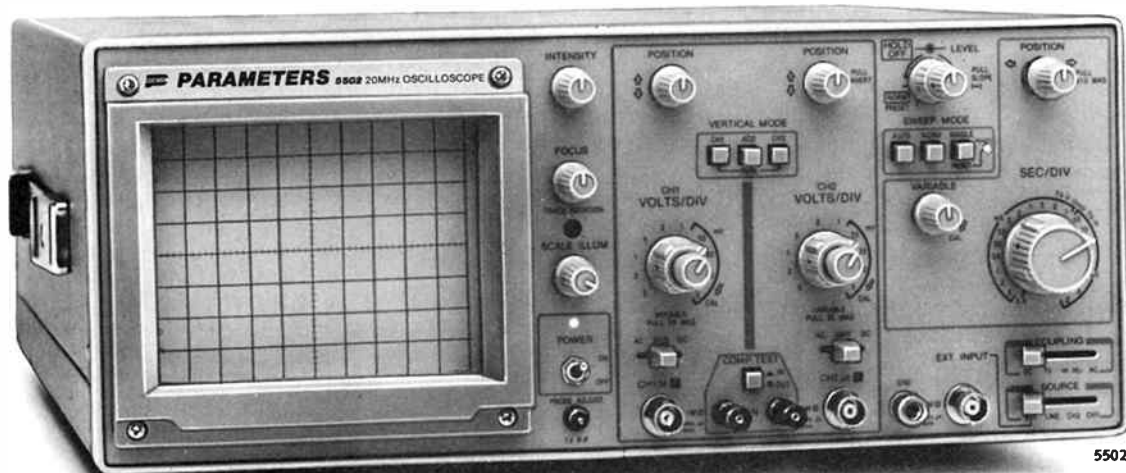
For further information on the ARISTA solutions and the name of your nearest retailer, please contact:

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PERFECTION IN MEASUREMENT



# Practical filter design — without fears or tears

Jack Middlehurst

## Part 2 — Butterworth filters

The 'ideal' filter is one that has as sharp a cutoff as the LCR filter but doesn't have any peaks or ripples in the passband. Such filters are known as Butterworth filters after the man who invented them. Butterworth was able to show mathematically that his design of filter would produce the maximum slope in the stopband of any filter that had a passband response free of peaks or ripples.

IT IS NOT POSSIBLE, even in principle, to have a filter that has a flat response in the passband and a steeper slope in the stopband than a Butterworth filter, so there is no point in beating your brains out trying to invent one!

There are many forms of Butterworth LC filters. Those that we are going to describe have special properties. They are fed, not from a zero impedance source, but from one having a fixed resistance. They must be loaded with a resistor identical to the source resistance. Because the source and load resistors form an attenuator, the minimum attenuation of such a Butterworth LC filter is 6 dB in the passband. In all textbooks and in the computer programs in this series of articles, no allowance is made for this 6 dB, the attenuation in the passband is always given as 0 dB a long way from cutoff. These LC filters consist of low loss inductors and capacitors only; as their name implies there are no resistors. The emphasis is on low loss. If the inductors have significant resistance or the capacitors significant leakage, the performance suffers.

Every LC filter has an order associated with it. This is simply the number of frequency sensitive components (the Ls and Cs in Figure 1.8) in the filter. The higher the order, the steeper the slope in the stopband. The simplest LC filter, such as the one we looked at in the first part of the series, is of order 2, one box containing R and L and the other containing C. Note that a box containing only resistors does not count since resistors are not frequency sensitive. So a filter containing only R and C is called a first order filter; so too is a single L or a single C. This means that an odd order LC filter will contain a number of 2nd order filters with the addition of a single L or a single C.

Figure 2.1 The four standard forms of Butterworth LC filters.

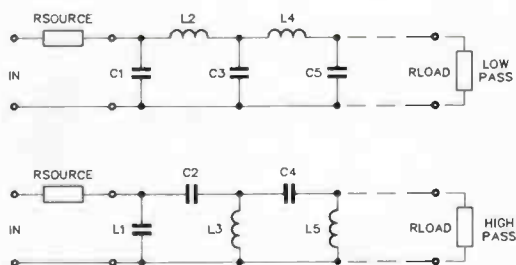
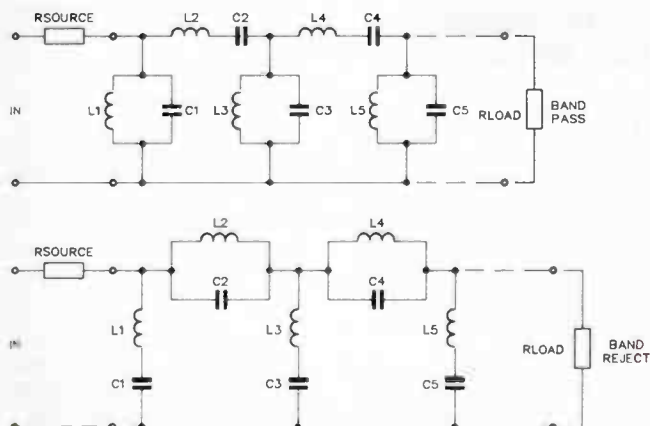


Figure 2.1 shows the standard filters in LC Butterworth form. You can see that the 5th order low pass (LP) filter consists of two 2nd order filters (L2C3 and L4C5) with an additional C at the front. The contents of each box alters depending on whether the filter is low pass, high pass (HP), band pass (BP), or band reject (BR). To convert an LP filter to an HP, all capacitors are replaced by inductors and vice versa. To convert an LP to a BP, all capacitors are replaced by parallel tuned circuits and all inductors by series tuned circuits. For a BR, filter all capacitors in the LP become series tuned circuits and all inductors become parallel tuned circuits. So a 5th order LP filter is transformed into a 10th order BP filter by this process since the number of frequency sensitive components has been doubled.

For LP and HP filters, each pair of boxes is tuned to a different frequency and has a relatively low Q factor. The Q or quality factor of a tuned circuit is simply the ratio of its centre frequency to the difference between its upper and lower 3 dB cutoff frequencies. So, if a circuit is tuned to 1000 Hz and its lower 3 dB point is 905 Hz and its upper 3 dB point is 1105 Hz, its Q is 1000/200, i.e. 5. For BP and BR filters, each individual box is tuned to the centre frequency.

As we said before, a 4th order filter has four frequency sensitive components, all connected together. Once they are connected, the circuits will all interact and alter their frequency responses as we saw with the two simple CR filters. Butterworth BP and BR filters and some other LC filters are designed rather cunningly. The individual circuits are all tuned to the cutoff frequency before they are connected together. However, they are designed so that when they are connected together, the interaction between them will





## Computer based analyser debuts at IREECON

**M**aking its debut at IREECON was the IVIE PC-40 computer controlled audio analyser, said to bring a whole new dimension to spectrum analyser technology.

The IVIE PC-40 is a complete acoustic analysis system capable of making a variety of measurements both quickly and accurately. The unit features 20 non-volatile memories for storing or accumulating data, plus parallel and serial outputs. In addition to its built-in functions, it is user programmable in Basic, with a typewriter style keyboard, giving it an almost limitless range of capabilities.

An LCD display features a display range of up to 64 dB with resolutions of 1, 2, or 3 dB per step. The screen has selectable octave, 1/3-octave and weighted

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Standard accessories include the IE-2P precision preamplifier, plus a choice of the 1133 free field response microphone or the 1134 random response microphone. Both microphones are laboratory quality, air condenser types.

For further information, contact: Amber Technology, Cnr Skyline Place and Frenchs Forest Road, Frenchs Forest 2086 NSW. (02)975 1211.

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**T**he MetraByte M1000 series signal conditioning modules are a complete family of interface solutions, according to the manufacturers. The modules accept real-world input signals from thermocouples, RTDs, strain gauges, frequency and pulse voltage, current or digital sources.

The input data is converted to engineering units in digital form and transmitted in RS232

or RS422/485 serial format. Each module has two digital output bits for controlling solid state relays. Trip set points are stored in non-volatile RAM, as are baud rate and input configuration.

All modules have screw terminals for field wiring and can be mixed and matched in any manner, up to 124 modules per bus. Transmission distances of up to 1 km from the host computer are possible when using the RS422/485 standard interface.

For further information, contact: Novatech Controls (Aust) Pty Ltd, Melbourne (03)645 2377 or Sydney (02)758 1122.

## DIP socket has built-in battery backup!

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The SmartSocket monitors the power supply for an out of tolerance condition and if this occurs, the internal lithium source is switched on and write protection is enabled to prevent data corruption.

Using the SmartSocket saves pc board space since the combination of socket and memory chip use no more area than the chip alone. The SmartSocket uses only pins 28, 26, 20 and 14 for RAM control. All other pins are passed straight through to the socket receptacle.

For further information, contact: Fred Hoe and Sons Pty Ltd, 246 Evans Road, Salisbury 4107 Qld. (07)277 4311.

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The 3000 series switches are available in top and side adjustable models with either a flush or extended actuator shaft. With a single pole binary coded decimal or complement codes, the 10 or 16 position (hexadecimal) switches are ideally suited for digital logic applications.

For further details, contact the exclusive Australian distributors: Tecnico Electronics, 11 Waltham Street, Artarmon 2064 NSW. (02)439 2200.

## Extra low prices on solid state relays

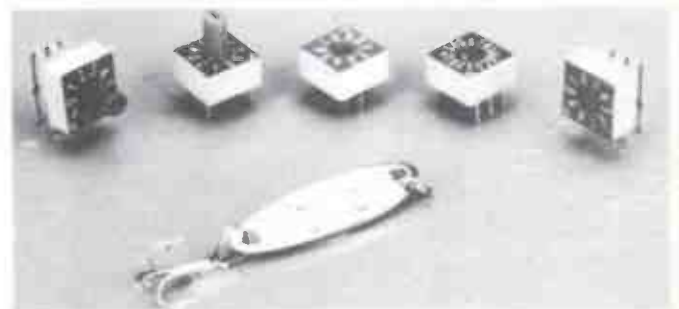
**L**ooking for solid state relays at very attractive prices? Or haven't you discovered their advantages yet? These devices use small switching signals to switch large ac loads and provide excellent isolation between the load and the switching signal.

Jaycar stocks a range that includes 10 amp, 15 amp, 30 amp and 40 amp devices, all of which can use TTL level signals for switching. These solid state relays are ideal for controlling mains powered devices from a computer or microprocessor based controller and avoid all the problems associated with conventional relays such as arcing and mechanical wear.

The 10 and 15 amp devices are available with either spade terminals or screw terminals. The 30 and 40 amp units are only available with screw terminals. Price for the 10 amp models is \$9.50 each or \$8.50 for 10 up.

The 15 amp devices are \$12.50 each or \$10.50 for 10 up and the 30 amp units are priced at \$14.50 each or \$12.50 for 10 up. The 40 amp device costs \$19.50 or \$17.50 for 10 up.

Contact your nearest Jaycar store or dealer for more information on these extremely useful devices. ♣





change the frequencies of the individual circuits in such a way that they will end up having the correct values for the filter.

With Butterworth filters it is the carefully controlled overlap of the slopes of the individual filter sections that gives the flat response in the passband. This means that, not only must the frequencies of each of the circuits be correct, but they must have carefully controlled values of Q. The Q of a tuned circuit depends on the ratio L/C, whereas the resonant frequency depends on the product LC. So, to get the correct values for the frequency and Q at the same time, the values of the individual Ls and Cs must be quite precise.

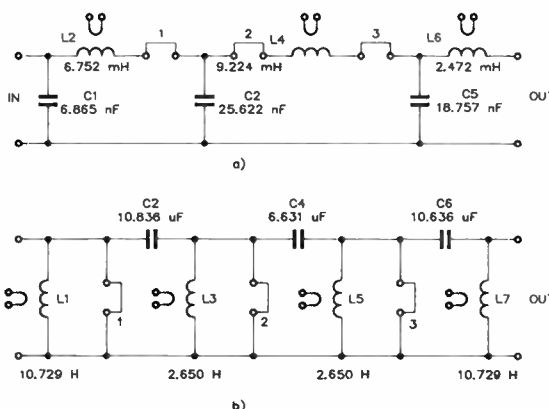
It is worth mentioning at this stage, for those not familiar with the jargon of filters, that there is a trap with BP and BR filters. The centre frequency is the *geometrical* centre frequency, not the *arithmetic* centre. So, if you have a BP filter with a centre frequency of 1000 Hz and a bandwidth of 200 Hz, the two cutoff frequencies are 904.99 Hz and 1104.99 Hz, not 900 and 1100 Hz as you might have thought. You can see that the 904.99 and 1104.99 are correct since

$$1000 = \sqrt{904.99 \times 1104.99}, \text{ and}$$

$$200 = 1104.99 - 904.99.$$

The program in Figure 2.2 computes the values of the various inductors and capacitors for Butterworth LC filters up to order 9 for LP and HP filters, and up to 19 for BP and BR filters. If you need a steeper slope than that provided by Butterworth filters of higher order than this, it is better to use a different type of filter such as the Chebychev or elliptic. These will be described later. Even though this program allows you to design a band reject filter, it is unusual to use a Butterworth design for band rejection since such filters commonly

need much steeper slopes than Butterworth filters can provide. Figure 2.3a shows the design of a 6th order Butterworth LP filter having a cutoff of 20 000 Hz to be used with 600 Ohm input and load resistors, intended to limit frequencies to the audio range. The extra windings on the inductors and the links are used for tuning.  $\blacktriangleright$



**Figure 2.3 a) Low pass Butterworth filter, Rsource = Rload = 600 Ohms, Cutoff = 20 kHz, Attenuation = 15 dB at 30 kHz, Order = 6. The links and extra windings on the coils are for tuning. Their use is explained in the text.**

**b) High pass Butterworth filter, Rsource = Rload = 600 Ohms, Cutoff = 20 Hz, Attenuation = 20 dB at 13.33 Hz, Order = 7.**

### FIGURE 2.2

**GWBasic program to calculate the components of Butterworth LC filters up to order 9. The program first calculates the normalized (Rsource = 1 Ohm, Omega = 1 radian/sec) LP filter, transforms that to HP, BP, or BR if requested, and denormalizes the result to practical units. The frequencies for tuning are displayed after the component values.**

Lines 30 and 40 set up the string expressions for the display.

Lines 140-230 contain traps against hitting wrong keys.

Line 200 checks to make sure F1 is within the stopband.

Lines 250-280: WN is the normalized frequency in radians per second.

```
10 PRINT "Butterworth LC Filter Design"
20 PRINT "Copyright Agilis Holdings Pty Ltd 1987" PRINT
30 A1$="L(" A2$="C(" A3$="P(" P1$="14592654$
40 A4$="Tune L(" A7$=" ) to " A9$="C("
50 PRINT "What type of filter would you like to design ?"
60 PRINT 1 Low pass
70 PRINT 2 High pass
80 PRINT 3 Band pass
90 PRINT 4 Band reject
100 PRINT 5 None. Quit
110 INPUT "Please enter the appropriate integer " X
120 IF X<=5 THEN GOTO 130
130 IF (X<1 OR X>5) THEN 50
140 INPUT "What is the value [ Ohms ] of the source (&load) resistance ? ".R:IF R<=0 THEN 140
150 IF (X=1 OR X=2) THEN INPUT "What is the cutoff frequency [ Hz ] ? ".FC:IF FC<=0 THEN 150 ELSE 190
160 INPUT "What is the centre frequency [ Hz ] ? ".FC:IF FC<=0 THEN 160
170 INPUT "What is the bandwidth [ Hz ] ? ".BW:IF BW<=0 THEN 170
180 FL:=(BW+SQRT(BW*BW+4*FC*FC))/2:FU:FL*BW:IF FC<=0 THEN PRINT "That bandwidth is a
too wide for the centre frequency " GOTO 190
190 INPUT "At what frequency [ Hz ] in the stopband is the attenuation known ? ".F1:IF F1<=0 THEN 190
200 IF (X=1 AND F1<=FC) OR (X=2 AND F1>=FC) OR (X=3 AND (F1>=FL AND F1<=FU)) OR (X=4 AND (F1<=FL OR F1>=FU)) THEN 210 ELSE 220
210 PRINT "That frequency is not in the stopband. GOTO 190
220 IF (X=4 AND F1<=FC) THEN PRINT "Sorry I can't use the centre frequency. please
choose another frequency GOTO 190
230 INPUT "What is the attenuation [ dB ] at that frequency ? ".AMAX:IF AMAX<=3 T
HEN PRINT "There must be more than 3 dB attenuation in the stopband. GOTO 230
240 ON X GOTO 250,260,270,280,920
250 WN=FC/F1 GOTO 290
260 WN=FC/F1 GOTO 290
270 WN=ABS((F1-F1-FC*FC)/BW/F1) GOTO 290
280 WN=ABS(F1-BW/(FC*FC-F1*F1))
290 N=INT(LOG(10*(1+AMAX)-1)/(10-3-1)/2/LOG(WN))+1:IF X=1 OR X=2 THEN N1=N:
2:10 ELSE N1=2*N:2:19
300 PRINT "This filter is of order :N1 A=P1/N:2 ODD=0 IF N MOD 2:1 THEN ODD=1
310 IF N1#2 THEN PRINT "Sorry I can only calculate components for filters of or
der less than " N2 GOTO 50
320 W0=2*PI*FC : IF (X=3 OR X=4) THEN BW=2*PI*BW
330 FOR I=1 TO N : IF I MOD 2:1 THEN C(I)=2*SIN((2*I-1)*PI)/R ELSE 470
340 ON X GOTO 350,370,390,430,920
350 C(I)=C(I)/W0 GOSUB 860
360 PRINT USING "\\##### $$$" \ A2$.I.A3$.S.A6$ GOTO 470
370 L(I)=1/W0/C(I) GOSUB 740
380 PRINT USING "\\##### $$$" \ A1$.I.A3$.S.A5$ GOTO 470
390 L(I)=BW/W0/C(I) GOSUB 740
400 PRINT USING "\\##### $$$" \ A1$.I.A3$.S.A5$
410 C(I)=C(I)/BW GOSUB 860
420 PRINT USING "\\##### $$$" \ A2$.I.A3$.S.A6$ GOTO 470
430 L(I)=1/C(I)/BW GOSUB 740
```

Line 290: N is the filter order

Line 300: A is an angle required later, ODD=1 if N is odd.

Line 320: W0 is the cutoff frequency in radians per second.

Line 330: If I is odd, calculate C first.

Lines 370, 390 etc: the factors change the Ls and Cs from the normalized system to practical units.

Line 470: If I is even, calculate L first.

Lines 630-660 calculate the tuning frequencies for LP filters.

Lines 670-730 calculate the tuning frequencies for HP filters.

Subroutines 740-770, 780-810, and 860-910 convert L, C, and F to convenient units for the display.

Subroutine 820-850 organises the format of the display.

```
440 PRINT USING "\\##### $$$" \ A1$.I.A3$.S.A5$
450 C(I)=C(I)*BW/W0 GOSUB 860
460 PRINT USING "\\##### $$$" \ A2$.I.A3$.S.A6$ GOTO 610
470 IF I MOD 2:1 THEN L(I)=2*PI*SIN((2*I-1)*PI)/R ELSE 610
480 ON X GOTO 490,510,530,570,920
490 L(I)=L(I)/W0 GOSUB 740
500 PRINT USING "\\##### $$$" \ A1$.I.A3$.S.A5$ GOTO 610
510 C(I)=1/W0/L(I) GOSUB 860
520 PRINT USING "\\##### $$$" \ A2$.I.A3$.S.A6$ GOTO 610
530 C(I)=BW/W0/L(I) GOSUB 860
540 PRINT USING "\\##### $$$" \ A1$.I.A3$.S.A5$ GOTO 610
550 L(I)=L(I)/BW GOSUB 740
560 PRINT USING "\\##### $$$" \ A2$.I.A3$.S.A6$ GOTO 610
570 C(I)=1/L(I)/BW GOSUB 860
580 PRINT USING "\\##### $$$" \ A2$.I.A3$.S.A6$ GOTO 610
590 L(I)=L(I)*BW/W0 GOSUB 740
600 PRINT USING "\\##### $$$" \ A1$.I.A3$.S.A5$
610 NEXT I
620 ON X GOTO 630,670,920,920
630 FOR I=2 TO N STEP 2: C(I)=1/(1+((C(I)-1)/(C(I)+1))
640 IF I<=N AND ODD=0 THEN P=C(I)
650 F=1/2*PI/SQR(1+(1+C(I)) GOSUB 780:IF I<=N AND ODD=0 THEN GOSUB 820 ELSE GOSUB 840
660 NEXT I GOTO 920
670 FOR I=1 TO N STEP 2: C(I)=1/(1+((C(I)-1)/(C(I)+1))
680 IF I<=N AND ODD=1 THEN P=C(I)
690 IF ODD=1 THEN IF I=1 THEN C(I)=1 ELSE C(I)=1
700 F=1/2*PI/SQR(1+(1+C(I)) GOSUB 780:IF I=1 THEN GOSUB 830 GOTO 730 ELSE 710
710 IF I=N-1 AND ODD=0 THEN GOSUB 840 GOTO 730 ELSE 710
720 IF I<=N AND ODD=1 THEN GOSUB 820 ELSE GOSUB 840
730 NEXT I GOTO 920
740 IF L(I)=1 THEN S=L(I) A5$="Henry$ GOTO 770
750 IF L(I)=.001 THEN S=L(I)*1000 A5$="milliHenry$ GOTO 770
760 S=L(I)/1000000 A5$="microHenry$
770 RETURN
780 IF F=100000 THEN F=F/1000000 A5$="MHz" GOTO 810
790 IF F=1000 THEN F=F/1000 A5$="kHz" GOTO 810
800 A5$="Hz"
810 RETURN
820 PRINT USING "\\##### $$$" \ A4$.I.A5$.I.LA7$.F.A5$ GOTO 850
830 PRINT USING "\\##### $$$" \ A4$.I.A5$.I.LA7$.F.A5$ GOTO 850
840 PRINT USING "\\##### $$$" \ A4$.I.A5$.I.LA7$.F.A5$.F.A5$
850 RETURN
860 IF C(I)=1 THEN S=C(I) A6$="Farad$ GOTO 910
870 IF C(I)=.001 THEN S=C(I)*1000 A6$="milliFarad$ GOTO 910
880 IF C(I)=1000000 THEN S=C(I)/1000000 A6$="microFarad$ GOTO 910
890 IF C(I)=1E+09 THEN S=C(I)/1E+09 A6$="nanoFarad$ GOTO 910
900 S=C(I)*1E+11 A6$="picoFarad$
910 RETURN
920 PRINT "End of program" END
```

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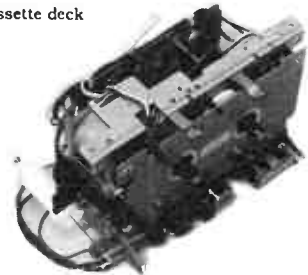
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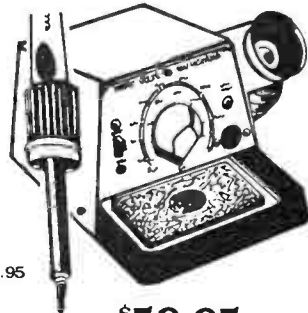
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Figure 2.2b is a 7th order HP filter with a cutoff of 20 Hz, designed to cope with lots of turntable rumble. You can see that the values of L and C are rather large. This filter will be used to demonstrate how HP filters are tuned, but it also emphasises the major problem of LC filters at low frequencies; they need very large inductors. It is not intended that you build this LC filter, it is presented to show the reason why active filters were invented: the large inductors needed to solve the rumble problem not only occupied lots of space, were difficult to build, and were expensive, but they had a distressing tendency to pick up lots of hum, particularly if mounted anywhere near the power supply transformer. Later we will describe an active filter suitable for solving the rumble problem.

One of the great advantages of all of the Butterworth filters we will be describing is that once you know the cutoff frequency and the filter order, you know all of the filter characteristics. For example, you know the frequency response, as well as the phase shift and the time delay at any frequency. The actual values of the components in an LC filter depend on the source resistance but this has no effect on these filter characteristics. Figure 2.4 is a program that calculates the attenuation, phase shift and time delay of all four types of Butterworth filters. This program has been arranged to print out the filter properties over a range of frequencies to give a better picture of the way in which the properties change.

Figure 2.5 has printouts for each of the four types of filter so that you can check your program. One thing that may appear a little curious on first examining this table is that the cutoff slope of a 7th order LP filter is less than either of those of a 12th order BP filter. This is typical of most filters. In BP and BR filters, the Qs of the circuits need to be much higher than those in LP and HP filters. Also, since the passband frequency range over which the filter response has to be flat is much less for a BP filter, the frequencies of the tuned circuits are much closer together and hence can reinforce each other's cutoffs. Similarly, for a BR filter the range of frequencies over which the response is not flat is small so, once again, the frequencies of the tuned circuits are close together and their cutoffs reinforce each other. So, for a given stopband slope, a BP or BR filter will always be of lower order than twice that of an LP or HP filter.

## Effects of phase shift and time delay

While the name of the filter type (e.g. low pass) describes the effect of the frequency response on signals fed to a filter, the effects of phase shift and time delay are not so obvious. The phase shift in the passband of most filters is a function of frequency a long way from cutoff, and changes more rapidly with frequency near cutoff. The maximum rate of change of phase occurs close to cutoff. This means that complicated waveforms become distorted, since the components whose frequency is near the cutoff are not adding to the waveform in the way that they should.

The way out of this is to make the bandwidth say 20% larger than you really need, then the rapid phase shift is occurring on frequencies outside the range of interest. Of course it is not always possible to do this, particularly if there are frequencies that we really must reject just outside the cutoff frequency. In this case the lesser of two evils is a bit of phase distortion in the passband. Alternatively, you can use an elliptic filter.

The time delay is a similar problem in some ways, since there is a relationship between phase shift and time delay. To maintain the shape of the wave, all parts of the wave must be delayed by exactly the same amount as they go through the filter. In other words, the time delay should be independent of frequency.

It so happens that time delay is proportional to the rate of change of phase shift with frequency. It is easy to see why this

## FIGURE 2.4

**GWBASIC program to calculate the attenuation, phase shift, and time delay of Butterworth LP, HP, and BP filters. As the reply to each question is entered, it is checked to see that it is in the allowed range for calculation. If it is not, the question is simply repeated. The program displays a table of values over a range of frequencies. To print out the table, change PRINT on lines 260 and 380 to LPRINT.**

**Line 50: LGE converts log to base e into log to base 10.**

**Line 200 calculates the upper and lower cutoff frequencies for BP and BR filters.**

**Line 250 allows for starting the table at a high frequency and stopping at a low frequency if this is what you want.**

**Lines 290-330: Z is the "normalized" frequency, FU the upper cutoff and FL the lower cutoff.**

**Line 310: The attenuation at the centre of a BR filter is theoretically infinite. This upsets the computer, so the output is given as 999 dB and the dangerous calculation is skipped.**

**Line 340: A is the attenuation.**

**Line 350: Factor and Omega are used for normalization.**

**Lines 360 and 370 are the main calculations for phase and delay.**

**Subroutines 400-440 and 450-480 are standard subroutines to put the output in practical units.**

```

10 PRINT "Calculation of
20 PRINT "Attenuation, phase, & delay of
30 PRINT "Butterworth filters
40 PRINT "Copyright Agula Holdings Pty Ltd 1987 PRINT
50 BS=" dB DS=" degrees PI=3.141592654# LGE= 434294481#
60 PRINT "Would you like the properties of
70 PRINT "1 a low pass filter ?
80 PRINT "2 a high pass filter ?
90 PRINT "3 a band pass filter ?
100 PRINT "4 a band reject filter ?
110 INPUT "Please enter the appropriate integer : X
120 IF (X<1 OR X>4) THEN 60
130 INPUT "What is the order of the filter ? N:IF((X=3 OR X=4) AND N MOD 2=0)T
HEN PRINT "The order of BP & BR filters must be even GOTO 130
140 IF N=2 THEN PRINT "I cannot compute an order less than 2 GOTO 130 ELSE ANG
LE=PI/2/N
150 IF(X=3 OR X=4) THEN N=N/2:GOTO 180
180 INPUT "What is the cutoff frequency [ Hz ] of the filter ? FC:IF FC<0 THEN
180
170 GOTO 210
180 INPUT "What is the centre frequency [ Hz ] of the filter ? FC:IF FC<0 THEN
180
190 INPUT "What is the bandwidth [ Hz ] of the filter ? BW:IF BW<0 THEN 190
200 FU=(BW+SQR((BW+BW+4*FC*FC))/2 FL=FU-BW IF FL<0 THEN PRINT "That bandwidth is
too large for that centre frequency ! GOTO 180
210 INPUT "At what frequency [ Hz ] would you like to start the calculation ? F
START:IF FSTART<0 THEN 210
220 INPUT "At what frequency [ Hz ] would you like to stop the calculation ? F
STOP:IF FSTOP<0 THEN 220
230 INPUT "What frequency step [ Hz ] would you like to use ? FSTEP:IF FSTEP<0
THEN 230
240 IF FSTEP>ABS(FSTOP-FSTART) THEN PRINT "That frequency step is too large G
OTO 210
250 IF FSTOP>FSTART THEN FSTEP=-ABS(FSTEP)
260 PRINT "Frequency Atten Phase shift Time delay
270 FOR F=FSTART TO FSTOP STEP FSTEP T=0 P=0
280 ON X GOTO 290,300,310,310
290 Z=F/FC FU=FC FL=0 GOTO 340
300 Z=FC/F FL=FC FU=1E+30 GOTO 340
310 IF(X=4 AND ABS(F-FC)/0001=FC) THEN A=999 GOTO 350
320 IF F<FC THEN Z=FC*FC/F ELSE Z=F*FC/FC/F
330 IF X=3 THEN Z=Z/BW ELSE Z=BW/Z
340 A=10*LGE*LOG(1+2*(2*N))
350 FACTOR=(1+FU*FL/F/F)/2/PI/(FU-FL) OMEGA=(F-FU*FL/F)/(FU-FL) AOMEGA=ABS(OMEGA)
360 FOR I=1 TO N THETA=(2*I-N-1)*ANGLE S=COS(THETA) W=SIN(THETA)
370 T=T+ABS(S)/(S*(S+(AOMEGA-W)^2) P=P+ATN((OMEGA-W)/(S-I)) NEXT I T=T*FACTOR P=P
180/PI:GOSUB 400:GOSUB 450
380 PRINT USING "###.###\ \ ### \ \ #### \ \ \ ### \ \ \ .FF.HS.A.BS
F.DS.G.FS
390 NEXT F GOTO 490
400 IF T=1 THEN G-T*FS=" sec GOTO 440
410 IF T=001 THEN G-T*1000 FS=" msec GOTO 460
420 IF T=000001 THEN G-T*1000000 FS=" us:c GOTO 440
430 G-T=1E+09 FS=" nsec
440 RETURN
450 IF F=1000000! THEN FF=F/1000000! HS=" MHz GOTO 480
460 IF F=1000 THEN FF=F/1000 HS=" kHz GOTO 480
470 FF=F HS=" Hz
480 RETURN
490 END

```

is the case. A delay of one millisecond (1 ms) represents 1/20 th of a 50 Hz wave i.e. a phase shift of  $360/20 = 18$  degrees. At 10 times that frequency, (500 Hz) 1 ms represents 1/2 of a wave i.e.

a phase shift of  $360/2 = 180$  degrees,

which is 10 times the phase shift at 50 Hz! So you can see that to get a constant time delay the phase shift has to be exactly proportional to frequency. If the time delay of the high frequencies with respect to the low frequencies is more than it should be, the high frequencies arrive late at the filter output and sharp waveforms become rounded.

You can see from the printouts in Figure 2.5 that the phase shift of Butterworth filters is reasonably proportional to frequency, except near cutoff. There are filters known as Bessel or Thomson filters that have extremely good proportionality



**FIGURE 2.5**

Printouts from the program of Figure 2.4

**1. LP filter, Cutoff = 10 kHz, Order = 7**

Frequency	Atten	Phase shift	Time delay
8.000 kHz	0.2 dB	-229.5 degrees	105.25 usec
8.500 kHz	0.4 dB	-249.2 degrees	113.53 usec
9.000 kHz	0.9 dB	-270.3 degrees	121.22 usec
9.500 kHz	1.7 dB	-292.6 degrees	125.23 usec
10.000 kHz	3.0 dB	-315.0 degrees	122.67 usec
10.500 kHz	4.7 dB	-336.3 degrees	113.62 usec
11.000 kHz	6.8 dB	-355.7 degrees	101.10 usec
11.500 kHz	9.1 dB	-372.7 degrees	88.29 usec
12.000 kHz	11.4 dB	-387.6 degrees	76.89 usec

**2. HP filter, Cutoff=20 Hz, Order=7**

Frequency	Atten	Phase shift	Time delay
5.000 Hz	84.3 dB	+561.5 degrees	36.60 msec
10.000 Hz	42.1 dB	+496.9 degrees	39.68 msec
15.000 Hz	17.6 dB	+418.8 degrees	49.01 msec
20.000 Hz	3.0 dB	+315.0 degrees	61.34 msec
25.000 Hz	0.2 dB	+229.5 degrees	33.68 msec
30.000 Hz	0.0 dB	+183.2 degrees	19.81 msec
35.000 Hz	0.0 dB	+153.9 degrees	13.49 msec
40.000 Hz	0.0 dB	+133.1 degrees	9.92 msec
45.000 Hz	0.0 dB	+117.4 degrees	7.65 msec
50.000 Hz	0.0 dB	+105.1 degrees	6.09 msec

**3. BP filter, Centre=1000 Hz, Bandwidth=200 Hz, Order=12**

Frequency	Atten	Phase shift	Time delay
800.000 Hz	42.3 dB	+439.0 degrees	1.69 msec
850.000 Hz	25.5 dB	+396.7 degrees	3.30 msec
900.000 Hz	4.6 dB	+289.4 degrees	10.36 msec
850.000 Hz	0.0 dB	+117.8 degrees	7.28 msec
1.000 kHz	0.0 dB	0.0 degrees	6.15 msec
1.050 kHz	0.0 dB	-111.6 degrees	6.50 msec
1.100 kHz	2.0 dB	-253.3 degrees	9.43 msec
1.150 kHz	17.7 dB	-368.7 degrees	3.64 msec
1.200 kHz	31.6 dB	-414.1 degrees	1.77 msec

**4. BR filter, Centre=50 Hz, Bandwidth=10 Hz, Order=12**

Frequency	Atten	Phase shift	Time delay
40.000 Hz	0.0 dB	+439.0 degrees	33.79 msec
42.000 Hz	0.0 dB	+407.7 degrees	56.31 msec
44.000 Hz	0.2 dB	+348.2 degrees	123.73 msec
46.000 Hz	9.9 dB	+209.9 degrees	207.81 msec
48.000 Hz	46.7 dB	+92.4 degrees	137.21 msec
50.000 Hz	999.0 dB	0.0 degrees	122.99 msec
52.000 Hz	48.8 dB	-88.6 degrees	125.91 msec
54.000 Hz	13.8 dB	-188.7 degrees	162.68 msec
56.000 Hz	0.9 dB	-314.0 degrees	139.52 msec
58.000 Hz	0.0 dB	-380.7 degrees	61.20 msec
60.000 Hz	0.0 dB	-414.1 degrees	35.47 msec

between phase shift and frequency. The price that they pay is to have a very slow change in their attenuation at the cutoff frequency. Since they can pass waveforms without introducing significant ringing or overshoot, these filters are used where there are extremely sharp waveforms, e.g. in pulse circuits in computers, radar, distance measuring equipment etc.

## Constructing LC filters

If the frequency response of the filter is to be stable with time and temperature, all of its components and its physical construction must be of high quality. For frequencies up to about 15 MHz, potcores are best for the inductors and, if possible, polystyrene capacitors are used because they have low losses and their temperature coefficient matches that of potcores. For higher frequencies, air-wound inductors are used, with polystyrene, polycarbonate, mica, teflon, or air capacitors. Before construction starts, all components should be measured and adjusted to within 1% of their design value.

It is essential that there is no coupling between the inductors. This means keeping potcores at least half their diameter apart and with air-wound inductors keeping them at least their largest diagonal dimension apart. It is good practice to arrange adjacent air-wound inductors to be at right angles to each other. If the filter is built on a printed circuit board, it is a good idea to use double-sided board and to put alternate inductors on opposite sides of the board so the spacing between inductors on each side is at least one diameter. This keeps coupling to a minimum. All leads should be soldered

carefully and any spare lead tied down. Capacitors should be Araldited, glued, or tied firmly in place so that they cannot move.

There are two handy tricks that make life easy when it comes to tuning. Since tuning involves disconnecting the various resonant circuits, it is best to design the printed circuit board (that is, if you're using one – and you should) with a set of links that are left out until the circuits are tuned. Also, since it is difficult to inject signals into a resonant circuit, it pays to add an extra winding of just one turn to each potcore and to bring that winding out to two pins that are used solely for tuning. These have been included in the circuits in Figure 2.3.

## Tuning LC filters

Before tuning any filter it is good practice to stabilize it. This is done by taking its temperature to 50-55 degrees Celsius for an hour and then letting it cool to room temperature. Repeat this a couple of times. You can use a clothes airing cabinet if you have one. A clothes dryer (NOT the tumble type!) will also work. Putting the filter in the oven, even if set to 50 degrees C, is decidedly risky since most ovens overshoot the set temperature considerably before turning off, and you can melt polystyrene capacitors very easily. Don't try the microwave.

On a sunny day, putting the filter in an open top cardboard box insulated with foam plastic, or even newspaper, will do the trick if the box is kept out of the wind and is tilted so that the open top points at the sun. It is worth checking the temperature to make sure things don't get too hot. If you can't bear to hold the potcores, they are too hot, so shade the box for a while.

For LP and HP filters, each of the tuned circuits has to be tuned to a particular frequency; for BP and BR filters they are resonant at the centre frequency. Of course, once they are coupled together to form the filter their resonant frequencies are different. So to tune them they have to be uncoupled. This is why links were mentioned in construction.

You will need a signal generator set accurately to either the tuning frequency (for LP and HP) or the centre frequency (for BP and BR) together with a high impedance ac voltmeter that works at the chosen frequency or a CRO with high impedance, low input capacitance probe (a x10 probe usually fulfils this requirement). For high frequencies, even a few pF of probe capacitance can affect the tuning so you will have to do the best tuning possible and then increase the inductance by a small amount or increase the capacitance to compensate for removing the probe.

As an example, here is how you would go about adjusting the two filters of Figure 2.3. Firstly, all capacitors would be set (by paralleling several units) to within 1% of the design value. For the LP filter, Link 1 is installed temporarily, the signal generator is set to 26.321 kHz (either an instrument with digital readout or a digital frequency meter is essential to obtain this accuracy) and connected to the tuning pins on L2. The meter or CRO is connected to link 1 and the core of L2 is adjusted for a maximum reading.

Next, link 1 is removed and links 2 and 3 installed. The signal generator is set to 15.925 kHz and applied to the tuning pins of L4 and the meter or CRO is connected to link 3. L4 is adjusted for a maximum reading. Link 3 is now removed and the load terminals short circuited. The signal generator is set to 23.375 kHz and connected to the tuning pins of L6. The meter or CRO is connected to the top of C5, and L6 is adjusted for a maximum reading. The filter elements have now been tuned and once all the links have been installed, the filter is ready for use.

For the HP filter of Figure 2.3, the procedure is somewhat different. Link 2 is installed, the signal generator is set to 14.899 Hz and applied to the tuning pins of L1. The meter or

CRO is connected to the input terminals and L1 is tuned for maximum reading. Link 2 is removed and links 1 and 3 installed. The generator is set to 23.529 Hz and applied to the tuning pins of L3. With the meter or CRO across Link 2, L3 is tuned for maximum reading. Link 3 is removed, Link 2 is installed and the output terminals short circuited. The generator is left at 23.529 Hz and applied to the tuning pins of L5. With the meter or CRO across link 3, L5 is tuned for maximum reading. Finally, link 3 is installed, the generator is set to back to 14.899 Hz and applied to the tuning pins on L7. With the meter or CRO connected to the putput terminals, L7 is adjusted for maximum reading. When all links are removed the filter is ready for use.

At high frequencies, where airwound coils are used, the signal is injected into the tuned circuit by putting near the coil a single turn connected to the signal generator. This turn should be as far away from the coil as possible so that there is no change in the inductance or capacitance of the coil caused by the presence of the single turn. For LP filters, in addition to having only the necessary links in place, it may be desirable to short out the other coils nearby on the pc board since the open-circuited links allow some capacitive coupling to them at high frequencies. For HP filters it may be desirable to insert all links except the one across the coil being tuned.

## Active filters

So far we have only given programs for calculating LC filters. It can be shown that the circuit of Figure 2.6a behaves exactly like a filter block having an order of 2 for an LP filter. This circuit, invented by R.P.Sallen and E.L.Key in 1955, has become the backbone of an enormous range of filters, appropriately dubbed "Sallen and Key filters". Since it behaves as if it contains an inductor, there is rarely any need to design LC filters in the frequency range in which the IC amplifier will work. Figure 2.6b is the equivalent HP circuit. You can see that it is derived from the LP circuit by replacing all resistors with capacitors and vice versa. There are several other ways of using IC amplifiers with RC networks that will simulate LC circuits. These will be described later in the series; for the moment we will stick to the Sallen and Key circuit. Circuits such as those in Figure 2.6 are known as active filters simply because they use active components (e.g: IC amplifiers) within them.

One of the many attractions of active filters is that, unlike LC filters, there is no interaction between the sections of an active filter containing more than one section. This means that in active filters each section must be tuned to the actual frequency appropriate to that section of the filter. This lack of interaction also means that a wideband BP system can be made by simply putting a LP filter in series with a HP filter as shown in Figure 2.6c. To make such a BP filter, the passbands of the LP and HP filters must overlap, so the cutoff frequency of the LP filter must be higher than that of the HP filter. The BP bandwidth then becomes the difference between the LP and HP cutoff frequencies.

Likewise, an active wide band BR filter can be made by summing the outputs of a LP and a HP filter as shown in Figure 2.6d. This time, the stopbands of the filters must overlap since we are trying to get a band reject filter, so the LP cutoff frequency must now be lower than that of the HP filter. The stopband of such a BR filter is the difference between the cutoff frequencies of the LP and HP filters.

Modern IC amplifiers specially designed for filter circuits will work reliably up to 1 MHz. Quad amplifiers of the LF347 type will work to 100 kHz or more. It is particularly convenient to use quad FET-input amplifiers in LP audio filters since they don't put a load on C2 and they lead to a compact physical design.

You will have noticed that each amplifier is connected with 100% negative feedback to give a gain of +1. This gives

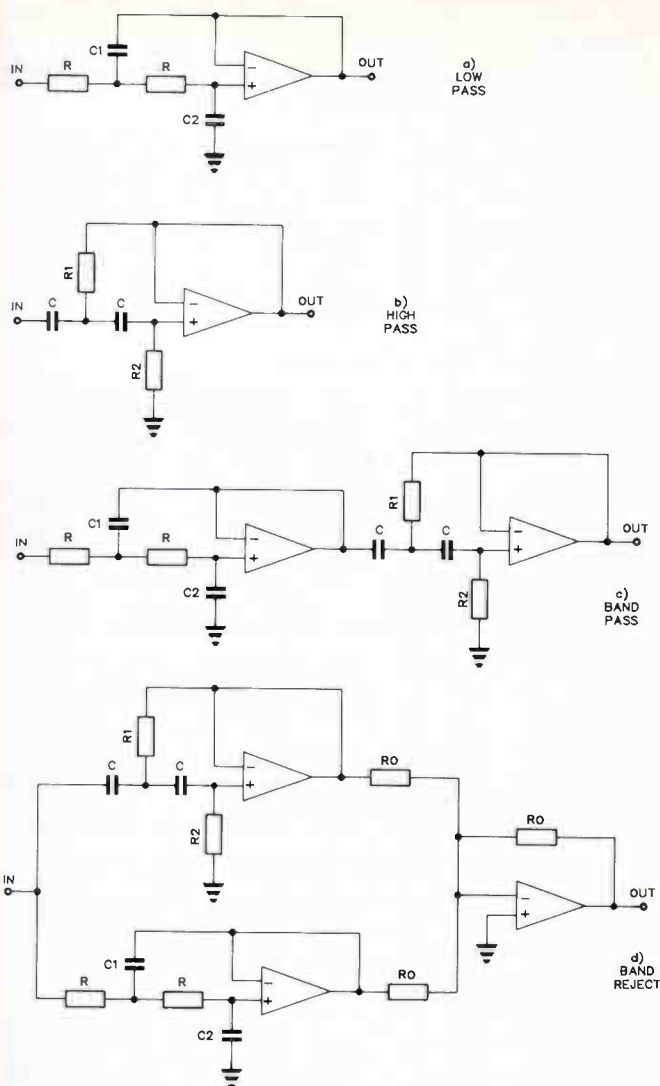


Figure 2.6 Sallen and Key active filters.

an output impedance of almost zero as well as very low distortion. The low output impedance is ideal for driving a following filter section. Also, since the gain of each stage does not exceed 1, each stage by itself is inherently stable. However, with this connection, the bandwidth is not the maximum of which the amplifier is capable. This is one of the reasons why such filters are somewhat limited in frequency range.

## Active Butterworth filters

There are rather complicated relationships between the Ls and Cs in an LC filter and the Rs and Cs in the equivalent active filter. Figure 2.7 is a program that computes the values of the Rs and Cs for active Butterworth LP and HP filters. For a 6th order filter, three circuits such as that in Figure 2.6a or 2.6b are needed. If the filter order is odd, a special circuit that incorporates an extra R and C, shown in Figure 2.8, is needed. The program of Figure 2.7 calculates the filter order and produces a listing of the required components, automatically listing components for the circuit of Figure 2.8 if it is required.

To give an example that can be used to check that you have entered the program correctly, we will calculate the components for a low pass filter whose response is 3 dB down at 10 000 Hz and is 25 dB down at 15 000 Hz. Such a filter would be used to limit the frequency response of an outdoors PA sys-



**FIGURE 2.7**

**GWBASIC program to calculate the values of resistors and capacitors to use in Sallen and Key active Butterworth LP and HP filters. All answers to requests for input are checked to make sure they are acceptable. If not, the question is simply repeated. If you want to print the results, convert PRINT in lines 300-460 into LPRINT.**

**Line 150: WN is the normalized frequency**

**Line 160: N is the filter order.**

**Line 180: W0 is the cutoff frequency in radians/second.**

**Line 200: the factor of 1 million converts uF to Farads.**

**Line 210 sets the start and finish of the main loop if the filter order is even.**

**Lines 220-240 calculate the components of the extra block that is needed if N is odd. This involves solving a cubic equation in C(1).**

**Lines 300, 310 etc: the factors containing W0, R1 return the Rs and Cs to practical units.**

**Subroutines 490-540 and 550-580 convert the display to convenient units.**

```

10 PRINT "          Design of"
20 PRINT "      Butterworth Active LP & HP Filters"
30 PRINT "      Copyright Agulla Holdings Pty Ltd 1987"
40 A1$="C1("A2$="C2("A3$="C3("A4$=")": PI=3.141592654#
50 B1$="R1("B2$="R2("B3$="R3("
60 PRINT "Would you like to design?"
70 PRINT "1. a low pass filter?"
80 PRINT "2. a high pass filter?"
90 INPUT "Please enter the appropriate integer.",X
100 IF (X<1 OR X>2) THEN 60
110 INPUT "What is the cutoff frequency [ Hz ]?",FC:IF FC<=0 THEN 110
120 INPUT "At what frequency [ Hz ] in the stopband is the attenuation known?",
F1:IF F1<=0 THEN 120
130 IF (X=1 AND F1<FC) OR (X=2 AND FC<F1) THEN PRINT "That frequency is not in t
he stopband." GOTO 120
140 INPUT "What is the attenuation [ dB ] at that frequency?",AMAX:IF AMAX<=3 T
HEN PRINT "The attenuation in the stopband must be more than 3 dB." GOTO 140

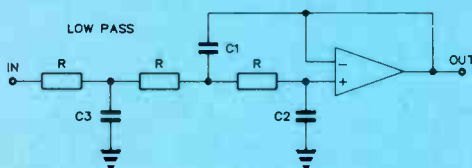
```

```

150 WN=PI/FC: IF X=2 THEN WN=FC/PI
160 N=INT(LOG((1+(1*AMAX)-1)/(1-(1-3)-1))/2/LOG(WN))+1: ANGLE=PI/N
170 PRINT "The filter order is "N:IF N>19 THEN PRINT "Sorry, I cannot calculate
values for orders greater than 19." GOTO 60
180 W0=2*PI*FC:IF X=1 THEN 190 ELSE 200
190 INPUT "What value [ Ohms ] would you like for the fixed resistors?",R1:IF R
1<=0 THEN 190 ELSE 210
200 INPUT "What value [ microFarads ] would you like for the fixed capacitors?",
C1:IF C1<=0 THEN 200 ELSE C1=C1/1000000!
210 IF N MOD 2=0 THEN START=1:FINISH=N/2:GOTO 260
220 A=1+ABS(2*COS(ANGLE)):D=4-2*A*A:PA=A*(4+3*A)/D:Q=-12*A/D:R=12/D:A1=(3*Q-P)/
9:B1=(P*(9*Q-2*P*P)/27-R)/2
230 ROOT=SQR(B1*B1+A1^3):CC=B1-ROOT:S=1:IF CC<0 THEN:CC=-CC:S=-1
240 C(1)=(B1+ROOT)*(1/3)*S*CC^(1/3)-P/3:C(2)=2*C(1)/(A+C(1)-2):C(2)=1/C(3)/C(1)
250 START=2:FINISH=(N-3)/2+1
260 FOR I=START TO FINISH:IF N MOD 2=0 THEN THETA=(2*I-1)*ANGLE/2 ELSE THETA=I*
ANGLE
270 C2(I)=ABS(COS(THETA)):C1(I)=1/C2(I):NEXT I
280 ON X GOTO 290,380
290 IF N MOD 2=0 THEN 330
300 I=1:CP=(1)/W0/R1:GOSUB 490:PRINT USING "\#\###.###\ "A1$.I
A4$.S,A5$
310 CP=C(2)/W0/R1:GOSUB 490:PRINT USING "\#\###.###\ "A2$.I,A4$
.S,A5$
320 CP=C(3)/W0/R1:GOSUB 490:PRINT USING "\#\###.###\ "A3$.I,A4$
.S,A5$:PRINT
330 FOR I=START TO FINISH
340 CP=C1(I)/W0/R1:GOSUB 490:PRINT USING "\#\###.###\ "A1$.I,A
4$.S,A5$
350 CP=C2(I)/W0/R1:GOSUB 490:PRINT USING "\#\###.###\ "A2$.I,A
4$.S,A5$:PRINT
360 NEXT I
370 GOTO 590
380 R(1)=1/C(1):R(2)=1/C(2):R(3)=1/C(3)
390 FOR I=START TO FINISH:R1(I)=1/C1(I):R2(I)=1/C2(I):NEXT I
400 IF N MOD 2=0 THEN 440
410 I=1:CP=R(1)/W0/C1:GOSUB 550:PRINT USING "\#\###.###\ "B1$.I,A4$.S
A6$
420 CP=R(2)/W0/C1:GOSUB 550:PRINT USING "\#\###.###\ "B2$.I,A4$.S,A6$
430 CP=R(3)/W0/C1:GOSUB 550:PRINT USING "\#\###.###\ "B3$.I,A4$.S,A6$
:PRINT
440 FOR I=START TO FINISH
450 CP=R1(I)/W0/C1:GOSUB 550:PRINT USING "\#\###.###\ "B1$.I,A4$.S,A
6$
460 CP=R2(I)/W0/C1:GOSUB 550:PRINT USING "\#\###.###\ "B2$.I,A4$.S,A
6$:PRINT
470 NEXT I
480 GOTO 590
490 IF CP>1 THEN S=CP:A5$=" Farads":GOTO 540
500 IF CP<.001 THEN S=CP*1000:A5$=" mlllFarads":GOTO 540
510 IF CP<.000001 THEN S=CP*1000000!A5$=" microFarads":GOTO 540
520 IF CP>1E-09 THEN S=CP*1E+09:A5$=" nanoFarads":GOTO 540
530 S=CP*1E+12:A5$=" picaFarads"
540 RETURN
550 IF CP>1000000! THEN S=CP/1000000!A6$=" MOhms":GOTO 580
560 IF CP>1000 THEN S=CP/1000:A6$=" XOhms":GOTO 580
570 S=CP:A6$=" Ohms"
580 RETURN
590 END

```

**Figure 2.8 Special Sallen and Key circuits to be used as the first stage when the filter order is odd. They consist of standard sections to which a simple RC or CR filter has been added. This changes the values of the other components in this section.**

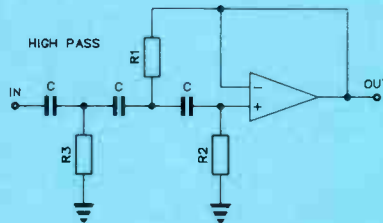


tem. The program printout is shown in Figure 2.9, together with suggestions for obtaining the necessary capacitor values. The complete circuit is in Figure 2.10. This filter can be built using only one quad FET amplifier. By selecting the value 6k8 for the resistors, the "Johnson" noise (thermal noise due to temperature) that they generate is negligible compared to the noise generated by the FETs. This choice also leads to easily obtainable values for the capacitors.

