



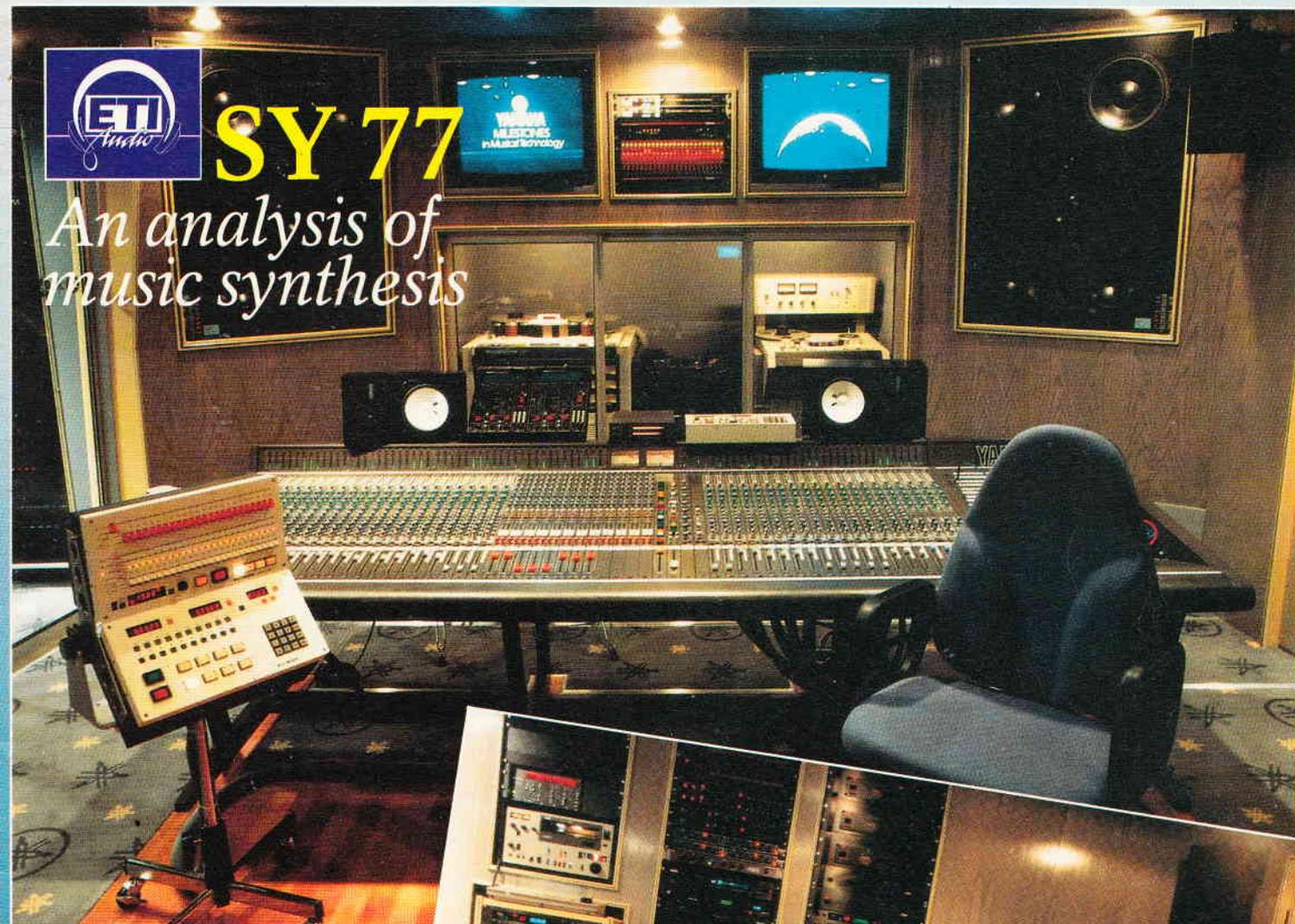
POWER FROM THE SEA

Waving goodbye to pollution



SY 77

An analysis of music synthesis



ELECTRIC EYE

Technology for the blind

FM GENERATOR
STEREO DECODER UPDATE
TEMPERATURE CONTROLLER



ISSN 0142-7229



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OMP POWER AMPLIFIER MODULES Supplied ready built and tested.
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PRICE £33.99 + £3.00 P&P.

NEW SERIES II MOS-FET MODULES

OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz - 3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D. Typical 0.002%, Input Sensitivity 500mV, S.N.R. - 125dB. Size 300 x 123 x 60mm.
PRICE £39.99 + £3.00 P&P.