For convenience in calculation and in construction, it is usual to make all the resistors the same in LP filters and all the capacitors the same in HP filters. In Figure 2.6a, R represents the main load on the preceding amplifier, so the value of R should not be less than 2k2 unless you are sure that the amplifier is capable of driving lower resistances at low distortion. Likewise the value of R1 in Figure 2.6b should not be too small since it becomes the load on the preceding amplifier at high frequencies.

The attenuation, phase shift, and time delay of active Butterworth LP and HP filters are the same as those for Butterworth LC filters of the same order and cutoff frequency, so the program of Figure 2.4 can also be used for active filters. For the circuits of Figure 2.6c and 2.6d the program of Figure 2.11 can be used. If you build a BR filter using Figure 2.6d, remember that the frequency having maximum attenuation is given by:

$SQRT(HP_{cutoff} * LP_{cutoff})$ , not  $(HP_{cutoff} + LP_{cutoff})/2$ . ▸



**FIGURE 2.9**

**Printout from GWBASIC program of Figure 2.7 for a LP filter, cutoff 10 kHz, having an attenuation of 25 dB at 15 kHz, and using 6k8 resistors. Suggested values of capacitors have been added in the column on the right. They don't appear in the printout. Notice that by choosing 6k8 for the resistors, the capacitor values can be made up using capacitors from the standard E12 series. The measured values should be made as close as possible to the calculated values by selection, i.e: by trying several 3.3 nF (3n3) capacitors you might find one that is 3.4 nF for C1(1), in which case you wouldn't need the extra 100 pF.**

The filter order is 9	Suggested values
C1(1) = 3.408 nanofarads	3n3 + 100p
C2(1) = 1.210 nanofarads	1n2
C3(1) = 3.109 nanofarads	1n5 + 1n5 + 100p
C1(2) = 3.055 nanofarads	1n5 + 1n5
C2(2) = 1.793 nanofarads	1n8
C1(3) = 4.681 nanofarads	4n7
C2(3) = 1.170 nanofarads	1n2
C1(4) = 13.487 nanofarads	12n + 1n5
C2(4) = 406.426 picafarads	390p + 10p the rest will come from strays.

FIGURE 2.11

GWBASIC programme to calculate the attenuation of Butterworth wideband BP and BR filters such as those in Figure 2.6.

Line 20: LGE converts log to base e into log to base 10.

Lines 60-110 have error traps in case of inadvertent entry of incorrect answers.

Lines 150 and 160 are the main calculations. These formulae look different from those in Figure 2.4 but they are based on the same principles and are more convenient for this type of filter.

```

10 PRINT "Attenuation of Butterworth wide band BP & BR filters"
20 AIS: "The attenuation is " A25: " dB LGE= 4343
30 PRINT "What type of filter would you like?"
40 PRINT "1 a wideband bandpass (BP) filter"
50 PRINT "2 a wideband band reject (BR) filter"
60 INPUT "Please enter the appropriate integer": X
70 IF (X=1 OR X=2) THEN 30
80 INPUT "What is the order of the low pass section?": NL: IF (NL=1 OR NL=20) THEN
N=80
90 INPUT "What is the order of the high pass section?": NH: IF (NH=1 OR NH=20) THEN
N=80
100 INPUT "What is the cutoff frequency [ Hz ] of the low pass section?": FL: IF
FL=0 THEN 100
110 INPUT "What is the cutoff frequency [ Hz ] of the high pass section?": FH: IF
FH=0 THEN 110
120 IF (X=1 AND FL<FH) THEN PRINT "For a BP filter, the high pass cutoff must b
e below the low pass cutoff": GOTO 100
130 IF (X=2 AND FL>FH) THEN PRINT "For a BR filter, the high pass cutoff must b
e above the low pass cutoff": GOTO 100
140 INPUT "At what frequency [ Hz ] would you like the attenuation calculated?":
F: IF F=0 THEN 140
150 IF X=1 THEN A=10*LGE*(LOG(1+(F/FL)^(2*NL))+LOG(1+(FH/F)^(2*NH))) GOTO 170
160 A=10*LGE*(LOG(1/(1+(F/FL)^(2*NL)))+1/(1+(FH/F)^(2*NH)))
170 PRINT USING \ \ " : A25: " dB \ \ : AIS: A: A: 25
180 INPUT "Would you like to try a different frequency?": ES
190 IF (ES="Y" OR ES="y") THEN 140
200 END

```

### Constructing active filters

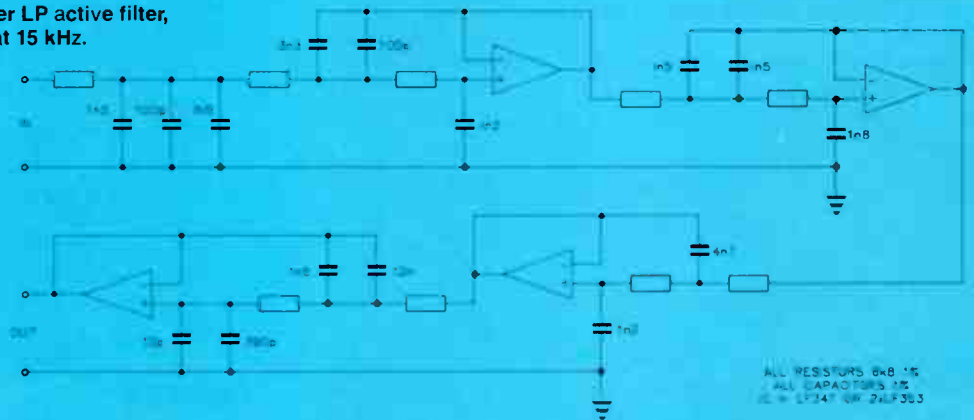
In principle, the circuit blocks of an active filter can be put together in any order. However, it is safest to put them in the order in which the program prints them out, with the input going to the first stage. The reason for this is that the effective tuned circuit in each section has a Q (the same as any tuned circuit has), and the value of this Q increases from the first to the last section. You can get a feel for the Q of such circuits by looking at the ratio C1/C2 for LP filters, or R2/R1 for HP filters. The higher the ratio, the greater the Q.

If a wide range of signals is fed into the high Q section first, that section will almost certainly overload since there is a peak in its frequency response. For example, the Q of the last section in the filter in Figure 2.10 is 2.88 whereas the Q of the first is only 0.53. With the circuit as shown, using ±15 V power supplies, the amplifiers overload with about 8 V RMS input. If the order of the blocks is reversed and the last block is placed at the input, the filter would overload with less than 3 V RMS input. Once the amplifier overloads, the feedback circuits no longer work and there is a complete loss of the filter's frequency response characteristics.

When building active filters, all components should be of 1% tolerance. This is easy with the resistors but some non-standard values of capacitance are needed. There is a trick that can be used to help move the values of the capacitors to be more reasonable. Within any block of an active filter (e.g. Figures 2.6a, 2.6b, 2.8a, or 2.8b), it is permissible to multiply all resistors by a factor, provided you divide all the capacitors in that block by the same factor. So instead of using 10k resistors in a particular block, it may produce more convenient

- to page 32. ▶

Figure 2.10 Complete circuit of 9th order LP active filter, Cutoff = 10 kHz, Attenuation = 25 dB at 15 kHz.



### LITERATURE

There are libraries full of books on filter design but, to this author's knowledge, only one specifically written for the neophyte or enthusiast. That is Howard M. Berlin's **The Design of Active Filters With Experiments** published in 1977 by E & L Instruments of Derby Connecticut, USA. This is one of the **Bugbook** series. All of the experiments use the old uA741 op-amp so the frequency range is restricted, but it is a good book for the beginner who wants to get the feel of filters before launching into them properly.

The best simple book is any recent edition of the **ARRL Handbook for the Radio Amateur**. This covers the field fairly well, but with an obvious bias towards RF filters.

The "bible", i.e. the book to which all other books refer, is Anatol I. Zverev's **Handbook of Filter Synthesis**. This runs to over 570 pages and contains a 200-odd page catalogue of filter types, components and graphs with the full set of equations to go with them. It is pretty heavy going. The book is still in print but is expensive, so borrow it from a library. If you write your own computer program and the results are different from Zverev's charts, you know your program is wrong. Zverev has written a sequel in association with H.J. Blinchikoff entitled **Filtering in the Time and Frequency Domains**. This book is complementary to his first and deals mainly with the problems of finding weak signals buried in noise, particularly in radar and related pulse systems.

A.B. Williams' **Electronic Filter Design Handbook**, McGraw-Hill, NY, 1981 is a good book on both passive and active filter design. It contains a comprehensive set of tables and circuits and, if you skip the maths, is easy to follow. Williams has written several books on filters, even his older ones are worth looking at if you find them in a library.

R.W. Daniels' **Approximation Methods for Electronic Filter Design**, McGraw-Hill, NY, 1974 is one of the standard texts for the more advanced person who wants to know "why" as well as "how". It contains some program, in an old programming language called Telcomp, for locating the poles and zeros of many types of filters. These programs are easy to understand and to translate into GWBASIC if you need them.

The Institution of Electrical and Electronic Engineers has collected 44 of the more important papers together in their book **Computer-Aided Filter Design** published in 1973. It is not for the faint hearted, but if you want to go to some of the foundations of the theory, this is a good place to start.

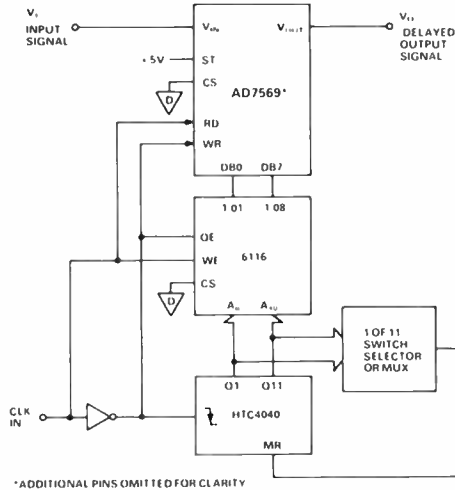
More general handbooks are : R.W. Landee, D.C. Davis, & A.P. Albrecht **Electronics Designers' Handbook** Section 6 of the 2nd Edition, Edited by L.J. Giocolletto, McGraw-Hill, NY, 1977 and the **ITT Reference Data for Radio Engineers**, 5th Edition, Chapters 7 & 8, reprinted by Howard Sams in 1969. Again, these are for the more advanced enthusiast.





ing to the 7569 involves an I/O write to the 74646 register which transfers data to the data inputs of the 7569 which is then latched into the 7569's registers on the rising edge of the PC's IO Write line.

And now for something a little fancy, but simply implemented. You can make an analogue delay line with the 7569, a bit of static RAM and 'glue' logic.



The input clock can be a square wave up to 200 kHz maximum. The clock low time has to be equal to the conversion time and an ADC access time plus the setup time required for the 6116. You can vary the clock mark/space ratio to maximise the sampling frequency. The clock high time has only to be equal to the DAC setup time plus the delay time through the counter and the 6116 access time.

The amount of memory and the sampling frequency determine the maximum possible delay. With 64K of memory and an 8 kHz clock input, the maximum delay is eight seconds on a maximum input frequency of 4 kHz.

This scheme can also be used as a transient recorder.

The AD7569 is just one product of a group of digital/analogue devices released recently by Analogue Devices. These include the AD7579/7580 10-bit ADCs which feature inbuilt sample-and-hold, and the AD7545A 12-bit buffered multiplying DAC that "looks like" the earlier 7545 (if you know it) but is a lot faster, more accurate and less expensive, says AD. And if you're into flash A-to-D, AD have also just released the AD9688 4-bit flash converter that samples at rates up to 200 megasamples/sec, ideal for digital radio communications and instrumentation we're told.

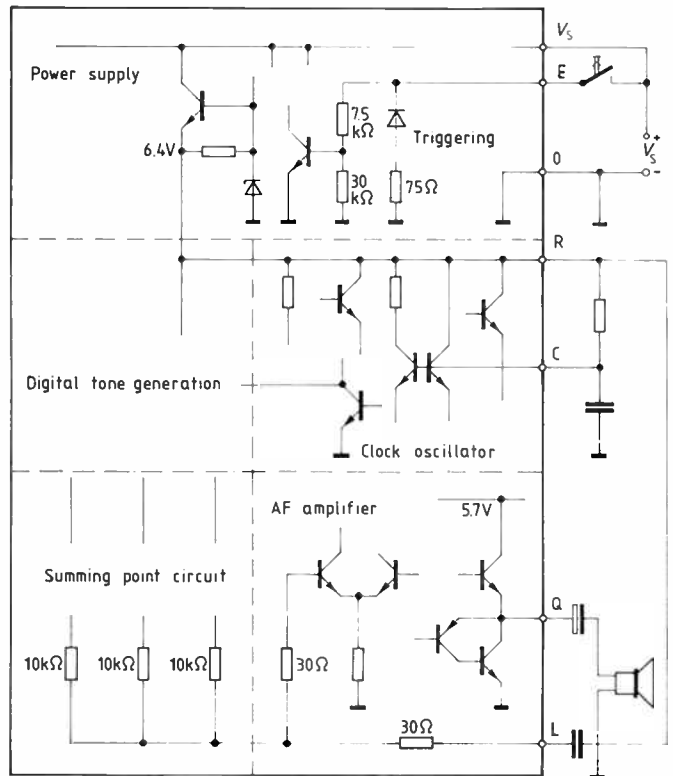
A 16-page data/applications sheet for the AD7569 is available from the suppliers, as is data for the other chips just mentioned, by writing on your company or institution letterhead. Contact Parameters Pty Ltd, PO Box 261, North Ryde 2113 NSW. (02)888 8777. Parameters also has offices in Melbourne. (03)575 0222, and Perth (09)242 2000.

## Well, ring my chimes!

A not-new, but commonly available and very useful device, oft-neglected in the literature these past few years, is the Siemens SAB0600 Three-Tone Chime. It's found in the odd domestic doorbell and industrial alarm/annunciator, much to the puzzlement of service personnel who may not recognise the component number.

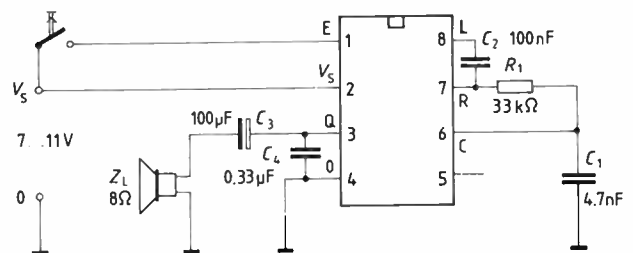
It's an 8-pin DIP device that generates a three-tone sequence of harmonically related "melodious tones" of 660 Hz, 550 Hz and 440 Hz which individually decay in amplitude. It

has a number of features: drives an 8 Ohm loudspeaker, single supply required - 7-11 volts (9 V transistor radio battery ideal!), standby current typically under one microamp so is ideal for battery operation, few components necessary (cheap!), trigger input offers considerable noise immunity (tolerates long lines). The block diagram here shows the general internal arrangement of the SAB0600.



The three output frequencies are derived from the output of a 13.2 kHz oscillator, divided down, one of which is further divided to obtain a timebase for the tone decay process. A 4-bit D-A converter (one for each tone) generates the decay voltage for the three tones. The decay periods overlap, so that as one is near the end of its decay, the next tone is triggered. An external RC network determines the fundamental clock frequency. A typical chime circuit uses just five external components. It makes a great doorbell!

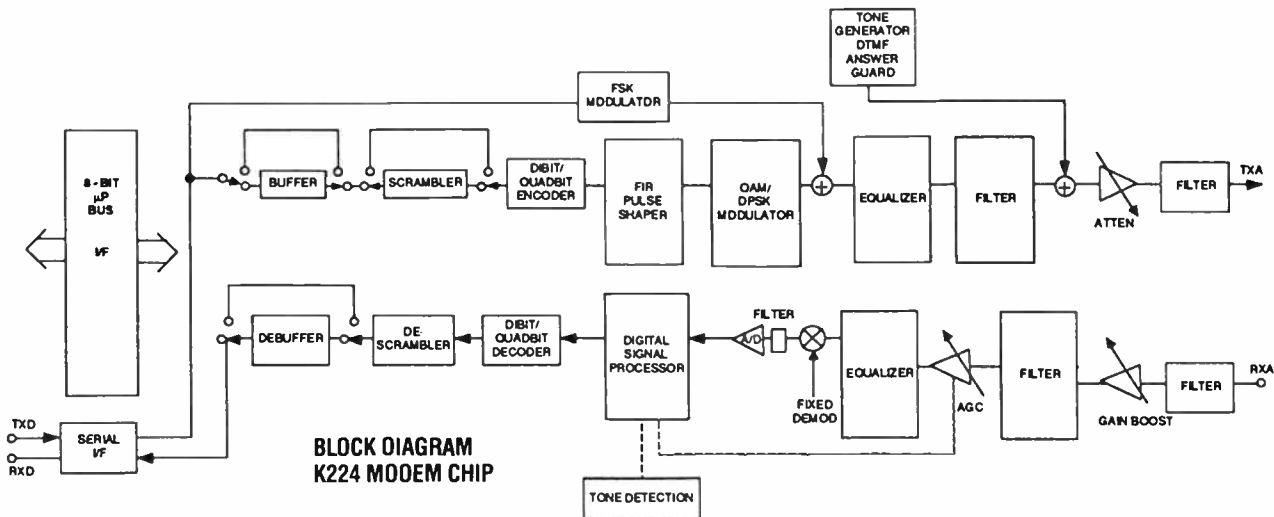
### Typical application circuit



The output develops about 160 mW in an 8 Ohm loudspeaker. The applications information suggests that, to improve the melodiousness of the output, a capacitor should be connected between pin 8 and ground. Start with 1n and vary "to taste". To vary the pitch of the chimes, vary the value of C1.

The circuit only draws current in the 'active' state. It is triggered when pin 1 receives a pulse of between 1.5 volts and





**BLOCK DIAGRAM  
K224 MODEM CHIP**

## Single chip modems from SSI

Silicon Systems, who are represented in Australia by R & D Electronics of NSW, have introduced two highly integrated single chip modems, the K222 and K224.

The SSI K222 is a single chip modem IC which provides the functions needed to construct a CCITT V.22, V.21 and Bell 212A compatible modem capable of 1200 bps full-duplex operation over dial-up lines. The K222 is an enhancement of the SSI K212 single chip modem which adds V.22 and V.21 modes to the Bell 212A and 103 operation of the K212.

The K222 modem supports V.22 and V.21 modes of operation, allowing both synchronous and asynchronous communications. Test features such as analogue loopback, digital loopback and internal remote digital loopback are provided. Internal pattern generators are also included for self-testing.

The device integrates analogue, digital and switched-capacitor array functions on a single substrate in a single 28- or 22-pin DIP package, the 22-pin device supporting a serial interface and the 28-pin device employing a parallel bus interface. It is ideal for use in either free standing or integral modem systems where full duplex 1200 bps communications over the two-wire switched telephone network is desired. A complete modem requires only the addition of the phone line interface, a control microprocessor and RS232 level convertors for a typical system.

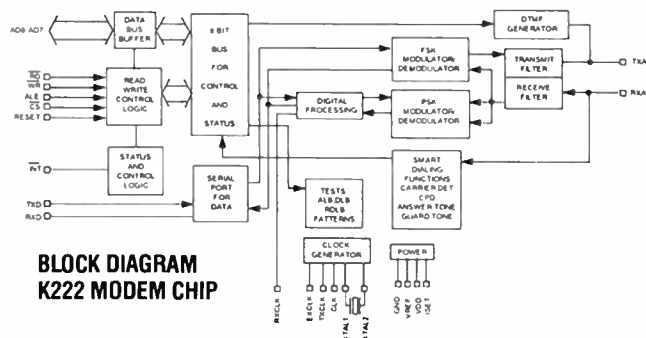
The other recently released device in the SSI family of single chip modems is the K224. This device provides the functions needed to construct a V.22bis compatible modem, capable of 2400 bps full duplex operation over dial up lines. The K224 is pin and software compatible with the K222 device, allowing system upgrades with a single component change.

The K224 supports all V.22bis, V.22, V.21, Bell 212A and

Vs (the supply voltage) of longer than 2 ms. This specification provides interference suppression, allowing lengthy lines between the trigger switch and the circuit. For improved noise immunity, shunt pin 1 to common with a capacitor (try 100n) and insert a resistor (try 47k-100k) in series with the trigger lead to pin 1.

Following triggering, each tone sounds and decays in succession. Once the last tone has decayed, the circuit returns to the standby state. If you hold your finger on the button, the three-tone sequence is repeated.

The SAB0600 costs around \$9-\$10 over the counter. You'll find it in Jaycar stores in Sydney, Brisbane and Melbourne, and Altronics in Perth.



**BLOCK DIAGRAM  
K222 MODEM CHIP**

Bell 103 modes of operation, allowing both synchronous and asynchronous communication.

Both modem chips are designed to appear to the system designer as a microprocessor peripheral and will easily interface with popular single chip microprocessors for control of modem functions. An ALE line control line simplifies address demultiplexing. CMOS technology is employed to provide low power consumption and all inputs and outputs are TTL or CMOS compatible.

These innovative products are sure to prove popular with modem designers by simplifying design. The market can probably look forward to some equally innovative and exciting products incorporating these devices in the not too distant future.

The SSI family of single chip modems are distributed in Australia by R & D Electronics, PO Box 57, Crows Nest 2065, NSW. Telephone (02)439 5488. R & D advise that the K222 is available ex-stock in both the 22-pin serial and 28-pin parallel versions. Production quantities of the K224 are expected to be available in late November 1987, according to R&D.

## More on Novix

As a continuation from last month's talk on the overall design of the Novix series of chips, we will now discuss some specific details.

### THE NC4016

The NC4016 is a 16-bit processor that runs at speeds from 0 to 10 MHz. Running at 8 MHz (equivalent to 8 MIPS) the NC4016 has been benchmarked by independents as being more than 20 times faster than a 68000 running machine code. Owing to the design of the chip, it can execute multiple Forth words in a single clock cycle. The NC series have all been optimised for running Forth as their "machine code," ▶

- Filter Design, from page 28.

values of capacitance if you use, say, 10k in series with 3k9 for each resistor, and divide all capacitors in that block by 1.39.

Incidentally, when designing a printed circuit board for such a filter, it is best to use a bridge or accurate capacitance meter on your capacitors first. Some values of capacitance can only be made by using two or more capacitors in parallel or series and space must be allowed for them on the board. Also, it is essential to use high quality, stable capacitors:- no electrolytics, and no ceramics for audio work.

The lack of interaction between the sections of active filters can only be achieved if you build the filter properly. As with any high gain IC amplifier, there will be trouble if your layout puts the output too close to the input. Indeed, building filters with cutoffs as low as 20 kHz on printed stripboards (e.g. Veroboard) can lead to oscillation because of the considerable coupling between adjacent strips. So the moral is to treat an active filter as if it were a high gain amplifier, taking all the usual precautions with bypassing and layout.

There are a couple more points worth watching, both related to the value chosen for the resistors in LP filters and the capacitors in HP filters. If the resistors are made too large, they tend to generate noise, so the filter can't be used for low level work such as audio preamplifiers. In addition, large resistors usually mean that the capacitors, particularly in the last section, will be small. It is essential to keep the capacitor values greater than, say, 220 pF otherwise the input capacitance of the amplifier plus the pc board capacitance will add significantly to the value and distort the frequency response of the filter.

For HP filters, too small a value for the capacitors leads to high value resistors at low frequency. This not only increases the noise generated but can lead to an unstable dc level at the output, even with FET amplifiers, if the temperature gets up a bit. So, once you have the initial design from the computer program, you can polish it up by looking at each block and

deciding whether you are happy with the resistor and capacitance values. If not, you can tailor them to your fancy provided that, whenever you multiply the resistors in the block by any factor, you divide the capacitors in that block by the same factor.

### Qualities of Butterworth filters

The good things about Butterworth filters are:

- Sharper cutoff than simple filters
- Reasonable cutoff rate for filters of high order
- Easy to construct
- LC filters only need low Q coils
- LC filters easy to tune
- Smooth and reasonably flat response in the passband
- Reasonably smooth phase shift away from cutoff
- Reasonably constant time delay away from cutoff
- Sallen and Key version of active filter is relatively insensitive to small changes in component values

The not so good things are:

- Sharp cutoff filters need inordinately high order and therefore lots of components
- Response is not flat in the passband, particularly near cutoff
- It is not possible to modify the shape of the frequency response once the order of the filter is chosen.

### COPYRIGHT

The copyright to several of the programs in this series is held by Aguila Holdings Pty, Ltd. These programs contain the copyright notice in their first few lines. All of these programs will become available on disc later in the series. Permission is hereby given by Aguila Holdings Pty., Ltd. for individuals to copy these copyright programs into a computer for their own personal use provided that the copy so made retains the copyright notice within it and with the understanding that copies are not to be given, sold, or traded to other persons.

## semiconductor scene

with subroutine calls and returns being implemented within one clock cycle.

The NC4016 supports a 64 Kword main memory address space, but can have addressing up to 2 Mwords, using either extended addressing or bank switching. It is possible to simultaneously access the Return Stack, the Data Stack, Main Memory and I/O bus at the same time as the ALU is operating. This concurrency provides for a large degree of parallel operation in processing and is what also helps to give the chip its high performance characteristics. A new

Forth instruction called "TIMES," allows for a counter to be placed in an auto-decrement register and then for the next instruction to be repeated however many "TIMES" are specified. This eliminates the need to re-fetch the instruction prior to each iteration.

### THE NC5016

The main differences between the NC4016 and the NC5016, are the slightly higher operating speed (12 MIPS compared to 10) and the addition of an Address Extension Port, which allows a WHOPPING 24 Mwords of memory to be addressed. As yet, only prototype versions of this chip are available.

### THE NC6016

The NC6016 is a bigger package than the other two and is not therefore pin compatible. The additional pins provided on the NC6016 allow additional addressing capabilities for the three main memory areas used. These are Program Space, Data Space and Local Space. Each of these has 256 pages of 64 Kbytes each page for each of the three address areas. Like the NC5016, the 6016 is also capable of running at 12 MIPS.

### Summary

The high speed of these chips, in terms of their actual program throughput, make them ideal for applications that previously required the power of a mainframe. Such applications as image and speech recognition, high speed colour graphics, Digital Signal Processing (DSP), Fast Fourier Transforms etc. are all areas where the Novix is already making its presence felt. AEM will shortly be presenting a project based on the Novix series which will give the home user the speed and power of a mainframe as an add-in board for an IBM PC, or a stand-alone board that can be driven by any computer/terminal.

## "FANTASTIC FORTH" AT 12 MIPS FROM NOVIX



**FEATURES:** NC4016 16-bit high-speed microprocessor • 35 ns CMOS memory (8 MIPS) • 28K words RAM, 4K words system ROM • 2 x RS232 I/O • SCSI BUS • 16-bit processor address bus, 16-bit processor data bus, 16-bit processor B-port, 5-bit processor X-port, 16-bit low speed Peripheral Bus, All system clock and enable lines • Complete polyFORTH operating system incl. • Hardware data stack and return stack each provide 256 16-bit cells per task.



Energy Control International Pty Ltd, 26 Boron St, Sumner Park Qld 4074. Phone (6107)376 2955. FAX (6107)376 3286. Telex AA4377B. (PO Box 6502 Goodna 4300).



# Elektor Electronics

# in AEM

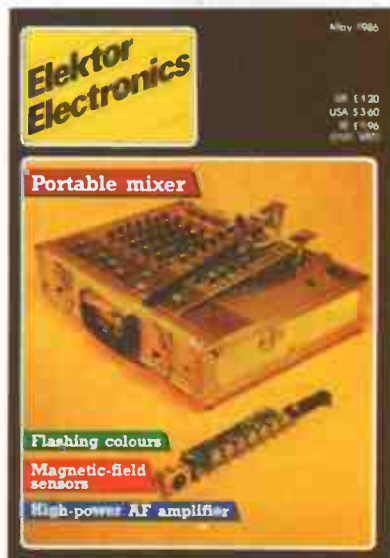
## CONTENTS

### PROJECTS

IEC-Centronics Interface	34
Low-noise Mic Preamp	38
SSB Adaptor	40

### ARTICLES

High Current Switching Regulator Simplifies Supply Design	42
Switch-mode Power Supplies	45
The Positive Impedance Converter	50



*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.*

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# IEC-CENTRONICS INTERFACE

by K Fiëtta

The use of an IEC or IEEE bus for driving a Centronics compatible peripheral device calls for a special interface circuit to ensure the correct timing of handshaking signals NRFD and NDAC.

The IEC bus is mainly used on minicomputers and mainframes, but is currently finding its way in some home micros also. In essence, the IEC bus is a parallel input/output port that can be adapted for use as a Centronics interface. The interface proposed here is a relatively simple type which enables driving virtually any Centronics compatible printer from an IEEE 488 bus. The IEC/IEEE 488 and Centronics interfaces have a number of technical features in common, and may be considered virtually identical when used unidirectionally.

In 1977, the International Electrotechnical Commission (IEC) published the document *Standard interface system for programmable measuring equipment*. This was the technical reference for the IEC interface, which enables controlling a wide range of measuring equipment with the aid of a central computer. The standardization of the interface was welcomed as a great help towards the development of the computer-controlled test site.

The IEC interface was not an entirely new concept, however. In April 1975, the American National Standard Institute (ANSI) had already documented the IEEE 488 interface standard for similar purposes. Interestingly, the proposals of both the IEC and the ANSI concerning an addressable interface were based on Hewlett Packard's system, which had been in use since 1965. Today, the IEC bus is used mostly in Europe, and the IEEE 488 bus in the United States. Apart from the connector system used—IEC 25-way; IEEE 488 24-way—these standards are very similar. The term GPIB (general purpose interface bus) is often used to refer to the IEC and IEEE 488 interfaces simultaneously. The use of a 24-way connector system was accepted for the IEC bus also in view of the widespread use of 25-way (D) connectors for RS232 based equipment. In the remainder of this article, the terms IEC bus, IEEE 488 bus, and GPIB bus will be considered synonymous for practical purposes. In spite of the strict standards for its implementation, the IEC

bus still leaves room for certain adaptations that may be required to solve compatibility problems. In practice, this means that equipment controlled via the IEC interface need not recognize all specified functions. Contrary to the Centronics interface, which is virtually always used to drive a single peripheral (usually a printer), the IEC bus is by definition tailored to connect several devices in a network.

remote sensor system. The IEC bus can only work with 1 active TALKER at a time.

**CONTROLLER:** addressed in, or set to, this mode, the device assigns the LISTENER or TALKER function to other devices. The CONTROLLER is usually a (mini or micro) computer with an IEC interface. The IEC bus can work with only 1 active CONTROLLER at a time.

The logic levels on the IEC bus lines are based on the definitions for TTL circuits:

0.00 V to 0.80 V: logic "1" level; low; active; true; valid.

0.81 V to 2.00 V: not defined.

2.01 V to 5.25 V: logic "0" level; high; inactive; false; invalid.

Note that the logic levels "1" and "0" are inverted with respect to the electrical high and low levels. The negation bars commonly put over logic signal names are not used in the following discussion to avoid confusion arising from the connection of a system based on positive logic (Centronics) to one based on negative logic (IEC). Voltages in the above mentioned non-defined range

## The IEC bus

The IEC standard defines 16 signal and 8 ground lines. Each device connected to the bus should recognize at least 1 of the following 3 functional modes:

**LISTENER:** addressed in this mode, the device reads the data received via the interface. Examples include printers, display units, and programmable signal sources.

**TALKER:** addressed in this mode, the device sends data via the interface. Examples include a paper tape reader and a

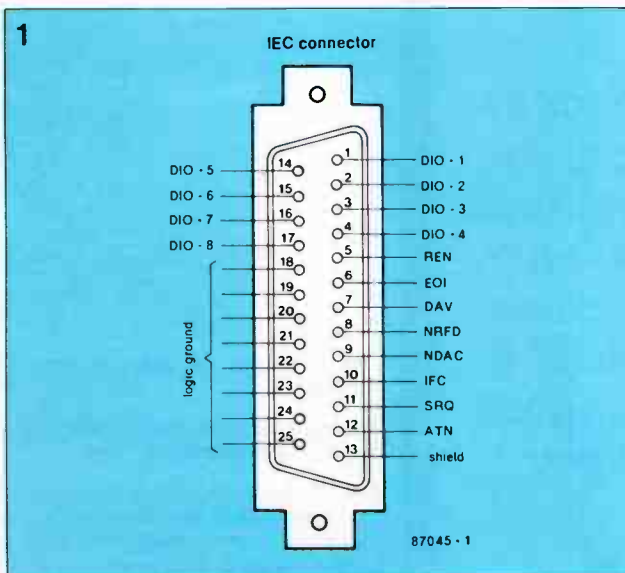


Fig. 1 The 25-way IEC connector.

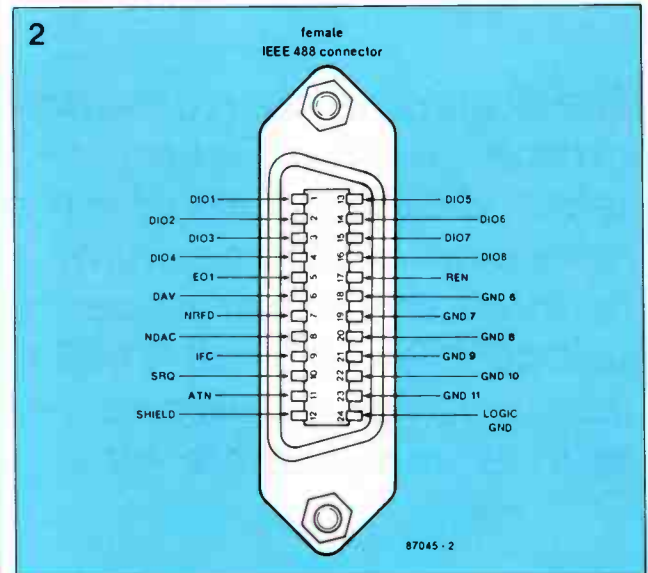


Fig. 2 The 24-way IEEE 488 connector.



may only exist during logic level transitions. The pinning and signal denotation of the connectors are shown in Figs. 1 and 2. The 16 signals can be functionally divided into 8 datalines, 3 handshake lines, and 5 command lines, as shown in Fig. 3.

Datalines DI01...DI08 incl. are used for sending and receiving bytes of which the least significant bit is carried by DI01. The datalines also carry status information of the devices connected to the bus. Signal ATN allows a distinction to be made between 2 types of information: ATN="0": data transmission ATN="1": interface-specific information

The control (management) bus uses the following 5 lines: IFC (interface clear); the CONTROLLER initializes all devices connected to the IEC bus. This line is activated immediately after power-up.

ATN (attention): indicates the presence of data or status information (see above).

REN: (remote enable): remote selection of the functional mode of devices connected to the bus. Usually, this line is permanently active. In the inactive state it enables manual mode selection of a device.

EOI (end or identify): when the ATN line is active, the CONTROLLER uses the EOI signal to identify a bus-connected device. A TALKER uses EOI as the "end of transmission" marker (ATN="1"; EOI="0").

SRQ (service request): devices can request communication with the CONTROLLER, which interrupts its current program to execute the servicing program.

The following signals on the handshaking bus accompany a dataword on the databus:

DAV (data available): by activating this line, the sending device indicates that the dataword on the bus is stable and valid.

NRFD (not ready for data): this line is activated when a bus-connected device is not ready to receive data (low = not ready).

NDAC (no data accepted): this line is activated when a bus-connected device has not (yet) read the dataword from the interface (low = not accepted).

The order in which the handshaking signals are active dur-

ing the transmission of data is shown in Fig. 4.

- (1). Initialization of the DAV signal by the source.
- (2). When a device is ready to process a new dataword, it switches its NRFD output to the high impedance state. NRFD goes high only when all devices are ready.
- (3). A new dataword can be sent, and DAV indicates the

- presence of valid data (4). Devices activate NRFD (5) to signal inability to accept new data while the previous dataword is being loaded (6). All devices have an individual NDAC line in view of the specific data loading and processing speed. When all devices have accepted the dataword, all NDAC lines form a high impedance, and the signal

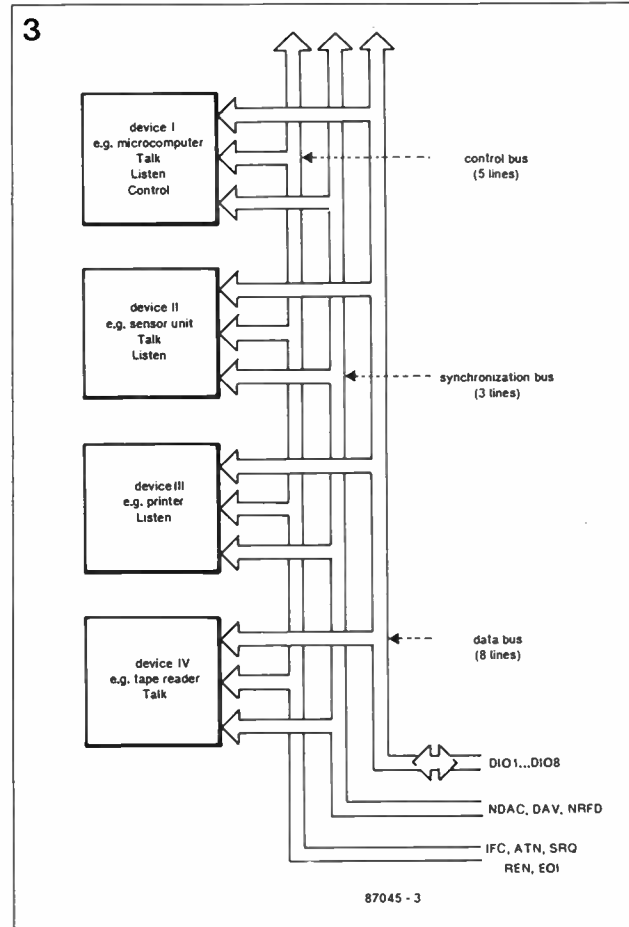


Fig. 3 Basic structure of the IEEE 488 bus, which supports up to 15 devices.

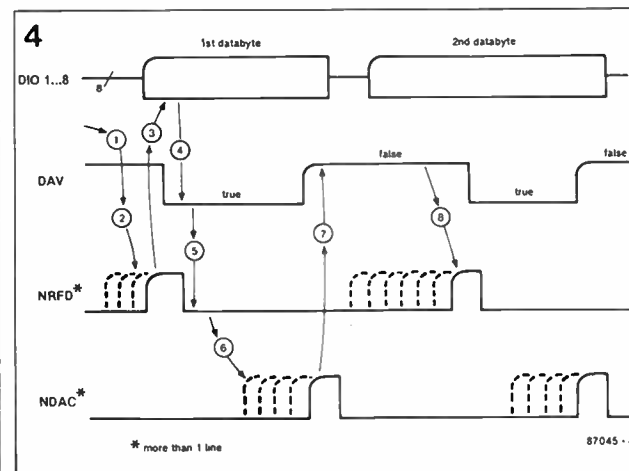


Fig. 4 Essentials of the handshaking procedure used in an IEC interface.

goes high. The sending device waits for all NRFD lines to revert to the inactive state, which means that all devices have processed the previously loaded dataword. It then de-activates the DAV line (= false) (7) and awaits state (8) (NRFD = false). The handshaking cycle is then complete.

### Functional aspects of the IEC interface

Equipment fitted with an IEC interface should have the following functions:

1. Source Handshake (SH): This function ensures the correct placing of dataword onto the bus, controls the DAV line while monitoring the NRFD and NDAC lines, and is used by TALKERS and CONTROLLERS for sending data and status information, respectively.

2. Acceptor Handshake (AH): This receiver function for datawords on the bus controls the NRFD and NDAC lines while monitoring the DAV line. The start of a transmission can be blocked, and the end delayed, with the aid of NRFD and NDAC, respectively.

3. Talker (T): This function entails sending data to one or more LISTENERS. The CONTROLLER selects this function by means of a 1-byte address in the device.

4. Listener (L): This function entails receiving data from the CONTROLLER or a TALKER. The CONTROLLER selects this function by means of a 1-byte address in the device.

5. Service Request (SR): This function controls the SRQ line. The CONTROLLER is to identify the SR source from the devices connected to the bus.

6. Remote/Local (RL): This function selects between bus controlled device settings and manual settings effected with switches, hardware controls, and the like.

7. Parallel Poll (PP): This function enables a bus-connected device to send its status information in response to an identification prompt from the CONTROLLER.

5

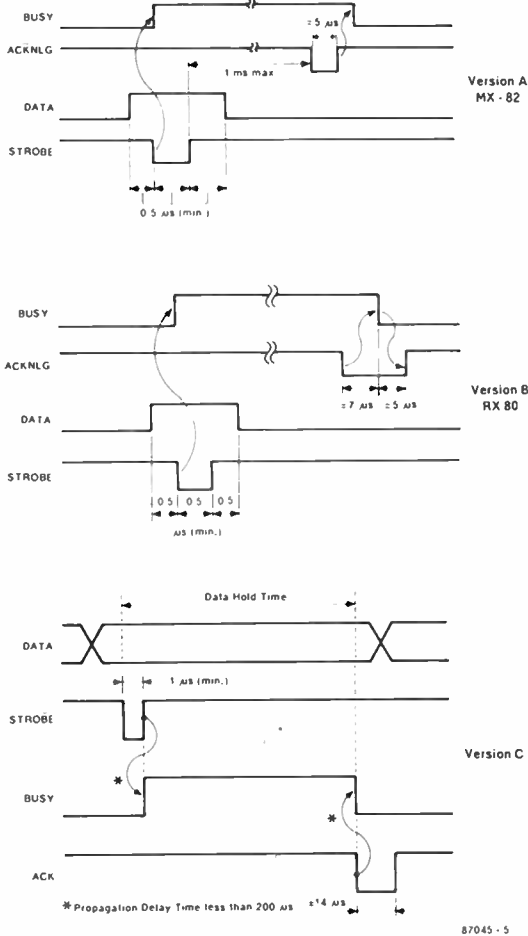


Fig. 5 The relative position of the ACKNLG pulse is different for 3 types of printer with a Centronics interface.

6

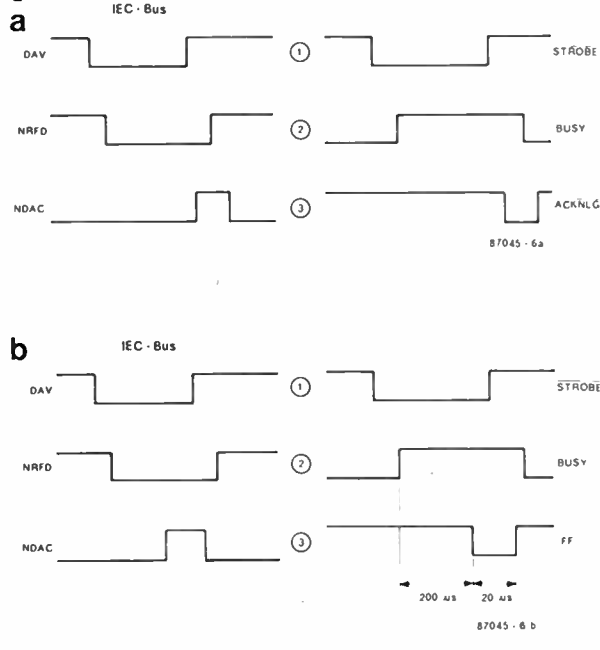


Fig. 6 The handshaking signals used for a Centronics and an IEC interface differ in respect of timing and polarity.



8. Device Clear (DC):

This is the individual or general reset command for bus-connected devices.

9. Device Trigger (DT):

This function enables a local process in the device to take place.

10. Controller (C):

This function is indispensable in any IEC bus where data is conveyed via different paths.

From this summary it is clear that the IEC-Centronics interface about to be described should at least comply with the Acceptor Handshake function.

nection of the asynchronous handshaking signals: DAV to STROBE, NRFD to BUSY, and NDAC to ACKNLG. Figure 6a shows that the DAV signal (1) can simply take the function of STROBE, even if it is considerably longer than usual. The BUSY signal from the printer (2) need merely be passed through an inverter to drive the NRFD input on the IEC bus. Converting ACKNLG into NDAC (3) is not so simple. It was already seen in Figs 5a, 5b and 5c that Centronics compatible printers may differ in respect of the position of the ACKNLG pulse relative to the trailing edge of the BUSY signal. For a printer of type A, it is sufficient to invert ACKNLG for obtaining a proper NDAC signal. Printer types B and C, however, call for a more complex way of obtaining NDAC. A monostable multivibrator triggered on the trailing edge of ACKNLG would do for printer types A and B, while a similar circuit, but triggered on the leading edge of BUSY is required to obtain the NDAC pulse from a printer of type C. In practice, it has appeared that the circuit designed for "type C" printers gives acceptable results on type A and B printers also. The circuit diagram of Fig. 7 shows that the ACKNLG signal is only used to drive a LED, while BUSY is applied to dual monostable IC<sub>1</sub> MMV<sub>1</sub> and MMV<sub>2</sub> provide a delay of 200 μs and 20 μs respectively to ensure that the NDAC pulse occurs always within the active period of NRFD—see Fig. 6b.

A matter of micro-seconds

A complete description of all the functions, specifications and technical requirements pertaining to the IEC standard would be beyond the scope of this article. None the less, a discussion on the difference in timing with respect to the Centronics standard is useful for detailing the operation of the present circuit. Datawords of 8 bits can be conveyed reliably via a Centronics compatible interface thanks to the use of the 3 handshaking lines STROBE, ACKNLG and BUSY, which operate as shown in Fig. 5, with 3 alternative timing arrangements, A, B and C, depending on the type of printer. It was already noted that the logic levels used for the IEC interface are inverted with respect to the Centronics standard, and this explains the use of 8 inverters on the datalines. The crux in designing the IEC-Centronics interface is the con-

Construction

Fig. 8 shows that the printed cir-





# LOW-NOISE MICROPHONE PREAMPLIFIER

A quality preamplifier that can be configured for low and high impedance, as well as balanced and unbalanced, microphones.

Most dynamic microphones of European make (AKG, Beyer, Sennheiser) have a characteristic impedance of 200  $\Omega$ , while those of Far Eastern origin are usually terminated in 500 to 600  $\Omega$ . The impedance of electret condenser microphones is type specific, and usually in the range from 600 to 1000  $\Omega$ . Most microphones have a sensitivity of 2...3 mV/Pa. The termination impedance, i.e., the input impedance of the preamplifier or the microphone transformer, should be equal to or higher than the impedance of the microphone. The transformer is often precisely matched to the microphone impedance (*power matching*), while preamplifiers give optimum performance when the termination impedance is slightly higher than the microphone impedance (*voltage matching*). The use of a transformer with an impedance ratio of 1:10 or 1:15 relaxes the requirements for the sensitivity and the signal-to-noise ratio of the preamplifier. However, the circuit may still be susceptible to hum and noise when the transformer is housed in the microphone. Obviously, this calls for high-quality microphone wire. Hum and other interference is minimized when the microphone preamplifier has a signal-to-noise ratio of 70 dB or more. Balanced systems (the microphone, cable, and preamplifier input) are known for their high immunity to noise.

## Circuit description

The circuit diagram of the microphone preamplifier is shown in Fig. 1. The amplifier can be configured for use with balanced and unbalanced microphones. Component values for the unbalanced version are shown in brackets.

Components whose value is not shown for a particular version are not required (also consult the parts list).

**Balanced version:** the input signal is applied to the + inputs of operational amplifiers IC<sub>1</sub> and IC<sub>2</sub>. Resistors R<sub>1</sub>...R<sub>4</sub> incl. determine the input impedance. When jumper A is fitted, the output signals of the opamps are subtracted in IC<sub>3</sub> for effective suppression of hum and noise. Due to the higher number of active components, the S/N ratio of the balanced version is a few decibels worse than that of the unbalanced circuit.

**Unbalanced version:** wire link B is fitted, so that IC<sub>3</sub> functions as a non-inverting amplifier. IC<sub>2</sub> and IC<sub>3</sub> are not required. The input impedance is determined by R<sub>3</sub>, R<sub>4</sub> and R<sub>11</sub>. The microphone signal reaches IC<sub>3</sub> via C<sub>1</sub> and the wire link fitted in position R<sub>9</sub>. IC<sub>3</sub> and IC<sub>4</sub> raise the input signal to enable driving the line input of an AF power amplifier.

The input impedance of the preamplifier can be switched

between high and low by connecting a switch between S<sub>y</sub> and ground, and S<sub>x</sub> and ground—the former is not required for the unbalanced versions. If necessary, the input impedance of the preamplifier can be altered to match a particular microphone. The input resistance of the balanced version should consist of 2 equal resistors with a value of half the required termination impedance. In the unbalanced version, R<sub>3</sub> and R<sub>4</sub> may be omitted, so that R<sub>11</sub> alone determines the input impedance.

## Construction and use

The printed circuit board shown in Fig. 2 can be used for constructing both versions of the preamplifier. Separate parts lists are given to avoid construction errors. Fit jumper A or B as appropriate, and do not forget the 2 wire links. Capacitors of 3 different pitch sizes can be fitted in positions C<sub>1</sub> and C<sub>4</sub>. Figure 3 shows prototypes of the microphone preamplifier fitted in diecast enclosures to ensure

robustness and freedom of induced noise.

The symmetry of the preamplifier, and hence the attainable signal-to-noise ratio, depends mainly on the quality and the stability of the components used around IC<sub>1</sub>, IC<sub>2</sub> and IC<sub>3</sub>. Equally important, however, is the use of a high-quality microphone and a suitable cable. Sv

### Low noise microphone preamplifier

#### Technical specification

Supply voltage:	$\pm 9 \dots 15$ V
Current consumption:	$\pm 7.5$ mA (unbalanced version) $\pm 15$ mA (balanced version)
Signal-to-noise ratio	
NE5534:	-87 dB (unbalanced version) -81 dB (balanced version)
OP-27:	-89 dB (balanced version) -83 dB (balanced version)
Distortion:	$\leq 0.003\%$
Voltage gain:	40 dB
Input resistance:	24 k $\Omega$ or 680 $\Omega$ (unbalanced version). 45 k $\Omega$ or 660 $\Omega$ (balanced version).

#### Measurement conditions:

R<sub>L</sub> = 4K7; U<sub>0</sub> = 1V<sub>rms</sub>  $\hat{=}$  0 dB; f = 1 kHz.  
S/N ratio measured with input short-circuited.



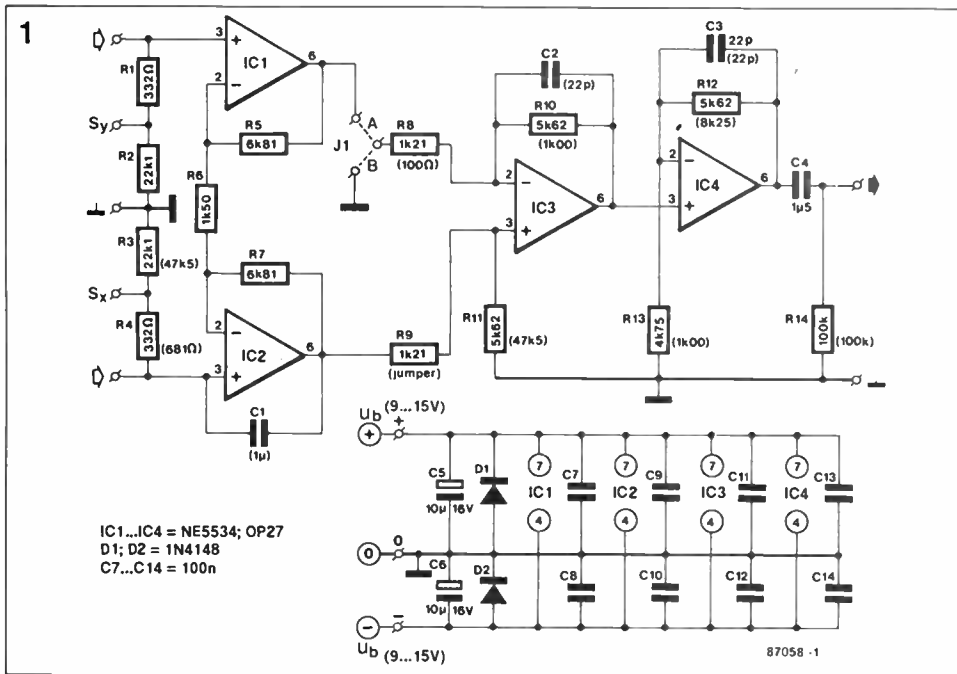


Fig. 1 Circuit diagram of the low noise microphone preamplifier.