OMP/MF200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz - 3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. - 130dB. Size 300 x 155 x 100mm.
PRICE £62.99 + £3.50 P&P.

OMP/MF300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz - 3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. - 130dB. Size 330 x 175 x 100mm.
PRICE £79.99 + £4.50 P&P.

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 - 15" 100 WATT C15100BS BASS GUITAR, LOW FREQUENCY, P.A., DISCO. RES, FREQ. 40Hz. FREQ. RESP. TO 5KHz. SENS. 99dB. PRICE £55.05 + £4.00 P&P
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 - 10" 100 WATT EB10-100 BASS, HI-FI, STUDIO. RES, FREQ. 35Hz. FREQ. RESP. TO 3KHz. SENS. 96dB. PRICE £27.76 + £3.50 P&P
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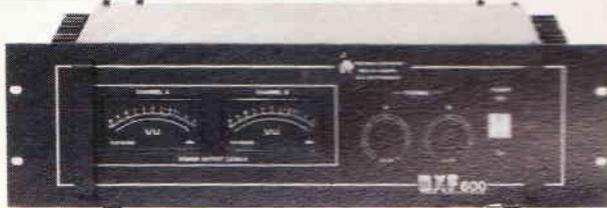
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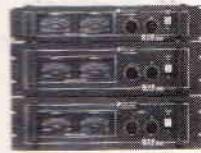
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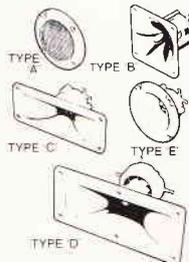
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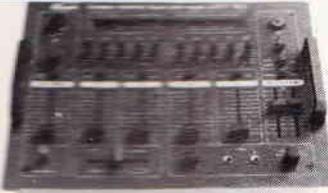
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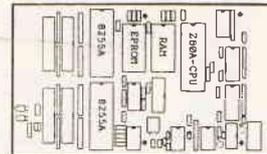
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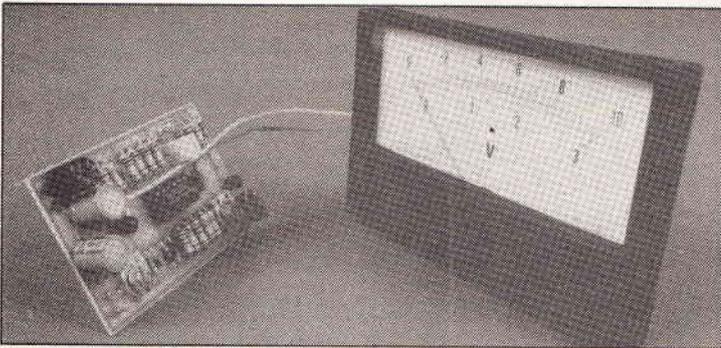
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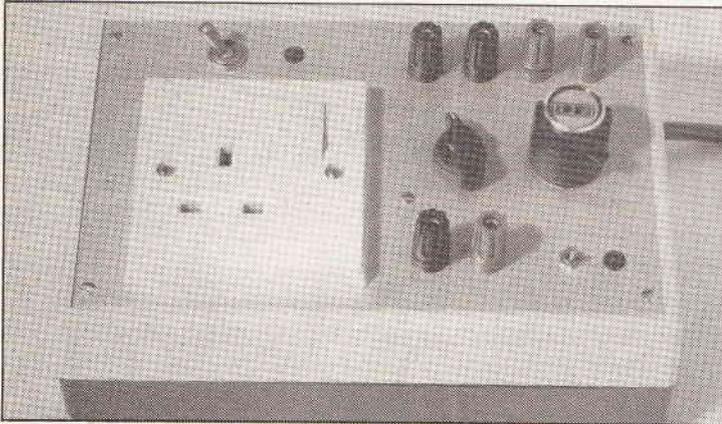
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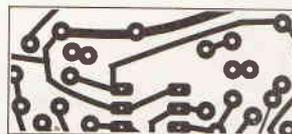
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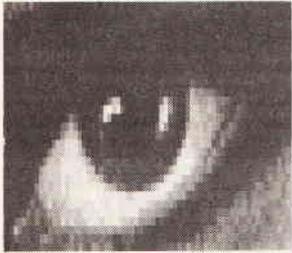
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FEATURES/PROJECTS