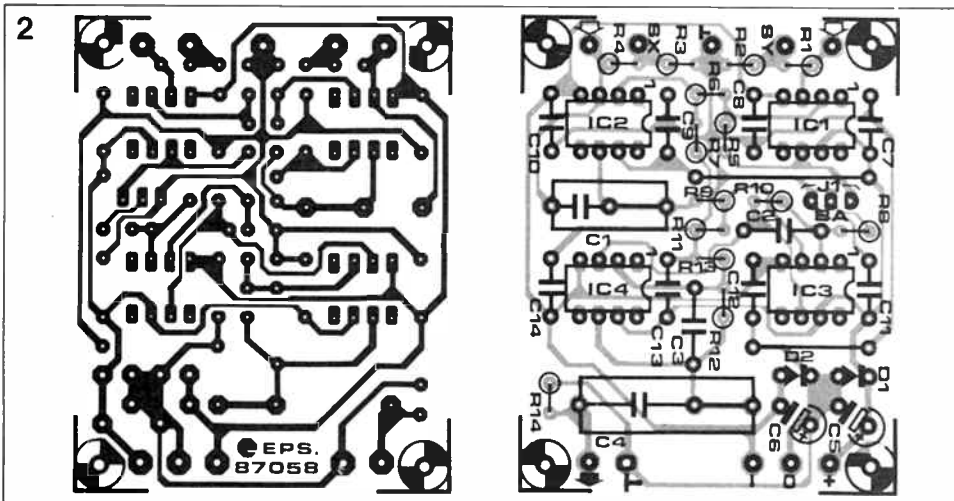


Fig. 2 The printed circuit board for the microphone preamplifier.



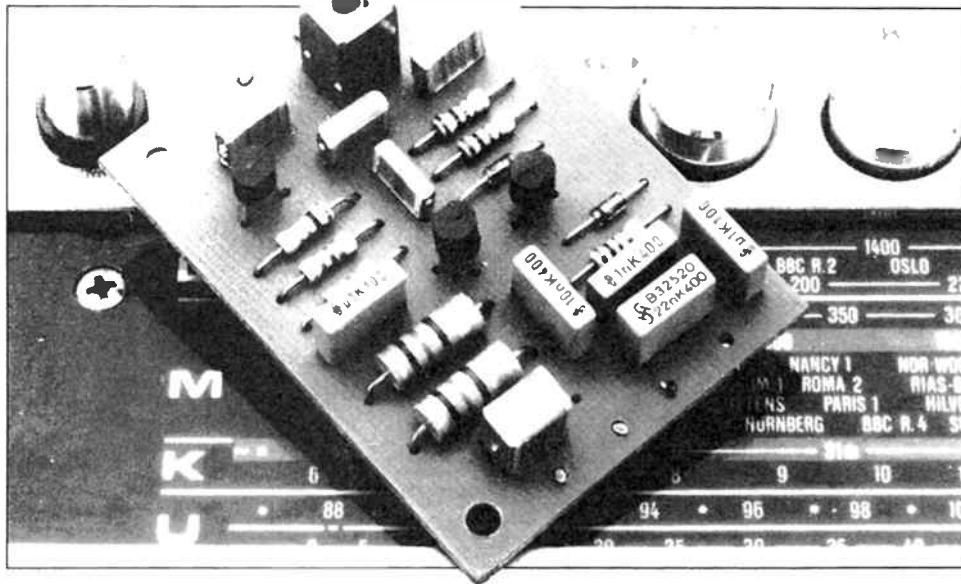
Fig. 3 Prototypes of the preamplifier housed in Eddystone enclosures.

- Parts list**
- Balanced version**
- Resistors ( $\pm 1\%$ ):  
 R<sub>1</sub>;R<sub>4</sub> = 332RF  
 R<sub>2</sub>;R<sub>3</sub> = 22K1F  
 R<sub>5</sub>;R<sub>7</sub> = 6K81F  
 R<sub>6</sub> = 1K5F  
 R<sub>8</sub>;R<sub>9</sub> = 1K21F  
 R<sub>10</sub>;R<sub>11</sub>;R<sub>12</sub> = 5K62F  
 R<sub>13</sub> = 4K75F  
 R<sub>14</sub> = 100KF
- Capacitors:  
 C<sub>1</sub>;C<sub>2</sub> = not required  
 C<sub>3</sub> = 22p; styroflex/polystyrene  
 C<sub>4</sub> = 1μ5; MKT\*  
 C<sub>5</sub>;C<sub>6</sub> = 10μ; 16 V; radial  
 C<sub>7</sub>...C<sub>14</sub> incl. = 100n
- Semiconductors:  
 D<sub>1</sub>;D<sub>2</sub> = 1N4148  
 IC<sub>1</sub>...IC<sub>4</sub> incl. = OP-27 or NE5534

- Parts list**
- Unbalanced version**
- Resistors ( $\pm 1\%$ ):  
 R<sub>1</sub>;R<sub>2</sub>;R<sub>3</sub>;R<sub>6</sub>;R<sub>7</sub> = not required  
 R<sub>4</sub>;R<sub>11</sub> = 47K5F  
 R<sub>5</sub> = 681RF  
 R<sub>8</sub> = 100RF  
 R<sub>9</sub> = wire link  
 R<sub>10</sub>;R<sub>13</sub> = 1K0F  
 R<sub>12</sub> = 8K25F  
 R<sub>14</sub> = 100KF
- Capacitors:  
 C<sub>1</sub> = 1μ0; MKT\*  
 C<sub>2</sub>;C<sub>3</sub> = 22p; styroflex/polystyrene  
 C<sub>4</sub> = 1μ5; MKT\*  
 C<sub>5</sub>;C<sub>6</sub> = 10μ; 16 V; radial  
 C<sub>7</sub>...C<sub>10</sub> incl. = not required  
 C<sub>11</sub>...C<sub>14</sub> incl. = 100n
- Semiconductors:  
 D<sub>1</sub>;D<sub>2</sub> = 1N4148  
 IC<sub>1</sub>;IC<sub>2</sub> = not required  
 IC<sub>3</sub>;IC<sub>4</sub> = OP-27 or NE5534

# SSB ADAPTER

A low-cost add-on unit that enables single-sideband reception on virtually any AM short-wave receiver.



Every experienced short-wave listener knows that single sideband (SSB) transmissions can not be received unless a special detector is installed in the receiver. Unfortunately, however, an SW receiver suitable for SSB reception is generally far more expensive than an AM/FM general coverage, radio set having adequate sensitivity and selectivity. To the dedicated SW listener, amateur and utility stations transmitting SSB signals are often more interesting than (broadcast) AM stations in view of their uniqueness, and the larger distance covered. SSB transmitters are more economical than AM transmitters as regards bandwidth and power consumption, due to the absence of the carrier and the second sideband.

## Carriers and sidebands

It can be shown that the RF power contained in the carrier and one sideband of an AM modulated RF signal is redundant, because it is not, strictly speaking, needed to convey in-

formation to the receiver. For this purpose, one sideband suffices. The RF output signal of an AM transmitter modulated with a single, sinusoidal frequency is shown in Fig. 1. The instantaneous amplitude,  $U$ , of the RF carrier is a function of the amplitude of the modulating AF tone, which can be reconstructed by drawing a line along the peak excursions of the RF voltage (the *envelope*

waveform). Mathematically simplified, this AM signal is described by the expression

$$U_{AM} = U_c(f_c) + mU_c(f_c + f_m) + mU_c(f_c - f_m)$$

It is seen that the amplitude of the AM signal,  $U_{AM}$ , is the sum of 3 terms. The first,  $U_c(f_c)$ , is the amplitude of the carrier with frequency  $f_c$ . The second and third term are of equal am-

plitude,  $mU_c$ , but denote signals adjacent to the carrier, i.e., below and above  $f_c$ . The factor  $m$  represents the relative amplitude of the modulating signal with frequency  $f_m$ . Figure 2a shows an analysis of the AM signal in the frequency domain (*spectrum analysis*). The carrier is modulated with a single tone that gives rise to 2 side tones, each having a lower amplitude than the carrier. Modulating the AM transmitter with a composite AF signal, e.g. music or speech, causes two *side bands* rather than side tones adjacent to the carrier, and so increases the overall bandwidth occupied by the signal. Returning to the above formula, it is readily seen that the terms  $mU_c(f_c + f_m)$  (upper sideband, USB) and  $mU_c(f_c - f_m)$  (lower sideband, LSB) convey the same intelligence, namely the modulated signal, while the carrier,  $U_c(f_c)$ , does not convey any intelligence. Evidently, the carrier and one sideband are not needed to convey information from the transmitter to the receiver, and this forms the basis of the SSB modulation method, which is sometimes—more properly—

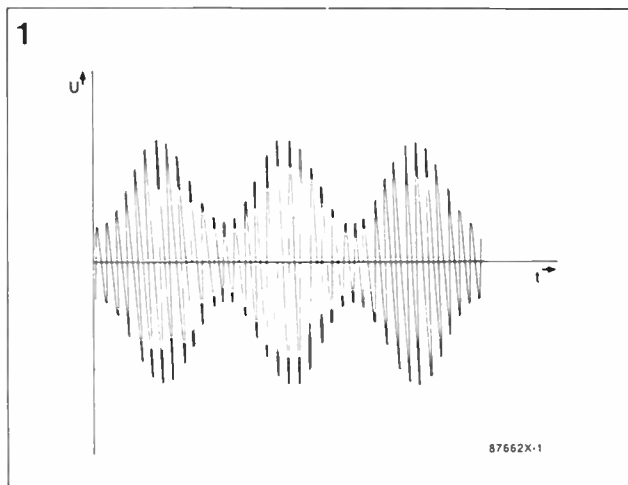


Fig. 1 RF output signal of an AM transmitter modulated with a single tone.



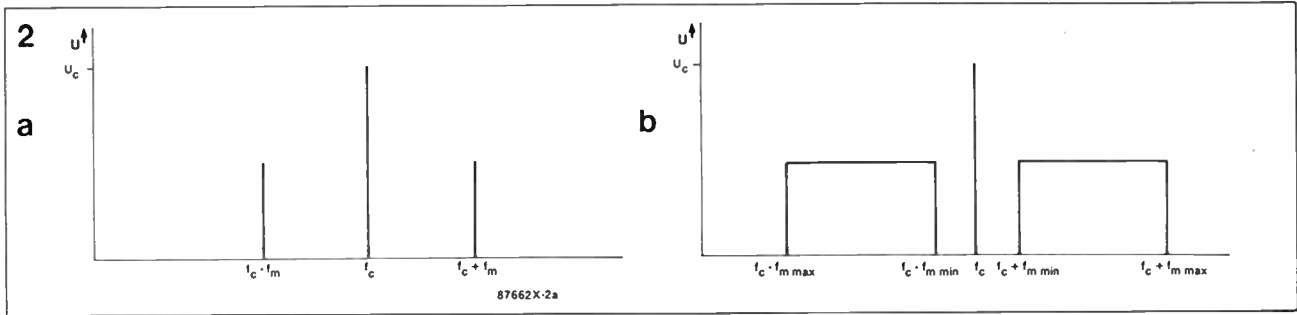


Fig. 2 Spectral analyses of AM signals. Fig. 2a: single tone modulation. Fig. 2b: modulation with a composite AF signal.

### Parts list

Resistors ( $\pm 5\%$ ):

- $R_1 = 10K$
- $R_2, R_3 = 1K0$
- $R_4 = 100R$
- $R_5 = 4K7$
- $R_6 = 6K8$
- $P_1 = 100R$  linear potentiometer

Capacitors:

- $C_1 = 200p$  variable capacitor
- $C_2 = 6n8$
- $C_3, C_4 = 39n$
- $C_5 = 2n2$
- $C_6, C_7 = 100n$
- $C_8 = 1n0$
- $C_9 = 10n$
- $C_{10} = 22n$
- $C_{11} = 470n$

Inductors:

- $L_1 =$  Neosid Type 7A1S\* inductor assembly (see text)
- $L_2, L_3 = 270\mu H$

Semiconductors:

- $D_1, D_2 = 1N4148$
- $T_1, T_2, T_3 = BF494$

Miscellaneous:

- $S_1 =$  miniature SPST switch.
- PP3 battery (9 V) and clip-on connector.

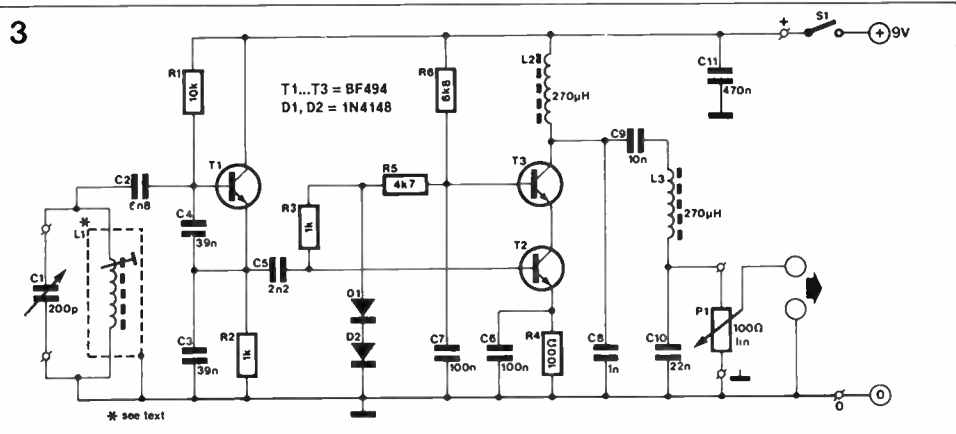


Fig. 3 Circuit diagram of the SSB adapter for AM receivers.

referred to as SSBSC (single sideband, suppressed carrier). In theory, an SSB transmitter uses only a quarter of the power of an AM transmitter for conveying the same information. In an AM transmitter, half the power is "wasted" in the carrier, the other half goes into the sidebands. The RF power of an (ideal) SSB transmitter drops to nought in the absence of a modulating signal. Hence an SSB transmitter has a far better power efficiency than an AM transmitter, and at the same time occupies less bandwidth; relatively low power SSB transmitters can, therefore, be used to cover considerable distances (maritime communications, radio amateurs, etc.)

without laying too heavy a claim on the available power source.

### From SSB to AM

The operating principle of the present adapter follows from the previously discussed relationship between AM and SSB. An SSB signal can be converted into AM by adding a carrier and a sideband. Both are obtained with the aid of an oscillator tuned to the receiver's intermediate frequency (IF), which is usually 455 kHz. The externally generated carrier serves as the reference frequency against which the (upper or lower) sideband is demodulated. The second sideband is automatically obtained

in this process, so that a double sideband AM signal is available for demodulating. The combination of the AM receiver and the SSB adapter is, understandably, not up to a real SSB compatible receiver with its special, narrow band, IF section. None the less, the results obtained with the present add-on unit are satisfactory for relatively strong, interference-free, signals.

### Circuit description

The SSB adapter is a simple circuit, shown in Fig. 3. Transistor  $T_1$  oscillates at 455 kHz with the aid of parallel tuned circuit  $C_1-L_1$ . The oscillator signal is raised and filtered in a cascode amplifier set up around  $T_2$  and

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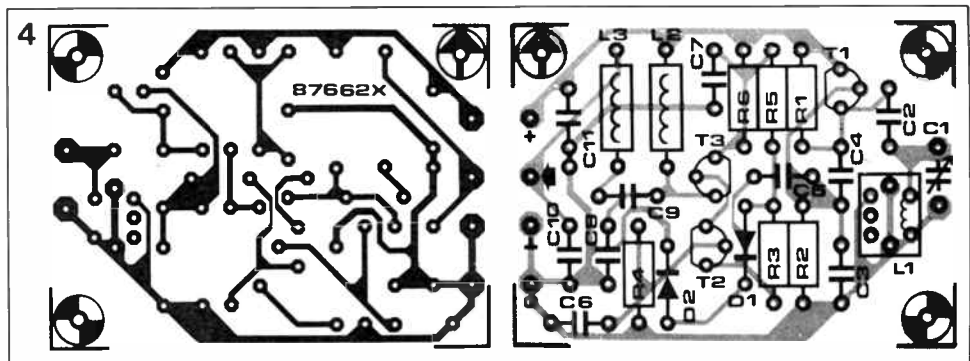
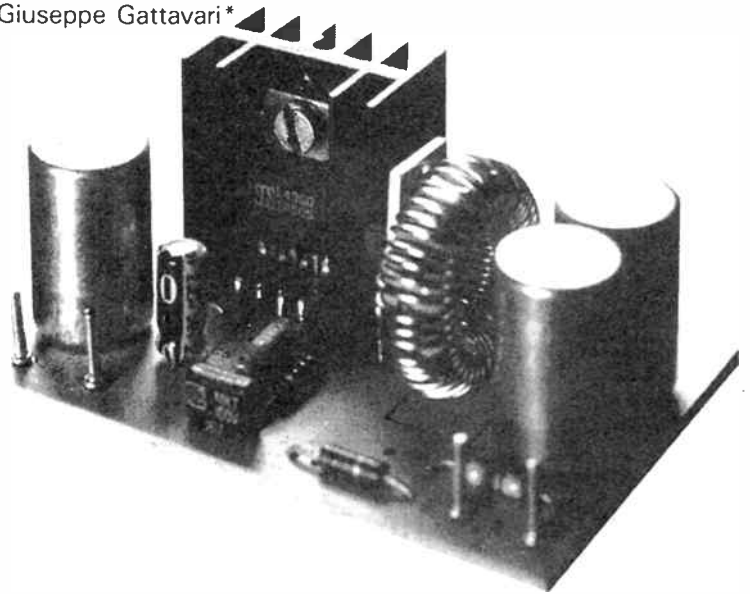


Fig. 4 Printed circuit board for the SSB adapter.

# HIGH CURRENT SWITCHING REGULATOR IC SIMPLIFIES SUPPLY DESIGN

by Giuseppe Gattavari\*

Containing a complete 2.5A switching regulator on a single chip, a power IC simplifies the design of many power supply schemes and reduces cost.



While designers are attracted by the high efficiency of switching regulators, they are often deterred by the complexity of circuits based on controllers such as the SG3524 and discrete power transistors. By integrating on a single chip a complete switching regulator capable of delivering 2.5A at 5V to 40V, the SGS L4960 High Cur-

rent Switching Regulator IC offers all the advantages of a switching regulator yet is little more complex to use than a linear regulator. A 2.5A/5V regulator can be built with one L4960 and just eight components (Fig. 1) and higher output voltages are obtained by adding two resistors. Moreover, the device includes current

limiting and thermal protection circuits, eliminating the need to add extra circuitry.

A further advantage is that the L4960's source-sink output stage can switch in about 70ns, allowing efficient operation (up to 90%) at switching frequencies of 100kHz. The IC is, in fact, tested dynamically at 100kHz in production. Thanks to

the high frequency operation the output LC filter components can be very small.

The IC itself is assembled in the compact Heptawatt 7-lead package—both horizontal and vertical mounting versions are available—and requires only a small heatsink. Considering also the few external components and small LC filter the complete application circuit is extremely compact (see photo). It can even be squeezed into the corner of a system card.

A versatile device, the L4960 may be used in a number of different ways.

The most obvious is a basic DC-DC converter configuration where a 50/60Hz transformer, rectifier bridge and filter capacitor feed the input of the device with an unstabilized DC voltage.

## Multiple outputs

Any number of devices may be combined to produce a multiple output supply, permitting a building block approach to supply design. In multi-chip supplies it is desirable to synchronize the switching frequencies and this can be done by connecting the oscillator pins in common to one RC network (Fig. 2).

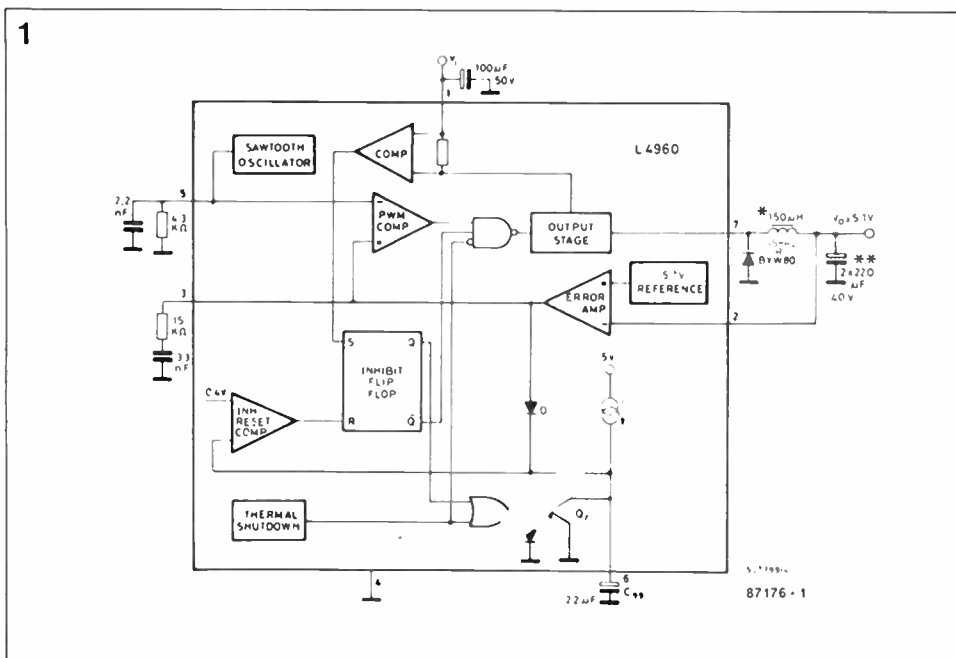


Fig. 1. Containing a complete 2.5A switching regulator with current limiter and protection functions, the L4960 High Current Switching Regulator needs few external components.



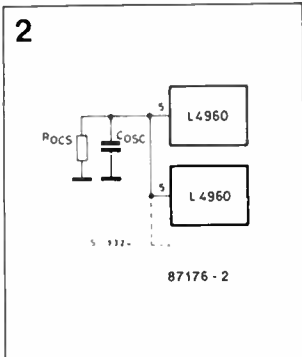


Fig. 2. So that several devices may be combined to produce modular multi-output supplies, the switching frequencies can be synchronized by connecting the oscillator pins together.

Very often low current auxiliary outputs such as  $\pm 12V$  are required. In this case it may be necessary to use several devices since an auxiliary output can be produced by adding an extra winding on the output inductor as shown in Fig. 3. In this example the secondary winding is not isolated—the bottom end is at 5V. This means that fewer turns are necessary than if it were isolated, and load regulation is improved.

Circuits of this type have the advantage of low cost and simplicity, and yield satisfactory performance as long as the power drain on the auxiliary output is no more than about 20% of the power delivered by the main output.

Extending this principle, positive and negative auxiliary outputs can be obtained by adding two windings, as shown in Fig. 4. Since designers always prefer to avoid inductors whenever possible it should be noted that all of these circuits require small toroids with a small number of turns.

### Pre-regulation

In all of the applications described above the L4960 supplies the load directly. The device may also be used effectively as a pre-regulator for supply schemes where on-card linear post regulators are used (Fig. 5). The advantage of this approach is that it enhances regulation at the expense of efficiency. Using an L4960 as the pre-regulator overcomes the poor efficiency of post regulation without making the supply excessively complex. The overall efficiency of this

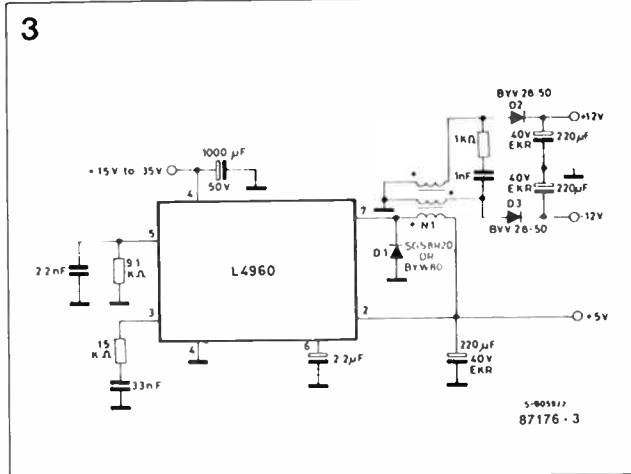


Fig. 3. A low-current auxiliary output can be obtained by adding an extra winding on the output inductor. This technique is simple and inexpensive, yet works well provided that power drain on the auxiliary output does not exceed 20% of the power delivered by the main output.

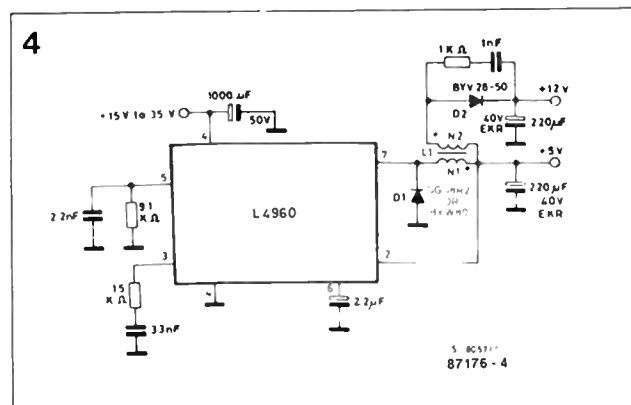


Fig. 4. With two extra windings both positive and negative auxiliary outputs can be produced with just one device.

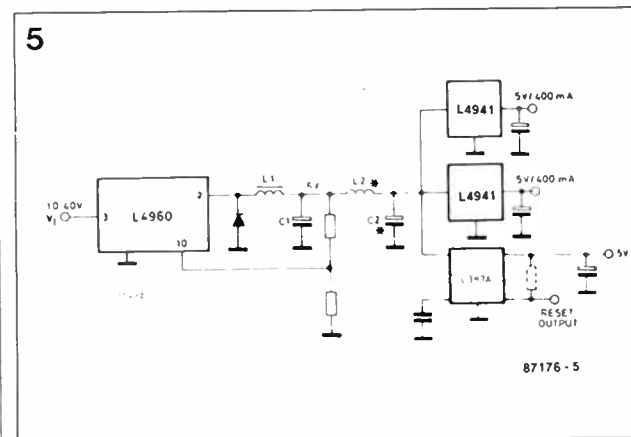


Fig. 5. An L4960 can be used as a pre-regulator in supplies where on-card linear post regulator are employed.

scheme can be further increased by using new-generation low drop linear regulators like the SGS L4941 for final regulation. These 5V/500mA regulators have a maximum dropout voltage of 650mV, allowing the use of a lower intermediate voltage.

### Offline switching supplies

Another important application is where the L4960 is used to regulate auxiliary outputs in high power supplies where the mains transformer has been replaced by an offline switching

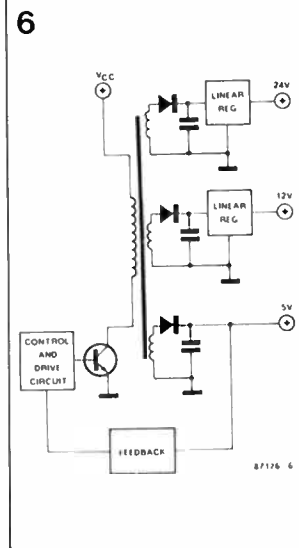


Fig. 6. In a conventional offline switching supply, linear regulators are used to stabilize the auxiliary outputs. This solution requires a costly transformer and dissipation is a problem.

regulator to reduce size and weight.

To understand the advantage of using switching regulator chips in this application it is necessary to examine the drawbacks of the conventional circuit, illustrated schematically in figure 6. In this example, a feedback circuit guarantees the necessary precision for the main 5V output while conventional linear regulators stabilize the other outputs.

A major drawback of this supply design is the cost of the transformer. A separate secondary is needed for each output and each must be optimized to obtain a low drop-out voltage, otherwise power dissipation will be excessive.

The linear regulators used in these supplies are either ICs (for currents up to 2-3A) or discrete circuits. Either way, power dissipation also becomes a problem in overload and short-circuit conditions since the current limiters are of the constant-current type. It is therefore necessary to complicate the circuit further by adding thermal protection circuits or to use a large, and costly, heatsink.

A final consideration concerns the rectifier diodes between the secondary windings (one for each output voltage) and the filter capacitors. With a linear post regulator the input current is always equal to the output

current so the diodes must be dimensioned accordingly. All of these problems are eliminated by using the L4960 as a post regulator as shown in Fig. 7. Note that for all of the auxiliary outputs only one secondary is needed, simplifying the transformer. Cross regulation is no longer a problem and the power dissipated in the stage depends mainly on load current and is almost unaffected by dropout. Moreover, the diode on the secondary can be smaller since the input current of a stepdown switching regulator is always less than the output current.

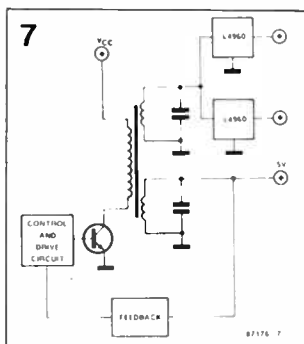


Fig. 7. Using DC-DC converter circuits in place of the linear regulators simplifies the transformer and reduces dissipation.

Finally, short circuit protection is provided for all of the auxiliary outputs by the chip's internal current limiter and thermal protection circuit.

## How it works

The SGS L4960 is a monolithic stepdown switching regulator providing output voltages from 5.1V to 40V and delivering up to 2.5A output current.

At the heart of the device is a regulation loop consisting of a sawtooth oscillator, error amplifier, comparator and source-sink output stage. An error signal is produced by comparing the output voltage with a precise 5.1V on-chip reference which is zener-zap trimmed to  $\pm 2\%$ . This error signal is then compared with the sawtooth signal to generate the fixed frequency pulse-width-modulated pulses which drive the output stage. Gain and frequency stability of the loop are adjusted by an RC network connected to pin 3.

When the loop is closed directly by connecting the supply output to the feedback input (pin 2) an output voltage of 5.1V is produced. Higher output voltages are obtained by inserting a voltage divider in this feedback path.

Output overcurrents at switch-on are prevented by the soft-start function. The error amplifier output is initially clamped by the external capacitor  $C_{SS}$  and allowed to rise, linearly, as this capacitor is charged by a constant-current source.

Output overload protection is provided in the form of a current limiter. The load current is sensed by an internal metal resistor connected to a comparator. When the load current exceeds a preset threshold, this comparator sets a flip flop which disables the output stage and discharges the soft-start capacitor.

A second comparator resets the flip flop when the voltage across the soft start capacitor has fallen to 0.4V. The output stage is thus re-enabled and the output voltage rises under control of the soft-start network. If the overload condition is still present, the limiter will trigger again when the threshold current is reached. The average short-circuit current is limited to a safe value by the dead time introduced in the soft-start network.

The thermal overload circuit disables circuit operation when the junction temperature reaches about 150 °C and has hysteresis to prevent instability.

\* Giuseppe Gattavari is with SGS Microelettronica SpA

## —SSB Adaptor, from page 41.

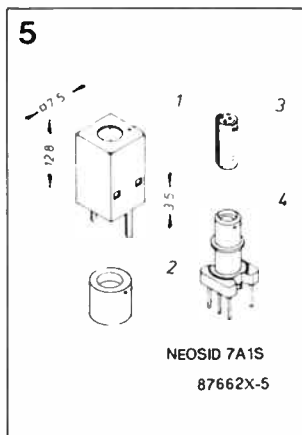


Fig. 5 The Type 7A1S inductor assembly from Neosid. 1: screening can. 2: ferrite cup. 3: iron dust core. 4: ABS former and base.

The amplitude of the output signal is made variable with  $P_1$ , enabling optimum performance with any receiver. The adaptor's output signal is connected direct to a length of insulated wire, wound as 1 or 2 turns around the receiver (inductive coupling). The adaptor is fed from a 9 V battery.

## Construction and alignment

The printed circuit board for the SSB adaptor is shown in Fig. 4. Construction is straightforward with the possible exception of inductor assembly  $L_1$  — see Fig. 5. Viewed from underneath, the base of the ABS former in the Type 7A1S as-

sembly has 5 pins, 3 at one side and 2 at the other. Inductor  $L_1$  is connected to the latter 2 pins. Close-wind 53 turns of  $\varnothing 0.2$  mm (36 SWG) enamelled copper wire onto the 2 sections of the former, and make sure that the ferrite cup (part 2 in Fig. 5) can be fitted on top. Secure the winding with a piece of Sellotape. Check the continuity at the base, and fit the former onto the PCB. Carefully slide the screening can over the former, then push-fit and solder its mounting tabs in the holes provided. Make sure that the top end of the former fits snugly in the hole in the top of the screening can. Tuning capacitor  $C_1$  and level control  $P_1$  are fitted as external components.

It is recommended to fit the SSB adaptor in a metal enclosure to prevent spurious radiation. Set variable capacitor  $C_1$  to the centre position, and  $P_1$  to maximum. Connect the coupling loop around the receiver to the adaptor output. Tune the receiver to an AM broadcast station, and switch the adaptor on. Adjust the core in  $L_1$  with a non-magnetic trim tool until a whistle (*beat note*) is heard in the receiver. Lower the frequency of the beat note by adjusting  $L_1$ , until it is no longer audible (zero beat tuning). Switch off the adaptor, and tune the receiver to an SSB station. Switch the adaptor on again, and adjust  $C_1$  and  $P_1$  until the speech becomes intelligible. B

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# SWITCH-MODE POWER SUPPLIES

Recent advances in power semiconductor technology and inductive components have boosted the use of compact, high efficiency power supplies of the switch-mode type. Now SMPs of various power ratings are becoming widely available at reasonable prices, it seems timely to focus on their design principles and practical aspects.

Most electronic circuits can not work without a power supply of some kind. The basic mains supply consists of a transformer, a rectifier, a filter (smoothing/reservoir capacitor), and a linear control circuit (regulator) for adjusting the output voltage to the desired value. It may be argued that the basic power supply has a number of important disadvantages. For relatively high powers, the mains transformer is often bulky and expensive, and the same goes for the smoothing capacitor(s). Moreover, the product of the voltage drop across the regulator and the current consumption of the load forms dissipated, and therefore wasted, power, which results in a very low overall ef-

ficiency, especially at relatively low output voltages. Not surprisingly, in the rapidly expanding world of microelectronics there arose a growing need for a high-efficiency power supply.

This need was met by the switch-mode power supply (SMPS), in which the output power is not regulated continuously, but pulsed at a relatively high frequency. An output filter is included for smoothing the supply voltage.

The filter components can be kept small thanks to the high frequency, and the same goes for the (toroidal) transformer if galvanic insulation is required.

## Basic configurations

A switch-mode power supply is essentially a DC-DC converter. The 3 basic circuit configurations are shown in Fig. 1. The **flyback circuit** works as follows. A magnetic field builds up in the inductor as long as the switch remains closed. When the switch is opened, the inductor functions as an energy source. The voltage across the inductor is reversed, and the conducting diode passes the energy to the reservoir capacitor. Note that the output voltage is reversed with respect to the input voltage.

The **forward converter** does not reverse the polarity of the input voltage. The capacitor is charged via the inductor when the switch is closed. The difference between the input and the output voltage is available on the inductor. In contrast to that in the flyback converter, the switch is closed when the capacitor is being charged. When the switch is opened, the magnetic field of the inductor is weakened via the flyback diode. The switch is, of course, a power transistor, and the di-

ode affords protection against the induced voltage. In a forward converter, the input voltage is higher than the output voltage.

The third basic configuration is referred to as **boost or step up converter**. This circuit increases the input voltage, and is functionally similar to the flyback converter. Energy is stored in the inductor when the switch is closed. When the switch is opened, this energy is supplied to the load at the output via the diode.

## The continuous and discontinuous mode

Two modes of operation can be distinguished, depending on the current in the inductor—see Fig. 2.

After closing the switch, the current in the inductor increases linearly up to a specific maximum value ( $U_i = \text{constant}$ ). After opening the switch, the current decreases linearly. The

circuit operates in the *discontinuous current mode* if the current is nought in every period. The capacitor supplies the load current during the remainder of the period. The discontinuous mode is characterized by the good response of the closed regulation circuit to fluctuations in the input voltage (*line regulation*), and the output load (*load regulation*). There is no energy in the inductor at the start of each period, and regulation can, therefore, take place on a period-to-period basis. It can, in fact, be argued that the inductor is not present in the regulator circuit. The maximum phase shift of  $90^\circ$  in the buffer capacitor ensures the stability of the closed regulation circuit. A disadvantage of the discontinuous mode is the relatively high peak current carried by the power switch. Flyback and step up converters usually operate in the discontinuous mode.

In the *continuous current*

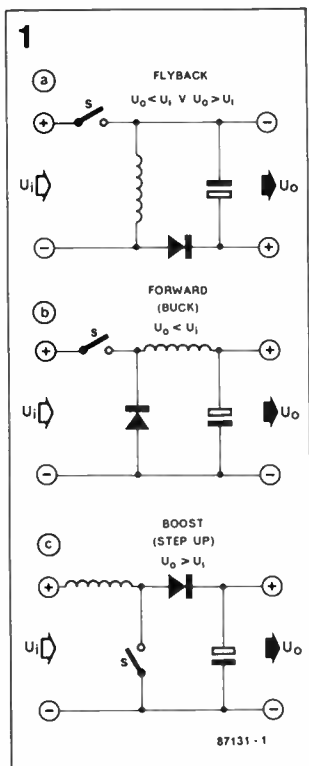


Fig. 1 The 3 basic configurations of a switch-mode power supply.

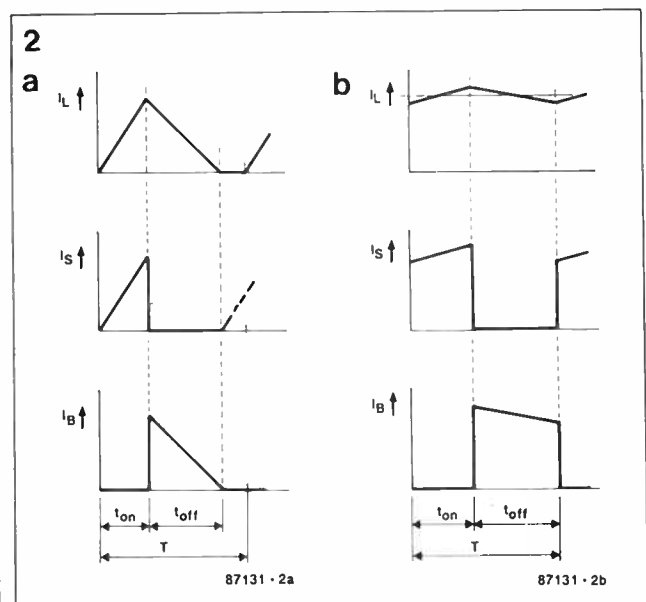


Fig. 2 The discontinuous (a) and the continuous current mode (b) differ in respect of the current carried by the inductor.

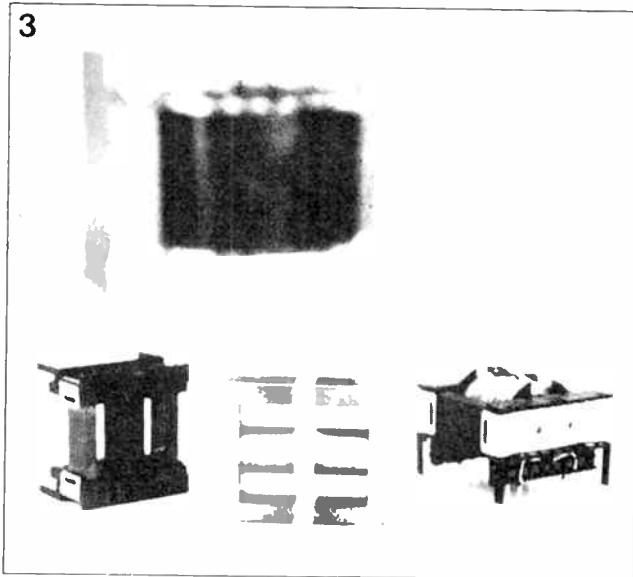


Fig. 3 A traditional soft iron core (background) and a modern ETD ferrite core of equal power rating.

mode, the current through the inductor does not drop to nought at the end of every period. The ripple current in the inductor is small relative to the load current, and this requires a fairly high self-inductance. The buffer capacitor, on the other hand, can be kept relatively small. The favourable shape factor of the current through the power transistor and the diode makes the continuous mode eminently suitable for high power applications. The response to load fluctuations is, however, worse than that of a circuit in the discontinuous mode. Each change in the output load current requires a corresponding change in the direct current through the (relatively large) self-inductance, and this process may take several periods to complete.

It is not possible for a system to automatically switch from continuous to discontinuous operation, or vice versa, because this would cause a considerable change in the open loop transfer characteristics, giving rise to instability of the closed regulation system. This means that the load current of a system in the continuous mode should be higher than half the peak-to-peak value of the ripple current in the inductor. Forward converters usually operate in the continuous current mode.

### Off-line operation

In many cases, the input voltage is a rectified and smoothed

voltage obtained direct from the mains. The direct voltage so obtained (approx. 335 V at a 240 VAC mains supply) is rarely used for converting down to, say, 12 V, in view of the resultant low duty factor, and the need for large self-inductances. Also, a direct connection to the mains is dangerous, and normally not permitted. This calls for a (ferrite) transformer, which, in an SMPS, has the advantage of being much smaller than a soft iron type used in the traditional 50 Hz mains supply (see Fig. 3). There are, however, a number of important considerations as to keeping the losses of the core material within acceptable limits. Ferrite is used instead of laminated iron, and offers a number of advantages. The construction of a ferrite core is relatively simple, and ferrite is a light and insulating material.

The turns ratio of the ferrite transformer enables converting the high input voltage down to a value close to the desired output voltage. The conversion increases the duty factor, and hence reduces peak currents in the power transistors.

### Transformer circuits

The simplest configuration of an SMPS is the single transistor flyback converter shown in Fig. 4a. This circuit is well-known in low power supplies with an output rating up to about 250 W. In this application, the transformer is more properly referred to as a coupled self-inductance,

because it assumes the function of the inductor shown in Fig. 1a. The forward converter in continuous mode is more suitable for feeding relatively heavy loads. The most commonly found version is based on a single transistor and a demagnetization winding in the primary circuit—see Fig. 4b. The transistor must be able to handle twice the input voltage. The demagnetization winding can be omitted if the circuit is extended with a transistor and a flyback diode as shown in Fig. 4c. In this circuit, the transistors need only withstand half the voltage. They are, however, driven with respect to different potentials, just as in the bridge circuits to be discussed.

Half or full bridge circuits are used mainly for high power applications. The full bridge variant is suitable for very heavy loads thanks to the fact that the effective input voltage is doubled. The last variant, shown in Fig. 4g, is also a bridge circuit, based on a centre-tapped transformer that enables the transistors to be

driven with respect to a common reference potential.

Bipolar transistors as well as power FETs can be used in the primary circuit. Bipolar technology is suitable for switching frequencies up to 50 or 100 kHz. Power FETs are faster, and can be used at higher frequencies without running into excessive switch losses. Currently, the maximum usable frequency is about 1 MHz, and power FETs are expected to become predominant in SMPSs in view of the ever increasing switching frequencies. Power FETs for relatively high voltages are, however, still quite expensive, and more attractive for use in countries with a 117 V mains supply, such as the USA.

### Core saturation

Any transformer winding forms a self-inductance, and the average voltage across it should, therefore, be nought. When this is not so, the remaining direct voltage causes an linearly increasing direct current until the core is saturated. The

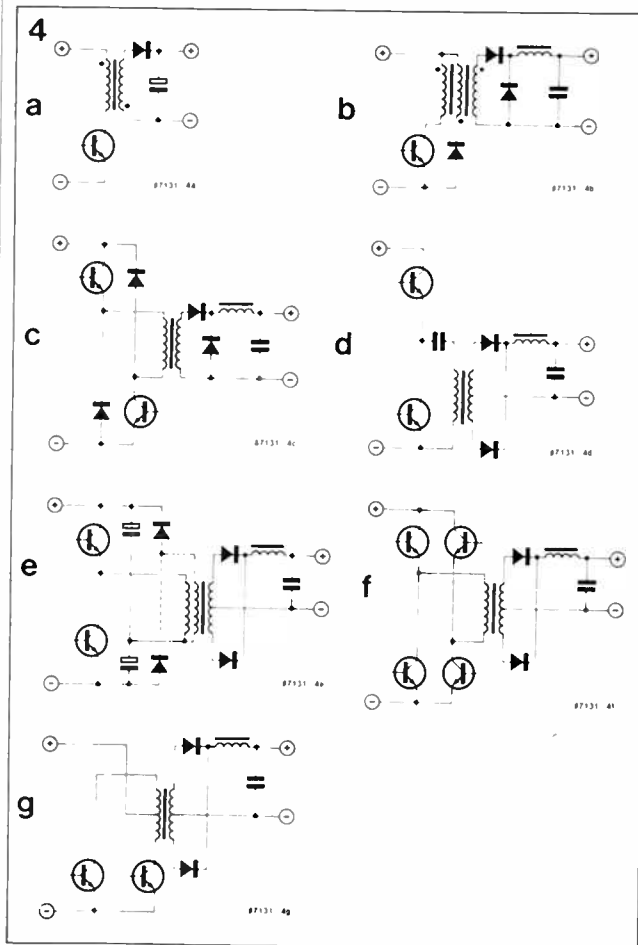


Fig. 4 Various configurations of the switching power stage in an SMPS.

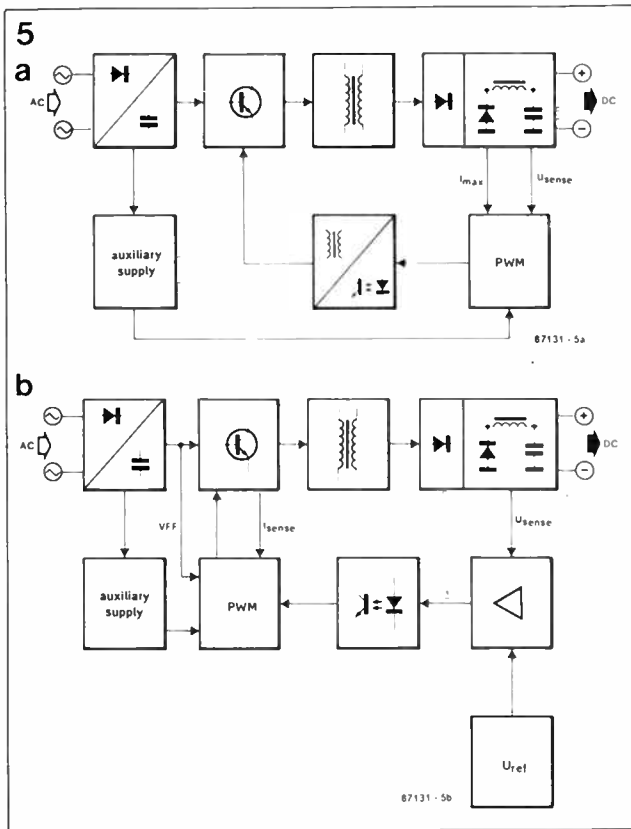


Fig. 5 Functional diagram of a SMPS with the control electronics located at the secondary side (a) or the primary side (b).

H-field, and with it the current, then increases exponentially, in accordance with Faraday's law of constant increase of the magnetic flux per unit of time. This effect must be prevented because it can lead to destruction of the primary circuit.

In the circuits of Fig. 4b and 4c, the field in the transformer core is weakened with the aid of the flyback diode(s), but only as long as the duty factor remains below 50%. Problems owing to permanent magnetization are not expected to arise in the circuit of Fig. 4d, where the coupling capacitor ensures the absence of direct current through the primary winding. The situation is more complex in Fig. 4e. Although the primary winding is AC coupled, a direct voltage may still exist at the junction of the capacitors. This positive or negative potential may arise from less than perfect (i.e., unbalanced) driving of the power transistors, which may have different recovery times also. Unbalancing of the primary circuit can be prevented with the aid of a compensation winding and 2 fly-back diodes.

A coupling capacitor for blocking the magnetizing

direct current is rarely used in the circuit of Fig. 4f, because this is rated for very high power. Both the positive and the negative current in the primary winding are measured, and any difference between them is compensated by controlling the duty factor. This safety measure can be applied to the circuit of Fig. 4g also.

### Voltage control

In a switch-mode power supply, the output voltage is measured, compared to a reference, and kept constant by controlling the duty factor of the drive signal applied to the power switches (i.e., transistors). The regulating effect of the control circuit depends on the open-loop characteristics of the system. The simplicity of the flyback converter makes it less suitable for many purposes, since the duty factor depends primarily on the load at a constant output voltage. Good voltage regulation requires a high amplification of the measuring and control circuit. In a forward converter, the voltage control circuit need not have a strongly regulating effect because in essence the output voltage

depends only on the turns ratio of the transformer (assuming a constant input voltage).

There are 3 basic types of voltage control system:

- Direct duty factor control.

The error signal is amplified, and drives a pulsewidth modulator, which in turn adjusts the duty factor as required. A high overall amplification is needed, at the cost of some stability—notably in the case of converters operating in the continuous mode.

- Voltage feedforward. This is the most commonly used system. Preregulation of the duty factor is implemented as a function of the input voltage, enabling the output voltage of the open loop system to be made independent of the input voltage. The control circuit is, therefore, only required for compensating load fluctuations. The preregulation system improves the line regulation, and so ensures sufficient suppression of hum.

- Current mode control. A second control circuit (inner loop) inside the voltage control circuit (outer loop) enables switching off the power transistor at a more or less fixed peak value of the current. The effect so obtained is the (quasi) disappearance of the inductor from the output filter. The whole system is then essentially a first order network with the capacitor in the output filter as the only phase changing element. The stability of the whole supply, as well as the response of the closed system to fluctuations in the input voltage and

the load current, is excellent. High power forward converters of the continuous type are often equipped with a current mode control for obvious reasons.

### Location of the control circuit

The voltage control circuit can be located at the primary or the secondary side of the supply. A circuit at the primary side (Fig. 5b) makes it possible to drive the power stage direct from the IC, while it is a relatively simple matter to implement circuits for primary current monitoring and preregulation. A disadvantage of the primary location is the need for an insulating device in the control loop for transmitting an analogue signal from the primary to the secondary side. This is usually done with the aid of an optocoupler. Only the error signal is transmitted to rule out instability of the output voltage owing to ageing effects in the optocoupler.

A control circuit at the secondary side (Fig. 5a) enables direct coupling of the voltage control circuit. Also, it allows the use of the reference circuit built into many of the currently available integrated SMPS controllers. The PWM signal is fed to the power stage via a fast optocoupler, or a special pulse transformer. Differences in the drive applied to several power transistors are relatively simple to monitor and correct, but the primary location makes it difficult to keep tabs on the primary current.

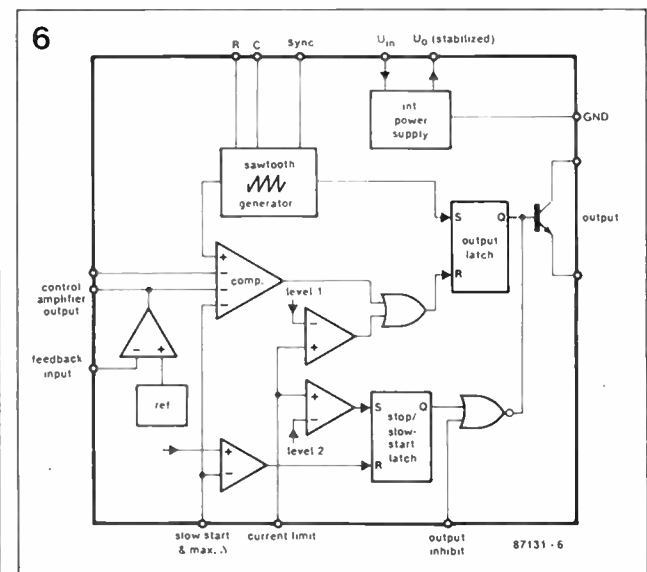


Fig. 6 General block diagram of an integrated SMPS controller.



Whatever control circuit is used, it must have its own (start) supply. The self-generated voltage is, of course, only usable after the supply is fully operational.

### SMPS controllers

A wide variety of integrated circuits is currently available for controlling switch-mode power supplies. These ICs are essentially very similar, and a general block diagram is therefore given in Fig. 6 to explain their operation.

The pulsewidth modulator is composed of a sawtooth generator, a voltage comparator and a set-reset bistable. A second input on the comparator is connected to the output of an opamp that amplifies the difference between the real and the required (set) output voltage. An accurate, and temperature compensated, voltage reference is often included for adjusting a specific output voltage.

The remainder of the circuits in the chip have auxiliary functions, and serve for various types of protection. Voltage feedforward or current mode control is possible by changing the slope of the sawtooth signal. Special control inputs make it possible to set a duty factor of nought. An analogue input is activated above a predefined voltage level, and can be used for making a 2-level short-circuit protection. When the output current reaches the first level, the duty factor is held constant, and the circuit supplies a constant, maximum, current. The duty factor is made nought above level 2. A digital input enables remote control of the supply (computer-controlled test sites, etc.).

An input for setting the maximum duty factor is standard on most SMPS controllers. Properly driven, it prevents saturation of the transformer core, and hence an exponentially rising primary current. This safety measure is especially useful for supplies operating in the continuous current mode. In these, the duty factor has a tendency to rise to the maximum value at each change in the output current, in an effort to correct the direct current through the inductor in the output filter in accordance with the new load.

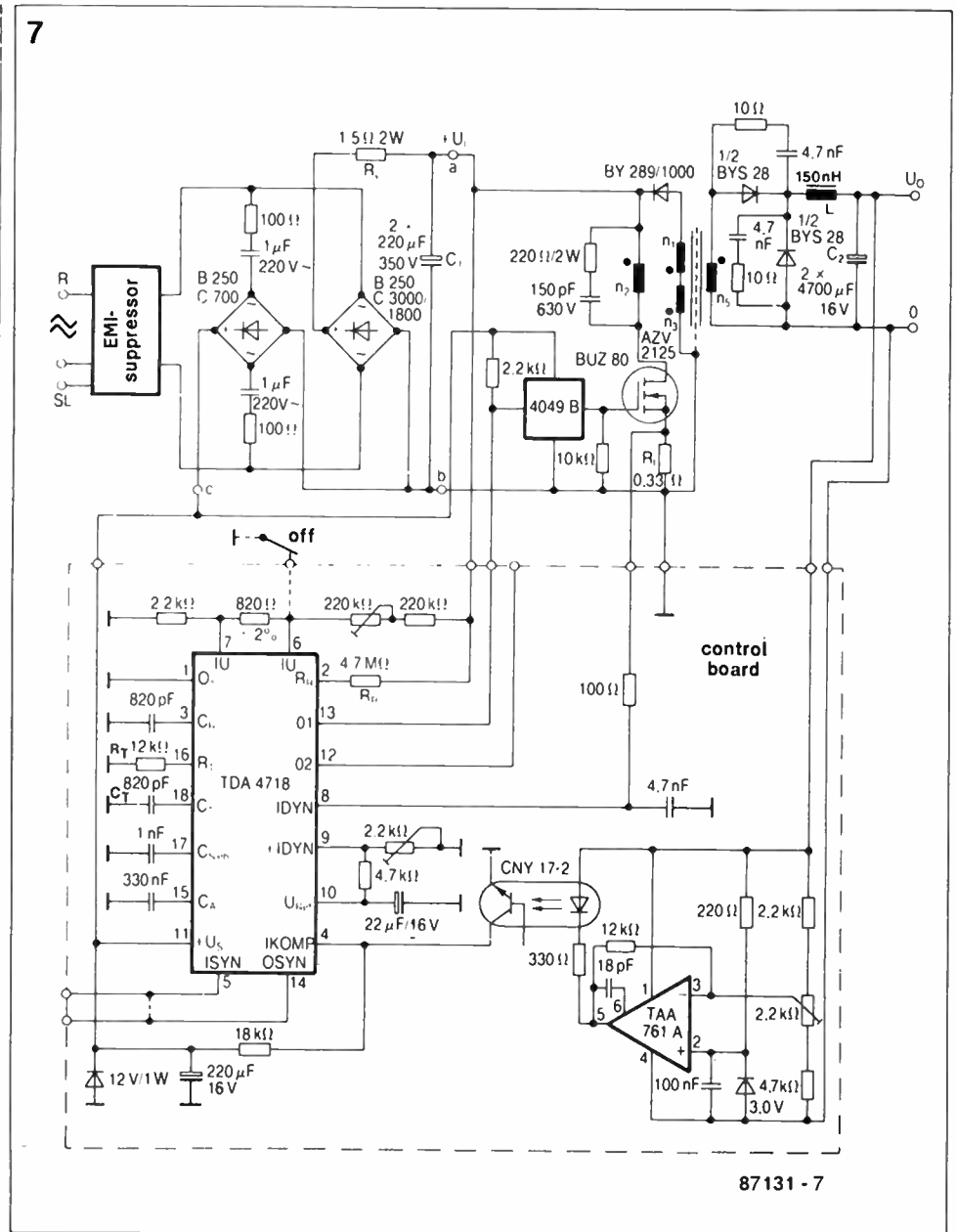


Fig. 7 Circuit diagram of a 5 V; 20 A; 50 kHz supply (courtesy Siemens).

### The multi-voltage supply

Additional supply voltages are fairly simple to implement in a SMPS with the aid of appropriate auxiliary windings on the secondary of the transformer. In computer equipment, the usual combination is a powerful 5 V section, and auxiliary  $\pm 12$  V supplies. Voltage control is usually only effected on the +5 V rail. If the magnetic coupling between the secondary windings on the transformer is sufficiently tight—this is typical of a well-constructed transformer—the output voltage of the auxiliary windings is regulated along with the main supply, at acceptable accuracy.

### Losses

Switch-mode power supplies are known mainly for their high efficiency. In spite of this, some power is, of course, wasted.

- Switching losses in the power transistors. Faster switching—e.g. with the aid of a speed-up capacitor—keeps these losses acceptable. The power loss incurred in the conductive transistor is relatively small, especially at high input voltages.
- Transformer losses can be classified as copper or core losses. At switching frequencies below 100 kHz, copper losses are the main consideration in finding the optimum specifications of the

transformer in the SMPS. Also, care should be taken to counter a considerable skin effect, which reduces the effective diameter of the copper wire as the frequency increases. Many SMPS manufacturers use litze wire for their transformers to prevent losses arising from the skin effect.

Core losses are due to eddy currents and hysteresis of the ferrite material. They depend on the so-called *flux density sweep*, and the frequency. Manufacturers of ferrite cores can supply graphs to establish the maximum permissible core losses as a function of the thermal resistance of the core, and other parameters. Core losses

form the crux in designing a transformer for use in an SMPS.

- Rectification and filter losses. These become more serious at relatively low output voltages (5 V), and are mainly due to the forward voltage drop across the diodes. Schottky diodes are often used in view of their low forward voltage drop and good switching characteristics. Some power is also wasted in the inductor as part of the output filter.

### A practical circuit

The circuit diagram of a typical switch-mode power supply is shown in Fig. 7 (Siemens Application).

Buffer capacitor  $C_1$  is fitted at the output of a bridge rectifier, which is fed from a mains filter. Power resistor  $R_v$  limits the peak charge current when the supply is switched on. The type of transformer used makes clear that the circuit is a forward converter. The primary and secondary winding ( $N_2$ ;  $N_3$ ) are in phase, as indicated by the dots. Auxiliary windings  $N_1$  and  $N_3$  serve to demagnetize the core. The dotted line in the core indicates the use of an electromagnetic shield. The configuration of the secondary output filter shows that the supply is designed for operation in the discontinuous current mode. A relatively small self-inductance is used in conjunction with a large buffer capacitance to ensure sufficient output power when the inductor carries no current. The output voltage is divided and compared to a 3 V reference. The error signal from the operational amplifier is fed to the TDA4718-based primary control circuit via an optocoupler. Components  $C_r$  and  $R_r$  define the switching frequency of 50 kHz. Provision has been made to set the maximum output current (pin 9). The maximum primary current is monitored with the aid of the network connected to pin 8. The capacitor fitted at pin 15 of the controller ensures a gradual increase of the duty factor after power-on (*soft start*). The input voltage is checked via pin 6 and 7. The duty factor is made nought when the input voltage is either too low or too high. Voltage feedforward is implemented with the aid of  $R_r$ , connected to pin 2. The switch

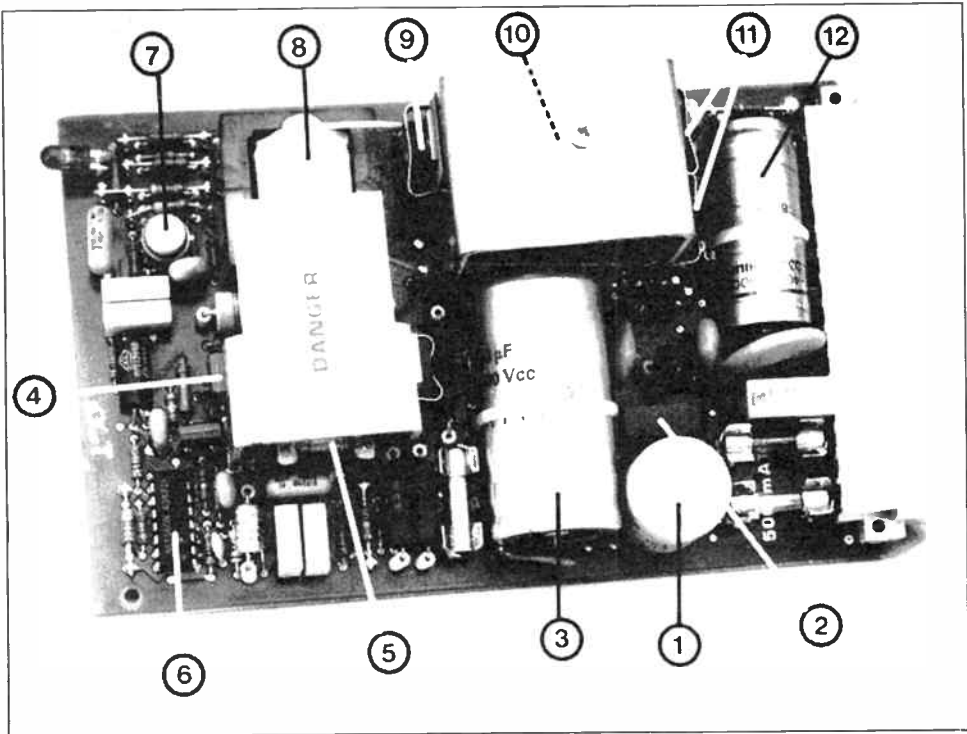


Fig. 8 A compact switch-mode power supply.

signal at the output of the controller is fed to the power MOSFET via a number of parallel CMOS buffers contained in a CD4049 package. The control circuit is fed from the mains via a capacitive voltage divider. Figure 8 shows a compact SMPS fitted on a printed circuit board. The arrows point to the following, essential, parts: (1) mains filter; (2) primary rectifier; (3) buffer capacitor for primary voltage; (4) switching transistor; (5) pulse transformer for base drive; (6) SMPS controller for pulsewidth modulation; (7) (secondary) voltage reference and error amplifier; (8) ferrite core transformer; (9) primary flyback diode for weakening the transformer field; (10) inductor in output filter; (11) secondary rectifier and flyback diode; (12) output capacitor.

### Further developments

The scope of this introductory article does not allow a detailed discussion of all the technical considerations that go into designing a switch-mode power supply. The theoretical aspects of the SMPS have been known for some time, but it was not until the coming of fast power transistors, integrated controllers and new ferrite materials that serious development of the SMPS was launched. Ever

### For further reading:

- *High frequency power transformer and choke design. Part 1.. 4 incl.*; Philips Technical publi-

- cation, September 1982.
- *Electronic Components & Applications. Vol. 2, No. 1*; Philips, November 1979.
- *SGS power supply application manual*; July 1985.

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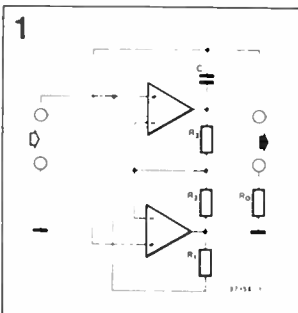
by A.B. Bradshaw

One of the very practical means of simulating inductance in electrical circuits is by the use of gyrators. The positive impedance converter is a member of this family. Its main use is to replace wound inductors in AF circuits, particularly where these have large values, or to simulate coils at very low frequencies.

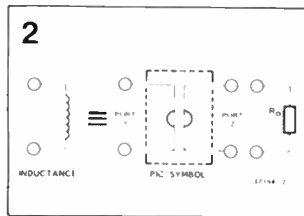
The positive impedance converter makes use of operational amplifiers: two are needed to simulate a grounded inductor; four are required to simulate a balanced inductor. But only four opamps are needed to simulate a node, containing balanced and grounded inductors, as will be shown later. Where simulation of grounded inductors is used, the opamps should be operated from balanced power supplies.

The writer has used the PIC as a circuit element for a number of years in the design of high-performance AF filters. The Q values obtained with these devices is very much higher than that of the wound equivalent. Instability problems are rare. Although the frequency response of the opamps usually limits the operating range of PICs to about 40 kHz, this is adequate for most AF and even a number of data filtering requirements.

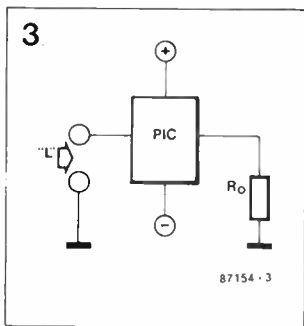
The circuit diagram of a typical PIC is shown in Fig. 1. The input impedance of this circuit appears as a pure inductance when the output is grounded through  $R_o$ . Resistors  $R_1$ ,  $R_2$ , and  $R_3$ , as well as capacitor  $C$ ,



are normally 1% types. Resistor  $R_o$  is used as the inductance setting component.



The general symbol of a PIC is shown in Fig. 2, but in practical circuits, when used as a circuit element, it is usually indicated as in Fig. 3.



## Analysing the PIC

The analysis of gyrators is normally performed with the aid of matrix algebra and the formal nodal analysis of network theory. The formal approach has a lot to offer as regards generality, but it sometimes tends to obscure the practical operation of the circuit. Because of this, the writer has adopted an approach which will be familiar to most readers. Assuming that opamps are perfect, the analysis can be

simplified considerably. In an ideal opamp,

- the voltage gain is infinite:  $A_{vo} = \infty$ ;
- the input resistance is infinite:  $I_{in} = \infty$ ;
- the output resistance is zero:  $I_{out} = 0$ ;
- the bandwidth is infinite:  $BW = \infty$ ;
- there is zero input offset voltage:  $E_o = 0$  if  $E_{in} = 0$ .

Since the voltage gain is infinite, any output voltage is the result of an infinitely small input voltage. In effect, therefore, the **differential input voltage is zero**.

The preceding assumptions are used as axioms in the following. For the purposes of examining the operation of a PIC, it is redrawn in Fig. 4. Some of the voltages and currents are shown twice to emphasize the circuit action.

$$(V_1 - V_2)/R_3 = I_3 \quad \text{Eq. 1}$$

$$(V_1 - V_3)/R_2 = I_5 \quad \text{Eq. 2}$$

$$(V_1 - V_4)/R_1 = I_2 \quad \text{Eq. 3}$$

Since the input resistance of the opamps is infinite,  $I_o = 0$ , whence

$$I_3 = I_5$$

and

$$I_2 = I_{in}$$

From Eq. 3:

$$V_1 - V_4 = R_1 I_2 = R_1 I_{in}$$

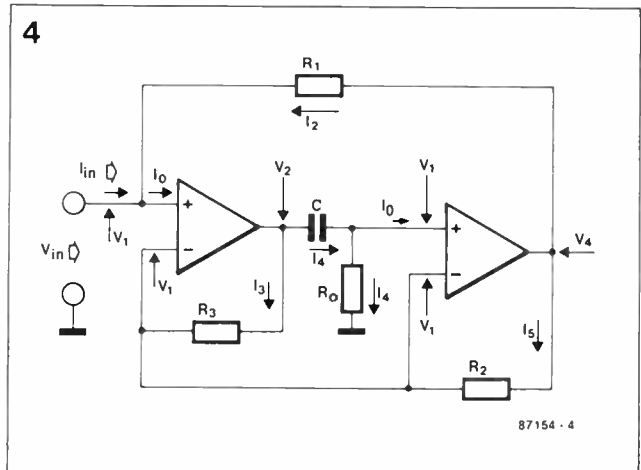
Dividing both sides by  $R_2$  gives

$$(V_1 - V_4)/R_2 = I_{in} R_1 / R_2 \quad \text{Eq. 4}$$

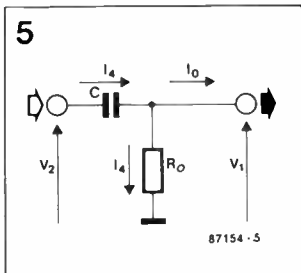
Since  $I_3 = I_5$ , Eq. 1 is equal to Eq. 2, so that

$$(V_1 - V_2)/R_3 = (V_1 - V_4)/R_2 = I_{in} R_1 / R_2 \quad \text{Eq. 5}$$

To remove  $V_2$  from Eq. 5, consider the middle section of Fig. 4, which for convenience's sake is reproduced in Fig. 5.







$$V_1 - V_2 = I_4 = j\omega C$$

Also, since  $I_o = 0$ ,  $I_4 = V_1 / R_o$

Combining these expressions gives

$$V_1 - V_2 = V_1 / j\omega C R_o \quad \text{Eq. 6}$$

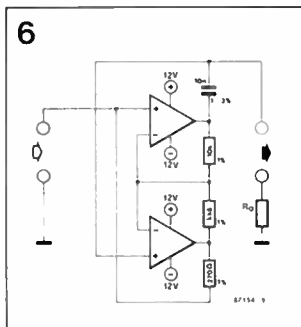
Dividing both sides of Eq. 6 by  $R_3$  gives

$$(V_1 - V_2) / R_3 = V_1 / j\omega C R_o R_3$$

in which the left-hand term is also that of Eq. 5, whence

$$I_{in} R_1 / R_2 = V_1 / j\omega C R_o R_3$$

from which  $V_2$  has been removed.



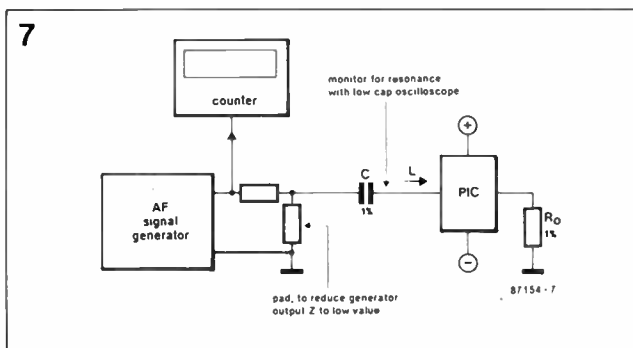
Cross multiplying this last expression yields

$$V_1 / I_{in} = j\omega C R_o R_1 R_3 / R_2$$

Since  $V_1 = V_{in}$ ,

$$V_{in} / I_{in} = Z_{in} = j\omega (C R_1 R_3 / R_2) R_o$$

which is the expression for a pure inductance in which



$$L = (C R_1 R_3 / R_2) R_o$$

$$\text{If } K = C R_1 R_3 / R_2,$$

$$L = K R_o$$

$K$  is called the conversion factor of the PIC.

This completes the basic analysis of the PIC without the need of anything more than elementary AC theory and algebraic manipulation.

### Practical applications

The numerical values of  $R_1$ ,  $R_2$ , and  $R_3$  affect the signal handling capabilities of practical opamps and are, therefore, a compromise. Typical values are:

$$R_1 = 270R \quad 1\%$$

$$R_2 = 5k6 \quad 1\%$$

$$R_3 = 10k \quad 1\%$$

$C = 10 \text{ nF } 1\% \text{ silver mica (two } 5000 \text{ pF types in parallel).}$

These values enable the computation of  $K$ :

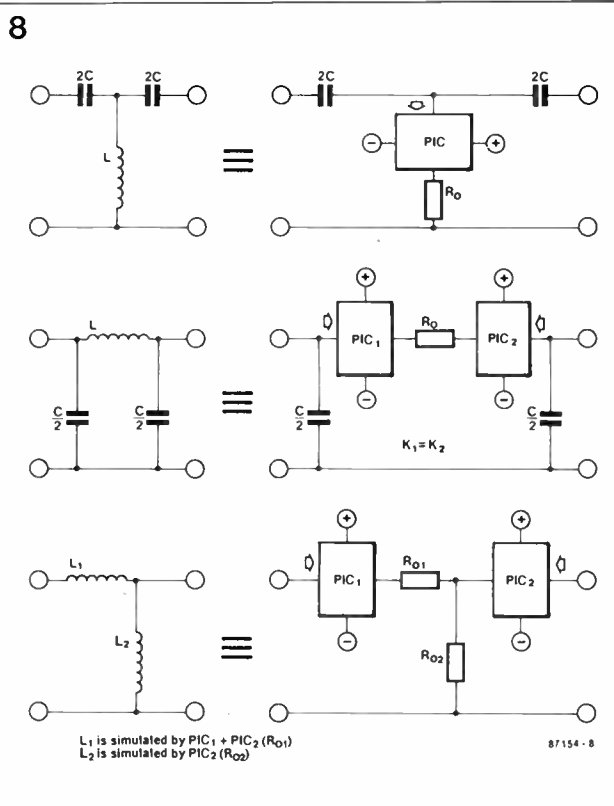
$$K = C R_1 R_3 / R_2 = 270 \times 10^4 \times 10 \times 10^{-9} / 5.6 \times 10^3 =$$

$$= 4.8214 \times 10^{-6}$$

In practice, the author used an MC1458 operating from a  $\pm 12 \text{ V}$  power supply, which has a  $K = 5.7155 \times 10^{-6}$ . The departure from the ideal  $K$  value is due to the approximations used with the opamps: this is not a real problem in practice. The complete circuit of the PIC with the values stated is given in Fig. 6.

### Checking the value of $K$ in practice

Build the circuit of Fig. 6 and bring it to series resonance with the aid of a test set-up as



shown in Fig. 7. If the generator equivalent impedance is small and  $C$  is known accurately, the frequency,  $f$ , can be measured. Since

$$f = 1 / 2\pi \sqrt{L_{eff} C},$$

and

$$L_{eff} = K R_o$$

$K$  can be found to 1-2% accuracy once  $R_o$  is given.

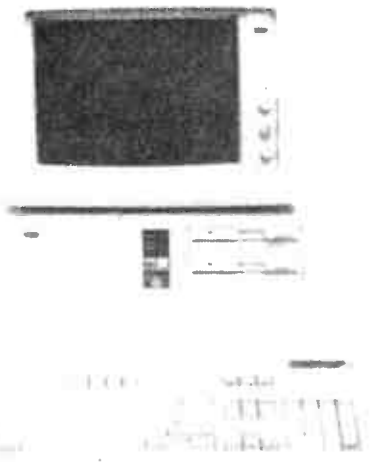
The conversion factor can be trimmed by small adjustments to  $R_3$ .

Inductances are simulated by PICs as shown in Fig. 8, where (a) is grounded coil simulation; (b) is balanced coil simulation; and (c) is grounded and balanced coil simulation. In (c),  $L_1$  is simulated by  $\text{PIC}_1 + \text{PIC}_2 (R_{o1})$ , and  $L_2$  by  $\text{PIC}_2 (R_{o2})$ .

In conclusion, the author would emphasize that the PIC is a very useful circuit element and should not be left shrouded in mystery. It is hoped that this article will help it find much larger appreciation and application.

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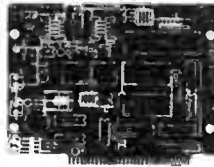
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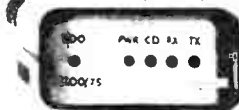
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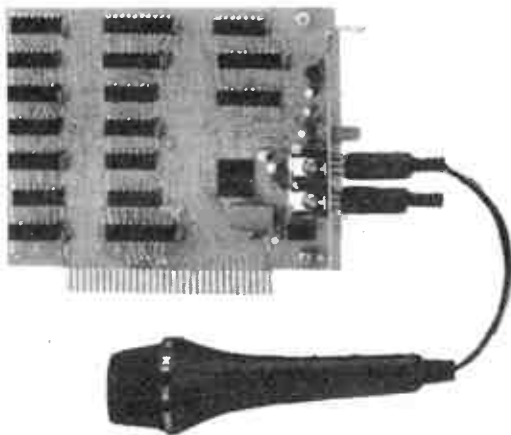
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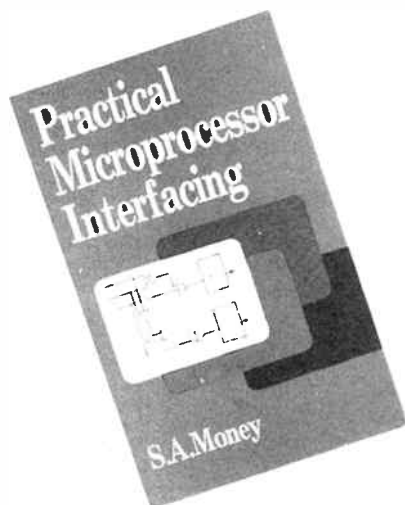
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**PRACTICAL MICROPROCESSOR INTERFACING** by S.A. Money. Collins Professional Books, 1987. Hard covers, 247 pages 150 x 235 mm. ISBN 0-00-383329-1. \$68.00 rrp. Review copy from Blackwell Scientific Publications, 107 Barry Street, Carlton, Vic. 3053.

WHILST intended as a reference book for engineers and designers of microprocessor based equipment, this practical book contains much information for the enthusiast. Although the book would not be considered a beginners' text, the opening chapters provide some good, down to earth material about different CPUs and bus systems.

Microprocessors covered in the initial chapters include the 6800/6809, 6500, 8085, Z80, 68000 and 8086 devices. Full details of the various bus systems employed are described and some useful comparisons between the various devices are made.

The book continues in logical order, with chapter 2 describing types of memory systems and decoding schemes and how these can be applied to specific microprocessors described in the first chapter. There are plenty of circuit diagrams to aid the reader and these are of sufficient detail to be used in practical applications.

Chapters three and four are concerned with parallel input and output, including practical designs for parallel interfaces. It is in these chapters that we start to see the author's seeming preoccupation with the 6800 series devices as chapter four on practical parallel interfaces deals almost exclusively with the 6821 PIA chip. Whilst these devices do have a wide application, there are other devices which are equally popular. To be fair, a few pages are devoted to the Z80 PIO in chapter three.

Chapters five and six deal with serial I/O schemes, with chapter five providing some good information on protocols and general principles. A description of both RS232C and RS449 serial interfaces is provided, as is a brief section on modulation and de-modulation methods. I still haven't made up my mind about the author's assertion that "The signals on all RS232 lines normally swing between voltage levels of +6 V (space) and -6

V (mark)". I was always led to believe that  $\pm 25$  V was closer to the mark (or should that be space!).

Chapter six is a little wider in the devices covered than the previous chapter on parallel interfacing. Devices such as the 6850, 6852, 8251 and the Z80 SIO are covered in good detail.

Chapter seven covers timing and counting systems and details devices such as the 8253, 6840 and 6818. The remaining chapters cover analogue input and output in good detail and the final chapter describes interrupt operation.

There are three appendices covering the ASCII code table as well as RS232C and RS449 signals and a comprehensive list of further reading is provided for those who wish to delve deeper.

In all, the book will be a useful reference to those who are designing systems incorporating microprocessors. There are a great many specialised interface chips available these days and it would be impossible to cover all of them in a book of this size. Sufficient background and theory has been provided in this text to enable an understanding of the principles involved in interfacing, even if the hardware for some schemes is not included. Definitely a book for the engineer, but at \$68.00 recommended retail, I can't see too many copies in the hobbyist bookshelves.

Andrew Keir



**COMPLETE HANDBOOK OF ELECTRONICS TROUBLESHOOTING - A Six-Step Guide**, by James W. Jacox. Prentice-Hall, 1987. Hard covers, 136 pages, 185 x 242 mm. ISBN 0-13-161050-3. \$66.50 rrp. Review copy from Prentice-Hall of Australia Pty Ltd, 7 Grosvenor Place, Brookvale 2100 NSW.

THE AIM OF THIS BOOK is to "... provide a simplified, logical approach to troubleshooting for any type of system (electrical, mechanical, hydraulic, etc)." According to the author "... it has been prepared for individuals (hobbyists, beginning students, working technicians, etc) who require the skill of troubleshooting equipment yet may not have a background in electricity or electronics."

Now to prepare a book to those specifications is a pretty tall order! But I can say the author has achieved his aims. He teaches you how to take a logical, systematic approach to troubleshooting, to divide a simple or complex piece of equipment into smaller functional units for easier analysis and to use all the "tools" and indications at hand to help your task - eyes and ears, along with instruments, diagrams and notes, etc.

The book is organised in 10 chapters. The first is an introduction, covering the whys and wherefores of a systematic approach and detailing the six-step procedure of symptom recognition, symptom elaboration, listing of probable faulty functions, localising the faulty section, localising trouble to the circuit and failure analysis. Chapters 2 through 7 take these as headings and the author elaborates on each at length.

So, stage by stage, Jacox takes you through all the routines associated with each step, using examples and questions along the way to reinforce the knowledge you gain as you go. Jacox makes the very useful point that you should write down your data, from that first presented, right through each step you take, including results of all tests and adjustments - even those which seemingly have little or no bearing on the problem or no effect.

Chapter 8 covers "A Typical Service Manual", in this case, a TV receiver. Although this describes an American NTSC system receiver and is thus of limited application here, it is nonetheless of some use. Chapters 9 and 10 then go on to show practical troubleshooting procedures using this equipment as a model.

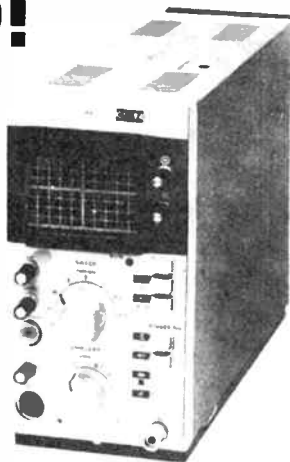
Ignoring the last three chapters, this book should teach you the fundamentals of electronics troubleshooting, and you'll learn it in a thoroughgoing manner which will stand you in good stead no matter what you may come across in the future. The only let-down is the last three chapters. Mistakes seem to have crept into the diagrams in Chapter 8. Figure 35 is a two-part diagram showing simple RC high pass and low pass filters, yet it is labelled "Low-pass filter circuit". And again, Figure 36 shows a UJT vertical oscillator circuit, with waveforms. A resistor from base 1 of the UJT to ground is missing, yet a waveform at base 1 is shown. However, these are minor quibbles and in no way detract from the rest of the book.

It's pretty pricey at a recommended retail price of \$66.50, so I doubt it will find its way onto many hobbyists bookshelves, but if you have to tackle service and maintenance jobs on a regular basis, then it would be invaluable. Even if you've been in the game a while, it could serve as a valuable "brush up" text. If you are only new to the game, or only need to undertake troubleshooting infrequently, then I would regard this book as essential. I'd recommend it as a "library text" for any service or maintenance workshop where it could be shared by a number of people. Our review copy came from Prentice-Hall Australia.

Roger Harrison



## The comrades' CRO!



Jaycar Electronics has limited stocks of a single trace, 10 MHz oscilloscope which must surely rate as one of the best bargains to appear on the market in a decade, or more.

Ideal for the budget-conscious enthusiast or serviceman, the instrument is made in the USSR and if you have ever seen Russian electronic equipment before, you will understand Jaycar's claim that it is "very solidly" constructed.

The instrument has a 75 mm (3") tube with square graticule and is supplied complete with a set of 10:1 probes. Both the horizontal and vertical deflection systems are properly calibrated, not continuously variable like some cheaper instruments, and a triggered sweep mode is provided.

According to Jaycar, most of the parts in the instrument are completely standard. If you are at all worried about spares, a comprehensive spare parts kit can be purchased for only \$20.

The instrument is powered from the 240 Vac 50 Hz mains and measures 100 mm x 180 mm x 250 mm. Mass is 3.5 kg. Priced at only \$399, you will have to be very quick as stocks are strictly limited.

Jaycar say they are so excited about this particular instrument that they are considering stocking a whole range of USSR-made test equipment including more stocks of this oscilloscope, but the price may never be this low again.

See your nearest Jaycar store or dealer for more information. The catalogue number for the oscilloscope is QC-1910 and the spare parts kit is QC-1911.

### DSE "seconds" centre

Dick Smith Electronics has established a "seconds" centre at their Chullora store in Sydney. Here you can buy a variety of DSE products at discount prices – demo models, stock repairs, samples etc. Most items have a normal DSE 90-day warranty, too!

Also featured at their Chullora centre are hobbyist "junk" bins – full of economically unrepairable or unserviceable products, broken samples, end-of-run items, etc. You can raid them for bits and pieces, otherwise unobtainable hardware items – or even try repairing them yourself! Of course, the "junk" items have no warranty.

So, chortle out to Chullora, you can't miss the DSE store right on the Hume Highway, and check out the bargains. It'd be worth a regular trip.

### Coil pack bargain

Tandy stores are currently running a ripper special on their "inductor assortment" pack. This comprises a 30-piece set of pre-wound coils and RF chokes, and it'll only set you back 99¢!

The pack contains quite an assortment of RF and IF coils

and transformers, video peaking chokes, RF chokes, etc. Now's the time to stock your "junk box" – every enthusiast has one!

Tandy has some 350 stores Australia-wide, so check your phone book for the nearest if you've forgotten where it is.

### SIL resistors

Looking for those single-in-line (SIL) resistor networks so widely used in digital circuits? Well, stop. Geoff Wood

Electronics is now stocking a range of 10-pin, nine resistor SIL package networks.

They are available in values of 220R, 330R, 470R, 680R, 1k, 2k2, 3k3, 4k7, 10k, 22k, 33k, 47k, 100k, and 200k. They're rated at one-eighth watt and have a standard tenth-inch pin spacing. And they're only 60¢ each!

Slip out for your SILs to Geoff Wood Electronics, 229 Burns Bay Rd, Box 671 Lane Cove West (PO Box 671 Lane Cove) 2066 NSW. (02)427 1676.

### PROJECT BUYERS GUIDE

Our feature project this month, the AEM6112 Active Two-way Loudspeaker is a system built up from several existing projects we've published: the 6102 Two-way Loudspeaker, the 6500 Universal MOSFET Amp module, the 6503 Active Crossover and the 6011 Balanced Line Driver. All are available as kits from Jaycar. The power supply components are all stock standard components from Jaycar also, along with many other retailers.

The AEM4601 Baud Rate Converter is based around the General Instruments AY-3-1015D UART. General Instruments ICs are currently represented by RIFA. Jaycar list it as a standard catalogue item ZK-8805. It is also obtainable through Geoff Wood Electronics, where we purchased several for our prototypes. Jaycar will be stocking this project as a kit, I understand.

The AEM3014 Multiband Trap Dipole Antenna should present few problems to intending constructors. As mentioned in the article, suitable 100 pF/3 kV ceramic capacitors are stocked by Jaycar, but other retailers may have them. If you choose to try dipped silver mica capacitors, try Stewart Electronic Components in Huntingdale, Melbourne. For those intending to make up coax capacitors, RG174 is widely available. It is stocked by Dick Smith and Jaycar, at least.

In this month's Elektor section, components for the IEC-Centronics Interface are all widely available at electronics retailers, so intending constructors should have no difficulty with this one.

The Low-Noise Mic Preamp specifies 1% resistors, with E96 series values. You'll have to shop around for these, but Stewart Electronic Components in Melbourne might be able to assist. Likewise with the capacitors. The OP-27 op-amp specified is rare, but the NE5534 may be substituted and is widely available.

The SSB adaptor employs readily available components, with the exception of the Neosid coil assembly, which has been scarce for some years. However, a 455 kHz IF transformer can be readily substituted here and various types are available from several retailers. Dick Smith stocks a set of 455 kHz IF and detector coils and one of these could be pressed into service. These have an internal resonating capacitor which may be removed (carefully!) to provide the widest frequency swing with the tuning capacitor specified. However, it's not essential, the frequency swing is just restricted which has the advantage of providing some vernier adjustment.

For the 200 pF tuning capacitor, one section of a transistor radio tuning gang could be used as they have a typical maximum capacitance in this region. The RF chokes are available from Stewart Electronic Components in Melbourne and Geoff Wood Electronics in Sydney.

Readers should be aware that All Electronic Components in Melbourne is gearing-up to stock a range of AEM and Elektor pc boards. Force Electronics in Adelaide also stocks a range of AEM pc boards, as do Eagle Electronics. In Sydney, Hi-Com Unitronics stocks some of the more specialised AEM and Elektor pc boards. We also keep a range of pc boards in stock ourselves. Just call us on (02)487 1207.

# An active two-way loudspeaker system

**David Tilbrook**

Technical Systems Australia Pty Ltd

The concept of an active, or electronic, loudspeaker system has been around for some time. But it has taken quite a while for the concept to gain acceptance. An electronic loudspeaker system, with its predictable and carefully controlled active crossover, offers unique advantages. And home construction offers considerable savings.

IN THE CONVENTIONAL passive loudspeaker the output of a power amplifier is fed to the input of a set of passive filters, generally referred to as the crossover network, usually mounted within the loudspeaker. The purpose of this network is to divide the signal into the different frequency bands required by the various drivers employed within the loudspeaker. In a two-way passive loudspeaker the audio spectrum is split into two bands, a low pass filter separating the frequencies for the bass driver and a high pass filter separating the frequencies for the other driver which handles the upper-mid and high frequency ranges. The frequency where the two filters "meet" is called the crossover frequency. The idea is illustrated in Figure 1.

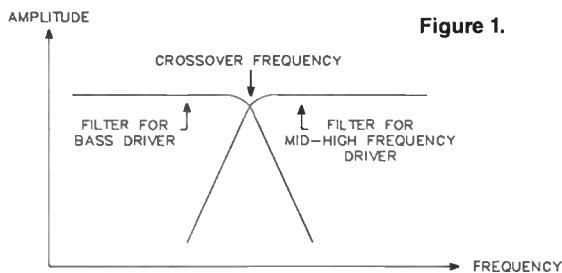


Figure 1.

In the AEM6102 Two-way Loudspeaker, described in our August 1985 issue, the crossover frequency is set at around 2.5 kHz. A 200 mm (8") polypropylene cone woofer is used to cover the frequency range from low frequencies up to this frequency point, while a 25 mm dome tweeter is employed to handle the frequencies from the crossover point through the upper midrange to the high frequencies. The two drivers have slightly different sensitivities and this is corrected for within the crossover by the introduction of a potential divider connected between the output of the filter section and the input of the driver. See Figure 2.

The use of this passive crossover network and potential divider causes a number of significant problems which degrade the sound quality of the loudspeaker.

The long speaker cables from the output of the power amplifier to the input of the loudspeaker, the dc resistance introduced by inductors within the crossover network and the potential dividers used to compensate for the different sensitivities of the drivers, all combine to decrease the effective "damping factor" of the power amplifier. Remember that most power amplifiers employ negative feedback which

decreases their output impedance and ensures true voltage drive to the loudspeakers.

Since a dynamic loudspeaker consists of a coil of wire interacting with a magnetic field, the movement of the cone itself generates a voltage which is referred to as the back emf. This changes the apparent impedance of the loudspeaker and alters the frequency response characteristics of the drivers. In the case of a bass driver for example, the effect of these resistances is to raise the Q of the driver, producing a system with a more pronounced, but less clearly defined, bass end.

Transients are muddled somewhat as the woofer has a greater tendency to "ring" in response to base transients. If the effect of these series resistances could be removed, then the negative feedback loop of the power amplifier is more closely coupled to the voice coil of the driver and it can then more accurately maintain a condition of constant voltage drive to the loudspeaker. This greatly helps to overcome the effects of the back emf and enables the driver response to be tightly controlled.

Another problem which results from the use of a passive crossover is that all passive filters assume a known, fixed, load impedance in order to function correctly. Designers of passive loudspeakers must usually introduce additional RC networks in parallel with the driver to linearise its impedance so that it provides a more appropriate load to the passive filter section within the crossover. While this works from a practical point of view, it is far from optimum since it makes extremely difficult to match the high pass and low pass sections of any crossover. ▸

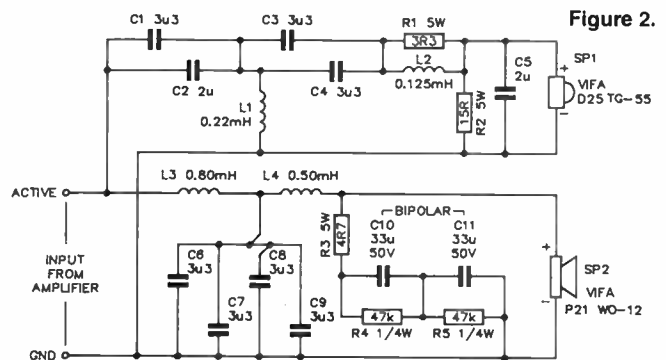


Figure 2.

CIRCUIT DIAGRAM—AEM 6102 PASSIVE 2-WAY CROSSOVER



Even if the design of the passive crossover were perfect and the component tolerance were exact, the variation in the load impedance due to different drivers limits the accuracy with which high pass and low pass sections around any crossover point can tract each other. Of course, in a practical crossover it is not possible to match component tolerances exactly and the design of passive crossover filters leaves a great deal to be desired.

Conventional passive crossover sections are formed from combinations of capacitors and inductors to form low and high pass filters. The number of inductors and capacitors employed determines what is referred to as the "order of the filter", which is a specification of the rate of attenuation of audio signals outside the passband set by the filter. A first order filter for example, attenuates signals outside its passband at a rate of 6 dB per octave. A second order filter attenuates these at a rate of 12 dB per octave while a third order filter, such as that employed in the AEM6102 speakers, attenuates these frequencies at a rate of 18 dB per octave.

Each of these filter types has advantages and disadvantages and the correct type for any application is usually chosen to suit the requirements for that particular application.

First order passive crossovers provide an overall flat frequency response when the listening position is equidistant from both drivers. Unfortunately, the crossover generates a 90 degree phase difference between the outputs of the two drivers at the crossover point. As the listening position is changed either above or below the point of equi-distance, the 90 degree phase shift would be converted to either a zero or 180 degree phase shift, resulting in a corresponding change in the frequency response of the system as the sound waves arriving at the listener's ears either add or subtract, respectively, resulting in either a hump in the response or a hole in the response.

This is a disadvantage of the first order crossover since the frequency response of this system has a tendency to change at different listening positions. An advantage of the first order crossover, however, at least at the point of equi-distance, is that phase errors introduced by the low pass section are cancelled by phase errors introduced by the high pass section so that at the point of equi-distance an overall phase correct crossover can be produced. It is important to realise however, that this is only true provided that the drivers are compensated for time delays created by the different voice coil positions and on the assumption that the drivers themselves are phase correct.

The second order crossover produces a 180 degree phase shift between the outputs of the two drivers. This is usually compensated for by reversing the polarity of one with respect to the other. The frequency response of the system then usually exhibits a 3 dB peak at the crossover point and a non-linear phase response. The faster rate of attenuation outside the passband, however, makes this a useful filter type and this is by far the most commonly employed.

The third order filter provides 270 degree phase shift between the drivers and therefore the same phase problems as the first order filter. It does provide, however, a significantly more useful rate of attenuation outside the passband,

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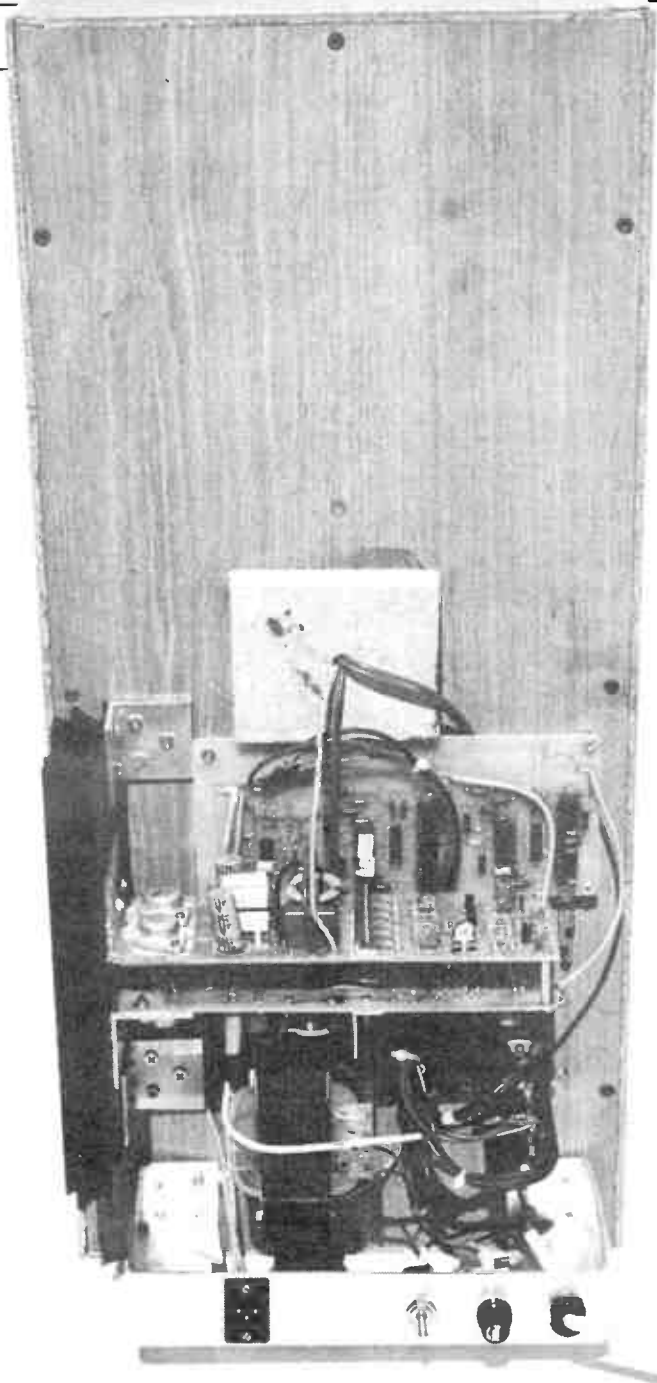
### LEVEL

We expect that constructors of an

### INTERMEDIATE

level, between beginners and experienced persons, should be able to successfully complete this project.

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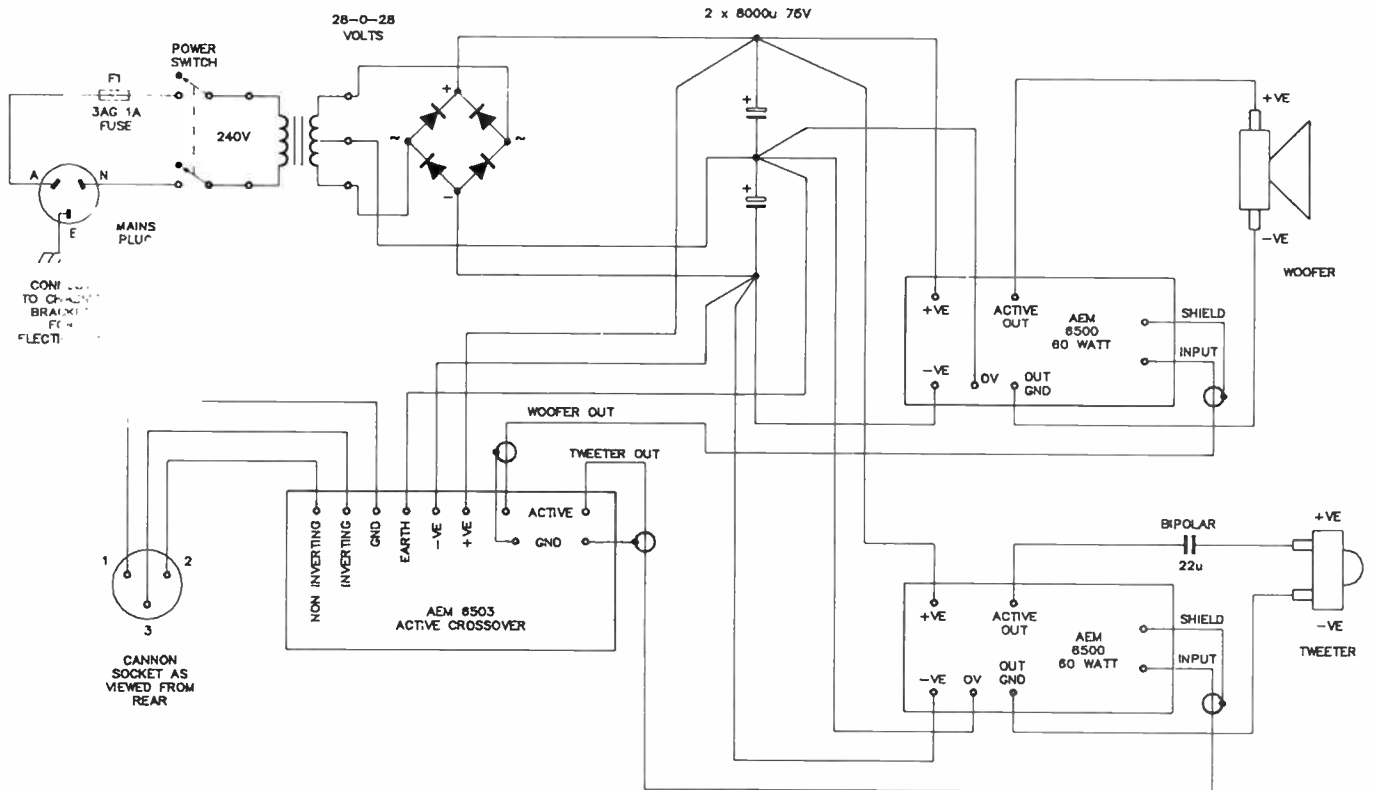


although at the expense of even greater phase errors. A third order filter is particularly useful in two-way loudspeakers for a rapid rate of attenuation outside the passband is often required. It is for this reason that this filter type was chosen for the initial design of the AEM6102 two-way loudspeakers.

### Evolution of the active speaker

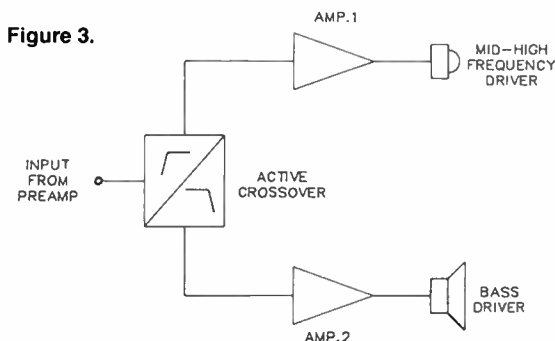
In order to overcome many of these problems, the concept of an active loudspeaker has evolved. In an active loudspeaker separate power amplifiers are used for each driver. No passive crossover or resistive potential dividers are fitted between the outputs of the power amplifier and their individual drivers. In this way the damping factor of the power amplifiers can be used to control the drivers. The crossover function is provided by an active or electronic crossover which is fitted prior to the power amplifiers. In this way the filter characteristics of the electronic crossover are well defined and are independent of





the type of load presented by the drivers. Furthermore, electronic crossovers can be designed to provide higher rates of attenuation outside the passband. Figure 3 illustrates.

The active crossover used in this project is the AEM6503, which was described in February 1986. This is a fourth order, 24 dB per octave active crossover which has the advantage that the output for all drivers remain in phase with each other for all frequencies. A loudspeaker therefore, does not change its character for different listening positions and the relatively high rate of attenuation outside the passband allows far greater flexibility in the choice of driver used.



The AEM6503 was designed to be driven from the output of a preamp. For that reason, it features a balanced input so that the long wires from the preamp. will not be susceptible to hum pickup.

The outputs of the different sections of the active crossover can be adjusted to compensate for the different sensitivities of the drivers without the necessity of inserting potential dividers after the power amplifiers. Another advantage of the active loudspeaker technique is that it is much easier to introduce networks to compensate for frequency response and phase characteristics of the separate drivers than it is in the passive approach. Frequency and phase response correction networks can be introduced as either part of the active cross-

overs or within the feedback loop of the power amplifier used to power the different drivers.