Electric Eye

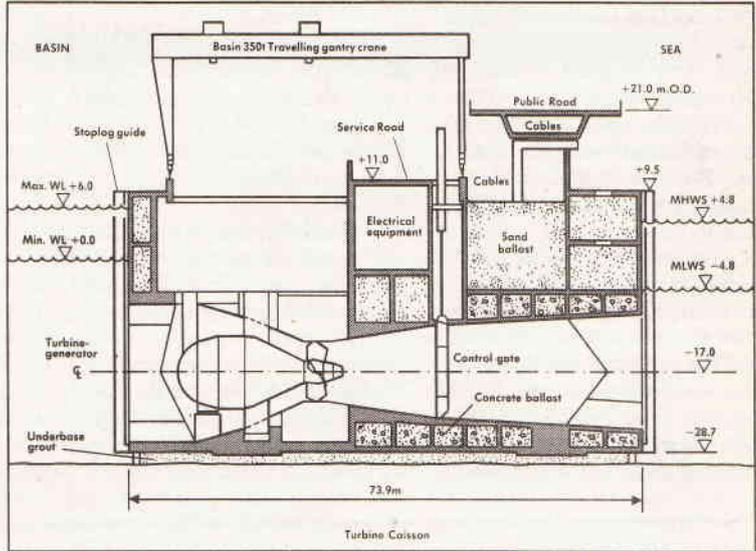
Technology can now give blind people easier access to written information. Helen Oughton reports.

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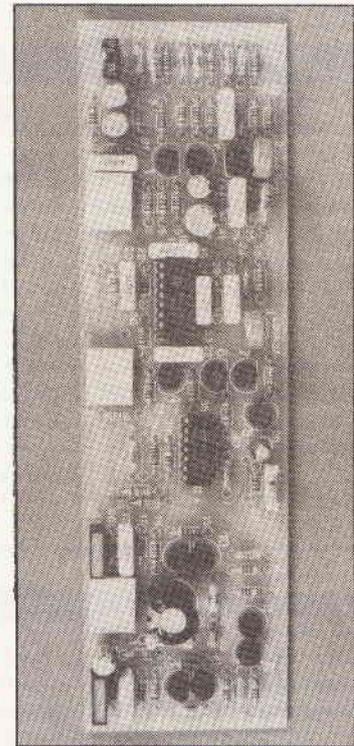
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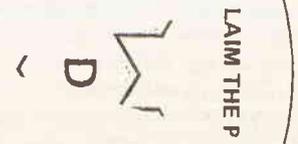
AC Millivoltmeter

Steve Bateson constructs this high performance meter.

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READ\WRITE



New Supplier For Tweeters

I am particularly interested in building your Micro Monitor Speakers featured in Top Projects 1989, but I am having difficulty in tracing the supplier of the tweeters used. The supplier quoted is Electromail, and the part number is 249-435, but I can find no address for this company. I would very much appreciate it if you could tell me where I may obtain these tweeters.

Alternatively, what other tweeters would be suitable for this application, and are available from another supplier (eg. Maplin). The quoted characteristics of the tweeters used are a flat response from 3-20kHz, amplitude variations kept within a few dB, and good sensitivity along

with wide dispersion capability.
RA Phimister
Wigan, Lancashire.

Electromail are the mail order outlet for RS Components. You can contact them at PO Box 33, Corby, Northants, NN17 9EL. Telephone 0536 204555. However...

Unfortunately, Electromail no longer supply the tweeters used in the Micro Monitor Speakers project.

The tweeters can instead be obtained from Maplin Electronics, PO Box 3, Rayleigh, Essex, SS6 8LR. Telephone 0702 554161. The part number for the tweeters is FD94C.

Non-Howling Mike

For months now, I have been hunting through magazines and library books for information on Public Address Systems which will give me some idea as to how 'Howl Back' can be eliminated.

When I went to the Adelphi Theatre to see Starlight Express the sound output must have been hundreds of watts (for me it was unbearable) and yet there was no 'Howl Back'. The performers appeared to be wearing radio mikes and yet those mikes seemed not to pick up any of the sound which filled the building.

How is it done?

I wondered if a bucket-brigade delay line in the circuit would put the sound so out-of-phase that the trouble would be

overcome. Is this a way out?

I would be most grateful for somebody to be able to tell me how to do it. I am sure a good many of your readers are concerned with amateur opera groups, dance bands, clubs and the like, where a non-howling mike is a long-felt want.

ET Metherell
Longport, Somerset.

Has anyone out there managed to overcome this problem? We are always happy to receive good project ideas.

Does Nanny Know Best?

Mr K Wilson (Read/Write ETI June 90) castigates you for publishing information on surveillance gadgets. Of course sensible people will not heed him, but still it is worrying that such 'nanny knows best' attitudes persist.

Please maintain ETI's excellent record by continuing to give us practical details about the wide range of electronic topics which interest and intrigue us. Give particular coverage to those which people like Mr Wilson might decide we have no need of! More seriously, please do your best within the law to keep us informed on techniques and equipment which the authorities

might prefer us to be ignorant of.
D Ferguson
Basingstoke, Hants.

Re item in Read/Write, ETI June 90 *Invasion of privacy*, concerning the publication and advertising of electronic surveillance equipment.

Mr Wilson seems to lose his otherwise logical train of argument when it is stated that no one who has a 'legitimate' need for the said equipment would have 'the slightest difficulty in obtaining it'.

I would like to ask the following:

i) Who can say who has a

'legitimate' purpose for using these devices? Is it antisocial for users to find out if they are being systematically cheated or robbed by someone else? Is it only legitimate for enforcement agencies or governments to use these devices?

ii) Why shouldn't ETI advertisers of surveillance equipment be allowed to do so? If they didn't, where would the 'legitimate' users of surveillance devices get to know about it?

In all fairness to Mr Wilson, however, it is a sad reflection on today's society that the use of bugs is so widespread, but on the other hand, it is also a reflection that they are in fact *needed*. It may be

safe to say that if everyone had been brought up by someone like Mr Wilson and were taught the true values of life, then I myself would be out of business! I have been selling surveillance devices in both kit and built form for three years, with an assortment of customers from every walk in life, and with every reason to purchase such items.

The comment that this magazine is not fulfilling any real public need could be classed as invalid, since whenever I have had an advert in for devices, the response has been more than acceptable, proving my point.

P Benton
AC Electronics

Flatmate Hints

Readers may find my experiences with the Flatmate speaker of some interest (ETI May 90).

In the first place, the output transistors specified are not strictly speaking a matched pair, so I ended up using BDV64 and BDV65s. These types are actually TO218 cases which are wider than the TO220s for which the

circuit board was designed.

On first powering up the system through a variac, it was found that if the voltage out of the bridge rectifier was increased beyond 13V, the output became noisy and unstable. This was cured by fitting 100n capacitors on the regulator IC outputs to ground.

Having brought about the

emission of music, it was immediately apparent that there was something drastically wrong with the tonal balance. There was hardly anything coming out of the tweeter, except at very high frequency, and the bass drivers were producing well into the high frequency range instead of rolling off.

This kind of circuit is an ideal

candidate for the Number One Systems Analyser program on the BBC computer. Plugging in the values confirmed what I was hearing, the low pass filter started rolling off at about 3kHz but was only 5dB down at 20kHz. Similarly, the high pass rolled off fairly steadily from 20kHz to -16dB at 3kHz and -87dB at 100Hz.

Comparing this circuitry with

Barry Porters' Active 8 design from earlier years showed two things.

1) The 4k7 feedback resistors in both filters (R10, R12, R15 and R18) should be pieces of wire (0 ohms).

2) In the high pass filter, R9, R8 and R11, R19 should both be the opposite way round.

This then gives basically the correct response. As a refinement to give the correct theoretical response, the following changes

are also required which give a crossover point of 3.1kHz:

C4 and C6 should be 4n4 (2x2n2).

R9, R11, R13, R14, R16 and R17 should be 16k5 (2x33 in parallel).

The system then sounds quite good!

One question remains, however, though not specifically concerning this design.

As I understand it, the requirements at the crossover point

are:

1) The drive units are in phase.

2) Each unit is 3dB down (half power) so the total output is at 0dB.

With the 4th order filter, a phase change of 180° occurs in each drive unit so they are in phase at crossover and also within the pass band. With this cascaded design though, the two second order filters are each 3dB down at the crossover point and

so the overall result is correct phasing but at a -6dB point. Surely this is wrong!

Maybe somebody out there can comment on this point and advise whether it is possible to devise a circuit which fills these requirements.

**J Lodge
Yardley Hastings, Northants.**

We're sure that other readers working on the Flatmate project will find these hints helpful.

Waterhole Won't Run Dry

I am writing in the hope that you can help me with a problem that I have with the Waterhole Project ETI March 90. I am having difficulty in adjusting the gain or sensitivity of the active filter. When I insert the probes (which are 4.5in. lengths of silver solder with leads soldered onto them), into the soil to their full depth, I cannot achieve a situation where the comparator indicates that the soil requires water. The soil in the pot is at the moistness I require and contains a little of the 'grow bag' type of compost but it is not excessively wet.