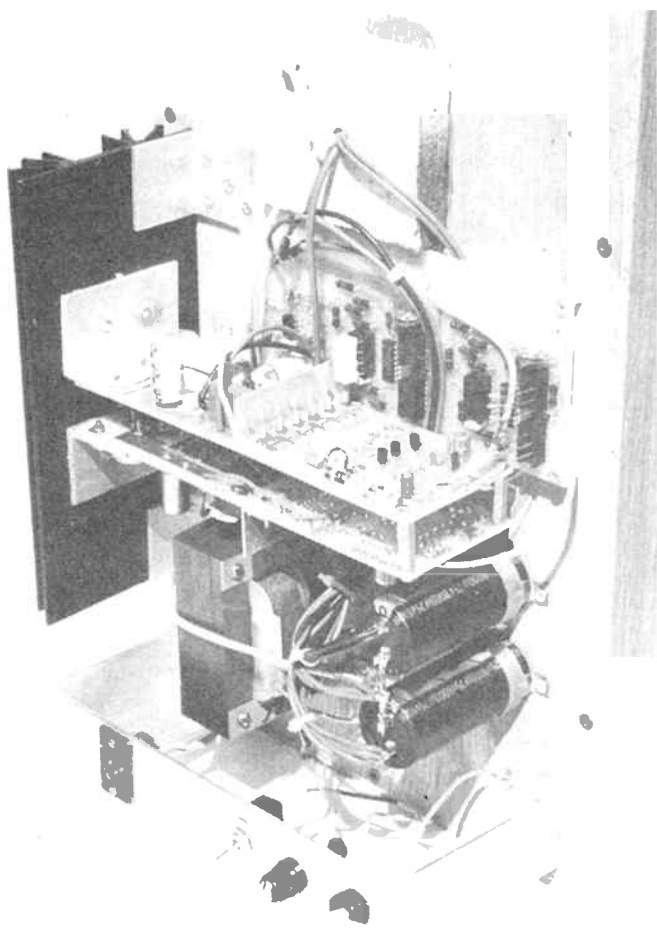
## The project

The AEM6112 is based around the AEM6102 Two-way Loudspeakers and the AEM6500 60 watt MOSFET Power Amplifier modules (described in July 1985) in conjunction with the AEM6503 Active Crossover already discussed. This features a choice of preset output attenuators. Alternatively, fixed value resistors may be used. In this article we have included our choice for fixed value resistors to compensate for the difference in sensitivities between the two Vifa drive units used in the 6102. Alternatively, you can fit preset potentiometers to the output of the 6503 and experiment.

The main circuit diagram shows the interconnection between the various modules. It is important that the wiring shown is followed closely since this arrangement of earth connections will minimise the possibility of hum pickup and earth loops. Note the use of a 22 µF bipolar capacitor in series with the tweeter. This capacitor is not intended to provide filtering within the passband of the filter. Instead it is used solely for the purpose of protecting the tweeter against turn-on and turn-off thumps which can otherwise cause net dc to be applied to the tweeter, possibly resulting in damage. The power supply consists of a 28-0-28 volt transformer, a bridge rectifier and two 8000 µF/75 V electrolytic capacitors. This provides ±40 V rails which is appropriate for the AEM6500 module when configured in the 60 watt version.

## Construction

Begin construction by assembling four 6500 60 watt power amplifier modules. Next assemble the two AEM6503 active crossovers and a pair of AEM6102 passive loudspeakers. The passive crossovers specified for the AEM6102 are not used. Instead, wires soldered to each of the drivers are brought through the rear of the box for connection to the power ▶



In the prototypes, we mounted all modules and their power supplies on the rear outside back of the 6102 loudspeakers. The transformer, bridge rectifier and filter capacitors are bolted directly to the rear panel using self-tapping screws. The two AEM6500 power amplifier modules are bolted to a 225 mm length of single-sided heatsink, such as the Dick Smith H3462, Jaycar HH-8574 or Altronics H 0526. This heatsink is bolted to the rear of the loudspeaker using two aluminium angle brackets which were fabricated from a length of 40 x 40 mm aluminium extrusion. Drilling details for these brackets have been included elsewhere with the article, as are the drilling details for the heatsink.

The input terminal, power switch, fuse and mains cable are attached to an extra bracket which is also formed from a length of 40 mm aluminium extrusion. This bracket is used to secure a safety and protective cover for the electronics. Drilling and cutting details for this bracket have also been included. The cover may be made from expanded steel or aluminium mesh to allow adequate ventilation for the heat-sinks.

Fabricate the large bracket as shown and mount the XLR input socket, mains power switch, fuseholder and mains cable and grommet and bolt this to the rear of the loudspeaker. Be careful to ensure that the earth lead from mains cable is mounted securely to this bracket with an appropriate solder lug, nut and bolt.

Mount the transformer, bridge rectifier and filter capacitors to the rear of the 6102 as shown in the accompanying photographs. We found it easier to make the connections to the power transformer, bridge rectifier and filter capacitors at this stage. The correct wiring is clearly shown on the circuit diagram. Be careful not to accidentally reverse the polarity of the electrolytic capacitors as these will undoubtedly be damaged if the unit is powered up in this condition. Similarly, check the terminals on the bridge rectifier. Two of these are usually marked with "ac" whilst the other two are marked

amplifiers which will be mounted on the outside rear of the loudspeaker cabinet.

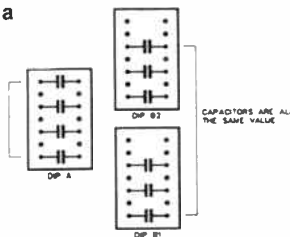
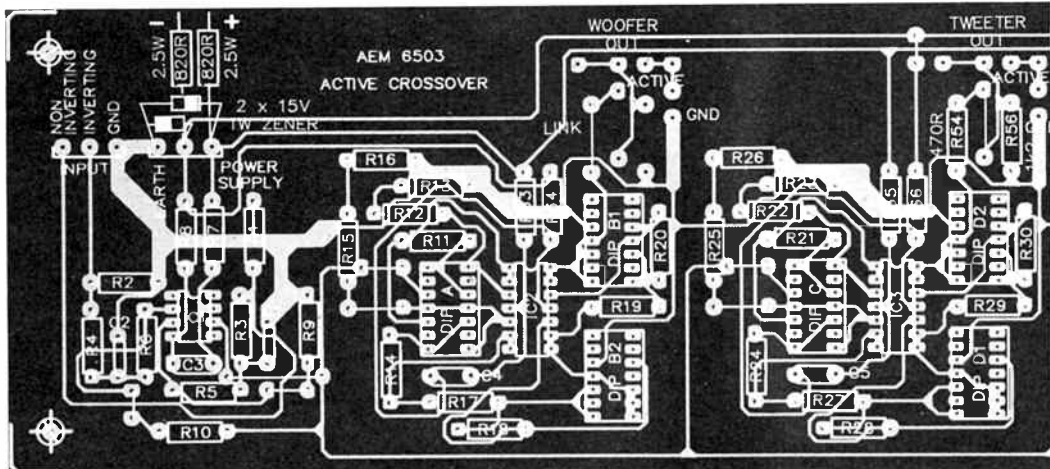
The AEM6500 power amplifier modules should be powered up and tested and quiescent current adjusted before proceeding further. Similarly, solder the crossover capacitors, as shown in the diagram here, in the correct positions on the AEM6503 pc board. If you were using the fixed value resistors specified these should be fitted to the tweeter section of the AEM6503. Note that a shorting link is required on the output of the woofer section of the AEM6503 as shown in the accompanying diagram.

**Active crossover overlay showing additions and modifications. You'll need two 15 V/1 W zeners, two 820R/2.5**

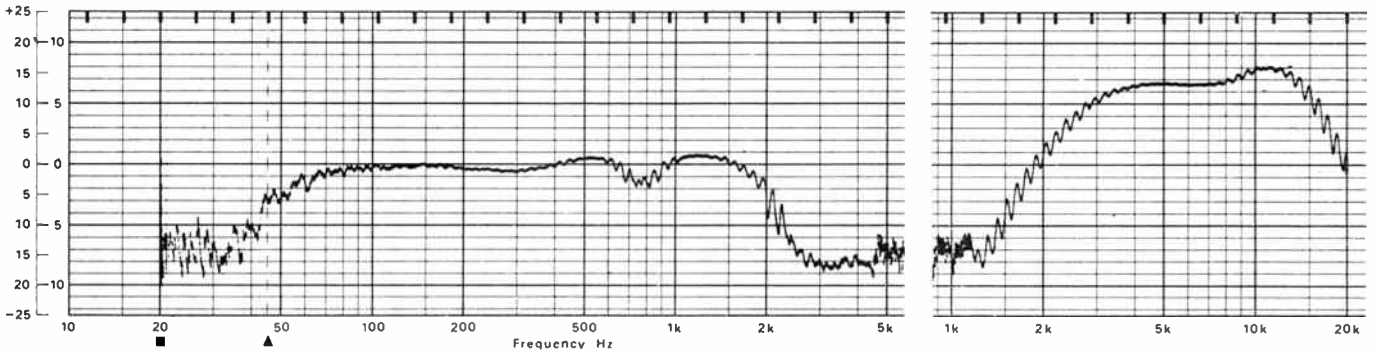
POSITION	VALUE	CROSSOVER
DIP A	470n	10.88 Hz
DIP B1	2n2	2325 Hz
DIP B2	2n2	2325 Hz
DIP C	2n2	2325 Hz
DIP D1	270p	18.946 kHz
DIP D2	270p	18.946 kHz

**TABLE 1:** Crossover capacitor values. Caps positioned according to diagram.

**W or 5 W resistors, plus a 470R and a 1k resistor (0.25 W) for the tweeter section output attenuator.**



CAPACITORS ARE ALL THE SAME VALUE



with a positive and negative symbol. The secondary of the power transformer should be connected to the lugs marked "ac". The centre tap of the power transformer is wired directly to the central wiring point of the two electrolytic capacitors.

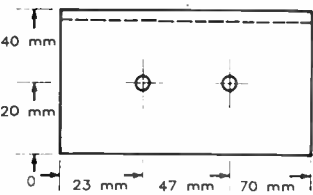
Ensure that all mains wiring is properly insulated to prevent accidental contact with these wires and check the power supply before proceeding further by measuring the voltage produced across the electrolytic capacitors by powering up the supply. The dc voltage across each capacitor should be approximately 40 volts. If all is well, turn the power supply off and allow time for the capacitors to discharge before soldering to their terminals.

The power supply for the AEM6503 is produced with a pair of zener diodes and a pair of extra resistors which are fitted to the AEM6503, as shown in the diagrams. Using this approach, the 6503 is effectively powered with the  $\pm 40$  volts supply used for the power amplifiers and so no additional transformer secondary winding is necessary.

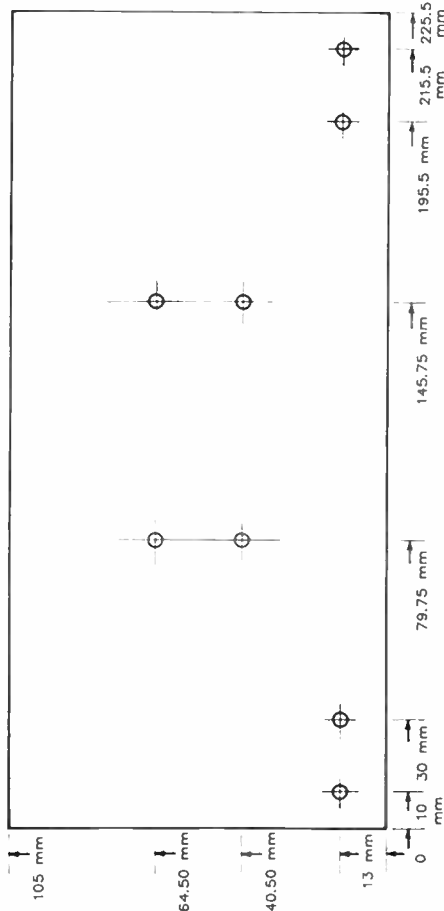
Fit these components to the 6503 and then mount the board in position on the rear of the loudspeaker. We used self-tapping screws and 6 mm spacers. All of the connections to the 6503 must be made before mounting it in position, unless solder pins have been fitted to the pc board. In this case, the module can be bolted to the rear panel and interconnecting wiring can be made to solder pins on the components side of

DRILLING DETAILS FOR BRACKET FOR MODULES TO BOLT TO HEATSINKS

ALL HOLES 4 mm

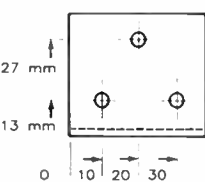


DRILLING DETAILS FOR HEATSINKS AS VIEWED FROM REAR

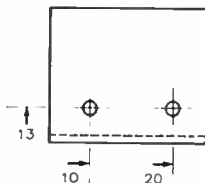


DRILLING DETAILS

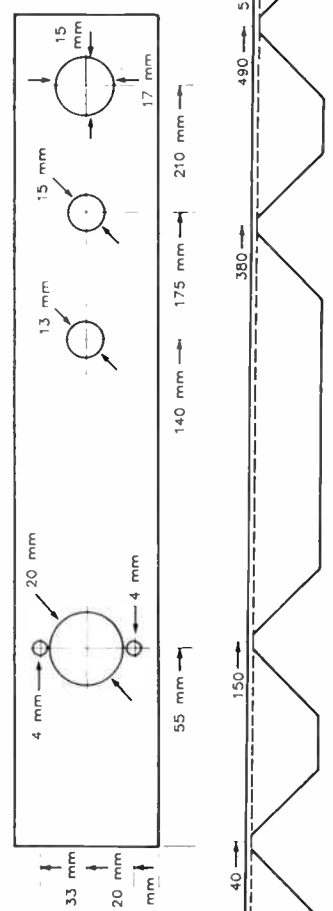
MOUNTING BRACKET FOR HEATSINK TO BOX



LOOKING AT BRACKET FROM ABOVE WITH BOX BEHIND



LOOKING AT BRACKET FROM SIDE WITH HEATSINK



**AEM6112 PARTS LIST**

- Pair of AEM6102 two-way passive loudspeakers;
- 4 x AEM6500 60 W MOSFET power amp modules;
- 2 x AEM6503 Active Crossover kits;
- 2 x heatsinks - DSE cat. no. H3426, or Jaycar HH-8574 or Altronics H 0526;
- 2 x XLR (Cannon) sockets;
- 2 x mains cables and clamp grommets;
- 2 x 3 A/3AG fuses and fuseholders;
- 4 x 8000u/75 V electrolytic capacitors;
- 2 x transformers, secondary of 28-0-28 V/2 A, e.g: DSE or Altronics type M-0144, or Jaycar MF-1095;
- 2 x PB40 bridge rectifiers;
- Assorted colours heavy duty (32 x 0.2 mm) wire for power wiring.



# aem project 6112

the board.

The AEM6500 modules can now be mounted in place using the two aluminium angle brackets fashioned for this purpose. Once again, connect all of the wires to the modules before mounting these in position. Once all of the modules are mounted in their correct positions on the rear of the loudspeaker, the remaining connections between the modules can now be made. Connect the XLR input socket to the input of the 6503s using a pair of shielded cables and be careful to ensure that these do not pass too closely to the power transformer to prevent the possibility of stray hum pickup.

The final step in the construction of the 6112 active loudspeakers is to fit a 22 uF bipolar capacitor in series with the tweeter. As mentioned above, this is to protect the tweeter from turn-on and turn-off dc thumps which might otherwise damage the tweeter voice coil. The value is large enough so that it does not introduce any significant effect on the passband of the tweeter so that the active crossover still determines the frequency response characteristics of the loudspeaker. We mounted this capacitor directly to the rear of the tweeter within the loudspeaker cabinet, securing it in place with an air-curing rubber compound (e.g. Selley's Silastic). Be careful when fitting this component, however, as the solder lugs on the tweeter are somewhat sensitive to pressure and easily broken.

## Powering-up

Before powering-up the system, check all wiring paying particular attention to the earthing and supply connections to the power amplifiers. If all is well, turn the loudspeaker on but be prepared to turn off quickly if a fault occurs. Watch the woofer diaphragm closely during this test.

It is normal for the diaphragm to move at the moment of switch-on, but it should rapidly return to its equilibrium position. If the diaphragm moves out or in and stays in that position, then this indicates a severe dc fault and the loudspeaker should be turned off immediately and the fault located.

## And the acid test?

The AEM6102 is generally regarded as a high quality passive two-way loudspeaker that is competitive with top quality commercial two-ways of similar design. The AEM6112 active two-ways, however, are a significant improvement. The prototype pair exhibited a cleanness and an attack which is not evident in the passive version. The sound is more confident and lively, but is not harsh.

The combination of the two 60 watt MOSFET power amplifiers, giving a total of 120 watts for each channel, was found to be a good choice and provided adequate sound pressure levels before any signs of distress were noted.

If you own a pair of AEM6102s, give consideration to the idea of converting these to the 6112 actives. It's worth the effort. ♣

— Project 4601, from page 73.

how much room you have in your modem. If things are a bit tight, you may choose to build the converter in a separate case and connect it to the modem with a suitable cable. If you have sufficient room inside your modem, the converter can be built-in.

## Checking it all out

Once you have completed the project and have it connected to your modem, you are ready to try it out. It may be wise to check the operation of your modem on 300/300 bps first, to check that it is still working in that mode. If you experience problems at 300/300, check that you have not pulled any wires away from the modem board whilst installing the converter. The most likely cause of problems at 300/300 is the failure of the crystal oscillator associated with the 7910 to start due to the extra loading of the converter. If this is the case, you may need to reduce the value of one of the capacitors associated with the oscillator. In the case of the 4600 modem this would be the 22 pF capacitor C9 and in the 4605 modem it would be the 10 pF capacitor C5.

If all goes well at 300/300 bps, you can try connecting to a service at 1200/75. You should set your modem speed to 1200/75 and the computer speed to 1200/1200. Make sure that the parameters of your communications program match the setting of both the service you intend to access and the converter's UART parameters as determined by the DIP switches or links. If you experience difficulties, check that SW1 is set to the correct position. You can also try monitoring pin 19 of the UART which should go high every time you type a character on your keyboard.

If you still have problems, make a thorough check of your wiring and soldering and also check that the +5 V supply is present at the converter board and is of the correct polarity. The project is fairly simple so you should not have too much difficulty getting it going. Our prototype worked first time! ♣

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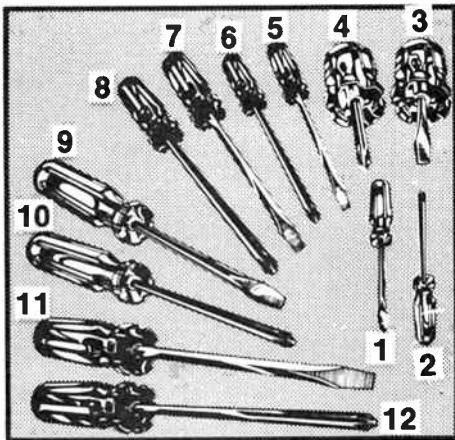
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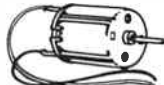
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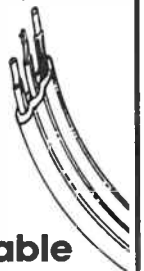
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• NSW • Ballina: A. Cummings & Co. 86 2284 • Bowral: F.R.H. Electrical 61 1861 • Broken Hill: Hobbies & Electronics 88 4098 • Charlestown: Newtronics 43 9600 • Coffs Harbour: Coffs Harbour Electronics 52 5584 • Deniliquin: Dani Electronics 81 3672 • Forster: Forster Photo Sound 54 5006 • Inverell: Lyn Willing Electronics 22 1821 • Llewellyn: Llewellyn Record Centre 53 2081 • Lightning Ridge: Lightning Ridge Newsagency 29 0579 • Lismore: Decro 21 4137 • Moree: Moree Electrical Services 52 3667 • Newcastle: Newtronics 43 9600 • Port Macquarie: Hall of Electronics 83 7440 • Orange: Fyfe Electronics 62 6491 • Springwood: Wellington's Electrical Discounts 51 4888 • Taree: Brad's Electronics 52 6603 • Tumut: Tumut Electronics 47 1631 • Ulladulla: Pauls Electronics 55 3989 • Wagga: Phillips Electronics 21 6558 • Wellington: Wellington Electrical Service 45 2325 • Windsor: M & E Electronics 206 George St. 77 5935 • Young: Keith Donges Electronics 82 1279 • VIC • Boronia: Ray Cross Electronics 762 2422 • Colac: Colac Electronics 31 2847 • Dunolly: Ken Roberts (Finders) 68 1333 • Echuca: Webster Electronics 82 2956 • Mildura: McWilliams Electronics 23 6410 • Morwell: Morwell Electronics 34 6133 • Rosebud: Pentronics 85 7688 • Shepparton: GV Electronics Centre 21 8866 • Sunbury: Calco Electrical 744 1584 • Warranook: Marrtronics 62 9870 • Warrinbee: Gobles Photographic & Video 741 7089 • QLD • Bundaberg: Bob Elkin Electronics 72 1785 • Cairns: Electronic World 51 8555 • Caloundra: Hume's Electro-Mart 91 4270 • Dysart: Dysart Videotronics 58 2107 • Gladstone: Supertronics 72 4321 • Mackay: Stevens Electronics 51 1723 • Mooloolaba: Mal's Electronics 44 6588 • Maryborough: Keller Electronics 21 4559 • Mt Isa: Outback Electronics 43 3331 • Nambour: Nambour Electronics 41 1604 • Noosa Heads: Sunshine Phone Systems 47 4444 • Townsville: Tropical T.V. 79 1421 • SA • Mt Gambier: Hutchessons Communications Centre 25 0400 • Whyalla: Eyre Electronics 45 4784 • WA • Albany: Micro Electronics 41 3432 • Karratha: Dave's Oscitronics 85 4636 • TAS • Devonport: A.I. Electronics & Hobbies 24 8322 • Launceston: Wills Electronics 31 5688 • NT • Alice Springs: Farmer Electronics 52 2967



**IT HAD  
TO HAPPEN!**

# BUILD-IT-YOURSELF 'AT' COMPUTER!



At last! The perfect opportunity for the hobbyist to build the perfect computer. . . Perfect because it has in it what YOU want! All the features of the "AT" - blinding speed, high expandability, and so on - but you put it together yourself - and \$ave!

There's more: each board or module comes with a full 12 month warranty PLUS individual, professionally prepared manuals - no Jnglish to decipher!

And best of all, you don't have to buy it in one hit: add what you want, when you want it (and when the pocket allows it!)

## Look at the features:

### SUPERB QUALITY HINGED CASE

"Baby AT" case in heavy gauge steel, heavily covered in damage-resistant bone crinkle finish. The lid is hinged and locks up for instant internal access - no more undoing screws! Large enough for expansion - but features a footprint of just 430mm square! Cat X-1005

**ONLY \$175**

### 200W POWER SUPPLY

Completely pre-assembled - even to the on/off switch and input sockets! Simply slots into place in cutouts provided in case. Heavily plated steel case for minimum RFI with integral whisper-quiet fan. 200W capacity is ready for . . . anything! Cat X-1010

**ONLY \$275**

### "BABY AT" MOTHERBOARD

Again, completely pre-assembled. No risk of dry joints - you just connect appropriate cables (as described in detailed manual included). On-board capacity for 1Mb RAM and 8 slots for expansion in true "AT" format. Offers 6, 8, 10 & 12MHz speed (switch & software selectable) giving outstanding software compatability PLUS blinding speed when you need it, and time & date memory with battery back-up. Cat X-1000

**JUST \$995**

### PLUG-IN CARDS

Cards for the various graphic standards, printer ports, serial ports, etc etc. Choose the one that suits your requirements - and remember, you can always upgrade later!

**CGA plus Parallel Printer Card** Cat X-2010 **\$129**

**MGA plus Parallel Printer Card** Cat X-8141 **\$149**

**EGA Card with Hercules compatability** Cat X-2013 **\$399**

**Serial/Parallel/Game Card** Cat X-2012 **\$139**

### DISK CONTROLLERS

Your choice of hard/floppy or floppy disk controller card: choose the one that suits your needs best. Both plug in to motherboard.

**Floppy Controller** (2 disk drives 1.2Mb or 360Kb) Cat X-2014 **\$129**

**Hard/Floppy Controller** (2 of each) Cat X-2008 **\$399**

### DISK DRIVES

Also include appropriate cables.

**1.2Mb Floppy Disk Drive** Cat X-2200 **\$269**

**20Mb Hard Disk Drive** Cat X-2203 **\$795**

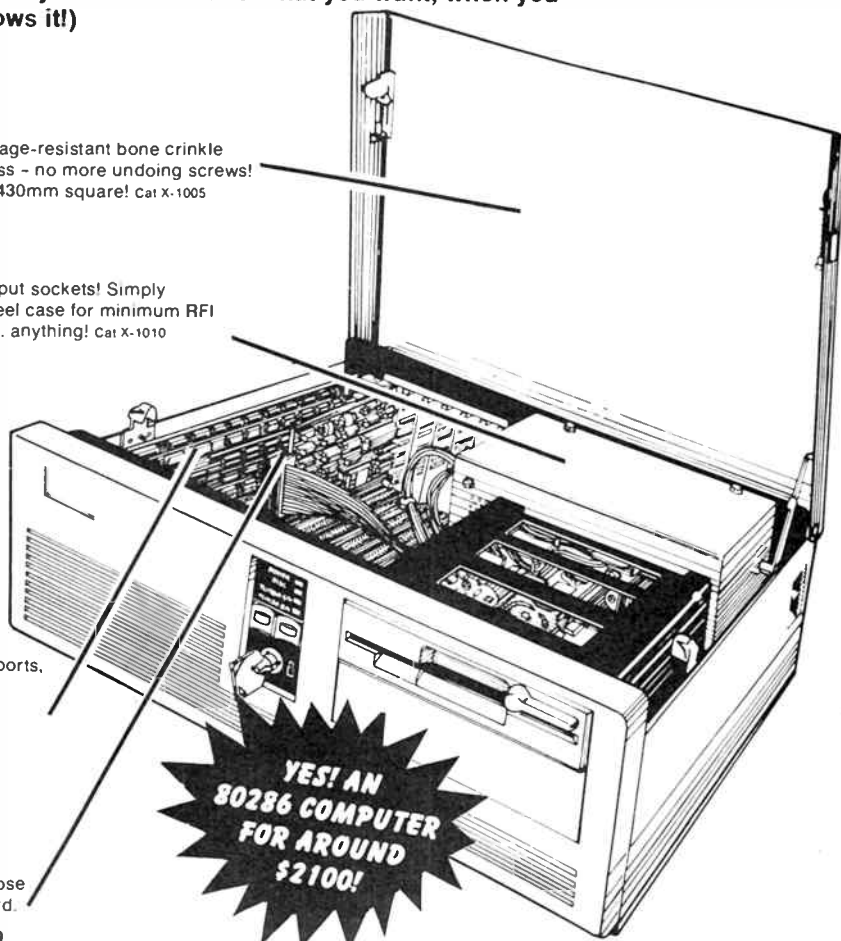
(Other higher capacity Hard Disks available if required)

### KEYBOARDS

Two types available:

**84 Keys with top quality "Alps" keyswitches** Cat X-3820 **\$129.00**

**101 Keys - with numeric keypad** Cat X-3821 **\$149.00**



## WHERE ELSE BUT

**DICK SMITH  
ELECTRONICS**

PTY LTD

OSEB450/RT1087

# Build (or give!) a Kit this Kitmas...

Kits make great gifts: beats a pair of sox anytime!

## Dick Smith's own Fun Way Into Electronics

Here's great value: the Fun Way One gift box. All the components needed to build any of the projects in Fun Way One... and the book is included too! All this for under \$25! Cat K-2605  
Projects to build include:  
Dog & Cat Communicator  
Beer Powered Radio  
Morse Code Practice Set  
Crystal Sets  
Mini Amplifiers And much, much more **\$24<sup>50</sup>**



## Fun Way One Project Packs

Two project packs to allow you to build any of the kits. Project Pack One allows you to build any of the first ten kits in Fun Way One. Project Pack Two gives you the additional components required to build any of the 20 kits (needs Pack one too!) Note - Fun Way One book is NOT included with these kits.



Fun Way One: Project Pack One **\$8<sup>95</sup>**  
Cat K-2600

Fun Way One: Project Pack Two **\$9<sup>95</sup>**  
Cat K-2610

## Fun Way TWO

Ready for something more advanced? Fun Way Two has another twenty projects to build - all on modern printed circuit boards. And we even teach you how to solder!



Fun Way Two Bonus Pack includes the Fun Way Two book, a quality soldering iron, a pack of solder, a nine volt battery, AND the most popular kit in Fun Way Two: the Wireless Microphone. **\$26<sup>95</sup>**  
Cat K-2620

## Fun Way THREE

The real professionals! Build the Fun Way Three kits and you'll be ready to tackle most projects. The Fun Way Three Bonus Pack includes the Fun Way Three book and not one, but TWO popular Fun Way Three kits: the Cricket and the Mini Amplifier. Great value!  
Cat K-2670



**\$29<sup>95</sup>**

## One, Two and Three Gift Box

If they're really into electronics, they'll LOVE the gift box. It has kits to build from all three Fun Way books: nearly one hundred dollars value for only \$59.95! Build a flashing brooch, a wireless microphone, cricket, mini amplifier and more. **\$59<sup>95</sup>**  
Cat K-2680



## And the really big one... Get the Jumbo Gift Box!

Over thirty great projects to build from all three Fun Way books. And the books are included! Over \$120 worth of goodies crammed into this value-packed box. Any kid from 6 to 60 would think it was Christmas. (Now that sounds like a good idea!)  
Cat K-2690 **\$99<sup>95</sup>**

## How do you test a Zener?

Let's see. Out with the power supply. Work out the series resistor. Get the voltmeter and put it across the zener. Turn on the supply. Woops! Wrong resistor. One cooked Zener... Or you can build the Zener Diode Tester. Very simply and accurately checks Zeners without danger. Especially handy in the service lab when the markings are worn off! Cat K-3051



**\$29<sup>95</sup>**

## Look Mum. No Bike!

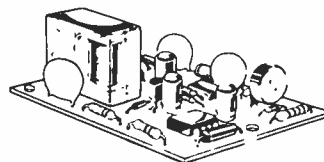
Bikes (the vroom vroom variety) are, unfortunately, very vulnerable. Don't become the victim of a very vulnerable vroom vroom. Fit a bike alarm to your bike and it'll scream its head off if some light fingered larrikin tries to lift it. Easy to build, easy to fit - suits most bikes. Cat K-3249

**\$39<sup>95</sup>**

## And one for the Car, Too!

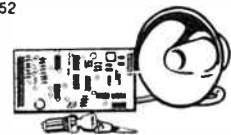
Police statistics are staggering: and your car could be next. Build this simple alarm and the odds are back on your side. It's very easy to make, operates on "voltage drop" principle so no holes are needed for key switches, etc. It works! Cat K-3250

**\$16<sup>95</sup>**



## Or the Deluxe Job

The ultimate in protection! One of the best alarms around - better than most commercial units. Includes its own siren output (doesn't rely on car horn), has provision for back-up battery... and it's about the best investment you could make for your car. Cat K-3252

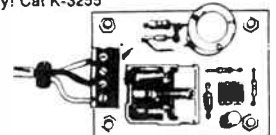


**\$79<sup>95</sup>**

## Add an Ignition Killer for 100% Protection

Nothing's worse than a car that misbehaves. Especially if you're trying to knock it off. Imagine. It starts, but very soon splutters and stops. Bill Sykes thinks the car's crook and goes off searching for another! You return to your car, reset the ignition killer - and drive away! Cat K-3255

**\$22<sup>95</sup>**



## Want a GREAT AMPLIFIER?

Build yourself a MOSFET AMP. It's great! And our value-packed kit makes it even greater! 42 watts per channel into 8 ohms - with professional specs and features. Comprehensive step-by-step manual included to make it easy on you. Compare it to commercial amplifiers at three and four times the price! Cat K-3515

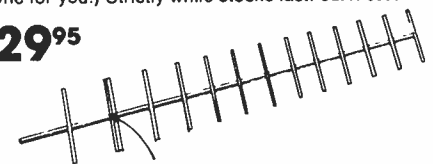


**\$219**

## 70cm YAGI KIT

Build your own Yagi for UHF. This 13 element design is simple to construct (all the hard work is done for you!) Strictly while stocks last. Cat K-6305

**\$29<sup>95</sup>**



## 70cm Phasing Harness

Want to stack a couple of Yagis for more gain? Use this ready-made Phasing Harness. At UHF every uB (microBel - as distinct from dB) is a help - so help yourself! Cat K-6299

**\$10<sup>95</sup>**



**While stocks last!**

**DICK SMITH ELECTRONICS**

PTY LTD

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DSXpress ON (008) 22 6610  
For 24 hour despatch

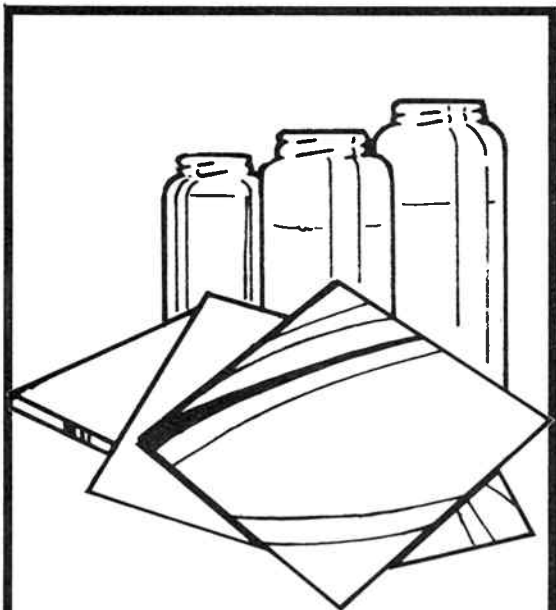
World Radio History



# Do it Yourself!

The poor old hobbyist or engineer wanting one-off pcb's: prototype boards from the manufacturers have been horrendously expensive, making your own always lacked that professional quality!

**DATAK** Until now! Dick Smith Electronics is proud to introduce you to the "Datak" range of US-made pcb materials. Top quality, easy to use, make a professional product . . . yet extremely good value. What more could you want?



## Complete Photo Tech PCB Kit

It's so simple! This kit contains everything the hobbyist or workshop could want to make pro-quality PCB's: 125 x 150mm steel printing frame, pos-neg film, film processing pack, yellow filter, 100g negative acting etch resist, resist developer, blank pcb's, dry concentrated etchant, 1:1 resist patterns and tapes and, best of all, COMPLETE INSTRUCTIONS.

Cat N-5700

**\$104<sup>95</sup>**

\* NSW • Albury 21 8399 • Bankstown Square 707 4888 • Blacktown 671 7722 • Blakehurst 546 7744 • Bondi Junction 387 1444 • Brookvale (Warringah Mall) 93 0441 • Campbelltown (046)27 2199 • Chatswood Chase 411 1955 • Chullora 642 8922 • Gore Hill 439 5311 • Gosford 25 0235 • Hornsby 471 6633 • Liverpool 600 9888 • Maitland 33 7866 • Miranda 525 2722 • Newcastle 61 1896 • North Ryde 88 3855 • Parramatta 689 2188 • Penrith (047)32 3400 • Railway Square 211 3777 • Sydney City 267 9111 • Tamworth 66 1711 • Wollongong 28 3800 • ACT • Fyshwick 80 4944 • VIC • Ballarat 31 5433 • Bendigo 43 0388 • Box Hill 890 0699 • East Brighton 592 2366 • Coburg 383 4455 • Essendon 379 7444 • Footscray 889 2055 • Frankston 783 9144 • Geelong 43 8804 • Melbourne City 670 9834 • Richmond 428 1614 • Ringwood 879 5338 • Springvale 547 0522 • QLD • Brisbane City 229 9377 • Buranda 391 6233 • Cairns 311 515 • Chermide 359 6255 • Redbank 288 5599 • Rockhampton 27 9644 • Southport 32 9863 • Toowoomba 38 4300 • Townsville 72 5722 • Underwood 341 0844 • SA • Adelaide City 232 1200 • Beverley 347 1900 • Darlington 298 8977 • Elizabeth 255 6099 • Enfield 260 6088 • WA • Cannington 451 8666 • Fremantle 3359 733 • North Perth 328 6944 • Perth City 481 3261 • TAS • Hobart 31 0800 • NT • Stuart Park 81 1977

## Individual Components to Build Up or Replenish your Packs.

### Photofilm Sheet

Makes film positives from magazine art, 1:1 patterns on film, etc. Two sizes available: 125 x 150mm (6 sheets) Cat

N-5705 **\$18<sup>85</sup>**  
200 x 275mm  
(2 sheets)  
Cat N-5709

**\$48<sup>85</sup>**



### Film Processing Chemical Pack

Processes either of above photofilm sheets.

Cat N-5909

### Tin your PCB pattern

Avoid oxidation & contamination of patterns: tin them without mess or electricity. Soluble powder puts bright tin plate over copper of pcb, ready for soldering. Cat N-5730

**\$12<sup>55</sup>**



### Circuit Fix-It

Damaged PCB? Fix it easily and simply with this one. Pure copper pads, sheets on self-adhesive carrier to allow virtually any repair. Cat N-5900

**\$62<sup>95</sup>**



### Dry Transfers for Panels, projects

Choice of three types for that real "factory made" appearance.

(1) Switches and Marks 2 sheets each of black and white. Cat N-5750

**\$41<sup>95</sup>**

(2) PCB pads, fingers, etc. DIL, surface mount and component donuts all in one handy pack. Cat N-5766

**\$49<sup>95</sup>**

(3) Targets. A must for accuracy in pcb making — especially on double sided boards! Cat N-5820

**\$7<sup>95</sup>**

### Yellow Filter

215 x 295mm yellow filter for exposing Datak light-sensitive products to pcb patterns. Full instructions included with master kit.

Cat N-5711

**\$10<sup>45</sup>**

### Burnishing Tool

Sure beats using the old ball-point pen! Professional quality results demand a professional approach. Aluminium ball one end, flat pastic the other. Cat N-5715

**\$10<sup>45</sup>**



### Contact Printing Frame

Pro quality frame makes negs or pos up to 225 x 300mm, from film pattern or even direct from printed magazine pages. Contains spring loaded steel exposing frame with glass, backboard, yellow filter & instructions. Cat N-5710

**\$35<sup>65</sup>**



### Photoresist Made Easy

Spray pump of negative photo resist (118ml) ready for coating blank pcb's. Easy to use, no tight tolerances required for heating, etc. Cat N-5907

**\$18<sup>95</sup>**



### Resist Developer

Suitable for above resist. 473ml tin. Cat N-5905

**\$41<sup>95</sup>**



**DICK SMITH ELECTRONICS**

PTY LTD

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CALL TOLL FREE (008) 22 6610 (Sydney Area, call 888 2105)

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# BarGraph

## Multimeter



**\$149**

### Specifications:

DCV: 100mV, 2.5V, 10V, 50V, 250V, 1000V,  
5Mohm impedance  
ACV: 10V, 50V, 250V, 750V (minimum 5k/V, 25k/V on 10V)  
DC: 2.5mA, 25mA, 250mA  
Res: 250 ohms, 2.5k, 25k, 250k, 2.5M  
Cont: 250 ohms max, continuity beeper approx <100 ohms

Finally, an LCD Multimeter which accurately shows analog-type readings! All those essential dynamics that are often lost on a DMM . . . often it's not so much a reading you're after as the change in readings!

But there's more: the information is displayed in "bar graph" format for instant recognition and ease of reading. And if you need to expand the scale, it's a simple one-button operation to go to a 10x magnification!

Plus a data hold function (last reading retained), a maximum hold function (highest reading retained & marked, but readings continue), diode check & continuity, etc. etc: it's one of the best general purpose multimeters available today — simply because it does everything better!

- 105 step LCD bargraph display giving 1% resolution on any scale (eg 10 volts on 1000V range with mag pressed).
- Fast 10/second sampling rate for virtually instantaneous display (much faster than most digitals).
- Automatic positive or negative indication
- DATA Hold key freezes reading immediately previous to pressing. This can then be magnified (by up to 10:1) for a more accurate and precise reading.
- 6 DC ranges (down to 100mV with virtual 1mV sensitivity), 4 AC ranges, 5 resistance, 3 DC plus diode check and continuity ranges.
- Single input terminals mean no swapping of leads when you change to different scales. Fully shrouded test leads supplied, with full instructions.

Cat Q-1777

Diode: Test current approx 0.5mA, reads  $V_f$  on display  
Measuring Method: dual integration mode  
Sampling: 10 times per second  
Power: 1.5V (AA) x 2  
Battery Life: Approx 800 hours or more.  
Size: 145 x 86 x 34mm (w x h x d)  
Weight: Approx 250g (inc batteries).

Available exclusively from  
**Dick Smith Electronics**

ORDER BY PHONE: TOLL FREE  
DSXpress ON (008) 22 6610  
For 24 hour despatch

**DICK SMITH**  
**ELECTRONICS**

PTY LTD

# Ready for the BIG ones in '88?

## The Right Antenna for YOUR Area . . . at the Right Price!

### ALL PACKS ONE SPECIAL LOW PRICE: \$39<sup>95</sup> EA!!!

That's right: DSE's special VHF/UHF antenna pack suiting EVERY local area translator in Australia! We've put together a number of special antenna packs to ensure that no matter what combination of VHF & UHF bands, or polarities, you're covered! Don't know which one you need? Ask us!

(Note: Many areas do not yet have local area translators. In that case the L-4025 antenna will normally suffice).

#### Specific Area Packs:

Most areas: Combination VHF/UHF band IV (SBS) L-4001  
 Canberra: Two antennas in pack (VHF & band V UHF) L-4002  
 Newcastle/Wollongong: Two antennas in pack L-4003  
 Ballarat: Special channel 3 & 6 VHF Antenna L-4006  
 Bendigo: Special channel 1 & 8 VHF Antenna L-4007  
 Albury: Special channel 1 & 4 VHF Antenna L-4008

Order by phone: 24 hour despatch through DSXpress.  
 CALL TOLL FREE (008) 22 6610 (Sydney Area, call 888 2105)

What a year on TV! The Bicentenary — think of the coverage that'll have. And the Olympics — sensational!

Is your TV antenna system up to it?

If it's typical of most, it's not (up to it, that is!). Probably put up when TV started (that's over thirty years ago!): the antenna's probably broken, corroded or bent, the lead-in's probably pretty suspect too.

Fix them — before '88. And get ready for the Big Events of '88!



### More than one TV?

Don't just connect them together: it doesn't work! Use a splitter for optimum performance — sets won't interfere with each other.

Cat L-4472

\$5<sup>45</sup>



### Two Antennas?

UHF & VHF Antennas don't need two leads. Save money by using a diplexer — one lead in is much more convenient (saves madly swapping leads!) Cat L-4470

\$4<sup>95</sup>

### Cable:

DSE stocks top quality TV cable in both 75 ohm coax and 300 ohm twin lead.

75 Ohm — Air dielectric, low loss cable for external/internal installations. Dual shielded (foil/braid) with UV stabilised outer cover. Cat W-2082



300 Ohm — UV stabilised twin flat ribbon, low loss. Cat W-2070



### Need more Signal?

We have two amplifiers which might solve your problems . . .



### Masthead Amp

Especially for long range viewing, a masthead amp often works wonders. Amplifies signal right at the antenna — away from the noise — for best possible results. Complete with mains supply. Cat L-4200

\$75



### In-line Amp

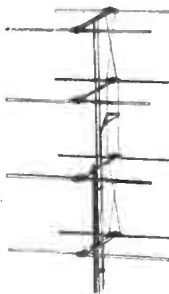
Especially suitable for multi-set use, great for VCR signal amplification. Simply plugs into output of VCR, splitter, etc. and lead to TV plugs into it. Mains power adaptor required. Cat L-4202

\$29<sup>95</sup>

### Need that extra range on VHF?

For country viewing (deep fringe area) or where signal levels are very low (shielded, etc) you'll probably need one of the "big guns": the phased array. High gain, high performance on all high VHF channels. Suitable for horizontal or vertical mounting. Cat L-4025

\$99



### How About FM Radio?

For best results an outside FM antenna is essential. Ours is specially designed for the FM band, can be erected in either polarity. 300 ohm type. Cat L-4064

\$34<sup>95</sup>



### Coax Extension Lead

Perfect for wall socket to TV, VCR to TV, etc. 1.2m coax lead with male plugs both ends. Cat L-4506

\$4<sup>50</sup>

### Wall Sockets for Coax Cable

Two different types to choose from for that really professional installation: Skirting board type — Small and unobtrusive Cat L-4504

\$4<sup>95</sup>



Wall Plate type — fits over standard wall box, can also be used as 75 ohm splitter for second or third TV. Cat P-2042