I have tried your suggestion of changing the values of R4 and R5 but to no avail, I have to

actually short out R4 to get the comparator to operate. I have checked the approximate resistance of the probes whilst in the soil, the reading I got with the probes in to their full depth was approx 1k3, with the probes in about 1/2in. the resistance is approx 7k. With the probes fully in the soil I am reading the following voltages on IC1b, pin 5, 3.85V DC; pin 6, 4.74 DC; also on pin 5, I am getting 5V AC; pin 7, 10V DC. Finally as a point of observation, I had to replace R18 (100k) with a 53k to get the safety feature down to approximately 2 hours.

I would be grateful if you could help with my problem.

Thanking you in anticipation.

**VP Fitzgerald
Wirral, Merseyside**

Edward Barrow replies:

When altering the values of either R4 or R5 a useful tip is to try values in the range of $R(\text{soil})/3$ to $R(\text{soil})$, where $R(\text{soil})$ is the measured value of the soil resistance. This sets the smoothed output voltage within the range of the comparator.

In the mentioned case with a soil resistance of 1.3K a suitable value for R5 should be around 330R to 680R, which is electronic terms is not too far off a short circuit. Another alternative is, if

space permits, is to place the probes further apart, logically if the distance apart if doubled the so too will the soil resistance. The same is true if the length of the probes is shortened as you noticed. In passing the safety feature time is only approximate and was not set accurately to two hours, this problem is made worse by the compulsory use of electrolytic or tantalum bead capacitors which have a large spread of leakage currents and are quoted at $\pm 25\%$, thus giving a 50% error margin (even higher if it was once a member of a large bargain pack of seconds). I hope my answer has been of some assistance to your plight.

Oops!

We have read with great interest Marc Masson's article on European Patents published in your May issue. May we draw your attention to two updatings:

The European Patent Organisation currently consists of 14 — and not 13 — Member States, as Denmark has joined the Organisation on January 1, 1990. Accordingly, it is possible to apply for patent that is valid in 14 different European states.

Our CD-ROMs, holding patent applications, contain approximately 650 Mbytes — less than a Gbyte — of information.

Please note that also the spelling of our address in Munich is not correct: It should read 'Erhardtstrasse' instead of Erhardstrasse. The name of this refers the Lord Mayor who died in 1888 and not the former German Chancellor Ludwig Erhard.

**Rainer Osterwalder
Press and Public Relations
Department
European Patent Office**

Fine Tuning!

I have built your FM Tuner design (February, March, April 87) via the Hart kit and after a few teething troubles it is all working perfectly and indeed does sound wonderful. The selectivity and sensitivity are unbelievably good with a 4 element dipole pointing towards Wrotham it gives good reception on the local stations in the opposite direction! It is very stable and does not appear to drift at all — well done. However, I have a few questions regarding its operation which Mr Milligan at Hart was not able to answer.

1. What is the function of the user controlled AGC? I understand what AGC does but why shouldn't it be in use all the time? No other tuner I have seen has an AGC switch on the control panel so I am most curious when to switch it off. Also, relating to this, when the AGC is switched on, the tuning meter does not change from full scale to 80% as stated in ETI April 1987. It stays as before — full scale. Hart set up the VCO PPL board so it should be right. When I set it up at first,

with only a multimeter, it reacted in the same way.

2. The tuning meter acts more as an off/on switch reading from 3 (no station) to 6 (any station). Radio 3 from Wrotham — 250 kW and 48 miles measures the same on the meter as Radio 3 from Oxford which is the same distance, only 46kW and about 90° from the maximum gain of the aerial. Is the meter supposed to read this way or can it be related to signal strength in a more linear fashion? Is this a function of the FM IC — in my case the HA11225? Have the two other modifications to the circuit since the publication of the original articles, namely, joining pins 6 & 7 of IC3 (HA11225) and the deletion of 2 of the ceramic filters from the IF amplifier affected the operation of the meter: The meter at present does not show relative signal strengths or faults in the aerial system and therefore not very useful.

3. Would you kindly list the components and values in the stereo decoder board necessary

for a 75µs de-emphasis? I am from the US and although I plan to remain here one never knows the future; such information would be valuable. I assume that the original article was in error as I believe the de-emphasis for Britain is 50µs and not 75µs as stated.

**FW Ohlendorf
Stevenage, Hertfordshire.**

John Linsley Hood replies: I am glad that you are so well pleased with your FM tuner. I think that the basic design is a sound one, though it lacks some of the frills and facilities of the best of the commercial units, and Hart have done quite a good job on the kit.

It is always gratifying to a designer if some kit supplier adopts a design, and especially, as in this case, if they make a good job of it — their kit design works better than my own prototype, as well as being tidier, so I've built one of their kits myself. Though this is about the MK6 PPL tuner design of mine, over the past 15 years, I think it is the best I've so

far done, and several of my Hi-Fi friends compare it favourably, in sound quality and signal-to-noise ratio, with their most up-market commercial tuners.

With regard to your queries. The effect of the AGC is to reduce the sensitivity of the tuner on strong signals, to avoid overloading, but it also will reduce the sensitivity on weak signals, though not by so much. In fringe areas, or when 'DX'ing with the mute 'off' switching off the AGC will give just a little extra sensitivity.

The tuning meter sensitivity on your set seems a bit high. This is controlled by RV2, which also controls the AGC output voltage setting. I did the prototype version using the RCA 3189, for which the HA11225 is a pin-for-pin replacement. The Hitachi IC is slightly different in characteristics to the 3189, and this alters a few of the DC output levels slightly. You can trim the tuning meter response by altering the values of R71 and R74 say to 33k and 3k3, in my Figure 111 (March 1987).

The modifications which I

had made to the circuit did not affect the AGC or tuning meter settings. The deletion of CR2 and CR4, because Hart had some rather better ladder filters than I had originally proposed will increase the sensitivity a little, but this is generally a good thing, since the max. output is still below the level at which the capture ratio decreases.

To adapt the tuner de-emphasis, to 75µs, in the most recent decoder circuit, which uses a FET/bipolar output pair as Q14/Q15 and Q11/Q12, in-

crease the values of R17 and R23 and 3K3 to 5K0: ie., two 10Ks in parallel. Hart do now have a new decoder PCB, I think.

An update to the FM Tuner project is included in this month's issue of ETI.

It's nice to be able to report someone actually reads this column! A few months back, I wrote a fairly severe criticism about junk mail and all its trickeries. To be truthful I can't say I was expecting any feedback — I was sure most people would agree with my sentiments. However, negative feedback was not to be. Within days of the magazine coming onto news-stands I had received a letter from Kay Beckett; chief executive of the Mailing Preference Service (MPS).

Kay brought to my attention two facts. First, many non-members of the service use lists which are cleaned against MPS lists as they pass through list brokers and computer bureaux. Thus, more lists are cleaned than would be thought.

Second, although over quarter of a million names have been removed, this does not correspond to over quarter of a million people — as any one person might have been direct mailed under a variety of misspellings. So, the number of people removed from lists is somewhat lower than quarter of a million.

Neither of these facts were made clear in the MPS brochure, so I thank Kay for her clarification.

To put direct mailings into perspective, a report from the Direct Mail Information Service quantifies a total of 2 billion items delivered last year! Remarkably, this averages out at just over one item a week for each household in the nation. The service also says that higher income households receive significantly greater volumes of direct mailed junk. These 2 billion direct mailed items meant over £650 million were spent on sustaining the industry.

Banking On Satellite

National Westminster, high-street bankers, are taking to the air in a high-technology data and communications network. In a 10-site pilot study, NatWest banks will be networked via satellite to allow one-way data transmissions at up to 64k bits per second and real-time video transmissions.

BSB Datavision is the network provider, using piggy-backed services on the BSB television satellite. The main function of the pilot network is to distribute training videos and software to branches.

If the pilot is successful, NatWest intends to expand the network to cover all its 3000+ banks in the country.

Land Mobiles

It looks as though all land mobile services over satellite links are to be undertaken over the international maritime satellite system, Inmarsat.

Inmarsat currently operates a satellite communications system covering the world, allowing voice, fax and data services between 9000 or so ships and oil rigs. Now Inmarsat is to provide land mobile satellite services, too, between cars and trucks on the earth's surface and head offices, worldwide.

This will represent a significant increase in Inmarsat communications capabilities, matched only by its recent provision of communications services to and from air-borne aircraft. Makes you wonder what it's going to do next, doesn't it?

Laying The Foundations

In just a couple of months BT switches on its trial of an optical fibre-based network providing TV, radio, telephone (and so on) services to 400 homes and businesses in Bishop's Stortford.