\$4<sup>35</sup>



# DICK SMITH ELECTRONICS

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```

10 PRINT "          E12 capacitor combinations"
20 PRINT "  This programme finds series & parallel combinations of two E12 capacitors"
30 PRINT "          that make up a non-E12 capacitor to a required tolerance."
40 PRINT "          Capacitance range 1 pF to 10 uF":PRINT
50 DIM C(85),G(85)
60 SW=0 "Switch SW remains at zero if no suitable combination is found."
70 REM ***** SET UP CHARACTER STRINGS FOR PRINTOUT *****
80 A10$="What exact value would you like for the capacitance [":A11$=" ]?"
90 A1$="parallel":A2$="series":A3$="":A4$=" %":A5$=" Error=":A6$="Allowe
d capacitance range is ":A7$=" to ":A8$=" is an E12 capacitor to the required tolerance."
100 REM ***** STORE CAPACITANCE ARRAY C(I) & CONDUCTANCE ARRAY G(I) *****
110 FOR I=1 TO 12:READ C(I):NEXT I
120 DATA 1.0,1.2,1.5,1.8,2.2,2.7,3.3,3.9,4.7,5.6,6.8,8.2
130 FOR J=1 TO 6:FOR K=1 TO 12:C(12*J+K)=C(K)*10^J:NEXT K:NEXT J:C(85)=1E+07
140 FOR I=1 TO 85:G(I)=1/C(86-I):NEXT I
150 REM ***** REQUEST INPUT DATA *****
160 INPUT "What units would you like to use, pF [ Enter P ], nF [ Enter N ], or uF [ Enter U ]?":A$
170 IF (A$<>"P" AND A$<>"N" AND A$<>"U") THEN 160
180 A12$="pF":FACTOR=1:IF A$="N" THEN A12$="nF":FACTOR=1000
190 IF A$="U" THEN A12$="uF":FACTOR=1000000:
200 PRINT USING "\ \ \ \ \ \";A
10$,A12$,A11$
210 INPUT C:C=C*FACTOR
220 IF (C<1! OR C>1E+07) THEN PRINT "Capacitance range is 1 pF to 10 uF.":GOTO 160
230 INPUT "What is the required tolerance [ % ]?":TOL
240 REM ***** CALCULATE UPPER & LOWER LIMITS *****
250 CU=C+TOL*C/100:CL=C-TOL*C/100:GU=1/CL:GL=1/CU:G=1/C
260 Z=CL:GOSUB 520:C1=S:A91$=A9$:Z=C:GOSUB 520
270 PRINT USING "\ \ \ \ \ \";A6$,
C1,A91$,A7$,S,A9$
280 REM ***** SKIP TO END IF E12 CAPACITOR REQUESTED *****
290 FOR I=1 TO 85:IF C(I)>=CL AND C(I)<= CU THEN Z=C(I):GOSUB 520:PRINT USING "#
\ \ \ \ \ \";S,A9$,A8$:GOTO 580
300 NEXT I
310 REM ***** FIND E12 CAPACITOR JUST LESS THEN REQUIRED CAPACITANCE *****
320 FOR I=85 TO 1 STEP -1:IF C(I)<C THEN KS=I:KP=I+1:GOTO 350
330 NEXT I
340 REM ***** SEARCH FOR PARALLEL COMBINATIONS *****
350 I=1
360 CTOTAL=C(KS)+C(I):IF(CTOTAL>=CL AND CTOTAL<=CU) THEN SW=1:GOSUB 470
370 IF CTOTAL<CU THEN 390
380 KS=KS-1:IF C(I)>C(KS) THEN 410
390 I=I+1:GOTO 360
400 REM ***** SEARCH FOR SERIES COMBINATIONS *****
410 I=1:KP=86-KP
420 GTOTAL=G(KP)+G(I):IF(GTOTAL>=GL AND GTOTAL<=GU) THEN SW=1:GOSUB 490
430 IF GTOTAL<GU THEN 450
440 KP=KP-1:IF G(I)>G(KP) THEN 570
450 I=I+1:GOTO 420
460 REM ***** PRINT RESULTS *****
470 Z=C(I):GOSUB 520:C1=S:A91$=A9$:Z=C(KS):GOSUB 520:C2=S:A92$=A9$:Z=CTOTAL:GOSUB 520:C3=S
480 PRINT USING "\ \ \ \ \ \";A6$,
C1,A91$,A1$,C2,A92$,A3$,C3,A9$,A5$,
(C-CTOTAL)*100/C,A4$:RETURN
490 Z=C(86-I):GOSUB 520:C1=S:A91$=A9$:Z=C(86-KP):GOSUB 520:C2=S:A92$=A9$:Z=1/GTOTAL:GOSUB 520:C3=S
500 PRINT USING "\ \ \ \ \ \";A6$,
C1,A91$,A2$,C2,A92$,A3$,C3,A9$,A5$,
(C-1/GTOTAL)*100/C,A4$:RETURN
510 REM ***** SUBROUTINE TO PUT RESULTS IN CONVENIENT UNITS *****
520 IF Z>=1000000! THEN S=Z/1000000!:" uF":GOTO 550
530 IF Z>=1000 THEN S=Z/1000:A9$=" nF":GOTO 550
540 S=Z:A9$=" pF"
550 RETURN
560 REM ***** IF SW IS STILL ZERO, NO COMBINATIONS FOUND *****
570 IF SW=0 THEN PRINT "Sorry, there are no series or parallel combinations of E12 capacitors that will give the required capacitance to the required tolerance"
580 PRINT "End of programme.":END

```

and so on. We keep this up until our trial resistor is down to 2200 Ohms by which time the only resistor to add is 2700 Ohms. It is time to stop the whole process because any value that we add will produce a resistance greater than 4830 Ohms. So we have found the lower limit for our trial resistor; we stop when the trial resistor is just less than half the value of our required resistance. Using these limits cuts the amount of computing, and hence the time taken, by a factor of about 20 compared to the bulldozer method. Indeed the time taken to display the results can now become the main limitation.

In the accompanying resistor program, line 190 finds the upper and lower allowable resistance values RU and RL.

Line 260 finds the first trial resistor by selecting the E12 value that is just less than the required value, and remembers KS, the trial resistor's position in the list of E12 resistors. Line 290 starts us off by adding the 1st resistor in the list, i.e: 1 Ohm. Line 300 tests to see whether the combination produces a value that is between the allowable limits, if so the result is displayed. If the total is less than the upper limit, line 310 switches to the next resistor i.e: 1.2 Ohms and tries that and so on. Once the total is greater than the upper limit, line 310 selects the next trial resistor as one lower on the list than the previous trial resistor and starts adding resistors commencing at the place where it left off. The IF statement in line 320 corres-

ponds to the test resistor being just less than half the required resistance; if it is, the program jumps to the next stage.

## Resistors in parallel

The problem of resistors in parallel is somewhat different. The resistance of two resistors in parallel is given by:  $1/R_{total} = 1/R_1 + 1/R_2$ . This complicates the search pattern considerably, but if we remember that the conductance G of a resistor is simply  $1/R$ , the above equation becomes  $G_{total} = G_1 + G_2$  which can be programmed along similar lines to the way in which we searched for resistors in series. All we have to do is convert the resistors to their conductances at the start and convert them back at the end. It is not quite as simple as that since we have been assuming that the list of resistors is in ascending order. To put our conductances in ascending order we have to label them starting from the 10M end.

This is done in line 130. This allows us to use lines 360-400 as copies of lines 300-330. While it is theoretically possible to use the same block of code for both series and parallel resistors, the switching necessary for the inputs into the block and for the display of results makes the code extremely difficult to follow and slower to run.

## Capacitors

Trying to find suitable combinations of capacitors is similar to the problem with resistors except that capacitors in parallel add together in the way that resistors in series do, and capacitors in series are best added using their "conductances". Because of the different units that are commonly used with capacitors, the second program asks what units you wish to use (line 160) and then converts everything to pF for use in the program.

Both programs are in Microsoft's GWBASIC. They have a few bells and whistles, all outputs being in convenient units, and the error in each combination being displayed as a percentage of the desired value. This latter enables you to improve your accuracy if you so desire. In the case of the 4830 Ohm resistor, one combination is 5600 Ohms in parallel with 33k giving 4788 Ohms. Simply adding a 39 Ohm resistor in series with this parallel combination makes 4827 Ohms, which is within 0.1% of the desired value.

All of this assumes that the E12 components that you use have exactly their nominal value. Using 1% components is a good start since they are usually well within 1% of nominal in which case the result will be within about 1% of the calculated value. For accuracy better than this, the final values should always be checked on a bridge or accurate meter.

# A baud rate converter for modems employing the 7910 "World Chip"

Andrew Keir

Some computers communicate via their serial port at a fixed rate in both directions. But, the widely used V.23 data communications standard, particularly common on "dumb" modems, provides "split" transmit and receive baud rates of 1200 bps and 75 bps. This project overcomes the problem, maintaining the serial port communications at the same rate in and out (Tx and Rx), while communicating with the modem at different rates.

BACK IN January 1987, we published in the "Dial Up" column a circuit for a simple baud rate converter for the AEM4600 Dual-Speed modem. The circuit was submitted by reader Allan Abbot of Longreach, Qld and since its publication we have had a steady stream of inquiries about the device and many requests asking us to publish the design as a project, complete with a pc board. For all of you who asked, here it is.

The popular V.23 data communications protocol specifies, in one mode, a receive rate of 1200 bits per second (bps) and a transmit rate of 75 bps. It is employed where the user primarily downloads data from a remote system, where it is more economical for the receive channel to operate at a higher speed than the transmit, or "back" channel. This is the mode used by videotex systems of which Telecom's Viatel is a prime example. Many dial-up bulletin boards also have this mode available. The reverse may also be used, where you receive at 75 bps and transmit at 1200 bps, but that's less common.

Many computers, including very popular models such as the IBM PC and Commodore 64 machines, have their serial transmit and receive rates fixed at the same rate. That is, if you set the receive rate to 1200 bps, the transmit rate will be the same. Now, if you want to connect your modem and use the V.23 protocol, you're stonkered because the computer cannot "split" its send and receive baud rates.

This situation necessitates either a modem which can convert the transmit and receive data rates, which usually means some sort of intelligent modem at an inevitably greater cost, or an accessory in the serial line between the computer and modem to convert the data rates.

The AEM4601 Baud Rate Converter described in this article is designed as an accessory for modems based around the 7910 World Modem chip, such as the AEM4600 and our Super Simple Modem, the AEM4605 (Sept. 1986). The project permits the use of 1200/75 bps on computers without a split baud rate serial port by intercepting the outgoing 1200 bps data from the computer and converting it to 75 bps to suit "back channel" rate of the modem. This serves only the videotex or Viatel mode, and any dial-up systems or situations

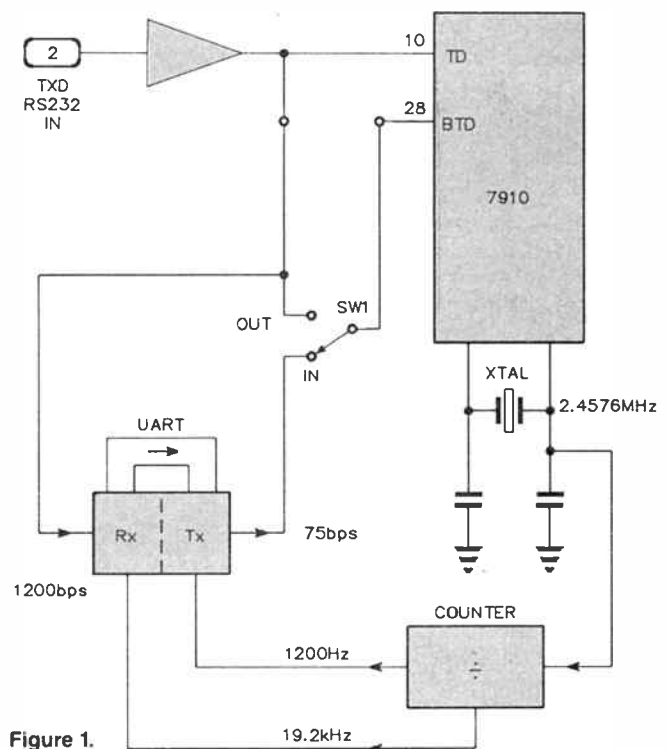


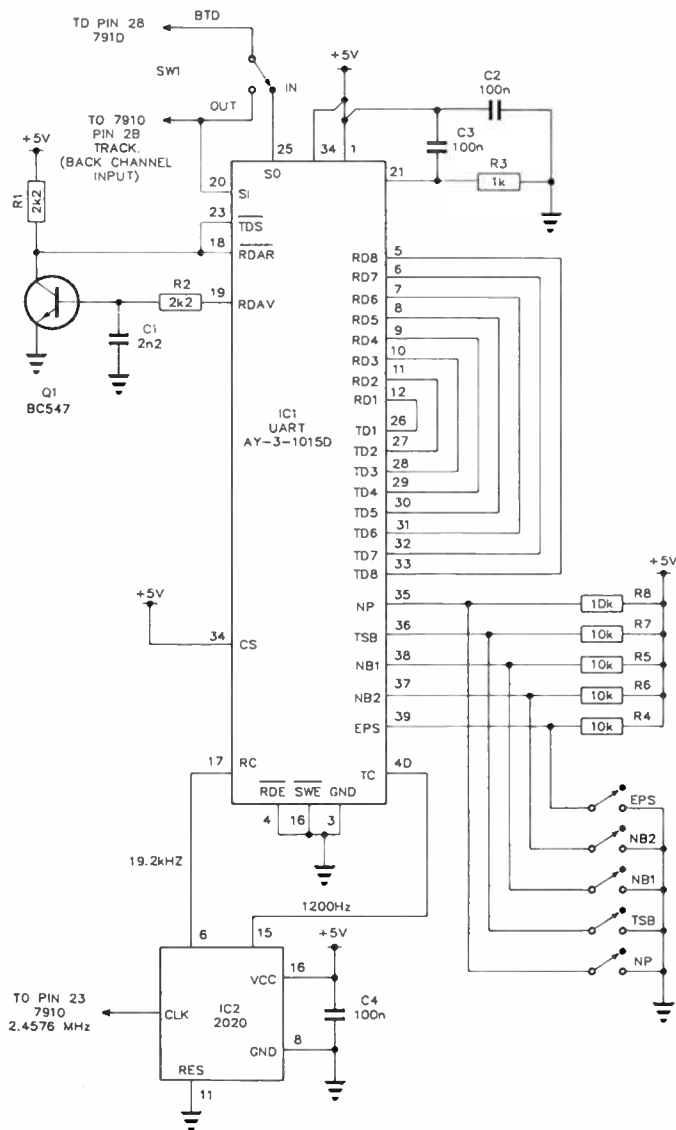
Figure 1.

which employ 1200 bps for the receive channel and 75 bps for the back channel at the originating system. As this covers the vast majority of applications, we've not covered or included any provision for switching the unit for "reverse Viatel" operation. It is however, a simple matter to add by means of a switch if desired.

## The circuit

The circuit is quite straightforward. Heart of the unit is a "universal asynchronous receiver-transmitter", or UART. This translates serial data coming in at one speed and sends





it out at another. In this application, it translates incoming data of 1200 bps and puts it out at 75 bps.

A block diagram of the system, and how it hooks into the modem, is shown in Figure 1. The UART has a receive section and a transmit section. Here they are linked together. The receive section takes in the serial data from the computer at 1200 bps and stores it in an internal buffer. From here it passes to the transmit section, directly into another buffer. The transmit section then takes the data from this buffer and passes it out to the modem at the slower rate of 75 bps. As the transmit and receive sections operate at different data rates, or speeds, their operation is timed by external clock pulses. These are derived from the 7910's clock oscillator, a divider dividing-down the incoming frequency to that required for the UART's transmit and receive sections. A switch permits switching the baud rate converter in and out as required.

The type of UART specified here allows presetting, or programming, of the serial data parameters – the number of data bits, number of start and stop bits and the parity. Provision has been made to set these with either an on-board DIP switch or simple links.

Several makes of UART may be employed. The General Instruments AY-3-1015D and the Standard Microsystems Cor-

## CIRCUIT DESCRIPTION

The circuit is based around a single supply rail programmable UART, either a G.I. AY-3-1015D or S.M.C. COM8017/COM8502. The UART is supplied with 19.2 kHz for the receive clock and 1.2 kHz from the transmit clock from a 4020 CMOS divider which is clocked from the 2.4576 MHz crystal oscillator of the 7910 World Modem chip.

When a complete character is received at 1200 bps, the "receive data available" (RDAV) line (pin 19) of the UART goes high and all received data bits are presented to the transmit data inputs. The RDAV signal is delayed slightly by the RC network in the base circuit of Q1 (BC547) as well as being inverted at its collector. This signal stokes the transmitter side of the UART (pin 23 "transmit data strobe", TDS) and resets the RDAV line by the pulse applied to pin 18 ("receive data available reset" – RDAR). This causes the character to be sent at 75 bps.

In use, the switched output of the converter is connected to the backward channel input (BTD, pin 28) of the World Modem chip. In this way, the circuit can be left connected without affecting the normal 300/300 bps operation of the modem as the backward channel is not used in that mode. It is necessary isolate pin 28 of the 7910 chip on the pc board so that the converter can be connected and details of this operation on both the AEM4600 and AEM4605 modems are given in the text.

Switch SW1 has been provided so that the circuit can be bypassed, restoring modem operation to normal as required.

In the original circuit as described in "Dial up", the UART was hard wired for 7-bit data, one stop bit and even parity. In this project, we have included pads on the pc board so that links or a DIP switch can be fitted, allowing the communications parameters to be altered.

In our prototype, we elected to use a DIP switch for changing the operating parameters of the converter, but as this is generally going to be a "once only" setting, you could use wire links between the pads if you wish. The pins which control the parameters of the UART are 35, 36, 37, 38 and 39. The pc board has been designed to accommodate a 16-pin DIP switch, so only the first five pairs of pads are used and the remaining pads are not connected.

The switches (or links) are arranged so that if the switch is closed (or a link is installed), the pin of the UART associated with the switch will be connected to ground. If the switch is left open, the pin of the UART will be pulled high through the associated 10k resistor (R4 to R8).

The five control pins of the UART have the following functions. Remember that a logic 0 means that the switch is closed or a link is installed, a logic 1 means that the switch is open or a link is not installed:

Pin 35 NP No Parity	Logic 1 eliminates parity
Pin 36 TSB Stop bits	Logic 1 is 2 bits, 0 is 1 bit
Pin 37 NB2 Word length	SEE BELOW
Pin 38 NB1 Word length	SEE BELOW
Pin 39 EPS Parity	Logic 1 is even parity, 0 is odd

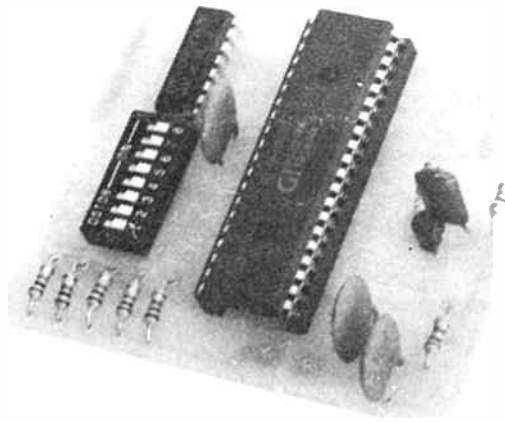
The word length is set using pins 37 (NB2) and 38 (NB1) as follows:

NB2	NB1	Word length
1	0	7-bit word
1	1	8-bit word

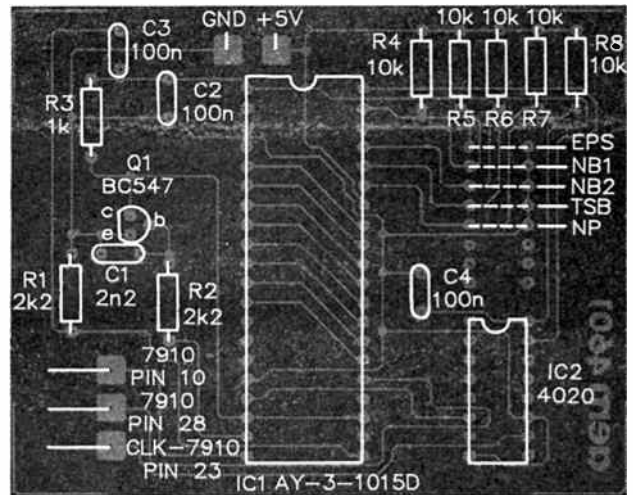
On power-up, C3 will appear as a short circuit, applying a pulse of +5 V to pin 21 of the UART. This is the master reset, or external reset, pin and this initialises the device. C3 will charge fairly quickly via R3 and the initial pulse decays. Pin 21 must be held low during UART operation and this is accomplished by R3. The UART's "chip select" (CS) pin is connected directly to the +5 V line so that the chip is activated immediately on power-up.

Capacitors C2 and C4 bypass the 5 V supply rail which is derived from the modem.





Here's the completed pc board. Simple, isn't it? Note that we used a DIP switch to set the communications parameters. We set them all open, giving an 8-bit word, two stop bits and no parity. At right is the overlay and full-size pc board artwork.



poration COM8017/COM8502 are, for all intents and purposes in this application, functionally similar. They are, fortunately, pin-compatible. A data sheet is reproduced elsewhere in this issue.

## Construction

Construction of the converter is quite straightforward using the pc board designed for the project. It is a wise idea, before you commence, to inspect the pc board, whether you've made your own or purchased a ready-made board. See that all the holes are drilled, in the right and the correct size. Check that there are no copper "bridges" or "fingers" between the closely-spaced pads for the ICs. See that there are no small cracks in tracks, particularly where they join a pad. Cracks are rare, but worth checking for. A small, low power magnifying glass is useful for this task. Correct any problems before proceeding.

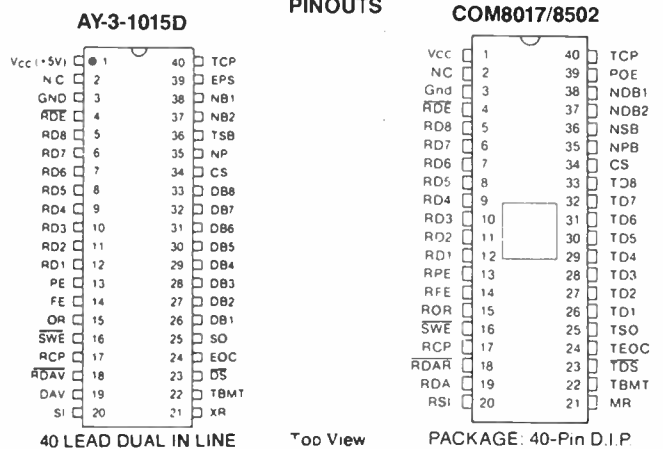
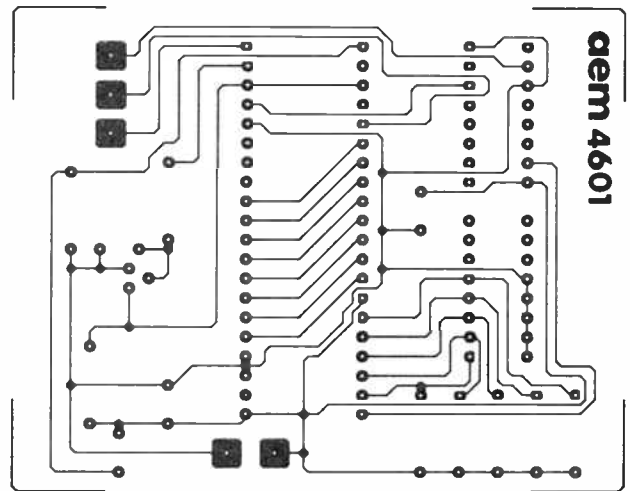
Using a fine-tipped soldering iron, commence by fitting the passive components – the eight resistors and four capacitors. There are no polarised capacitors, so you don't have to watch that here. Continue by fitting the BC547 transistor and the two integrated circuits. If you wish, sockets can be used for the ICs, but whatever method you use, make sure the ICs are inserted the right way around. If you intend fitting a DIP switch to control the UART parameters, do so now. Otherwise, choose the parameters that suit your computer's serial communications standard or that you intend to use and fit small wire links across the pads provided on-board according to the table given in the Circuit Description.

After you have completed the construction of the pc board, check your work thoroughly. The tracks are very fine and some are quite close together so make sure you do not have any solder bridges. Check also that there are no unsoldered or dry joints. These can be quite tricky to spot on a board such as this where there are many small, closely spaced pads.

## Connecting the project

The project can be installed in two ways, depending upon how much room you have in your modem. If things are a bit tight, you may choose to build the converter in a separate case and connect it to the modem with a suitable cable. If you have sufficient room inside your modem, the converter board can be built-in.

If you decide to use a separate case, we would suggest making a cable terminated with suitable DIN plugs for the inter-



connections. Five connections are required, the +5 V supply, ground, clock from the 7910 chip and the incoming and outgoing data. The converter pc board can be mounted in a suitably sized jiffy box, or similar, and a matching DIN socket mounted on the case. Connections from the converter pc board to the DIN socket can be made with short lengths of insulated hookup wire. A matching DIN socket will have to be installed on your modem cabinet. The switch for bypassing the converter can be mounted either in the modem or the converter case.

We would advise the use of shielded cable for the connection between the modem and the converter and use only the

The photo at right shows the 4601 installed in the 4605 Super Simple Modem. It was secured in the case with double-sided adhesive tape.

### AEM4601 PARTS LIST

#### Semiconductors

IC1 ..... AY-3-1015D,  
COM8017 UART  
IC2 ..... 4020  
Q1 ..... BC547/548

**Resistors** all 1/4 W, 5%  
unless noted  
R1-R2 ..... 2k2  
R3 ..... 1k  
R4-R8 ..... 10k

#### Capacitors

C1 ..... 2n2 greencap  
C2-C4 ..... 100n disc

#### Miscellaneous

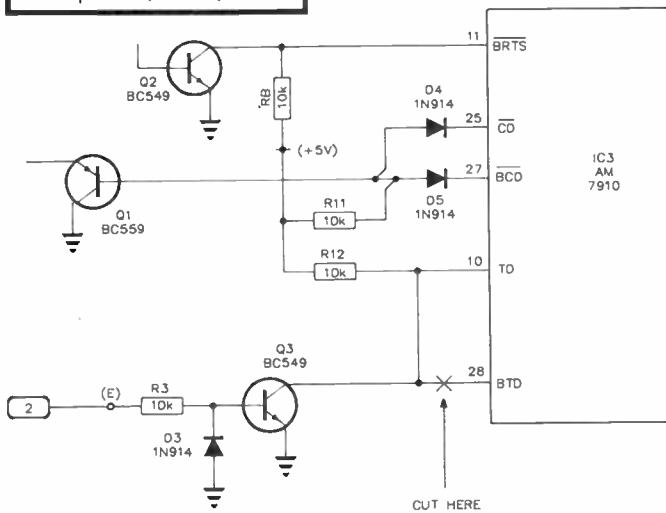
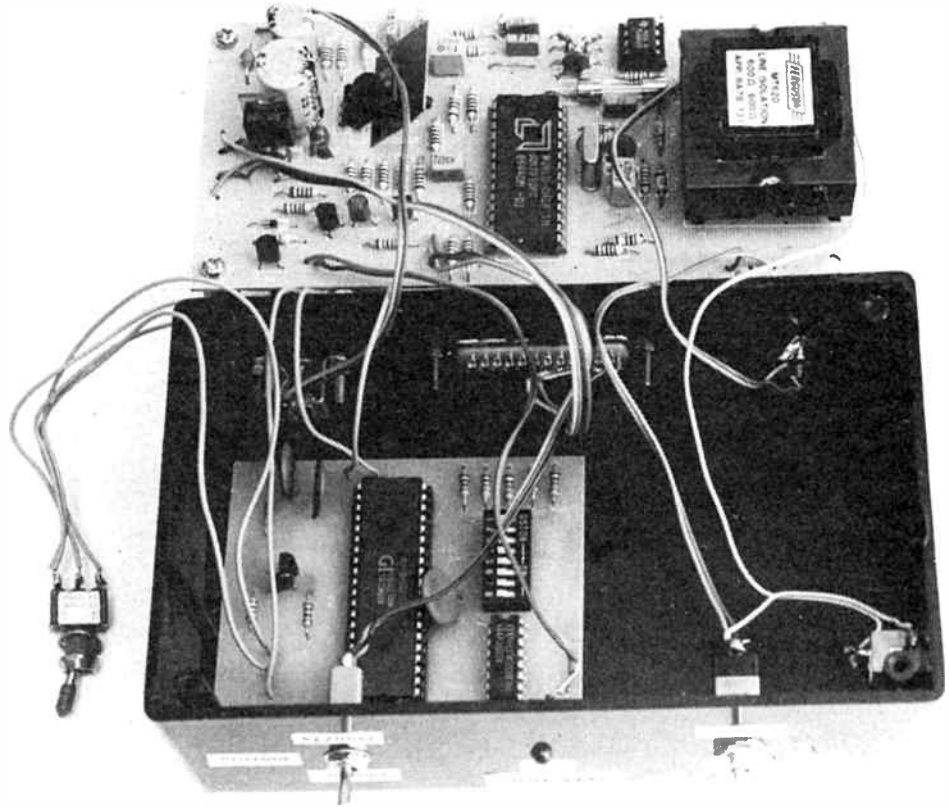
SW1 ..... SPDT toggle switch  
AEM4610 pc board; hookup  
wire;  
tinned copper wire.

#### Optional

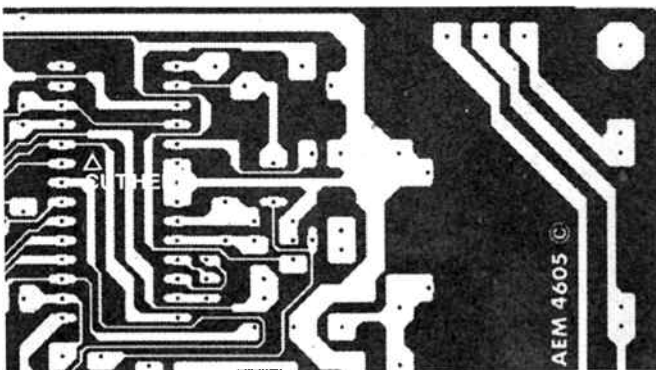
16-pin DIP switch; 2 x 5-pin  
DIN sockets; 2 x 5-pin DIN  
plugs; shielded cable;  
case approx. 100 mm x 75 mm  
x 40 mm; 40-pin IC socket,  
16-pin IC socket.

#### Estimated cost:

Basic project **\$27 - \$30**  
with options **\$37 - \$40**



Here's where you cut the track to pin 28 on the 7910 in the 4605 Super Simple Modem. On the 4600, pin 28 is totally isolated. Other modems will require something similar.



minimum length that is practical so as to allow the converter case to sit atop the modem.

If you have enough room in your modem case, the converter can be installed inside. In our case, we installed the converter inside an AEM4605 modem and secured the converter pc board with double-sided adhesive tape. Connections between the modem and the converter were made with short lengths of insulated hookup wire and the by-pass switch can be mounted in a convenient location on the modem case.

The simplest way to describe how the project should be connected to your modem is to say that it is connected in series with pin 28 of the 7910 World Modem chip. What this means is that pin 28 of the 7910 modem chip needs to be isolated in the modem. In the AEM4605 modem, this is easily accomplished by cutting the track which connects pins 10 and 28 together and the accompanying diagrams show where to do this. The leads from the relevant pads on the 4601 pc board are then simply soldered to the cut track, one to the pin 28 side and the other to the pin 10 side.

Because the AEM4600 modem is built on a double-sided pc board, it would be most difficult to cut one of the tracks to pin 28 of the 7910 modem chip, as it runs underneath the chip itself. In order to isolate pin 28 of the 7910, the easiest method is to unsolder the pin and lift it clear of the board. If you have used a socket for the 7910 chip, you can simply lift pin 28 clear of the socket.

The connections to the baud rate converter can now be made by soldering the lead from the pad on the 4601 board associated with pin 25 of the UART, directly to pin 28 of the 7910 in the modem. The lead from the pad on the 4601 board which is associated with pin 20 of the UART is then soldered to the pad on the modem pc board where pin 28 was previously connected.

The project can be installed in two ways, depending upon

- to page 60 ▸

# aem data sheet

## AY-3-1015D

## UAR/T: Universal Asynchronous Receiver/Transmitter

### FEATURES

- DTL and TTL compatible—no interfacing circuits required—drives one TTL load
- Fully Double Buffered—eliminates need for system synchronization, facilitates high-speed operation
- Full Duplex Operation—can handle multiple bauds (receiving-transmitting) simultaneously
- Start Bit Verification—decreases error rate with center sampling
- Receiver center sampling of serial input, 46% distortion immunity
- High Speed Operation
- Three-State Outputs—bus structure capability
- Low Power—minimum power requirements
- Input Protected—eliminates handling problems

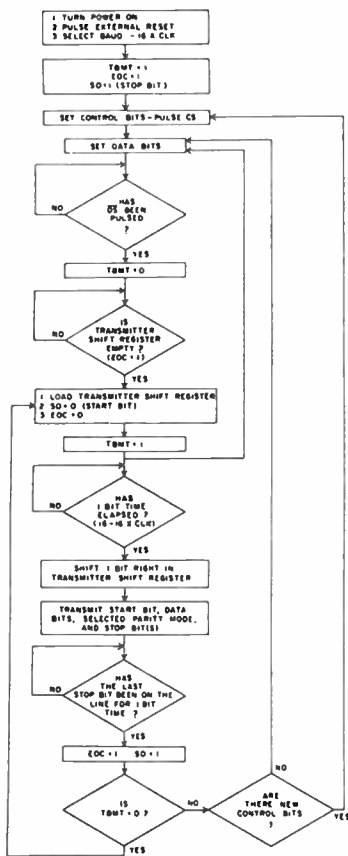
### AY-3-1015D

- Single Supply Operation  
+4.75V to +5.25V
- 1½ stop bit mode
- External reset of all registers except control bits register
- N-channel Ion Implant Process
- 0 to 25K baud
- Pull-up resistors to V<sub>CC</sub> on all inputs

### DESCRIPTION

The Universal Asynchronous Receiver/Transmitter (UAR/T) is an LSI subsystem which accepts binary characters from either a terminal device or a computer and receives/transmits this character with appended control and error detecting bits. All characters contain a start bit, 5 to 8 data bits, 1, 1½, or 2 stop bit capability, and either odd/even parity or no parity. In order to make the UAR/T universal, the baud, bits per word, parity mode, and the number of stop bits are externally selectable. The device is constructed on a single monolithic chip. All inputs and outputs are directly compatible with MTOS/MTNS logic, and also with TTL/DTL/CMOS logic without the need for interfacing components. All strobed outputs are three-state logic.

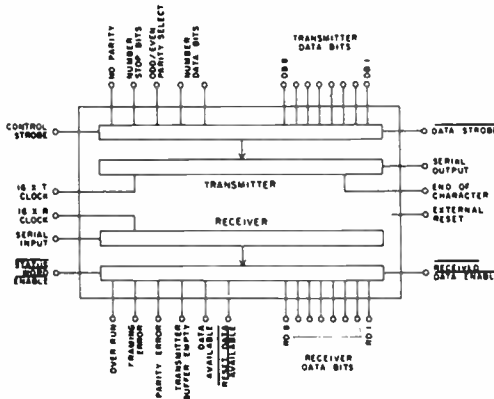
### TRANSMITTER OPERATION



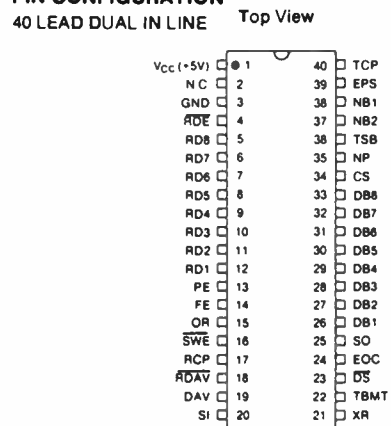
### Initializing

Power is applied, external reset is enabled and clock pulse is applied having a frequency of 16 times the desired baud. The above conditions will set TBMT, EOC, and SO to logic "1" (line is marking).

### BLOCK DIAGRAM



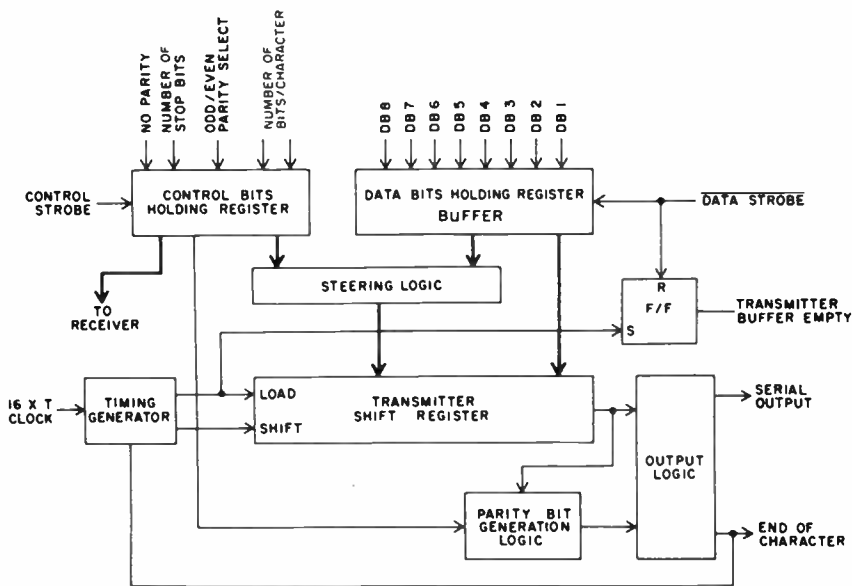
### PIN CONFIGURATION



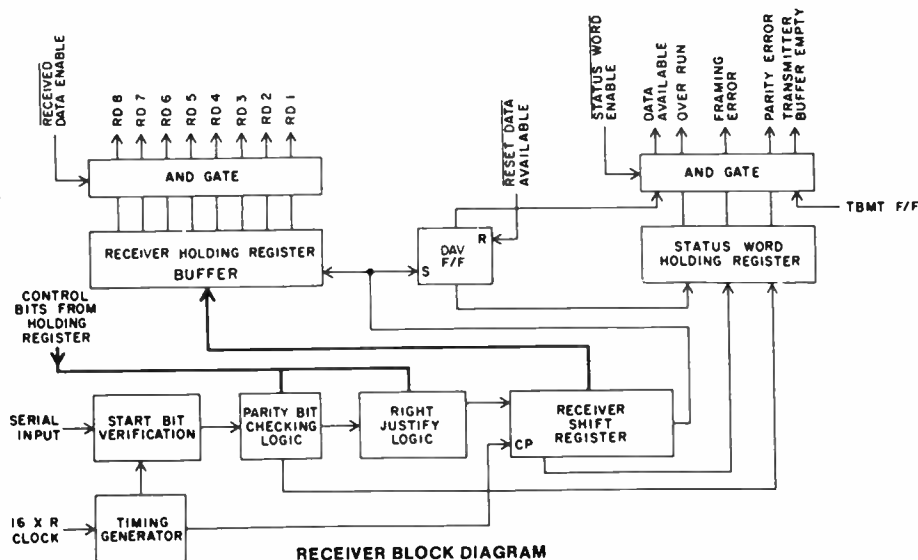
### PIN FUNCTIONS

Pin No.	Name (Symbol)	Function															
1	Vcc Power Supply (V <sub>CC</sub> )	+5V Supply															
2	N.C.	(Not connected)															
3	Ground	Ground															
4	Received Data Enable (RDE)	A logic "0" on the receiver enable line places the received data onto the output lines															
5-12	Received Data Bits (RD8-RD1)	These are the 8 data output lines. Received characters are right justified. The LSB always appears on RD1. These lines have tri-state outputs, i.e., they have the normal TTL output characteristics when RDE is "0" and a high impedance state when RDE is "1". Thus, the data output lines can be bus structure oriented															
13	Parity Error (PE)	This line goes to a logic "1" if the received character parity does not agree with the selected parity. Tri-state															
14	Framing Error (FE)	This line goes to a logic "1" if the received character has no valid stop bit. Tri-state															
15	Over-Run (OR)	This line goes to a logic "1" if the previously received character is not read (DAV line not reset) before the previous character is transferred to the receiver holding register. Tri-state															
16	Status Word Enable (SWE)	A logic "0" on this line places the status word bits (PE, FE, OR, DAV, TBMT) onto the output lines. Tri-state															
17	Receiver Clock (RCP)	This line will contain a clock whose frequency is 16 times (16x) the desired receiver baud															
18	Reset Data Available (RDV)	A logic "0" will reset the DAV line. The DAV F/F is only thing that is reset															
19	Data Available (DAV)	This line goes to a logic "1" when an entire character has been received and transferred to the receiver holding register. Tri-state. Fig. 8															
20	Serial Input (SI)	This line accepts the serial bit input stream. A Marking (logic "1") to spacing (logic "0") transition is required for initiation of data reception. Fig. 7, 8															
21	External Reset (XR)	Resets all registers. Sets SO, EOC, and TBMT to a logic "1". Resets DAV, and error flags to "0". Clears input data buffer. Must be tied to logic "0" when not in use															
22	Transmitter Buffer Empty (TBMT)	The transmitter buffer empty flag goes to a logic "1" when the data bits holding register may be loaded with another character. Tri-state. See Fig. 14, 16															
23	Data Strobe (DS)	A strobe on this line will enter the data bits into the data bits holding register. Initial data transmission is initiated by the rising edge of DS. Data must be stable during entire strobe															
24	End of Character (EOC)	This line goes to a logic "1" each time a full character is transmitted. It remains at this level until the start of transmission of the next character. See Fig. 13, 15															
25	Serial Output (SO)	This line will serially, by bit, provide the entire transmitted character. It will remain at a logic "1" when no data is being transmitted															
26-33	Data Bit Inputs (DB1-DB8)	There are up to 8 data bit input lines available															
34	Control Strobe (CS)	A logic "1" on this lead will enter the control bits (EPS, NB1, NB2, TSB, NP) into the control bits holding register. This line can be strobed or hardwired to a logic "1" level															
35	No Parity (NP)	A logic "1" on this lead will eliminate the parity bit from the transmitted and received character (no PE indication). The stop bit(s) will immediately follow the last data bit. If not used, this lead must be tied to a logic "0"															
36	Number of Stop Bits (TSB)	This lead will select the number of stop bits, 1 or 2, to be appended immediately after the parity bit. A logic "0" will insert 1 stop bit and a logic "1" will insert 2 stop bits. The combined selection of 2 stop bits and 5 bits/character will produce 1½ stop bits															
37-38	Number of Bits/Character (NB2, NB1)	These two leads will be internally decoded to select either 5, 6, 7 or 8 data bits/character															
		<table border="1"> <tr> <th>NB2</th> <th>NB1</th> <th>Bits/Character</th> </tr> <tr> <td>0</td> <td>0</td> <td>5</td> </tr> <tr> <td>0</td> <td>1</td> <td>6</td> </tr> <tr> <td>1</td> <td>0</td> <td>7</td> </tr> <tr> <td>1</td> <td>1</td> <td>8</td> </tr> </table>	NB2	NB1	Bits/Character	0	0	5	0	1	6	1	0	7	1	1	8
NB2	NB1	Bits/Character															
0	0	5															
0	1	6															
1	0	7															
1	1	8															
39	Odd/Even Parity Select (EPS)	The logic level on this pin selects the type of parity which will be appended immediately after the data bits. It also determines the parity that will be checked by the receiver. A logic "0" will insert odd parity and a logic "1" will insert even parity															
40	Transmitter Clock (TCP)	This line will contain a clock whose frequency is 16 times (16x) the desired transmitter baud															





TRANSMITTER BLOCK DIAGRAM



RECEIVER BLOCK DIAGRAM

After initializing is completed, user may set control bits and data bits with control bits selection normally occurring before data bits selection. However, one may set both DS and CS simultaneously if minimum pulse width specifications are followed. Once Data Strobe (DS) is pulsed the TBMT signal will change from a logic "1" to a logic "0" indicating that the data bits holding register is filled with a previous character and is unable to receive new data bits, and transmitter shift register is transmitting previously loaded data. TBMT will return to a logic "1". When transmitter shift register is empty, data bits in the holding register are immediately loaded into the transmitter shift register for transmission. The shifting of information from the holding register to the transmitter shift register will be followed by SO and EOC going to a logic "0", and TBMT will also go to a logic "1" indicating that the shifting operation is completed and that the data bits holding register is ready to accept new data. It should be remembered that one full character time is now available for loading of the next character without loss in transmission speed due to double buffering (separate data bits holding register and transmitter shift register).

Data transmission is initiated with transmission of a start bit, data bits, parity bit (if desired) and stop bit(s). When the last stop bit has been on line for one bit time, EOC will go to a logic "1" indicating that new character is ready for transmission. This new character will be transmitted only if TBMT is a logic "0" as was previously discussed.

**RECEIVER OPERATION**

**Initializing**

Power is applied, external reset is enabled, and clock pulse is applied having a frequency of 16 times the desired baud. The previous conditions will set data available (DAV) to a logic "1".

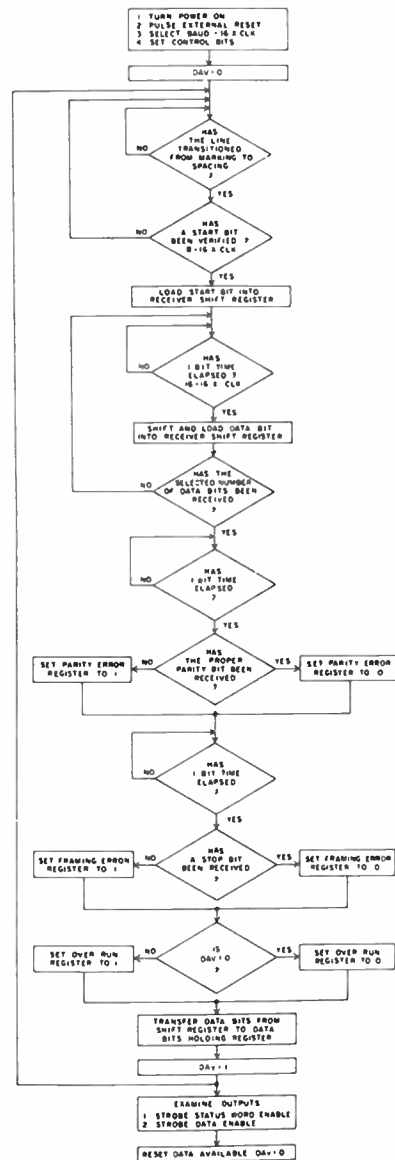
After initializing is completed, user should note that one set of control bits will be used for both receiver and transmitter making individual control bit setting unnecessary. Data reception starts when serial input signal changes from Marking (logic "1") to spacing (logic "0") which initiates start bit. The start bit is valid if, after transition from logic "1" to logic "0", the SI line continues to be at logic "0", when center sampled, 8 clock pulses later. If, however, line is at a logic "1" when center sampling occurs, the start bit verification process will be reset. If the Serial Input line transitions from a logic "1" to a logic "0" (marking to spacing) when the 16x clock is in a logic "1" state, the bit time, for center sampling will begin when the clock line transitions from a logic "1" to a logic "0" state. After verification of a genuine start bit, data bit reception, parity bit reception and stop bit(s), reception proceeds in an orderly manner.

While receiving parity and stop bit(s) the receiver will compare transmitted parity and stop bit(s) with control data bits (parity and number of stop bits) previously set and indicate an error by changing the parity error flip flop and/or the framing error flip flop to a logic "1". It should be noted that if the No Parity Mode is

selected the PE (parity error) will be unconditionally set to a logic "0".

Once a full character is received, internal logic looks at the data available (DAV) signal to determine if data has been read out. If the DAV signal is at a logic "1" the receiver will assume data has not been read out and the over run flip flop of the status word holding register will be set to a logic "1". If the DAV signal is at a logic "0" the receiver will assume that data has been read out. After DAV goes to a logic "1", the receiver shift register is now ready to accept the next character and has one full character time to remove the received character.

This data is presented with the permission of the distributors of General Instruments products, Rifa Pty Ltd. We are indebted to Ian McCracken of Rifa's Sydney branch for his strenuous efforts in obtaining a rare copy of the G.I. data book just before press deadline.



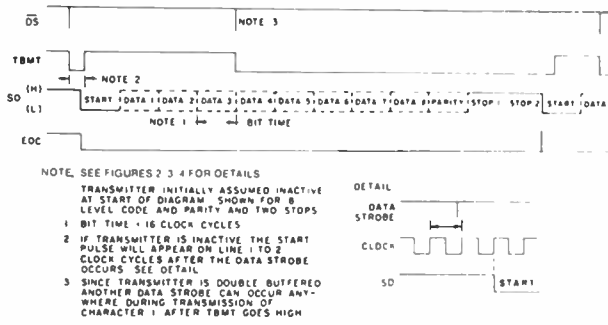


Fig. 1 UAR/T — TRANSMITTER TIMING

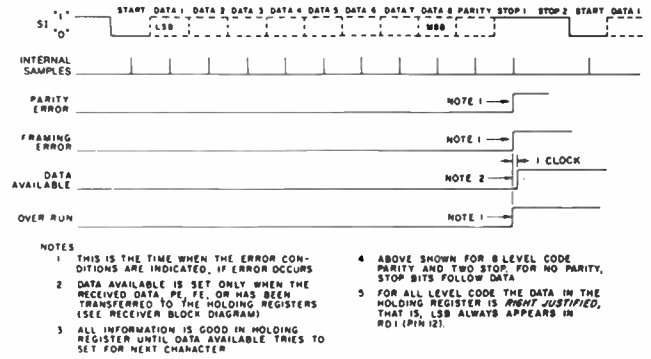


Fig. 6 UAR/T — RECEIVER TIMING

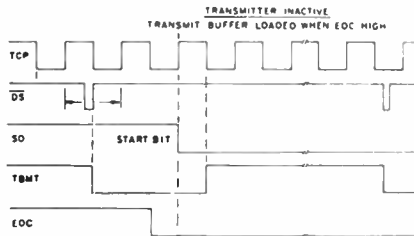


Fig. 2 TRANSMITTER AT START BIT NOT A TEST POINT

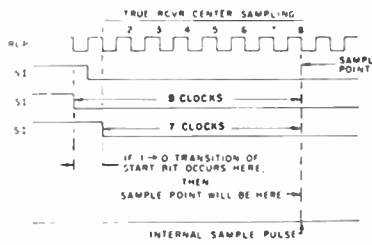


Fig. 7

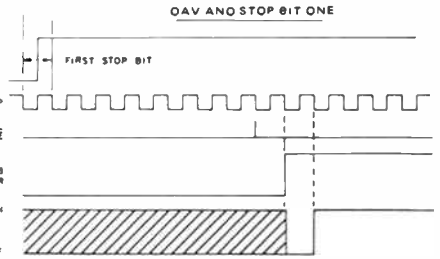


Fig. 8 RECEIVER DURING 1ST STOP BIT

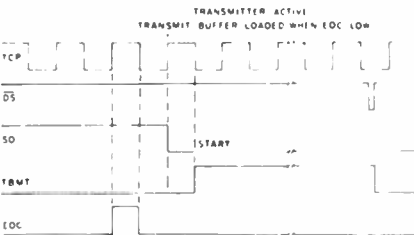


Fig. 3 TRANSMITTER AT START BIT

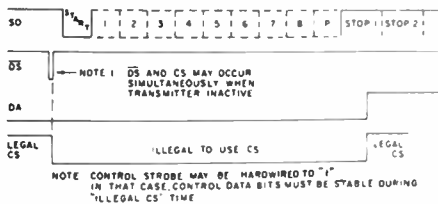


Fig. 4. ALLOWABLE POINTS TO USE CONTROL STROBE

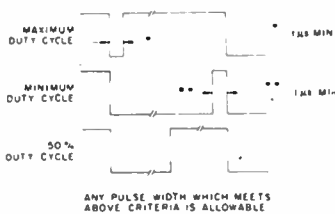


Fig. 5 ALLOWABLE TCP, RCP

## ELECTRICAL CHARACTERISTICS

### Maximum Ratings\*

V <sub>CC</sub> (with Respect to GND)	-0.3V to +16V
Storage Temperature	-65°C to +150°C
Operating Temperature	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	+330°C

### Standard Condition (unless otherwise noted):

V <sub>CC</sub>	+4.75V to +5.25V
Operating Temperature (T <sub>A</sub> )	0°C to +70°C

### DC CHARACTERISTICS

Characteristic	Min	Typ**	Max	Units	Conditions
<b>Input Logic Levels (AY-3-1015)</b>					
Logic 0	0	—	0.8	Volts	Has internal pull-up resistors to V <sub>CC</sub>
Logic 1	2.0	—	V <sub>CC</sub> +0.3	Volts	
<b>Input Capacitance</b>					
All inputs	—	—	20	pF	0 volts bias, f = 1MHz
<b>Output Impedance</b>					
Tri-State Outputs	1.0	—	—	MΩ	
<b>Data Output Levels</b>					
Logic 0	—	—	+0.4	Volts	I <sub>OL</sub> = 1.6mA (sink)
Logic 1	2.4	—	—	Volts	I <sub>OH</sub> = -40μA (source)—at V <sub>CC</sub> = +5V
<b>Output Capacitance</b>					
Short Ckt. Current	—	—	—	—	See Fig. 19
<b>Power Supply Current</b>					
I <sub>CC</sub> at V <sub>CC</sub> = +5V	—	10	15	mA	See Fig. 21

### Standard Conditions (unless otherwise noted)

T<sub>A</sub> = 25°C, Output load capacitance 50pF max

### AC CHARACTERISTICS

Characteristic	Min	Typ**	Max	Units	Conditions
Clock Frequency	DC	—	400	kHz	at V <sub>CC</sub> = +4.75V
Baud	0	—	25	kbaud	at V <sub>CC</sub> = +4.75V
<b>Pulse Width</b>					
Clock Pulse	1.0	—	—	μs	See Fig. 5
Control Strobe	200	—	—	ns	See Fig. 11
Data Strobe	200	—	—	ns	See Fig. 10
External Reset	500	—	—	ns	See Fig. 9
Status Word Enable	500	—	—	ns	See Fig. 17
Reset Data Available	200	—	—	ns	See Fig. 18
Received Data Enable	500	—	—	ns	See Fig. 17
<b>Set Up &amp; Hold Time</b>					
Input Data Bits	20	—	—	ns	See Fig. 10
Input Control Bits	20	—	—	ns	See Fig. 11
<b>Output Propagation Delay</b>					
TPD0	—	—	500	ns	See Fig. 17 & 20
TPD1	—	—	500	ns	See Fig. 17 & 20

\*\* Typical values are at -70°C and nominal voltages

## Microbee feels the Impact

Australian microcomputer manufacturer Microbee systems, has been bought out by Impact Systems, a high tech company predominant in the laser printer market. The deal, which will see Impact take up shares in a private placement and buy on market for a controlling 51%, comes after two years of losses for Microbee.

Four years ago, Owen Hill, the chairman of Microbee, was enthusiastic about the planned sales of his Australian designed and manufactured computer. At that time, he resisted a fund raising public listing of the company, claiming that public floats of high tech companies in Australia had a bad record.

Now, two years after the company's 1985 public fund raising with 7.6 million 25 cent shares, Impact is buying up at 13 ¢ a share.

An inability to produce and market viable products to succeed the ageing 8-bit Microbee computer, coupled with what Owen Hill calls "immature management", led to lower turnover and falling profits.

Microbee Systems emerged from Applied Technology, a company founded by Owen Hill in 1972 to sell his build-it-yourself car alarms, hi-fi kits and electronic components by mail order and over the counter in a shop at Hornsby in Sydney's northern suburbs.

In the late '70s, Hill's Applied Technology joined the fledgling microprocessor bandwagon, offering a variety of system components as kits, later releasing a Z80-based S100 computer system in 1979.

In 1982, the company released the Microbee computer which, as Australia's first microcomputer and with an attractive price, captured an estimated 23-30% of the education market.

Deals were made with Swedish education authorities and 100 units were even sold to the USSR. In 1985, export sales

contributed \$1.5 million and bold projections of \$20 million in revenues and \$2.5 million in profits were being made for the company's first public year.

The results presented at the board's first annual general meeting showed the company had lost a little over half a million dollars.

The board blamed the loss on increasing overheads resulting from reorganisation following the float, which included an increase in staff, a new distribution centre in the Sydney suburb of North Ryde and offices in New Zealand. The sagging Australian dollar also caused problems, inflating the cost of imported components.

In an effort to stem the first year losses, a temporary general manager was appointed which resulted in the closure of North Ryde and the retrenchment of some of Microbee's 150 staff.

More of a problem were the delays in the development and release of new products. The Microbee computer was based around the CP/M operating system and whilst this still had a following, it was being largely replaced by the IBM standard MS-DOS system.

Two major new products, the 8-bit "Delta", said to be based on Hitachi's "super Z80" chip the HD64180, and the much-heralded 68000-based "Gamma", failed to reach production so no new source of cashflow was generated there.

Owen Hill now concedes the company should have made the jump to the more sophisticated MS-DOS standard instead of

relying on the continued strength of the Microbee as a main revenue generator.

A scheme to promote the Microbee as a "plain and simple" office machine product failed to impress its intended audience.

The deal with Impact includes access to Impact's technology as well as an injection of between five and eight million dollars into Microbee through private placement.

Microbee will get preferred distributor status for the supply of Impact products, enabling it to address new opportunities and support new developments.

In the meantime, Microbee has pruned back expenses. The workforce is down to 70 from a high of 150 two years ago. Owen Hill still has an 8% stake in Microbee, although Impact has an option on this. He says that Impact want him to stay, probably in a marketing role and he is hopeful of profits in the coming year.

The cost of survival may be high, but it's encouraging to see an Australian success story being saved from foundering by another Australian success story.

### "Baby AT" motherboard

Electronic Solutions has just announced a "baby" version of their AT motherboard which uses surface mount technology to pack full expansion capabilities (including eight expansion slots) in around half the space of the "normal" AT motherboard.

The "baby" AT board is designed to drop straight into an existing PC or XT case.

Ian Hardwick of Electronic Solutions believes the "baby" AT is a better bet than the many "speedup" cards on the market. "It offers full AT expansion capabilities which are not available with speedup cards. It also offers just about the highest performance on the market" says Ian.

The "baby" AT motherboard

features an 80286-8 processor running at 10 MHz, switchable to 6 MHz, as well as a 7-channel DMA for disk and special I/O.

An on-board, battery backed real-time clock is provided as are eight expansion slots, six of which are full AT standard. The motherboard is supplied with 640K of RAM fitted and is capable of accepting up to one megabyte.

The price of the "baby" AT motherboard is \$995.00 inc. tax, and comes with a 14-day money back guarantee. For those contemplating building an AT from scratch, Electronic Solutions can also supply cases, power supplies, expansion cards and keyboards.

For further information, contact: **Electronic Solutions, PO Box 426 Gladsville, 2111 NSW. (02)427 4422.**

### First ever Australian FORTH symposium

FORTH is a widely available computer programming language that offers a great deal to the professional user, particularly in science and engineering.

With the arrival of the Novix microprocessors whose machine language is FORTH and which execute instructions at 8 MIPS-plus, the advantages of FORTH in time critical applications are very strong indeed.

A symposium has been initiated by a group of professionally involved FORTH users from both industrial and academic organisations, who believe that the language should be more widely known and used by the professional community.

The symposium will take place on May 19th and 20th 1988 at the NSW Institute of Technology and will feature a keynote presentation by Charles Moore, the inventor of FORTH.

For further details on the symposium, contact Jose Alfonso or Dr Paul Walker on (02)20930 or Roy Hill on (02)217 3828.



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## “OCTOBYTE 64”

# A monitor program for the Commodore 64

**Andrew Pierson**

Here is a monitor program for the Commodore 64 computer, written in BASIC. It will allow you to load, enter, modify and save hexadecimal dump programs with a minimum of fuss.

OCTOBYTE 64 is a no-frills mini monitor which can enter or read hexadecimal numbers to or from memory, eight bytes at a time. If you are fundamentally a BASIC programmer, but need to enter hex information from time to time, this program should suit you. It is very “user friendly” and is thoroughly error trapped.

The program has a cumulative checksum counter, which means that it is not necessary to run a separate checksum program. In addition, the C64's SETLFS, SETNAM, LOAD and SAVE kernel routines are properly implemented. This means that machine code programs you have entered and saved can be reloaded later by simply using the LOAD command from BASIC. When specifying the end address for a save, you don't even have to add the customary one byte. How's that for service!

### Entering the program

Take great care when typing the program into your computer. The listing published here was made directly from the computer and is known to work correctly. The greatest cause of problems is always a missed or incorrectly typed line, so if you experience trouble, be sure to check your typing first.

Read the notes at the start of the listing which indicate the conventions used for entering Commodore graphics and reversed characters. Many of these characters cannot be reproduced in a printed listing, but the method used in the listing is quite straightforward and shouldn't cause you any difficulties. You will need to edit line 110 of the listing depending upon whether you are using tape or disk. Make sure the device number in this line is correct for your system before running the program.

### Using Octobyte 64

Once you have entered Octobyte 64, it can be put straight to work. When the program is RUN, the familiar INPUT question mark appears. If a four digit (i.e. two-byte) hex address is entered, the hex contents of that location, together with the following seven location will be displayed across the screen. The display will be followed by a \*MEM indicator which shows that the display is a readout and not an entry. The decimal figure at the right of the display shows the total checksum value for the line.

If a four digit hex address is entered, together with eight bytes of hex data in the following format:

```
C0E8 83 C7 C9 19 D0 03 4C 8D
```

these eight bytes will be loaded into memory, starting at the hex address specified. When this has been done, the operation is confirmed by an ENTRY message on the right of the display. Underneath, two checksum figures are displayed. These indicate the total for the eight bytes just entered as well as a cumulative value for everything you have entered since the last CLR command.

There are four commands to which Octobyte 64 will respond: CLR, LOAD, SAVE and EXIT.

The CLR command resets both checksum counters to zero and is used at the end of blocks during the entry of hex dumps.

The LOAD command re-enters a previously SAVED machine code program. All that is required is that the program name be entered when the prompt appears. If you are using tape and don't specify a name, the first program encountered will be loaded.

The SAVE command does what the name implies. You will need to enter the program name, the address of the first byte of the block to save and the address of the last byte of the block to save. The program is very friendly and prompts for all these inputs are provided.

The EXIT command simply takes you neatly back to BASIC.

### Rules

There are a few simple rules to keep in mind when using Octobyte 64. All addresses must contain four digits. This would normally be the case as it's unlikely that you will be using page zero memory very often. If you do need to specify a single byte address, it should take the form 00FF, etc.

When the eight bytes are being entered, you must enter all eight bytes, separated from the address and each other by a single space. If you make a mistake at this point, or in any other regard, Octobyte 64 has a variety of error messages which will pinpoint it for you.

Finally, as program names are entered via INPUT statements, it is not necessary to enclose them within quotes unless commas or colons appear in the name. The name

PLEASE NOTE:

WHEN SUBSTITUTE GROUPS ARE PRINTED FOR COMMODORE GRAPHICS AND REVERSED CHARACTERS. THE FOLLOWING CONVENTIONS ARE OBSERVED:

- 1 AN UNDERSCORE IS PRINTED ON EITHER SIDE OF THE GROUP. E.G. \_(CLEAR-HOME)\_
2 IF INSUFFICIENT SPACE FOR A SUBSTITUTE GROUP IS AVAILABLE AT THE END OF A LINE, IT WILL BE PRINTED AT THE BEGINNING OF THE NEXT LINE. THE END OF THE PREVIOUS LINE WILL THEN BE MARKED BY A BACKSLASH (\)
3 FOR COMMODORE GRAPHICS AND REVERSED CHARACTERS WHICH ARE NOT 'QUOTE-MODE' SYMBOLS, THE CORRESPONDING SCREEN DISPLAY CODE WILL BE PRINTED. E.G. \_SDC 90 \_L\_ OR \_[SEC 129]\_

```
10 REM
20 REM *** OCTOBYTE 64 ***
30 REM
40 REM AN 8 BYTE MINI-MONITOR
50 REM BY ANDREW PIERSON, 1987
60 REM
70 POKE55,176 POKE56,159 CLP
80 REM NEW TOP OF MEMORY 40880 DECIMAL
90 FORJ=1024 READD NEXTJ FEM SI IP DATA
100 FORIM=40907040955 PERC POEIM,C NEXTIM RESTORE CLR REM M/C LOADER
110 POKE40901,1 FEM TAPE=1 [IS]=8
120 POKE1020,PEEK53280, POKE53280,0
130 PRINTCHR$(142),GOSUB490
140 X$="RET" INPUTX$ IFX$="RET"THEN140
150 IFX$="LOAD"THEN500
160 IFX$="CLR"THEN480
170 IFX$="SAVE"THEN550
180 IFX$="EXIT"THEN920
190 GOTO390
200 GOSUB280 IFEF=1THEN470
210 A=V IFJLEN(X$)GOTO250
220 FORI=0T07 GOSUB290 C(I)=V IFEF=1THEN470
230 NEXTI T=0 FORI=0T07 POKEA+I,C(I) T=T+C(I) NEXTI PRINT"_[CRSR-UP]_"TAB(34)"E
BITV"
240 PRINT"_[CRSR-RIGHT]_"_[CRSR-RIGHT]_LCSUM="T CT=CT+T PRINTTAB(14)"_[CRSR-UP]_L
OTRL="CT"_[CRSR-DOWN]_" GOTO140
250 T=0 PRINT" +HEM", FORI=0T07 V=PEEK(A+I) T=T+V V=V/16 PRINT" ", FORJ=1T02
260 VZ=V V=(V-VZ)*16 IFVZ>9THENVZ=VZ*7
270 PRINTCHR$(VZ+48), NEXTJ NEXTI PRINT" --"_[CRSR-DOWN]_" GOTO140
280 P=1 L=4 GOTO300
290 P=J L=2
300 EF=0 V=0 FORJ=P TO LEN(X$) X=ASC(MID$(X$,J)) IFX=32THEN NEXTJ
310 IFJLEN(X$)THEN380
320 P=J FORJ=P TO LEN(X$) X=ASC(MID$(X$,J)) IFX<>32THEN NEXTJ
330 IFJ=PCOL THEN380
340 FORY=P TO J-1 X=ASC(MID$(X$,Y)) IF X<58THEN X=X-48
350 IFX>64THEN X=X-55
360 IFX<0 OR X>15THEN380
370 V=V+16*X HEXK RETURN
380 EF=1 RETURN
390 VLEN(X$) IFV<5THEN200
400 IFV<28THEN450
410 DATA 5,8,11,14,17,20,23,26,6,7,9,10,12,13,15,16,18,19,21,22,24,25,27,28
420 FORZ=1T08 READS IFMID$(X$,S,1)<>" THEN450
430 NEXTZ FORZ=9T024 READD IFMID$(X$,D,1)*" THEN460
440 NEXTZ RESTORE GOTO280
450 PRINT"_[CRSR-UP]_"_[SDC 90]_ INCORRECT FORMAT " RESTOR
E GOTO140
460 PRINT"_[CRSR-UP]_"_[SDC 90]_ HEX CODE MISSING " RESTOR
E GOTO140
470 PRINT"_[CRSR-UP]_"_[SDC 90]_ ILLEGAL CHD OR HEX INPUT "
GOTO140
480 T=0 CT=0 GOTO240
490 PRINT"_[CLEAR-HOME]_"_[CRSR-DOWN]_"TAB(12)" + OCTOBYTE 64 +_[CRSR-DOWN]_"\
_[CRSR-DOWN]_" RETURN
500 REM 'LOAD' ROUTINES
510 GOSUB490 P$="" INPUT"PROGRAM NAME",P$ NL=LEN(P$) IFNL>16THEN510
520 PRINT"_[CRSR-DOWN]_"LOADING "P$"
530 POKE40902,NL GOSUB850 PRINT SV540907 SV540928
540 GOSUB490 PRINT"_[CRSR-RIGHT]_"_[CRSR-RIGHT]_"P$" LOADED_[CRSR-DOWN]_" GOTO1
40
550 REM 'SAVE' ROUTINES
560 GOSUB490 P$="" INPUT"PROGRAM NAME",P$ NL=LEN(P$) IFNL>16THEN560
570 PRINT"_[CRSR-DOWN]_"_[CRSR-RIGHT]_"_[CRSR-RIGHT]_"SAVE "P$" PRINT"\
_[CRSR-DOWN]_"_[CRSR-RIGHT]_"_[CRSR-RIGHT]_"ENTER ADDRESSES IN 4-DIGIT HEX CODE\
_[CRSR-DOWN]_"
580 PRINT INPUT"FIRST BYTE OF SAVE",HE$
590 GOSUB700 IFEF=1THEN680
600 POKE40903,DL POKE40904,DH
610 PRINT INPUT"LAST BYTE OF SAVE",HE$
620 GOSUB700 IFEF=1THEN690
630 IFDL=#255THEN650
640 POKE40905,DL+1 POKE40906,DH GOTO660
650 POKE40905,0 POKE40906,DH+1
660 POKE40902,NL GOSUB850 PRINT"_[CRSR-DOWN]_" SV540907 SV540934
670 GOSUB490 PRINT"_[CRSR-RIGHT]_"_[CRSR-RIGHT]_"P$" SAVED_[CRSR-DOWN]_" GOTO14
0
680 PRINT"_[CRSR-DOWN]_"_[SDC 90]_ START ADDRESS ERROR - REDO" GOTO580
690 PRINT"_[CRSR-DOWN]_"_[SDC 90]_ END ADDRESS ERROR - REDO" GOTO610
700 EF=0 IFLEN(HE$)<4THEN840
710 H$=LEFT$(HE$,2)
720 H$=LEFT$(H$,1) H$=RIGHT$(H$,1)
730 H$="0123456789ABCDEF" CN=0
740 C$=MID$(H$,CN+1,1) IFCC$=H$THEN770
750 CN=CN+1 IFCN=16THEN840
760 GOTO740
770 DR=CN CN=0
780 C$=MID$(H$,CN+1,1) IFCC$=H$THEN810
790 CN=CN+1 IFCN=16THEN840
800 GOTO760
810 DB=CN CN=0 IFRF=1THEN830
820 DH=(DH+16)+DB H$=RIGHT$(HE$,2) RF=1 GOTO720
830 DL=(DL+16)+DB RF=0 RETURN
840 EF=1 RETURN
850 SH=1272 FORNA=40881T040896
860 SC=PEEK(SH) IFSC>31 AND SC<64THEN880
870 SC=SC+64 IFSC>127THENSC=32
880 AC=SC POKEA,AC SH=SH+1 NEXTNA RETURN
890 DATA 169,1,174,197,159,160,1,32,186,255,173,198,159,162,177,160
900 DATA 159,32,189,255,96,169,0,32,213,255,96,173,199,159,133,251
910 DATA 173,206,159,133,252,174,201,159,172,202,159,169,251,32,216,255,96
920 PRINT"_[CRSR-DOWN]_"_[CRSR-RIGHT]_"_[CRSR-RIGHT]_"EXIT FROM OCTOBYTE\
_[CRSR-DOWN]_"_[CRSR-DOWN]_" POKE53280,PEEK(1020) END
```

length is limited to 16 characters as usual and if you enter a name longer than 16 characters, it will be ignored.

How it works

The algorithm which enters and reads the hex data is contained between lines 200 and 380. This code has been adapted from the "Tiny PEEKer/POKER", published in appendix F of "Machine Language for Beginners" by Richard Mansfield. Extensive modifications have been made to the original code, particularly with regard to the on-screen presentation.

The remainder of the listing is taken up with extended error checking, the addition of a cumulative checksum counter and the implementation of the C64 LOAD and SAVE routines. As you can see from the listing, these routines occupy about half the program, so a brief explanation is in order.

The C64 SETLFS (set up logical file), SETNAM (set program name), LOAD and SAVE kernel routines must be called from a machine code program. After the top of BASIC memory has been lowered, the necessary code is put in place by a BASIC loader (lines 90-100 and 890-910). Note that the first 24 bytes of data in line 410 are used for input error checking and are not part of the loader's data. Line 90 bypasses this extra data by reading the first 24 data items and ignoring them.

Machine code

OctoByte 64's machine code extends from 40881 to 40955 and consists of a data area and three mini-program areas. The data required consists of the program name (40881-40896), the device number (40901), program name length (40902), SAVE start address (40903-40904) and the SAVE end address + 1 (40905-40906). The appropriate data is POKEd into the machine code area by the BASIC program before a LOAD or SAVE command is executed.

SETLFS and SETNAM (40907-40927) are called together before either LOAD (40928-40933) or SAVE (40934-40955). Note that these routines don't actually perform the LOADING or SAVEing, they merely establish the correct conditions before the kernel routines are called.

In case you are wondering how the program name is put in place, the secret lies in lines 850-880. When the name is entered as a string (P\$), it is printed on the screen in a known position. The Commodore screen display code characters are PEEKed from the screen memory, converted to ASCII values and then POKEd into their respective memory locations. For this reason, be sure to enter lines 520 and 570 exactly as shown in the listing.

# Public domain comms packages

LAST MONTH I promised to discuss two very popular but vastly different comms packages for use with an IBM PC and a dial-up modem. The two packages concerned are Zcomm (written by Chuck Forsberg for a group called Omen Technology) and Qmodem (written by a group calling themselves the Forbin Project). Let's take Zcomm first.

Zcomm is one of those packages that you either love or hate. The package fails miserably on the "pull-down menus" test, because they're non-existent. The writers of Zcomm make no apologies for not including pull-down menus. They state quite clearly that given the nature and power of the package, pull-down menus would be inappropriate. Instead, Zcomm is a totally command driven type of program, taking its commands from a series of abbreviated instructions and parameters sent as a string to the package. Here I quote from the documentation -

"ZCOMM is a command driven program. Once learned, ZCOMM's command interface is more powerful, faster, and less cumbersome than a menu interface with equivalent choices. Indeed, menus comprehensive enough to describe all the nuances of ZCOMM's capabilities would take up more memory than most computers can afford. In addition, remote operation of ZCOMM would be cumbersome due to transmission delays while displaying the numerous menu pages that would be required."

I am not overly keen on having to come to grips with a command driven program, given the rather large investment in time required to learn the syntax of those commands. My wife already complains that I am starting to talk to her in hex codes (I told her it could be worse - I could talk in binary), because of the large amount of time I spend staring at "hieroglyphics on a screen" (her words, not mine). To have to spend even more studying abbreviated command codes is more than I could bear. Zcomm and Qmodem only have one feature in common and that is the fact they are both enormously

large packages. They both take up three 360k floppy discs in their extracted form. To use of these packages effectively, one really needs to have a hard disc. As an example of the command driven nature of Zcomm, I have extracted portion of a typical session from the documentation. It's shown below in Figure 1.

Zcomm's documentation is extremely comprehensive and well laid out (as is Qmodem's). Commercial software houses would do well to examine some of the documentation provided with \$40-\$60 public domain/shareware programs, and then compare it with their own \$400-\$600 packages. Often it's ten times worse, instead of ten times better. The volume of Zcomm's documentation runs to some 80 pages. My printer (An original model Epson MX100) worked solidly for seven hours printing out the manuals for Zcomm and Qmodem. The sheer volume of Zcomm's manual was slightly daunting and, combined with command driven nature, was enough to make me slip it away for "a rainy day's investigation."

Qmodem, on the other hand, is very similar in operation to both Procomm and Telix, in that it operates from pull-down menus. Let me cast my vote right at the start - I LIKE QMODEM. Despite what its detractors say about its size, and rather lengthy installation process, Qmodem is a TOP public domain comms package. Packages of this quality on the commercial market could easily cost upwards of four hundred dollars, but Qmodem only costs fifty dollars for its registration fee.

Rather than reiterate previous features, let me discuss where Qmodem differs from Procomm and Telix. Firstly, rather than change operating parameters from the appropriate menu, Qmodem allows the user to run a program called QINSTALL, which takes the user through a series of installation menus, covering such features as screen and colour, dialing parameters, comms ports and their set-up etc. The screen colour set-up is shown below in Figure 2. You then

Figure 1. A typical Zcomm session.

<pre> wlaw speed 110 putw "ATSI0=255 C0 HD D-r" t -v -v prints control chars as C so they won't erase the screen, etc. Ignore Carrier Detect, Carrier Dfl, Special Off Hook (Don't close relay), Originate, Online WIAW ASCII transmissions are at 110 bps  and here is what a typical Zcomm session would look like:-  A ZCOMM call unit: Connect to a local system named Unit: jabber jabber ... Login to system, change directory. ALT-2 Command: Get a ZCOMM command prompt sz prg", " prghlp.mm Upload some files jabber jabber ... sz *.c *.h Download some source files Receiving ... ZMODEM Autobdownload accepts them !ermit -! Start the Unit, permit server F1 c: Get ZCOMM's command prompt remote dir Get a directory listing Directory... Directory listing on screen get f2 Get (fetch) a file f2 Open ... File arrives send myfile Send "myfile" to server finish Finish server access t Enter term function !ermit send f1 Start a !ermit file transfer F4 Receive the file f1 Open... File is received jabber jabber ... Log off local system F1 c: Get ZCOMM's command prompt port l Select modem on COM1 call rcpm Dial a system called "rcpm" jabber jabber ... Keyboarding with remote </pre>	<pre> Home /to superhacker t /to j. fred muggs b w F1 E ENTER ALT-2 Command: open -p letter  dir xmodem s foo.bar ALT-2 Command: rc foo.bar PgUp PgUp ...  !ENTER- xmodem s dr.who ALT-2 Command: rc /misc/dr.who jabber jabber ... !F1 -!c: Connect the modem create rtty.tmp call wlaw bleep twort sneep  !F2   OST DE WIAW ... END ... AR ALT-C: !F1 -!c:fff </pre>	<pre> Review function at top of text Search for beginning of message to you Set top pointer Search for beginning of next message Set bottom pointer Write selected text to a disk file Return to term function Tell the rcpm to enter a message Get a ZCOMM command prompt Open "letter" and send to bbs, using prompt and throttle modes to slow transmission so the remote system won't drop characters. Find out what files are on the RCPM Command RCPM to download a file Get a ZCOMM command prompt Download a file with XMODEM/CRC Flip back to the first part of directory previously listed Back to term function Download a critical file Get a ZCOMM command prompt Download the file More keyboarding, logoff Get ZCOMM's command prompt Connect to the radio's audio and tune in WIAW Create a disk file for the bulletins Static on the radio - pure line hits until WIAW is received while sending ASCII Review/! command clears the buffer Close the capture file Return to DOS </pre>
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------



have the option of either saving or abandoning the changes, prior to running the actual Qmodem program.

This type of feature could be a distinct disadvantage, for those who wish to change a parameter on the fly, except that the builders of the program have provided an option whereby QINSTALL can be run from inside the Qmodem program. The advantage of having a separate install program may not be immediately obvious to novices, but it is fairly clear – when installing a program the first time using internal set-up commands, it is fairly easy to overlook a setting. When you go through a step-by-step set-up, overlooking a feature is almost impossible, so the program is installed correctly from the start.

Figure 2. Qmodem colour screen set up

```

-----
Qinstall - Color Setup
-----
This is Foreground Text and Background.          * Color Chart *
* Qmodem Information Message
-----
**[ Window Colors ]*****
: 0 1 2 3 4 5 6 7 8 9 0 1 2
: 1 .....
: 2 .....
: 3 .....
: 4 .....
: 5 .....
: 6 .....
: 7 .....
-----
EEEEEEEEEEEEEEEE Status Line EEEEEEEEEEEEEEE
-----
Foreground Text   [0-15] [3 ]   Background [0- 7] [0 ]
Screen Border    [0-15] [0 ]
Primary Text (Window) [0-15] [3 ]   Secondary  [0-15] [2 ]
Window Border    [0-15] [6 ]   Background [0- 7] [0 ]
Information Message [0-15] [7 ]
Status Line Foreground [0-15] [1 ]   Background [0- 7] [3 ]
-----
Press F2 to Update the Screen Example above
Press F1 for Help, F10 to Accept changes, or Esc to Exit      Insert Off
-----

```

Secondly, Qmodem has the ability to post-install new comms protocols. Several examples are included of what the builders call "External Protocols." Zcomm is one of these, as are WXMDEM and Kermit. This means that when an improved version of a protocol becomes available, it can be easily incorporated into the existing package. This is a far more flexible arrangement than sitting swearing at your existing package because it hasn't got the protocols supported by your latest BBS. Top marks for this one. The Download protocol menu is shown below in Figure 3.

Figure 3. Qmodem download protocol menu.

```

+=[ Download Protocols ]+=
| Free Space 4614144 |
| A) Ascii |
| X) Xmodem |
| C) Xmodem CRC |
| R) Relaxed Xmodem |
| I) Imodem |
| Y) Ymodem |
| G) Ymodem-G |
+=====[ External ]====+
| B) Batch Ymodem |
| Z) Zmodem |
| K) Super Kermit |
| W) WXMDEM |
| Your choice ? _ |
+=====+

```

Finally, QModem is far more informative about the file transfer process than are other packages. I have included here a diagram of what a typical transfer menu appears like when Qmodem is downloading a file.

Notice the section marked "Efficiency." This little window

```

+=[ Download File (receive) ]=====+
:Press [PgDn] to abort.
:Total Blocks received : 64   Bytes/Blk : 1029
:-- Long Block errors  : 0   Tot. Bytes: 65536
:-- Short Block errors : 0
:-- SDH errors         : 0   Average CPS : 963
:-- Complement errors  : 0   Efficiency : 50.2%
:-- Block number errors: 0
:-- Timeout errors    : 0
:-- Resend Block errors: 0
:-- CRC errors        : 0
:-- Last error message :
+=====+

```

is continually updated during the transfer process, showing the actual transmission as a percentage of the selected transmission speed. Combined with the overall transmission error rate, one can very easily calculate which is the most efficient transfer protocol under the existing conditions. Multiplying the Average CPS figure by 10 will also provide the effective bps transmission speed. This figure, together with the efficiency figure, indicate that the transmission was taking place with a comms port setting of 19.2 kbps. Also, QModem provides far more extensive error reporting than do other packages. Once again, top marks.

Now for some of the duds.

Boyan, WAM and PC-DIAL are three programs to be avoided. Considering the other offerings available from the public domain/shareware arena, these are definitely not worth the effort. They are all minimal systems and two of the three are command driven, rather than menu driven. In Zcomm's case this is due solely to the size and power of the program. It is certainly not the case with any of the above.

Next month I shall discuss Boyan and Pibterm. Both of these are very similar in operation to Procomm, and the minor differences between the two are not sufficient to prefer one to the other. I simply discovered Procomm before either Pibterm or Boyan (although I do prefer Procomm).

All of these programs were dragged off SORCIM's bulletin board (043-693658), operated by my old friend John Caine. Before you all rush off to dial him up, John will have moved to sunnier parts of the state by the time you read this. We (the magazine and myself) wish John all the best on the North Coast and hope to see a new BBS appearing in the Taree area shortly.

## More on Forth and Novix

As a result of the large amount of interest that has been shown in Forth in recent months, Paul Walker of the NSW Institute of Technology and myself have decided to hold a combined Forth symposium/workshop on May 18th and 19th next year.

Charles Moore (the great man himself) will be coming to Australia to perform the role of keynote speaker and to give a paper on the developments of the Novix chip set. It is expected that registration will cost in the vicinity of \$100 and the whole operation is being planned as a non-profit venture. The event is being planned as joint symposium/workshop, with papers being presented on a wide range of Forth topics. Exhibitions from industry specialists in Forth applications will also be provided.

Anyone interested in attending this two-day (maybe even three if there's enough interest) symposium/workshop, should direct their enquiries to the Conference organiser, Mr Jose Alfonso at the Institute of Technology.

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- Hayes compatible • auto-answer/auto-dial/auto-hangup • baud rate sense • built-in bit rate converter • meets Telecom requirements • expansion bus for easy upgrades • V21, V23 (300/300, 1200/75, 75/1200 bps) operation • V22 (1200/1200 bps) upgrade board available • RS232 interface • powered from 16 Vac plugpack.

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- (b) AEM4610 with V21, V22, V23 – **\$350.00!**

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Visa: \_\_\_\_\_

Mastercard: \_\_\_\_\_

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# HERE'S THE SMART DATA COMMS PACKAGE WITH ALL THE 'SMARTS'

## SUPERCOM

SuperCom is a product of Operating Systems Research Pty. Ltd and is produced and supported in Australia.

Winner of the coveted Australian Software of the Year Award, this is the ideal program for those who have an IBM PC or compatible and use or want a 'smart' modem, or even a 'dumb' auto-dial modem.

Just the thing you need to team with your PC/clone and the Supermodem!

Just look at these great features and facilities!

Incorporating the best of Crosstalk, Gateway, and Carbon Copy, Supercom is, as its name implies, a unique 'super program' when it comes to communications. Straight communications, file transfer, Viatel and a sophisticated remote facility are just some of the features of the package.

The authors have integrated all the facilities into the one package. As a result, the user is presented with one easy-to-learn user interface, rather than being asked to battle with a series of programs for each purpose.

### THE RIGHT PACKAGE FOR BOTH CORPORATE AND EXPERT USER

Supercom is designed for both the occasional, non-technical user and the experienced operator. An initial 'beginner' mode (which may be disabled) allows the non-expert to establish communications from a simple menu with only one keystroke.

Autodialling is provided for both 'smart' and many older 'dumb' modems (via DTR dialing). Full automatic setup of speed and modem type is provided from this initial menu.

Once in 'expert' mode, the user is presented with a menu of functions which may be selected via the menu or directly from the command line, via short mnemonic titles.

### A SUPERIOR TERMINAL EMULATOR IS INCLUDED

Very complete terminal emulation facilities are provided. Terminals which may be selected directly from the menu include:

- ADM3A
- ADM5A
- ADM31
- Televideo 910, 912, 925, 950
- IBM 3101
- Hazeltine 1500
- Espirit series

plus many more - over 40 in total.

Learning is enhanced with extensive context-sensitive help. The status line quickly reflects the user's selections.

But for those still not satisfied, the inbuilt emulation editor allows the experienced user to alter and create further emulations.

### ALL MAJOR FILE TRANSFER PROTOCOLS SUPPORTED

Supercom supports both SYMDEMOD and MODEM 7 batch transfer protocols for error free file transfer.

### 'PHOTOSTAT' FACILITY RUNS POPULAR IBM PC SOFTWARE REMOTELY

For those needing to use IBM programs remotely, the Supercom 'Photostat' facility is essential. Unlike the normal DOS mode provided with other comms packages, 'Photostat' provides access to the screen, essential for many popular PC programs, including Lotus, Open Access, Enable and WordStar.

Competing software offering this feature alone, sells for much more than the complete Supercom package.

### AUTODIALLING AND REDIALLING - BEAT THOSE BULLETIN BOARD BLUES

Supercom will dial a number of predetermined numbers in rotation. All your favourite bulletin boards are dialled until you get onto one.

Supercom allows the user to build a dialling directory so that services can be quickly called up by name.

### SCRIPT FACILITY FOR UNATTENDED INFORMATION GATHERING

For users needing information from Viatel or other services on a regular or time-dependent way, Supercom incorporates a Script facility. Once set up, the program will dial up, log on, get and store information, and log off again. It will do this at a specific time, or every so many hours. Perfect for getting financial or other information, automatically.



### COMPLETE VIATEL COMPATIBILITY

Supercom supports Viatel, even on low cost modems that do not support split baud rates. Capture mode can be switched on and off with just one keystroke.

Complete facilities for playing back Viatel frames are provided.



### THE FASTEST SERIAL TRANSFER IN THE BUSINESS

Supercom provides baud rates from 75bps to a staggering 38,400bps, making it excellent for high speed local file transfer as well as modem work.

### FULLY SMART MODEM COMPATIBLE

Full support for HAYES compatible modems is provided, with user-installable strings to take advantage of special modem features. Includes support for the extended HAYES command set as used in 2400bps modem (V22 bis).

### SUPERCOM RUNS ON ALL THE LATEST PCs

Supercom works on all IBM PCs and compatibles running colour graphics (CGA), Enhanced Graphics (EGA) and monochrome (including Hercules). Disk formats including both 5 1/4 inch and the newer 3 1/2 inch formats. Recent machines confirmed for Supercom include:

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- IBM Convertible
- Toshiba T3100
- Toshiba T2100
- Toshiba T1100 Plus
- Compaq 386

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# Using the Microbee in your amateur station

G. J. Wilson

## Part 5 – towards a more versatile log (cont.)

IN THIS PART we get down to some of the fancier "bells and whistles" you might like to add to your basic logkeeping software.

### [6]

Sometimes data is entered over an extended period with other activities distracting your attention from the keyboard and monitor while you are working. In these circumstances it is handy to have a display showing the details of the last entry made without having to refer to printouts, etc. A typical example of this would be when entering material from a long list. Which entry WERE you up to when the phone range?

This routine produces two identical strings when a data entry is made. One becomes the normal entry while the other is retained to display the same data again as the "LAST ENTRY" while the subsequent entry is being made. The display of the original data is erased as the new entry proceeds but is retained in memory until the current entry is printed. This ensures that the original data entry is still available should the new entry be aborted and have to be re-entered.

The demonstration routine has only two inputs for simplicity but there is no reason why all the data input for a given log entry could not be displayed if needed.

```
00010 REM (6) DISPLAY OF DATA PREVIOUSLY ENTERED
00020 B2# = KEY: B3# = KEY: B4# = KEY: B4# = ""
      GOTO 40
00030 PLAY 20; 0; 20: RETURN
00040 CLS: IF B4# = "" THEN 70
00050 CURS 24,12: UNDERLINE: PRINT "LAST ENTRY":
      NORMAL
00060 CURS 10,14: PRINT "Callsign: " B3#: CURS 26,14:
      PRINT: "   Frequency: " B6 " MHz."
00070 CURS 16,5: INPUT "CALLSIGN ?  :", B2#
      CURS 25,5: PRINT "   "
00080 IF B2# = "" THEN GOSUB 30: GOTO 70
00090 CURS 16,8: INPUT "FREQ. MHz.  :", B5:
      CURS 27,8: PRINT "   "
00100 B3# = B2#: B4# = "*": B6 = B5
00110 REM PROGRAM CONTINUES ->
00120 GOTO 40: REM SIMULATES PROGRAM LOOPING TO START
```

### [7]

A log contains a considerable variety of numerical values, such as the page number, QSO number, line number on the page etc. It may not be possible to show these figures on the screen at all times, but they do need to be available for checking every so often.

One solution to this problem is to provide a page of data which can be toggled on and off from one or more of the usual entry points, such as "CALLSIGN". By entering [+] [RETURN], the page can be called up and viewed without interfering with the operation of the program. Entering [RETURN] at the bottom of the page restores the program to the point from which it departed.

This avoids crowding the screen unnecessarily with a lot

of information which may be distracting if displayed all the time. All numbers are updated at the completion of each entry and the page number is increased by one after every fifty entries. Toggling the data page has no effect upon the counting systems in the program.

```
00010 REM (7) DATA UPDATE PAGE TOGGLE
00020 B7# = KEY
00030 C0 = 1: REM SETS FIRST PAGE No.
00040 C1 = 0: REM SETS QSO No. TO 0 AT START OF LOG
00050 C2 = 0: REM SETS LINE No. TO 0 AT START OF LOG
00060 C4# = KEY: GOTO 160
00070 PLAY 20; 0; 20: RETURN
00080 CLS: C3 = 50 - C2: REM CALCULATES No. OF LINES
      TO NEXT PAGE ( 50 ENTRIES PER PAGE )
00090 CURS 26,1: UNDERLINE: PRINT "DATA PAGE": NORMAL
00100 CURS 18,5: PRINT "Page number: ....." C0
00110 CURS 18,7: PRINT "Total QSOs: ....." C1
00120 CURS 18,9: PRINT "QSOs this page: ....." C2
00130 CURS 18,11: PRINT "Lines to next page: ..." C3
00140 CURS 26,15: INPUT "[RETURN]", C4#
00150 IF C2 = 51 THEN LET C2 = 0: C0 = C0 + 1: REM
      RESETS LINE COUNTER AND INCREASES PAGE No. BY
      1 AT START OF NEW PAGE
00160 CLS: CURS 16,8: INPUT "CALLSIGN ?  :", B7#:
      CURS 25,8: PRINT "   "
00170 IF B7# = "+" THEN B0: REM [+] SELECTS DATA PAGE
00180 IF B7# = "" THEN GOSUB 70: GOTO 160
00190 REM PROGRAM CONTINUES ->
00200 C1 = C1 + 1: C2 = C2 + 1: REM INCREASES QSO No.
      AND LINE No. BY 1 AFTER EACH ENTRY IS COMPLETED
00210 GOTO 150: REM SIMULATES PROGRAM LOOPING TO
      START
```

### [8]

In some circumstances it may be necessary to maintain a constant mode, frequency, signal report etc. During contest operating this can save a lot of time when the same information would otherwise be keyed in repeatedly.

As with the DATA PAGE routine, the character which is entered at a normal input location toggles an optional page. By entering [%] instead of "CALLSIGN", the mode can be changed to a fixed entry which is automatically inserted in each input cycle. The same entry point can also be used to change back to manual insertion by entering [/] when needed.

This routine can be used for any input and placed at any suitable point in the program, provided that the particular input does not lock out of the cycle after it is initiated. i.e: In the sample routine you could not use the "2x MODE" input instead of "CALLSIGN" to vary the mode. Once the "MODE" entry has been made it is then bypassed on all subsequent cycles until cancelled via the "CALLSIGN" input.

A selective sorting section is included in this routine which will only accept a specified group of options for "MODE". The entry must be for CW, FM or SSB using only the variations listed in lines 40-60. Any entry other than these will cause the question "NEW MODE ?" to be asked again until a suitable answer is given. The same technique

may be used in numerous other similar applications where an answer must fall within a set group of parameters.

Once the correct choice has been made, the mode is then printed on screen as either "CW", "FM" or "SSB" regardless of the input, such as "c", "F", "ssb" etc. The mode then retains this form whenever it is used until deliberately changed by the operator.

```

00010 REM (8) CONSTANT DATA OPTION
00020 C5$ = KEY: C6$ = KEY: C7$ = KEY: GOTO 100
00030 PLAY 20: 0: 20: RETURN
00040 IF C6$ = "C" OR C6$ = "c" OR C6$ = "CW" OR
C6$ = "cw" THEN LET C6$ = "CW": RETURN
00050 IF C6$ = "F" OR C6$ = "f" OR C6$ = "FM" OR
C6$ = "fm" THEN LET C6$ = "FM": RETURN
00060 IF C6$ = "S" OR C6$ = "s" OR C6$ = "SSB" OR
C6$ = "ssb" THEN LET C6$ = "SSB": RETURN ELSE
LET C6$ = "": RETURN
00070 CLS: CURS 16,8: INPUT "NEW MODE ?  :", C6$:
GOSUB 40
00080 IF C6$ = "" THEN GOSUB 30: GOTO 70 ELSE GOSUB 30
00090 C7$ = "C": REM [C] = CONSTANT MODE
00100 CLS: CURS 16,8: INPUT "CALLSIGN ?  :", C5$:
CURS 25,8: PRINT " "
00110 IF C5$ = "%" THEN 70: REM [%] SELECTS CONSTANT
MODE OPTION
00120 IF C5$ = "/" THEN LET C5$ = "": C7$ = "": REM
(/) DESELECTS CONSTANT MODE OPTION
00130 IF C5$ = "" THEN GOSUB 30: GOTO 100
00140 IF C7$ = "C" THEN 170
00150 CURS 16,9: INPUT "2x MODE ?  :", C6$: GOSUB 40
00160 IF C6$ = "" THEN GOSUB 30: GOTO 150
00170 CURS 16,9: PRINT "2x MODE  : " C6$
00180 REM PROGRAM CONTINUES ->
00190 CURS 26,15: INPUT "[RETURN]", D0$: REM HOLDS
PROGRAM PRIOR TO STARTING NEXT CYCLE
00200 GOTO 100: REM SIMULATES PROGRAM LOOPING TO START

```

## [9]

When commencing a contest it is often useful to show a distinct separation between the normal and contest log sections. This routine does so by leaving a line space, providing a contest heading, then leaving another line space.

The heading (up to 62 characters maximum) is entered between the limits delineated and when printed on the page will be centred. It should be quite easy to fit a heading, such as "John Moyle Memorial Field Day 14/15 March 1987"

within the limitation of a single line.

This routine will have to be added to the main log program at an appropriate location. Three lines are added to the total number used on the current page each time the routine operates. When there is insufficient room for three additional lines on the current page, the routine is automatically bypassed.

The printing starts four spaces from the left hand margin of the page (plus justified spaces) in this example. To change the position of the printout, alter the space before "TAB" and the value "74" in line 190 to suit your particular application.