The system has been developed at BT's Martlesham Heath research laboratories, in collaboration with BICC Cables, Fulcrum Communications, and GPT. It's an interesting trial, this one, as it could well show the way satellite services are to be provided to individual homes in the long-term future.

If you think about it, although a short-term solution to receiving satellite television programmes is a dish (two if you want to receive BSB's transmissions, too), not everyone wants their home spoiled by such additions. Although there will always be some viewers who want to pick-up unusual signals from weak, non-commercial satellites, most just want the bog-standard satellite television programmes — whether by air or by optical fibre. One other solution, of course, is microwave terrestrial television services, which give a quicker, cheaper method of providing large numbers of television channels to many homes than optical fibre networks. Such microwave services are, though, non-interactive and, in the end, optical fibre networks have to be the optimum.

The first phase of pipe-laying in the BT trial has been completed at the time of writing, so things look good for an Autumn start. We will keep ETI readers in touch with developments.

Finally, has anyone seen a squarial yet?

Keith Brindley

WEATHER WISE



Maplin Electronics have come up with a project for a weather monitoring system which accurately measures wind direction and speed from your home or workplace. The project is in two halves, an outside unit which gathers data on wind speed and direction and an indoor unit which displays the data gathered.

An analogue meter shows the wind speed in mph and knots, and a 16 point LED compass display shows the wind direction. Additionally, an optional digital temperature module gives a readout of inside and outside temperatures.

For more information, contact Maplin on 0702 554161.

TRAINING BY SATELLITE

A series of live satellite television programmes have been used to give interactive training in advanced manufacturing technology.

The programmes were broadcast from the Polytechnic South West in Plymouth, and used material produced by the Institution of Production Engineers and Engineering Industry Training Board for their own advanced manufacturing technology (AMT) courses, and can lead to the award of their certificate in AMT awareness.

The project was funded by the

WATER LOGGED

To warn of rising water levels, Bristol Water Company is using a new type of portable data logger and alarm monitor from Stonefield Systems of Horsham. The logger will check digital and analogue values such as water pressures and water levels at Bristol Water's remote sites, and will transmit values and alarms over a Racal-Vodafone network.

The logger can start sending status information to the central station immediately after connection to the point to be logged, without the need to install telephone lines.

The central control station is a portable PC, so water board engineers anywhere in the Bristol area can obtain up-to-date reports on local sites and deal with emergency or fault conditions as soon as possible.

Commander, an industrial control system board from Stonefield Systems, is being used for monitoring and control functions within the outstation. The outstation's enclosure contains the Commander Board, Vodata CDLC modem and handset, power supply and rechargeable battery.

It is programmed to monitor analogue points and digital inputs, compare values against pre-set high or low limits, and automatically dial up and report to the central control stations whenever values go over the limit or changes of state occur.



NO TROUBLE ON HUBBLE

The extreme conditions of space present particular problems to experts in the lubrication and wear of mechanical parts. In the case of the Hubble Space Telescope, lubrication is critical because of the telescope's mechanical complexity. The solar arrays which provide all the telescope's power are deployed by a unique and complex set of mechanisms designed by the European Space Agency, ESA. The North American Space Agency NASA described them as a "technological miracle".

Tribology is the study of friction, wear and lubrication. The European Space Tribology Laboratory (ESTL), part of the AEA Technology at Risley, was asked to advise on how the mechanisms of the solar array would behave and how they should be lubricated to cope with the space environment.

ESTL proposed the use of their ion-plated lead film as the lubricant for several of the array mechanism bearings, as conventional lubricants are inappropriate in extreme temperatures and

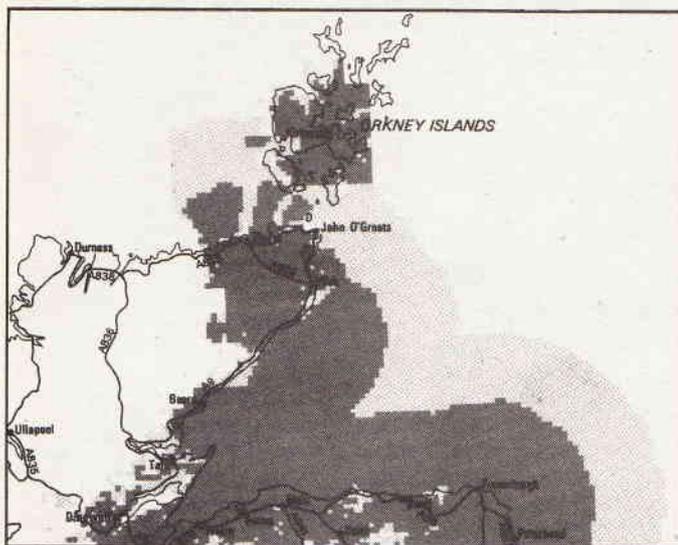
vacuum conditions.