```

00010 REM (9) HEADING WITH CONTEST NAME
00020 IF D1 = > 48 THEN 240 ELSE 60: REM D1 = No.
OF LINES ON CURRENT PAGE
00030 PLAY 20: 0: 20: RETURN
00040 CLS: OUT#1 ON: RETURN
00050 CLS: OUT#1 OFF: RETURN
00060 D2$ = KEY: D3$ = KEY: GOSUB 40: PRINT
CHR$(27); CHR$(15);: GOSUB 50: REM SETS
CONDENSED PRINT MODE
00070 CLS: CURS 9,7: PRINT
"Do you require a HEADING with CONTEST NAME ?"
00080 CURS 20,10: INPUT "YES (Y) or NO (N) ?:", D2$:
00090 IF D2$ = "Y" OR D2$ = "y" THEN LET D2$ = "Y":
GOTO 110
00100 IF D2$ = "N" OR D2$ = "n" THEN LET D2$ = "N":
CLS: GOTO 240 ELSE GOSUB 30: GOTO 70
00110 CLS: CURS 1,5: PRINT "Maximum number of
characters to be used is 62, BETWEEN ARROWS."
00120 CURS 24,8: PRINT "CONTEST NAME ?:" CURS 2,11:
PRINT "": CURS 63,11: PRINT " "
00130 CURS 1,15: PRINT "Start at LEFT ARROW, heading
will CENTRE AUTOMATICALLY on page."
00140 (CURS 2,12: PRINT "": CURS 63,12: PRINT "":
00150 CURS 1,10: INPUT " ", D3$
00160 IF D3$ = "" THEN GOSUB 30: GOTO 110
00170 GOSUB 40: PRINT: REM SPACE 1 LINE
00180 PRINT CHR$(27);"E": PRINT CHR$(27);"4":
REM SETS EMPHASIZED PRINT MODE AND
ALTERNATE CHARACTER SET
00190 PRINT "    TAB ( 74 - LEN ( D3$ ) ) / 2:
REM CENTRE JUSTIFIES HEADING
00200 PRINT D3$
00210 PRINT CHR$(27);"5": PRINT CHR$(27);"F":
REM CANCELS ALTERNATE CHARACTER SET AND
EMPHASIZED PRINT MODE
00220 PRINT: GOSUB 50: REM SPACE 1 LINE
00230 D1 = D1 + 3
00240 REM PROGRAM CONTINUES ->

```

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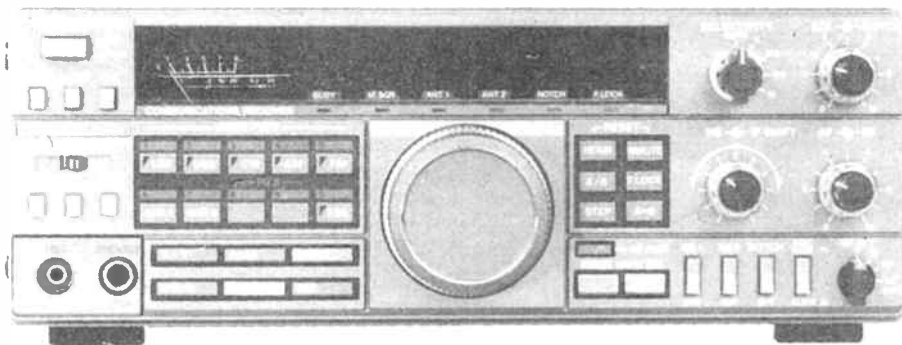
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Nov. 1987 — Australian Electronics Monthly — 85

# KENWOOD

# R-5000 COMMUNICATIONS RECEIVER



## CAPTURE THE WORLD

The R-5000 is a new competition grade communications receiver which incorporates every conceivable operating feature. Designed for all modes of reception (SSB, CW, AM, FM, FSK), the R-5000 covers the frequency range from 100 kHz to 30 MHz, and with the addition of the optional VC-20 VHF converter, will also cover the 108 to 174 MHz range, again with all mode reception. The R-5000 has been designed with high performance in mind, and has an excellent dynamic range, together with carefully chosen operating facilities to match today's conditions. Micro-processor control is used for main functions, including dual digital VFO's, 100 memory channels, memory scrolling, memory and programmable band scan, and many other facilities.

### FEATURES

Coverage is 2 MHz to 30 MHz in 30 bands, with an additional range from 108 to 173 MHz using the optional VC-20 VHF converter.

Advanced microprocessor control allows frequency band and mode data to be stored, recalled, and displayed, even in the VHF band of the VC-20

The RF circuits of the R-5000 have been designed to give a high dynamic range, and with the 500 Hz bandwidth selected (YK-88C option), the intermodulation free dynamic range is 102 dB, with a third order intercept point of +14 dBm, and a noise floor of -138 dBm

\*100 kHz to 30 MHz optional extra.

### High stability frequency control.

The reference oscillator which determines the frequency stability and readout accuracy of the R-5000 is accurate to + or - 10 ppm within a temperature range of -10 to +50 degrees Celsius.

### 10 Hz step dual digital VFOs.

Built in dual VFOs operate independently of each other, and allow split frequency and split mode operation. The frequency steps are basically 10 Hz, giving that "True VFO" feel when tuning. The frequency steps are changed to 1 KHz in AM mode, and 5 kHz in FM mode.

Provision is made for the connection of both high and low impedance antenna systems.

### Superb Interference Reduction.

Selectivity is enhanced by the use of dual crystal IF filters for SSB, and further features include IF shift and tunable notch filters. The IF filter selection system is fully flexible, in the same manner as the TS-440S transceiver, and offers automatic selection by mode, or manual selection according to the operator's requirements.

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### Keyboard Frequency Selection

Frequencies can be entered using direct keyboard control, and a frequency lock switch prevents accidental frequency changes from occurring.

### 100 Memory Channels Capability

100 memories are provided, which store frequency, mode, and which antenna has been selected. Memory information can be scrolled to review contents of any memory channel.

### Memory Scan and Programmable Band Scan.

Further memory facilities include memory scanning with programmable memory lockout, and programmable band scanning with centre stop for accurate on-channel tuning.

### Plus a full list of other desirable features:

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- Optional VS-1 voice synthesiser for frequency announcement
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To summarise: the R-5000 from KENWOOD offers the operator a top performance communications receiver of the very highest quality, with all the features and functions which the discriminating user could demand.

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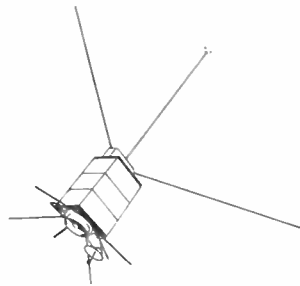
## Latest news from UoSAT UO-11

Those of you who have built the UoSAT Decoder project published in the September issue will probably have read all the news from the UO-11 "diary". For those who have not, here are a few of the highlights.

A significant step has been made in the U/SAT-2 Digital Communications Experiment (DCE) program. Whilst the DCE has been supporting digital store-and-forward communications for radio amateurs for almost two years, engineers at UoS have also been using the DCE to evaluate the electronic components which will be needed to build a full-scale store-and-forward satellite.

As part of this study, Stephen Hodgart and Jeff Ward (G0K8KA) at UoS have been developing software error-correcting codes to detect and correct radiation-induced single event upsets (SEUs) in the DCE RAM.

The DCE carries 96 kbytes of



RAM for message storage (as well as 28 kbytes for programs). This message store (called the RAMUNIT) is composed of high-density CMOS RAM ICs; each IC

carries either two kbytes or eight kbytes of memory. It is impractical and inefficient to provide hardware circuits to detect and correct memory upsets on this much memory in such dense ICs. Hence the need for software memory protection.

### UO-9 Operations

Special doppler tracking experiments are scheduled for UO-9 on Wednesday 071087 which will entail the transmission of a single tone or silent carrier instead of CCD data.

### Moscow space forum

Among the many international delegations attending a Space Future Forum in Moscow October 4 and 5 will be a group supported by AMSAT-NA.

The meeting is being sponsored by the Space Research Institute of the USSR and will be held at the Space Research Institute in Moscow. It is timed to coincide with the 30th Anniversary of the launch of the first artificial Earth satellite, Sputnik, October 4.

### OSCAR 10

AO-10 remains in hibernation. It has been off since power availability fell below required levels. Engineers estimate it will be late autumn when power levels return to required levels. Restoration of AO-10 Mode B operation is anticipated on or about December 1.

### Novice numbers in the USA

Since enhancements were granted to USA Novice amateur operators, licence applications have quadrupled! Larry Weikert, Chief of the General Radio Branch in Gettysburg, is quoted in the W5YI report as saying, "We will probably process in

excess of 6000 Novice applications this month, as opposed to a normal of 1500".

It is obviously too early to make a judgement about any long-term effects of US Novice enhancement, but it's possible that the desirability of voice and digital privileges to prospective hams may be strong enough to offset the negative aspect of having to learn Morse code.

With the controversy over Novice enhancements still raging in Australia, perhaps there are some lessons to be learned from our American brethren, particularly with regard to the granting of "digital" privileges to Novice licences.

### Goodnight, VNG!

Regretfully, Australia's own time and frequency standard station, VNG, was closed on October 1st. The service operated on 4.5 MHz, 7.5 MHz and 12.5 MHz and could be readily received in the Australasian region.

Located in Lyndhurst, Victoria, VNG served as an accurate time signal source for many years and was used by people from all walks of life, such as astronomers and sailors. It was also used by shortwave listeners and amateur radio operators as a frequency standard and propagation indicator.

The closure has been threatened for more than a year. Telecom however, who operated the service in recent years, has closed VNG as it did not appear to serve a purpose any more. With its closure, Australians and our Pacific Basin neighbours have lost a cheap and readily available time and frequency standard, and must now rely on more expensive means instead.

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### AEM ON THE AIR - VK2FJO

The Australian Electronic Monthly Amateur Radio Club is now on the air with the callsign VK2FJO - the "finest journal out"!

The day-old callsign was given a good airing during the WIA NSW Division's Two Metre Activity contest on the evening of Friday 25th, scoring 47 contacts. The contest was the brainchild of Peter VK2EMU. The object was to contact as many different stations as possible during the specified two-hour period (9-11 pm), in as many different postcodes as possible. Only one contact per station was permitted and contacts had to be made on simplex FM between 145 and 145.6 MHz. Scoring was number of valid contacts times number of different postcodes. We scored 1833 from 47 contacts in 39 different postcodes. (How come there were five operators in our postcode?!)

Look out for VK2FJO on the bands.

# Build a multi-band trap dipole for the HF amateur bands

Andy Keir VK2AAK

With the new sunspot cycle on the rise, there's renewed interest in the high frequency amateur bands. If you're refurbishing your station, or only a recent licensee just getting established, here's a simple, economical antenna that provides multi-band coverage, features coax feed and does not require an antenna tuner.

ONE OF THE SIMPLEST ANTENNAS that an amateur radio enthusiast can erect is the wire dipole. The dipole antenna can provide good results as well as being easy to construct and match to the transmitter. The biggest disadvantage of the simple dipole is the fact that it is usually only suitable for operation on a single band, or at best, a couple of harmonically related bands. As we will show, by the simple expedient of adding some tuned circuit "traps" to a simple dipole,

tions is resonant at 7 MHz, we will have the equivalent of a loaded dipole at 7 MHz which will exhibit the same feed point impedance as a simple dipole for that band.

The tuned circuits L2-C2 are made resonant at 7 MHz and therefore act as a high impedance to that frequency in the same way as L1-C1 did at 14 MHz. The 7 MHz dipole is therefore effectively isolated from the remaining outer parts of the antenna, C-C. If, as before, we adjust the sections C-C so that

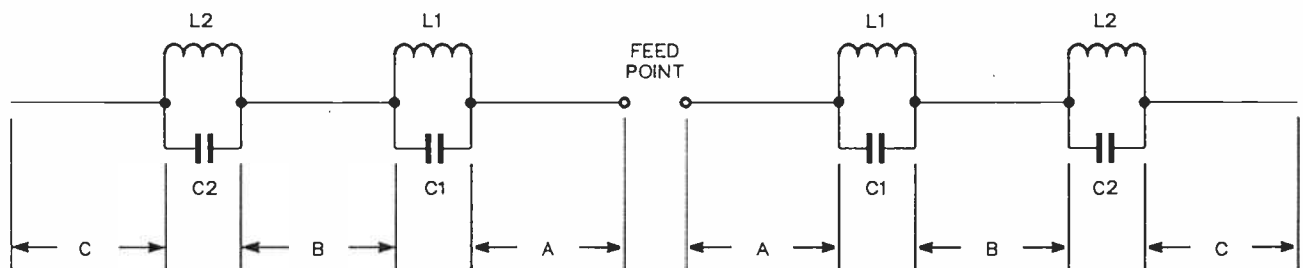


Figure 1. General arrangement of the multi-band trap dipole.

the antenna can be made to operate on a number of different frequency bands.

## The trap dipole principle

The basic principle is illustrated by Figure 1. The two inner lengths of wire, marked "A", form a simple dipole resonant at the highest frequency of interest. We will assume that the inner section is resonant at 14 MHz. The two tuned circuits L1-C1 are also resonant at this frequency and so, when connected as shown, they will offer a high impedance to the RF current of that frequency which may be flowing in the section A-A. The two tuned circuits therefore act effectively as "insulators" at the ends of the inner dipole and the outer sections appear as if they are not connected.

If we now examine the next lower frequency of interest, say 7 MHz, the tuned circuits L1-C1, which are resonant at 14 MHz, will show an inductive reactance and will appear electrically to be a simple coil. If the two sections marked "B" are now adjusted in length so that together with the coils represented by L1-C1, the system out to the ends of the "B" sec-

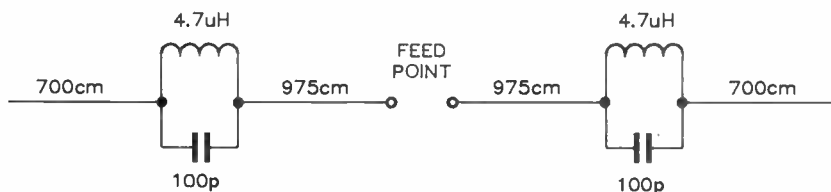
together with the two sets of loading coils represented by L1-C1 and L2-C2, the whole structure is resonant on 3.5 MHz, we now have a loaded dipole for the 3.5 MHz band as well.

## More bands

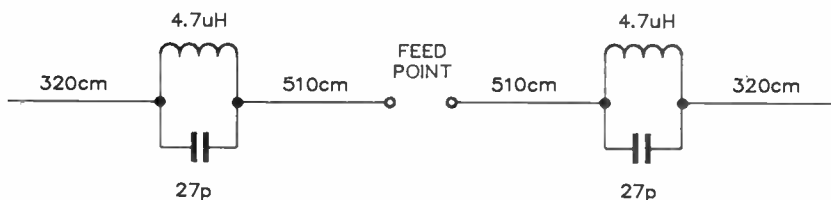
On bands which are higher in frequency than that at which the inner dipole A-A is resonant, all the tuned circuits or "traps" will show capacitive reactance. The capacitive reactances have the effect of raising the resonant frequency of the antenna as compared to a simple dipole of the same dimensions. In this way, the antenna can be used on higher frequencies as a harmonic type antenna, but achieving resonance whilst maintaining a low feed point impedance will require careful attention to the L/C ratios of the traps as well as the lengths of the various antenna sections.

By using a combination of harmonically operated dipoles and traps, it is possible to construct a five-band antenna using only one pair of traps. Referring to Figure 2, the traps are designed to resonate at 7 MHz and thus isolate the inner 7 MHz dipole from the outer section. The dimensions of the

**Figure 2. Five-band trap dipole covering the 3.5, 7, 14, 21 and 28 MHz bands. Overall length is a little over 33.5 metres.**



**Figure 3. The four-band version is a little over 16.6 metres long and covers the 7, 14, 21 and 28 MHz bands.**



outer sections are adjusted such that the overall system is resonant at 3.5 MHz. On 14, 21 and 28 MHz, the antenna operates harmonically on the capacitive reactance principle as described above. The feedpoint impedance will be much the same as a simple dipole at around 70 ohms (if mounted at least a half wave above ground. The impedance is lower if the antenna is mounted lower).

For those of you who don't have the space for the full length, five-band antenna, a four-band version covering the 40, 20, 15 and 10 metre bands can be constructed by simply altering the dimensions of the dipole sections and using different value capacitors. You will notice that we have used the same value of inductance in the traps for this antenna so that they can be modified for the full size version at a later date if required. The dimensions for the four-band version are shown in Figure 3 and in this case, the traps are designed to be resonant at 14 MHz.

## Trap construction

As you will see from Figures 2 and 3, both traps require an inductance of 4.7 uH. There are a number of ways to produce such a coil, including the use of pre-wound air dielectric inductors. However, we wanted to make this project cheap and easy using readily available materials, so we decided to wind our own coils for the traps.

A suitable former which is easy to obtain from any hardware store is the white PVC pipe used in plumbing. This material is available in a number of sizes, but the one we chose measured 56 mm (2 3/8 inches) outside diameter. This pipe is actually marked 50 mm, but this refers to the inside diameter. To find out how many turns we need for a given inductance, we use the following formula:

$$N = \frac{\sqrt{L(9r + 10l)}}{r}$$

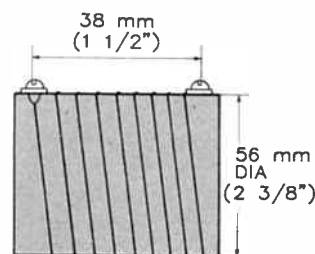
where N = the number of turns required

L = the inductance required in uH

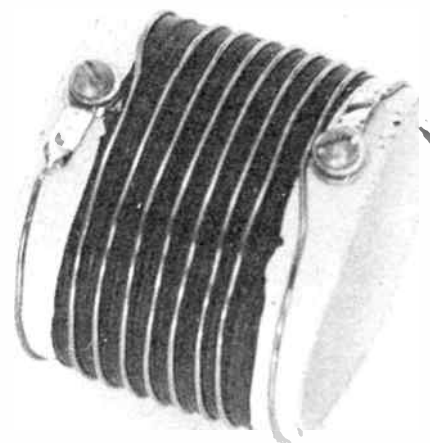
r = the radius of the coil in INCHES

l = the length of the coil in INCHES

We know that L will be 4.7 uH, the radius of the coil will be 2.2 inches (28 mm) and the length of the coil will be 1.5



**Figure 4. The coil arrangement. The former is a short length of "50 mm" (inside diameter) PVC pipe.**



inches (38 mm). By substituting these values in the formula, we arrive at an answer of 9.8 turns. This formula is for air wound coils, but in our case we are using a PVC former. Keep reading and you will see what effect this has on our coil.

Before winding the coil, you will need to prepare the former. Start by cutting a 50 mm length of pipe and then drill a hole about 6 mm in from one end. Measure 38 mm from this hole and drill a second hole at the other end. The holes should be about 3.5 mm diameter to suit small bolts which will be used to anchor the ends of the coil.

You will find it much easier if you wrap some plastic or rubber tape (such as 3M self-amalgamating tape) around the former before winding the wire. The tape stops the copper wire from slipping and results in a more mechanically stable assembly. The accompanying photograph shows a former already prepared and the nuts, bolts, lockwashers and solder tags fitted in the holes.

The wire used for the coil should be about 1 mm diameter enamelled copper. We used 18 B&S for our trap and whilst there is some tolerance allowable here, we suggest you stick to something close to this size. If you use wire that is markedly different in diameter, you will end up with an incorrect value of inductance.

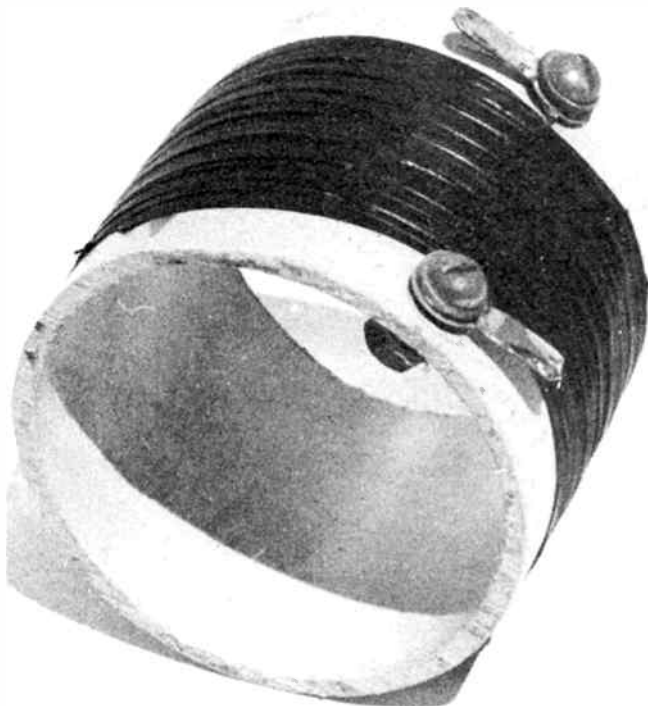
The wire is carefully wound on the former, maintaining tension throughout the operation. Take care to evenly space the turns. As a guide, you might mark where the turns are to lie on the taped former using typists' correcting fluid.

For our initial effort, we wound 10 turns on the former and then measured it's inductance with a Philips PM6303 digital RCL meter. The value obtained was about 6 uH, but as the meter uses a very low frequency when measuring inductance (1 kHz), we suspected that there may be some error in our results (undoubtedly – the Q was less than 1!). To check this, we soldered a 27 pF dipped mica capacitor in parallel ▶



This picture shows the coil former ready for winding the wire. Notice how rubber tape has been applied to help keep the windings in place, also take note of how the nuts, bolts, lock washers and solder tags are fitted ready to accept the wire on the outside and the capacitor on the inside.

This photograph shows a completed trap. Notice how the capacitor is soldered inside the former and also how the turns at the start and end of the coil have been spread to resonate the trap. This trap uses a 27 pF dipped mica capacitor and resonates at 14.1 MHz for the four-band version of the antenna.



with the coil and used a grid dip meter to check the resonant frequency. Now, a 27 pF capacitor resonates with a 6 uH coil at around 11 MHz, or around 14 MHz with a 4.7 uH coil. The result we got was about 12.5 MHz. The PVC former increased the self-capacitance (turn-to-turn stray capacitance) of the coil, marginally lowering the resonant frequency.

We removed one turn from the coil and repeated the measurement. This time we got about 13.8 MHz. Removing another turn resulted in resonance at around 15 MHz, so we settled for nine turns. As you will see in the accompanying photograph, it was necessary to spread the first and last turns in order to get the trap to resonate a little above 14 MHz (actually, they turned out to resonate at 14.1 MHz, but it's not all that critical).

Using the 27 pF capacitor as we did above, made a 14 MHz trap which would be suitable for the four-band antenna. Exactly the same method can be used for making the 7 MHz trap for the five-band version, but in this case, you would use a 100 pF capacitor. If you don't have a grid dip meter to check resonance, it is possible to use your receiver to tune the traps. Simply connect a long wire antenna to the receiver with the

trap installed in series near the receiver end. You will notice a deep null in the receiver's response when it is tuned to the trap's resonant frequency. If you have a reasonably accurate signal generator, then so much the better for tuning the traps by this method.

## Capacitors

As this antenna will be used for transmitting, you will need to choose a capacitor with adequate RF voltage and current ratings. In the example of the 14 MHz trap above, we used a 500 V dipped silver mica capacitor and this proved to be quite adequate for use with a 100 watt PEP transmitter. If you are building the five-band version, then a suitable 100 pF capacitor can be obtained from your nearest Jaycar stockist. Their catalogue number RC 5380 is a 3 kV working 100 pF ceramic capacitor and although we have not tried it in a practical antenna, it should be ideal for the purpose. Other stockists may carry a similar capacitor, but we know this is a standard stock item.

If you are stuck for a low value, high voltage capacitor then

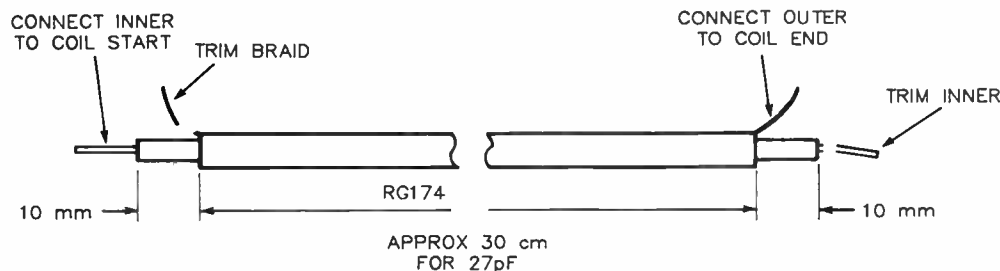
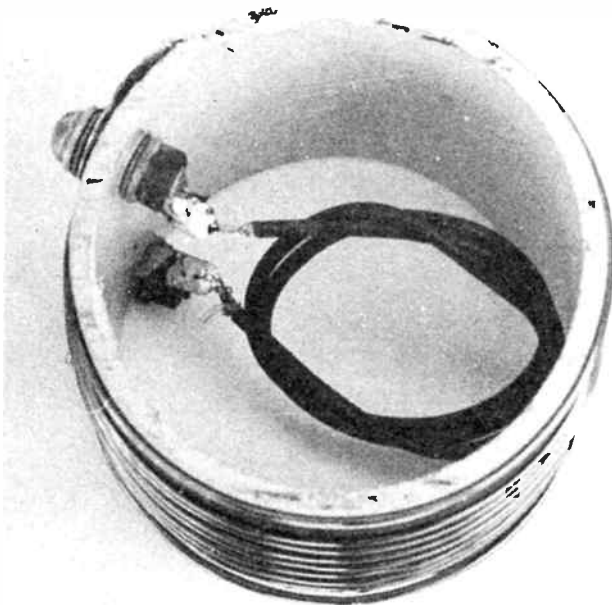


Figure 5.  
How to make a "coax capacitor" to resonate the coil.

This picture shows how the alternative "coaxial capacitor" can be fitted to the trap. Using around 300 mm of RG174 coaxial cable (for 27 pF) with the inner conductor soldered to one end of the coil and the outer braid soldered to the other end of the coil, is an easy method of obtaining a low value, high voltage capacitor that can be "pruned" to resonate the trap.



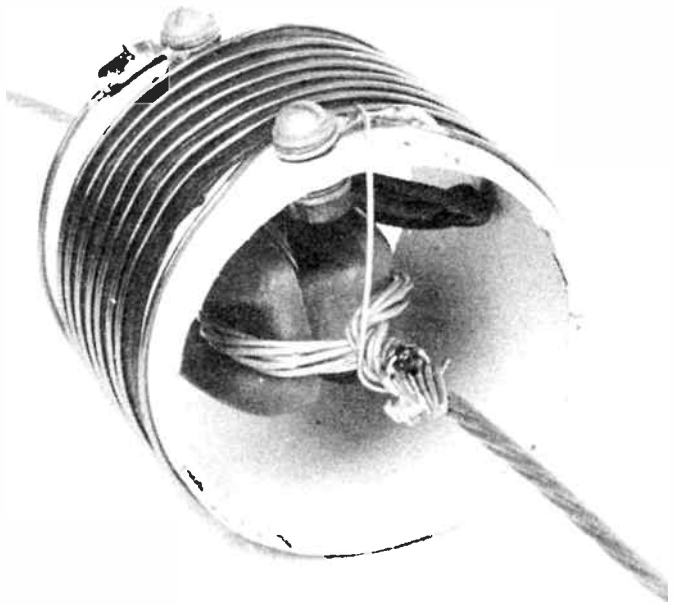
it is quite easy to make one from a piece of coaxial cable. It would be impractical to use anything other than the miniature types due to the bulk, but the RG174 type which is available from Dick Smith, Jaycar stores and other sources is ideal.

RG174 coax has a nominal capacitance of 30 pF per foot. We measured some and calculated it to be about 0.925 pF per cm which works out to be close to the nominal value. If, for example, you wanted to make a 27 pF capacitor, you would require  $27/0.925$  or 29.2 cm (292 mm). It would be better to start with a piece somewhat longer and trim it until the desired value is obtained as there is, naturally, some manufacturing variation in its characteristics. RG174 has a Teflon dielectric and is rated at 1500 volts, so is ideal as a "coax capacitor" in this application.

When using such a coax capacitor with the traps, you simply connect the inner conductor to one end of the coil and the outer braid to the other end. Figure 5 and the accompanying photograph show the general idea. Once the "coax capacitor" has been trimmed to the right value, it can be coiled up as shown on the photograph, or held in place with a nylon cable tie-wrap.

One advantage of using capacitors made from RG174 is your ability to adjust them. If you use a nine turn coil as we did in our trap, you will probably find it easier to trim the capacitor rather than adjust the spacing of the turns on the coil. If the resonant frequency is too low, simply trim 10 mm off the capacitor and try again. If the resonant frequency is too high, you are in trouble because it is difficult to add turns to the coil and impossible to lengthen the "coax capacitor". Make sure you start with a length of coax that is a bit longer than the calculated value so that there is room for adjustment.

This photograph shows how the completed trap should be attached to the dipole sections using an "egg" insulator for strain relief. If you are using the "coax capacitor" as we have here, take care not to dislodge it when assembling the trap to the dipole wires.



### Supporting the traps

It would be a bit risky to expect the traps to support the weight and straightening tension of the whole antenna system, especially if you are building the five-band version. A far better idea would be to fit the trap over a ceramic or plastic "egg" insulator.

To accomplish this, simply slip the completed trap over one end of a dipole section where the trap is to be fitted. Terminate the dipole section wire on the egg insulator and the end of the next dipole section on the other half of the egg insulator. The trap can now be fitted over the insulator and a small piece of stiff wire used to connect the ends of the dipole section wires to the solder lugs on the trap. In this way, the weight and tension of the antenna wire will be supported by the insulator, not by the trap.

### Using the antenna

When you have completed building and tuning the traps and have the dipole sections measured and attached, you can erect the antenna. The rule here is generally, "the higher the better." If you are limited in how high you can erect the antenna, you may have to do some pruning to get it to resonate properly on all bands.

When the antenna is up in the air, check the VSWR on the lowest band of operation. This is eighty metres for the five-band version and forty metres for the four-band version. If the VSWR is lowest at a frequency which is higher than desired, the antenna is too short. You should add a small amount of extra wire to the outer ends of the outer dipole sections. If the VSWR on the lowest band is best at a frequency which is

# The Tokyo Hy-Power HT-180 mono band HF amateur transceiver – a users review

**Andy Keir VK2AAK**

If you're daunted at the price of getting on the air, or getting back on the air, here at last is good news. We suspect this line of rigs will become the Fiat of the amateur rigs: small, high performance, economically priced – and owners will have a love affair with them!

THESE DAYS, many radio amateurs are acutely aware of the cost of commercially made equipment. Apart from the obvious repercussions from poor exchange rates, part of the reason for the escalating prices is the increasing complexity of the equipment. You pay for "bells and whistles".

Much of the equipment in use these days bears a closer resemblance to a computer than it does to a radio and although some excellent features have been incorporated in some designs, many of these features could be considered luxuries rather than necessities. I have felt for some time that there was a place in the market for a simple, "no frills" transceiver which is priced within the grasp of the beginning enthusiast or the amateur returning to activity after some absence.

It is all very well to say that amateurs should be capable of building their own equipment, but the problem of parts supply gets ever more daunting and most amateurs, even those with a good deal of experience, would have to admit that home brewing a complete transceiver is not an easy task. For these reasons, I was pleased to hear that one manufacturer seemed to have noticed the apparent gap in the market and introduced a range of reasonably priced HF transceivers and that these would be stocked in Australia by Emtronics. I was even more pleased when Emtronics made their one and only sample unit available for us to take a look at!

Tokyo Hy-Power are a well known manufacturer of amateur radio equipment, particularly with their comprehensive range of power amplifiers. I don't know if this range of HF transceivers is the company's first foray into the transceiver market, but they are certainly the first such product that I have seen from them.

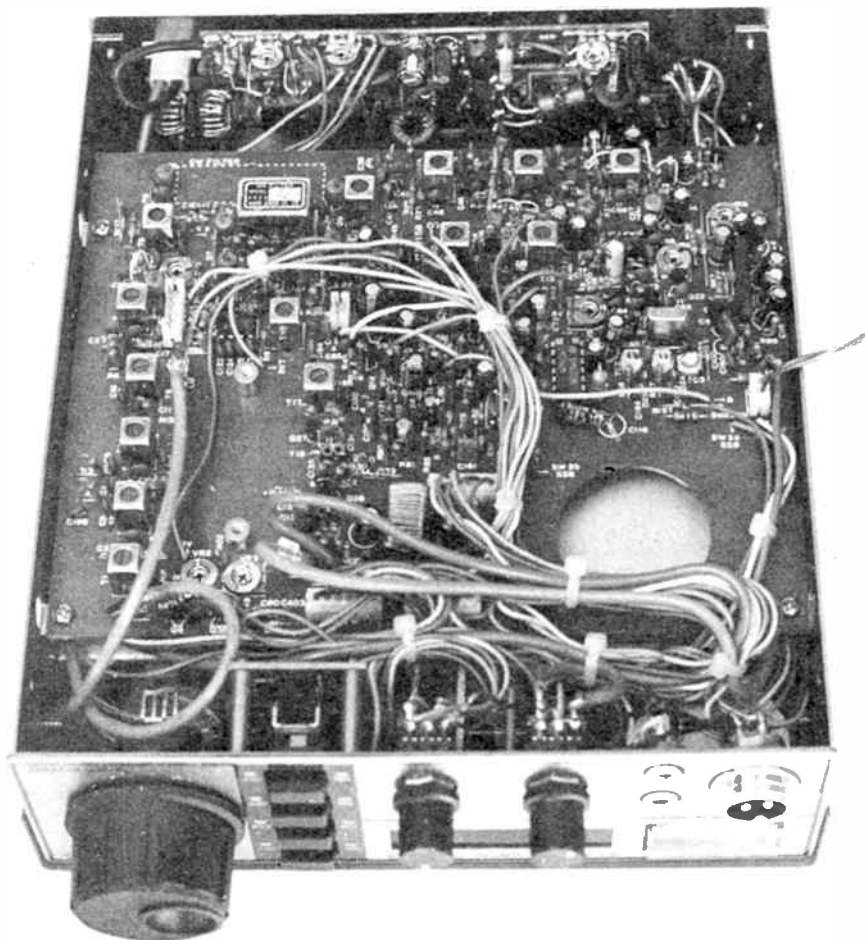
Known generically as the HT-100 series, the units are compact and light weight HF SSB/CW mono band transceivers. There are five models in the range, the HT-180 covering the 80 metre band, the HT-140, covering 40 metres, the HT-120 covering 20 metres, the HT-115 for 15 metres and the HT-110 for 10 metres. All the models are fully solid-state and employ a digital synthesised VFO utilizing PLL circuitry. Maximum power output is 20 watts PEP or 20 watts CW and all units cover a 500 kHz segment of the respective

band with the exception of the HT-110 which covers the entire 28.000 to 29.9999 segment.

The unit which we were loaned was the 80 metre model HT-180, but as all the models are virtually identical except for operating

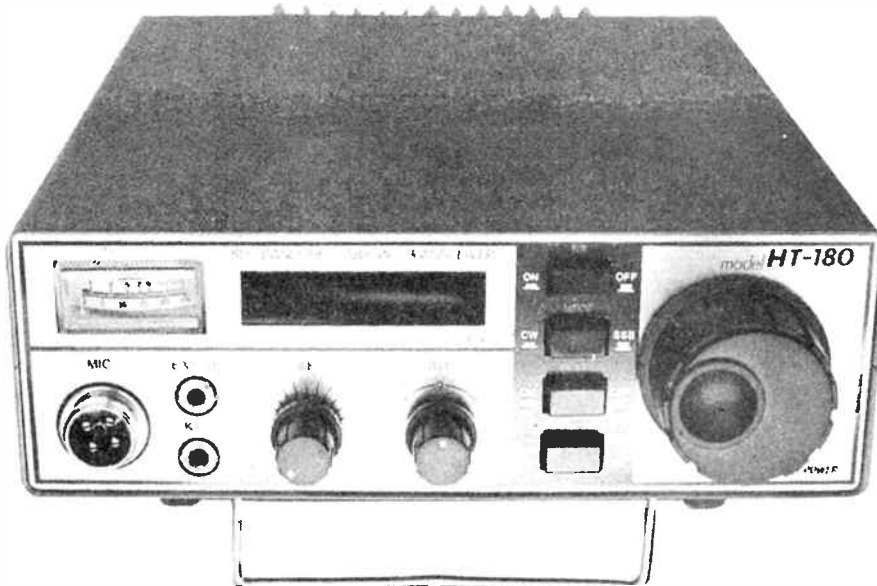
frequency, any comments we make on the review unit should be equally applicable to other models in the range.

We decided that rather than send the unit off to a laboratory and then write a review



This photograph shows the internal construction of the HT-180 transceiver. This view is of the "analogue" board. Notice the power amplifier section attached to the rear panel backing on to the heatsink.





This view of the front panel of the HT-180 shows just how straightforward the rig is. Whilst a little "spartan" compared with some up-market, multi-band rigs, the layout is functional and easy to use for fumble fingered types like me. This is a pleasant relief from some of the modern mobile rigs which are so fiddly, they can be a real danger in mobile use.

which finitely detailed the measured performance as compared to the published specifications, we would write a review from a users point of view. We felt that it would be more beneficial, considering the intended market for these transceivers, to write a subjective review indicating how the unit performed in a real life situation.

Here then is one amateur's impression of the HT-180 mono band transceiver from Tokyo Hy-Power.

### First impressions

The unit weighs in at 2.6 kg and measures 180 mm wide x 60 mm high and 250 mm deep. This makes it slightly larger than the average two metre mobile unit and somewhat smaller than a base station rig. This size is a reasonably good compromise as it won't take up too much space on your benchtop, but is not so small that the controls are fiddly. Some of the popular mobile rigs around these days require microscopic fingers to operate some of the controls, but the uncluttered front panel of the HT-180 make it a good choice for mobile operation.

After unpacking the HT-180 my first reaction, like most inquisitive amateurs, was to "have a look at what's inside". The internal construction of the unit appears to be of good quality. There are two main printed circuit boards, one being mainly "digital" the other, predominantly analogue. The digital board contains all the PLL digital VFO circuitry as well as part of the frequency display circuitry. Both boards are silk screened with the component designations and the digital board has some "spaces" where components have not been fitted. Presumably, the same board is used in all models and I would guess that the "missing" components would be fitted to the 10 metre version in view of the extended frequency coverage.

The transmitter final stages are accommodated on a third pc board mounted on the rear face of the case. The final transistors are bolted directly to the inside face of a heatsink which is mounted on the rear panel. There are a number of smaller printed circuit boards accommodating switches and the display drivers. Access is good, and servicing the unit should not present any difficulties.

Externally, the unit is fairly "utilitarian" as would be expected in a transceiver of this type. The cabinet is finished in a grey "textured" paint, whilst the front panel is mainly silver anodised aluminium with black writing. The rear panel is mostly taken up with the gold anodised heat sink. There is the familiar SO-239 antenna socket as well as a polarised socket for the dc power. A 5-pin DIN socket is also provided, but as there is no annotation on the back panel, it was necessary to refer to the supplied manual to discover that this connector was for "accessories". The various pins of this DIN connector provide +8 V on reception, +8 V on transmission, 13.8 V out (0.5 amp max) and ground as well as an ALC input presumably for use with an external power amplifier.

Unlike some of the "whiz-bang" transceivers on the market today, the front panel is not reminiscent of a Boeing 747 cockpit. There are seven user controls as well as microphone, speaker and key sockets. A four digit frequency readout is provided which reads down to 100 Hz and a small edgewise meter which indicates relative power output and received signal strength is also fitted.

On the right hand side of the front panel is the VFO control. This is a decent sized knob and has a "finger hole" for fast tuning changes. The VFO control uses an optically encoded system and provides dual rate frequency changing. If you turn the knob slowly, the frequency changes at the rate of 5

kHz per revolution. If you turn the VFO knob quickly, you go into "turbo mode" and the frequency changes at 50 kHz per revolution making it easier to go to the other end of the band quite quickly.

To the left of the VFO control is a vertical row of four pushbuttons. These control the noise blanker, operating mode (SSB or CW), receive attenuator and a "lock" function which disables operation of the VFO knob so it doesn't get jarred in mobile or portable operation. When the lock switch is depressed, the unit will memorise the frequency which was selected, even if power is removed. The manual gives no hint as to how much attenuation is provided by the attenuator button, in fact, the manual supplied with our unit said that this button was used for selecting which band segment was to be used in the 10 metre version.

The only remaining user controls are the combined on/off and volume control and receiver incremental tuning (RIT) control. The RIT control allows you to offset the received frequency by plus or minus 1 kHz without altering the transmit frequency. The frequency display uses green LEDs and displays the four least significant digits of the frequency in use. For example, if 3.5257 MHz was selected, the display would show 5257. The display thus reads down to 100 Hz which is the smallest tuning increment available from the digital VFO.

The external speaker jack is on the front panel as opposed to the rear panel where it is more often placed. Also on the front panel is the key socket for connecting your Morse key. Again, this is more usually found on the rear panel, but if you have ever struggled trying to blindly find the correct hole at the back of a rig to plug your key or speaker into, this could be a blessing. The microphone socket is a standard four-pin type, designed to accept the supplied 600 ohm dynamic microphone.

### In use

I connected the transceiver up to my dc power supply and hooked up a random long wire antenna via an antenna coupler. This is where I came unstuck. I am used to switching my own rig to the AM mode so that I have a constant carrier with which to tune up when I hit the press-to-talk switch. The HT-180 does not have AM, but it does have CW. It was necessary to connect a Morse key to the front panel jack and hold the key down whilst I tuned up. I realise that this is only a minor inconvenience, but it would have been nice if a manual transmit switch was provided so that a constant carrier was easily obtained for tuning purposes.

Listening around the band produced the usual busy conditions experienced on 80 metres in the evenings. The HT-180 was able to quite adequately separate closely spaced stations indicating the quoted selectivity of -60 dB at plus and minus 3 kHz was not unrealistic. Sensitivity is quoted as 0.4 uV input for 10 dB S+N/N. Comparing the HT-180 with my own FT707 on the weakest signals I could find showed that the sensitivity was all that could be desired, the noise level being the limiting factor. ▶

This brings me to the noise blanker. In an obvious measure to cut costs to the minimum, the HT-180 and indeed all the transceivers in the range, are not fitted with a noise blanker. It's an option. The review unit wasn't fitted with one, so I can't comment on its performance. Now I don't know about you, but I can live happily without infrared remote control, 99 memories and multiple VFOs, but what with suburban lawn mowers, un-suppressed VWs and thunderstorms, I would have thought that a noise blanker in an HF rig was an option few could do without. For the sake of a few dollars, surely it would be more sensible to incorporate this feature as standard.

Notwithstanding the lack of a noise blanker, the HT-180 performed very well whilst receiving, so I decided to answer a couple of CQs. The first station contacted was a ZL. When asked for his comments on the signal he replied that the audio was clean and crisp and that my signal strength was five and nine. I called him back on the FT707 and he replied that apart from the slight increase in signal strength (100 watts from the 707 as opposed to 20 watts from the HT-180) there was no real difference in the signal. He added that if anything, he preferred the audio from the HT-180.

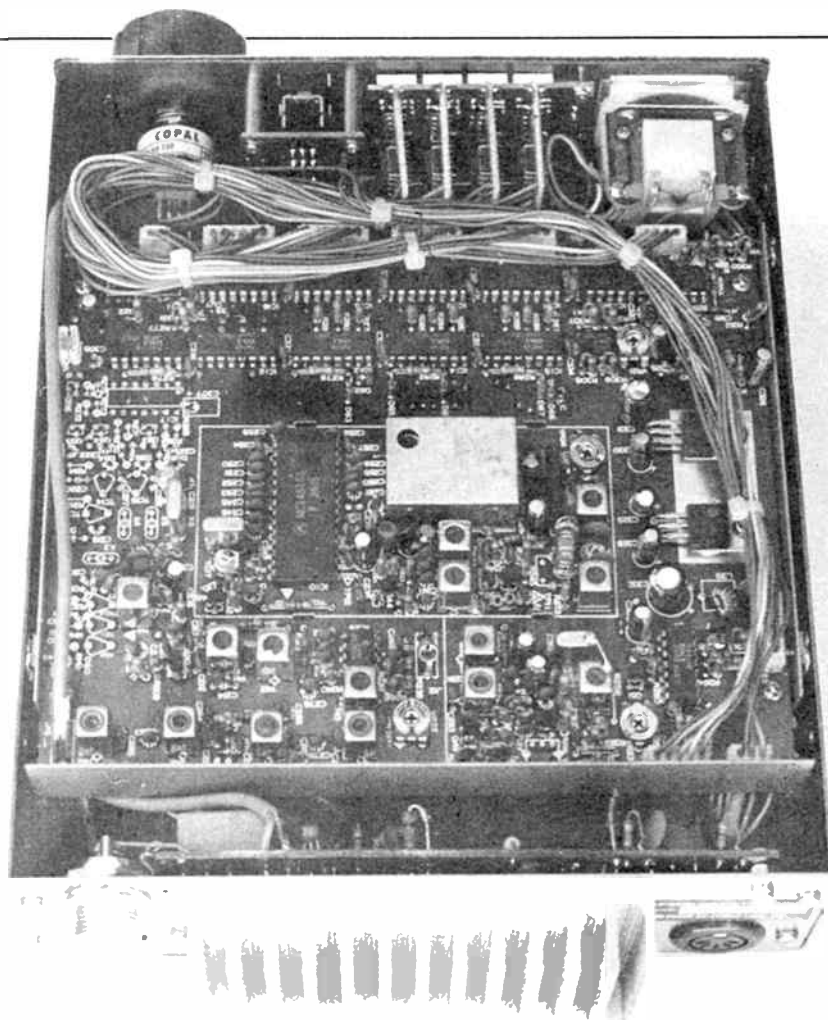
Over a period of a few hours, I contacted a number of stations, both local and DX. I had no trouble making myself heard and all gave me good reports. Many stations were surprised to hear that I was only running 20 watts and were even more surprised when I told them I was only using a random wire antenna!

As the transceiver is designed to be used both as a base station and as a mobile, I decided to try it out in the car. I occasionally use my FT-707 mobile, so it was simply a matter of connecting up the power and the antenna. Everything went well until I started the engine. Have you ever tried running 80 metres mobile without a noise blanker! I parked the car and made a couple of contacts without the engine running. Results were as would be expected considering the highly inefficient loaded whip antenna, but still I managed to make myself heard.

Where the HT-180 comes into its own in mobile operation is the way it is constructed. Unlike my old FT-707, there is no mechanical VFO to get shaken around. The HT-180 is stable enough for extended mobile use and is light enough for conventional "under-dash" mounting without pulling the dashboard apart. The "lock" button is a great idea, avoiding the inevitable bumps of the VFO knob and the resulting inadvertent frequency change.

The only criticism I have with regard to mobile operation concerns another cost cutting exercise. The mobile mounting bracket is an optional extra. I can understand a mobile bracket being an option for one of those heavy, multi-band HF rigs that were really never meant to leave the shack, but this rig cries out for mobile operation and the bracket would surely only be the bent piece of metal similar to those used for mounting CBs.

The transceiver was tried out on the CW mode and results were just as pleasing as the



Another internal view of the HT-180, this time of the "digital" board. If you look carefully, you can see the spaces left for additional components. These are presumably for the 10 metre version which has extended frequency coverage. You will also notice the four small boards associated with the four-digit LED frequency readout which are mounted on the rear of each display.

SSB mode. Semi break-in operation is provided as is an inbuilt sidetone oscillator. For those of you who prefer the key to the microphone, an optional narrow CW filter is available as an accessory and provides a bandwidth of plus or minus 250 Hz at -6 dB and plus and minus 800 Hz at -60 dB.

The manual supplied is basic but quite adequate and provides most information, including a full circuit diagram. In common with many imported items, the grammar is somewhat quaint, but all the pertinent information is there. Supplied accessories include the dynamic PTT microphone, a suitably terminated dc power lead and a spare fuse. If you are contemplating using the transceiver as a base station, you will need a 5 A/13.8 V dc supply to power the unit.

### To sum up

Despite my criticism about the "options" for the HT-180, I was thoroughly impressed with the unit. Receive sensitivity and selectivity were all that could be desired and I was amazed how much could be accomplished with the modest power output. The units are robust and frequency stability is excellent, making the rig ideal for mobile or portable

operation. The HT-100 series of transceivers will appeal to those amateurs on a limited budget, but who don't want the uncertainty of second-hand equipment or the hassle of home brewing. It would also make an ideal, economical supplementary rig.

With propagation improving all the time, I can see many of these great little rigs turning up in field day events or as portable emergency stations. In the few weeks that I have been using the rig, I have derived a great deal of pleasure from it and will feel quite a loss when I have to give it back. Perhaps I will even invest in a 20 metre version, just for the car. Now, I wonder if I can hang onto it long enough for JOTA... 🐦

The review sample model HT-180, serial number 7070162 was kindly supplied by Emtronics Pty Ltd. Further details on the Tokyo Hy-Power HT-100 series can be obtained from Emtronics who are located at 92-94 Wentworth Avenue, Sydney 2000. Telephone (02)211 0988. Emtronics also have stores in Queensland (07)394 2555 and Victoria (03)670 8551. Recommended retail price for the HT-100 series transceivers is \$599.00 and Emtronics advise that they will be stocking all models in the range as well as the full range of accessories and options.



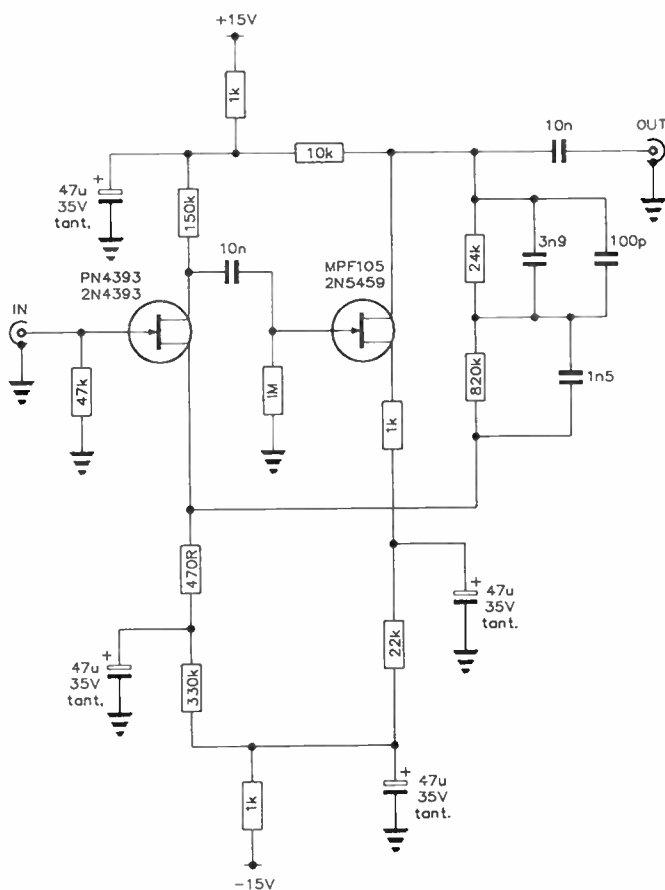




# BenchBook

## Magnetic pickup preamp

While compact disc might be all the rage, your collection of vinyl discs still deserve playing and modern magnetic pickups have improved out of sight over the past few years, while their cost has come down. Give that music on vinyl a new lease of life, like I did, with a new magnetic cartridge and good preamp, like this one. Like me, you'll agree they never sounded better!



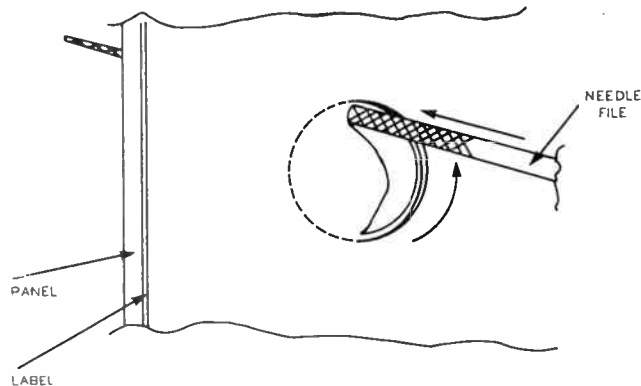
This preamp circuit is quite straightforward and was adapted from one of the semiconductor manufacturers' application notes. It employs two JFETs in quite a straightforward circuit, with feedback applied between the drain of the output FET and the source of the input FET. The use of FETs here reduces the effect of cartridge impedance interaction compared to bipolar or op-amp circuits, I believe.

An RIAA equalisation network is employed in the feedback network. A resistors should be 1% metal film types. All capacitors, with the exception of the tantalums, should be MKTs (metallised polyester) or MKPs (metallised polypropylene); those in the feedback network should be selected to be within 1% or 2% of the required values.

L. Johnson,  
Randwick NSW

## Cutting holes in Scotchcal on panels

Scotchcal labels are popular for "dressing up" projects. Assuming all holes are drilled, punched or cut in the panel of a project, the time comes to stick the Scotchcal to it. Up to



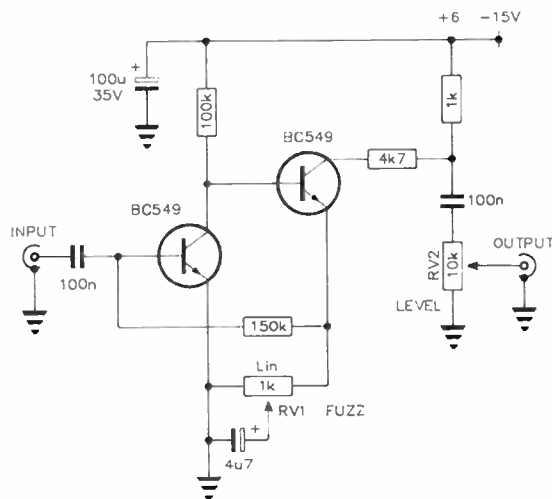
now, the suggestion has been to use a scalpel or other sharp-bladed knife from the rear of the panel and to cut the Scotchcal through the hole. Well, I have found this stresses the label around the hole, leaving an undesirable finish.

I have discovered a very easy way of obtaining a near perfect finish around any shaped hole where a Scotchcal label is used. The technique is as follows:

- 1) Finish the panel with all holes cut out.
- 2) Produce the Scotchcal and stick it to the front panel.
- 3) Using a round needle file, mark the point of entry from the rear of the panel by using the file point to produce a very slight indent just adjacent to the edge of the hole and easily seen from the front. Now, from the label side, push the point of the file through the label where you've marked it.
- 4) Once the file has penetrated it should contact the edge of the hole, then the cutting action between the file and the hole edge continues for the full stroke of the file.
- 5) Withdraw the file, being careful to ensure it does not contact the label as you do so, until the point comes almost out, then start another plunge.

With rectangular holes, use a square needle file.

Eric Rodda,  
Albion S.A.



## Simple guitar fuzz unit

This simple fuzz unit employs a two-stage bootstrapped transistor amplifier. The emitter load of the second transistor is a variable control (RV1), the wiper being connected to a 4u7 capacitor. This permits varying the bypass amount

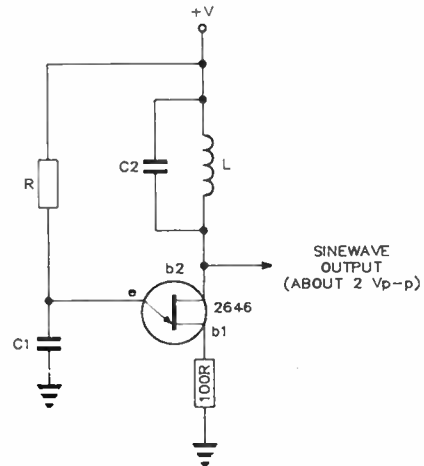
applied to the emitter load, and thus the ac signal gain. Thus, the amplifier can be run at varying clipping levels, producing the fuzz unit.

The unit is meant to be inserted between the guitar's preamp or mixer output and the main amp input. Set the fuzz level "to taste", and then set your output level keeping the other controls in your system where they are normally set.

**B. Gordon,**  
Carlton, Vic.

### Sine output from UJT oscillator

A standard UJT oscillator can be adapted to produce a sine wave output by simply putting a parallel tuned circuit in series with base 2.



Frequency of oscillation depends on R-C1, determined in the usual way, and L-C2 are tuned to the same frequency, or even a harmonic.

Output depends on the supply voltage, but typically, with a 6 V supply, it's about 2 V peak-to-peak. The tuned circuit should have a medium to high Q. Values for L-C2 can be selected from an LCf chart, such as that reproduced in the ARRL Handbook (Chapter 2).

The common 2646 will work in this sort of circuit well into the hundreds of kilohertz region. The supply should be well-bypassed for RF.

**Roger Harrison**

**Benchbook** is a column for circuit designs and ideas, workshop hints and tips from technical sources of the staff or you — the reader. If you've found a certain circuit useful or devised an interesting circuit, most likely other readers would be interested in knowing about it. If you've got a new technique for cutting elliptical holes in zippy boxes or a different use for used solder, undoubtedly there's someone — or some hundreds — out there who could benefit from your knowledge.

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### — Project 3014, from page 91.

lower than that desired, the antenna is too long and small sections should be pruned off the ends of the outer dipole sections. Remember to prune equal amounts from each dipole section and only cut off small sections at a time.

Next, you should check the band for which the traps are made. In the case of the five-band antenna, this will be forty metres. For the four-band model, use twenty metres. If you have built and resonated the traps correctly, the VSWR should be less than 2:1. If it is badly out, you may have a problem with the traps or maybe the inner dipole sections need pruning. If you do trim the inner dipoles to obtain the best VSWR, remember to go back at re-adjust the outer dipoles on the lowest band afterwards as there will be some interaction.

### Feeding the antenna

As mentioned earlier, the feed point impedance of the antenna will be around 70 ohms. This is close enough to 50 ohms to enable normal 50 ohm coaxial cable to be used. If you wish, 75 ohm cable can be used, but in any case, feeding a 70 ohm antenna with a 50 ohm impedance line will only result in a VSWR of slightly under 1.5:1. This is quite acceptable at HF and solid state rigs will cope readily with a VSWR of this order. The use of a 1:1 balun at the feedpoint is recommended, though not essential. Sounds like a good idea for another project!

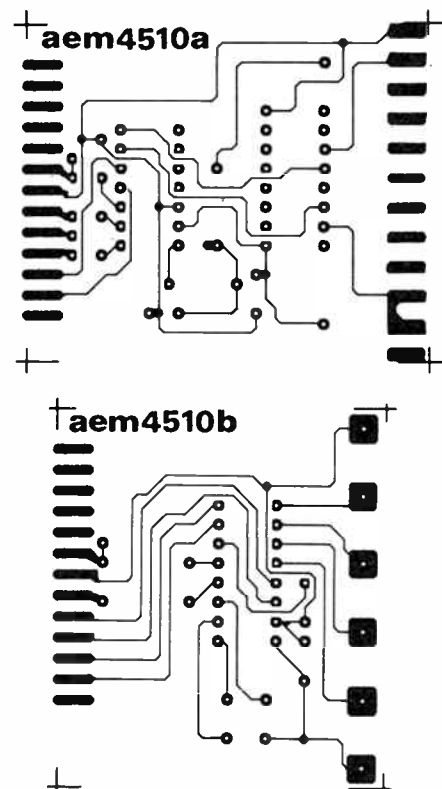
### FURTHER READING

The ARRL Antenna Book 1982 (and later editions) provides a good background for the principles and practices outlined in this article, covering trapped antennas of all types.

Coil construction information was taken from Appendix A.2 of the VHF/UHF Manual by G.R. Jessop G6JP, Fourth Edition 1983, published by the RSGB.

### PC BOARD ARTWORK FOR PROJECT 4510

These were unfortunately omitted from the article in our September issue.



# The Last Laugh

## Of SALT and varnish

I HAD gathered with my staff around the fire at the end of the Great Dining Hall of the Sackville Academy of Lateral Thinking (SALT of the Hawkesbury). Dinner was over and the table had been cleared. The old fence posts on the fire were blazing cheerfully and the Hall echoed gently to the relaxed intellectual conversation.

It was at this time of the day that I often considered the great minds of the teaching staff to be to be at their most vibrant and penetrative, ready to analyse the deepest subject brought before them.

We had just finished an in-depth discussion about who had won the 1965 Melbourne Cup. Unfortunately the debate had become somewhat enthusiastic and we were forced to separate Hilary and Leslie who were now seated on either side of the fireplace, glaring at one another.

There was Leo, probably our most distinguished academician, with a long list of letters after his name: B.A. (failed) from a distinguished university in Central Africa, leading to his Ph. D. from the Peasant's University of Outer Slobbovia. The firelight played on Franklin's handsome features, the broken nose, the cauliflower ear. He had been a successful Prelim. boy many years ago but had left the ring to devote himself to his studies. He had saved hard for his first degree and was now awaiting a small bequest from a recently deceased aunt to get his Ph.D. at a celebrated university in South America.

The others of my staff were cast in the same mould; intellects all. Mike would have undoubtedly gone far in the medical world had it not been for that unfortunate affair about the waitress. Ron, a leader of Industry before the days of double-entry book-keeping.

We had asked Franklyn, our electronic giant, for some music, but the crystal in his set had fallen out so Colin was about to take his Stradivarius from its case and Leslie had moved to the Bechstein grand, when Leo spoke.

He had been looking at the coils and massive wiring of Franklyn's wireless, which were all heavily varnished, and obviously something had stirred deep in his brain.

"Do you know what shellac is made from?", he asked. Even if someone had said "yes", it would not have mattered, Leo was going to tell us anyway.

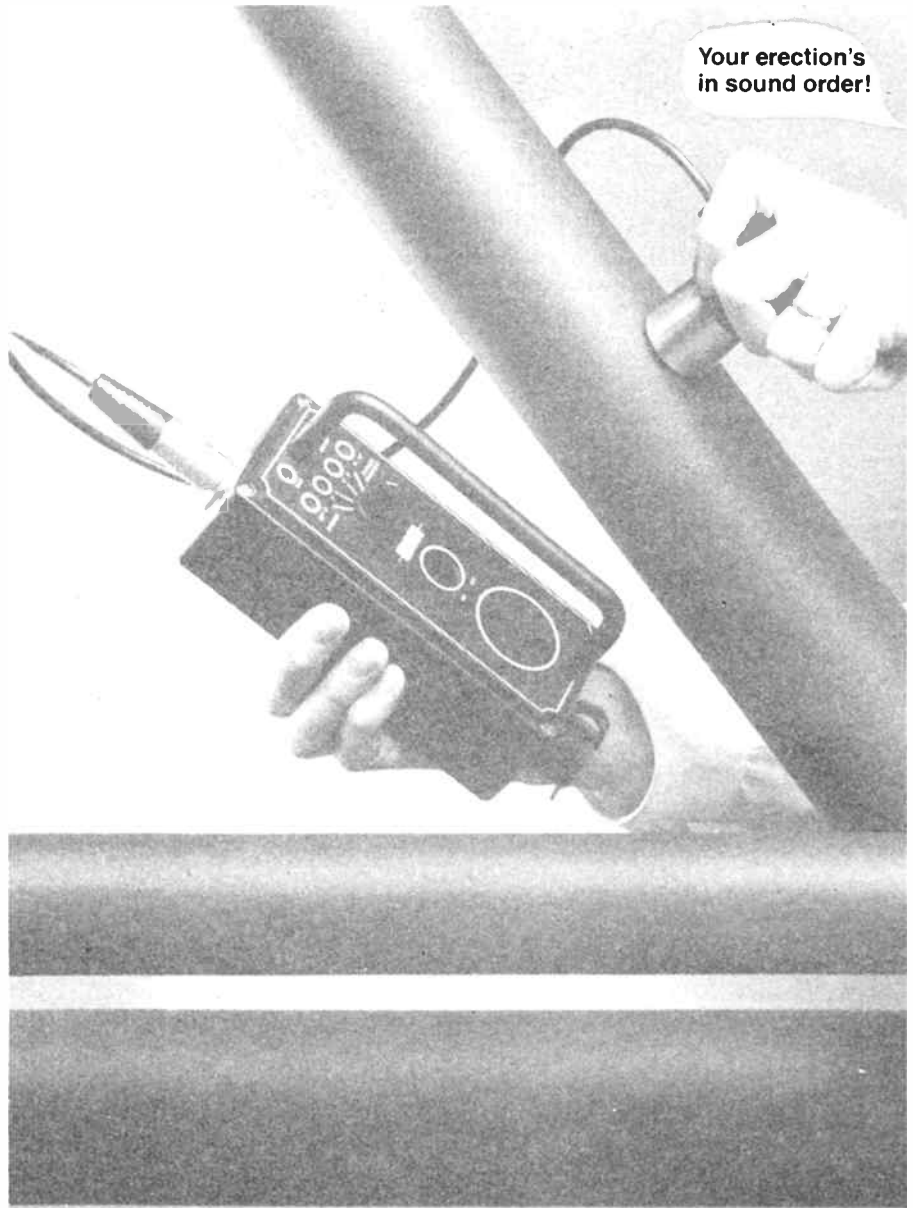
"Well, I'll tell you," he continued. "It comes from the excreta of insects."

A shudder ran down my spine. The last time Leo had told us anything like this we had stopped drinking red wine for almost the entire week.

"The insects inhabit a certain tree and the natives collect their excreta from the bark," he went on relentlessly. "They burn the tree, not enough to hurt it, and scrape the excreta off."

I thought that the trees might not mind being burnt a bit after what the insects had done.

"The excreta is dried into flakes," Leo went on, "and exported. You buy it in the shop,



dissolve it in methylated spirits and use it as shellac!" He glared around triumphantly.

Franklyn hastily put his wireless on the floor.

"Do you mean to tell me," asked Colin incredulously, "that this Strad of mine is finished in insect poo?"

Leo nodded.

Colin returned the instrument to its case and closed the lid firmly.

"And this Bechstein?" asked Leslie, a quaver in his voice.

"Most certainly!" pronounced Leo.

Colin and Leslie rejoined the group, wiping their hands surreptitiously on the seats of their pants.

"It is also used as a coating on some medicinal pills to allow them a longer time in the stomach before the digestive juices attack them." Mike added cheerfully.

The group was silent. Each was afraid to speak in case we found that it was also used in breakfast food or put in honey to give it colour, or something equally disturbing."

For my part, and looking at the matter objectively, I was not unhappy with the revelation. For some years, I now realised, I had been hopelessly confusing shellac with cochineal. I had some distant recollection that each came from an insect, but more than that had slipped my mind.

I used cochineal frequently when preparing some delicacy for a special occasion, but I was not going to mention cochineal now in case Leo went on to explain in detail how the natives stamp on the cochineal beetle with their bare feet or rub them on their thighs or chew them up and spit them out. I wouldn't put it past them, after what they do with whatever it is that excretes on the trees.

Professor Donald F. Richards  
S.A.L.T. of the Hawkesbury



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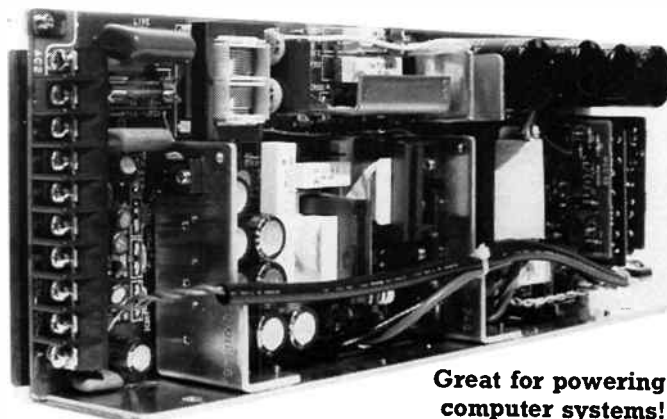
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Input Line Regulation	Full input voltage range +5V output. Other outputs 3 terminal regulator. Non reg.	0.2% max. 0.6% max. 1.0% max.
Load Regulation	Load change from 20 to 100% of rated output current at rated input voltage. +5V output. Other outputs 3 terminal regulator. Non reg.	0.6% max. 1.0% max. 5.0%/A (typ)
Ripple and Noise	Peak to peak	1% +75 mV max.
Over Current Protection	120% of rated output current (typ)	+5V output
Short Circuit Protection		Other outputs
Over Voltage Protection	+5V output	6.0 - 7.0V (typ)
Operating Temperature	Convecting cooling	0 to 50°C no derating.
Storage Temperature		-25 to 85°C
Weight		2.0 kg (4.4 lb.)

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