Using vacuum chambers to simulate space conditions, ESTL also rigorously ground-tested the solar array drives which are responsible for slewing the arrays to face the sun, independent of where the telescope is actually pointing.

The Hubble telescope was launched in April this year, and is now a free-flying, self-powered spacecraft. It is a 2.4 metre diameter reflecting telescope of great power and accuracy. Its 350 mile orbit, free from the distortion of the earth's atmosphere, will allow astronomers to see further back in time, to around 15 billion years, which cosmologists believe will reveal the origins of the Big Bang.

It carries a special camera, called the Faint Object Camera, which can detect celestial objects 50 times fainter than can be achieved on Earth. For example, the camera could detect the light of a candle on the moon. Again, the camera's vital optical mechanisms are lubricated by ion-plated lead.

CELL PHONE TRANSMITTER FOR ORKNEYS



The Orkney Islands are to have a cellular telephone transmitter, bringing the service for the first time to the area and its surroundings.

The site, located at Keelylang Hill on mainland Orkney, will give extensive coverage to Orkney itself and will also partly cover the islands of Burray, South Ronaldsay, Rousay, Eday and Shapinsay, and the east side of Hoy. Partial coverage also extends to the islands of Westray, Sanday and Stronsay. As the site covers large areas of coastal waters around the islands, extending to the Scottish mainland, it will be of particular interest to the fishing industry. Coverage of sea areas includes the Pentland Firth from Duncansby Head across to mainland Orkney, and partial coverage as far as Sinclairs Bay on the north-east coast mainland.

Coverage is also extensive well into the Atlantic Ocean and the North Sea.

The Vodafone service has over 500,000 subscribers, and is extending its service throughout the UK. One of the areas yet to receive any significant coverage is the north-west coast of the Scottish mainland, mainly due to the topography of the land and the number of potential users. Vodafone has now identified a number of future sites, and will eventually offer coverage to these more remote areas of Scotland.

As the network operator, Vodafone is prohibited under its licence to sell equipment or air-time to the end user. There are however a number of cellular service providers and dealers throughout Scotland who can offer the full range of equipment and services on the Vodafone network.

SHUTTLE SPACE FOR STUDENTS

Engineering students from Robert Gordon's Institute of Technology, Aberdeen, are to have a project sent into orbit on a NASA Space Shuttle.

The group are the winners of the Space Shuttle Competition organised by the Institute of Electrical Engineers and British Sugar. The project is to test the strength of gravitational fields at altitude.

Pupils at Elrick School, Aberdeen, who collaborated with the winning team, developed a second, experiment which will

also be carried on the Shuttle, to monitor the effects of space flight on particular types of seed.

The nationwide competition was launched in 1988, for engineering students to design and build a small self-contained payload to be carried on NASA's Space Shuttle 4060. Space on the Shuttle was bought from NASA by British Sugar and donated to the Institution.

The winning team now have one year to build their project ready for launch in late 1991.



POCKET NEWSFLASH

Mercury Paging and the BBC have launched the world's first "Pocket Newsflash" service, which allows paging customers to receive BBC Newsflashes on their raipager's display screen.

The service is offered to new customers for Mercury's latest executive-class message pager, Messenger One. It adds about 50p per week to the cost of normal personal paging.

Using this service, customers still receive personal messages, but can also keep in touch with world events. The average number of newsflashes is 12 per day, covering national and international news. The service operates 365 days a year, updating automatically as news situations develop. News gathering and full editorial responsibility rests with the BBC.

Newsflash broadcasts to the pagers are automatically triggered



as soon as the news is entered into the BBC Ceefax Teletext computer. Transmissions are then routed through the Mercury Data Network to Mercury Paging's transmitter sites throughout the UK.

For further information contact Mercury Communications, telephone 071 528 2000.

LASER LINKS

CASE Communications has announced a device which connects two local area networks (LANs) without any physical cabling. The device is called the MegaBeam, and it uses secure, infra-red lasers to connect LANs in different buildings at distances up to 1km. Full speed operation (10 Mbps for Ethernet LANs and 4 or 16 Mbps for Token Ring

LANs) eliminates the potential bottleneck of telecommunications links, as well as the cost of bridges and leased lines.

The full speed operation of MegaBeam makes it particularly suited to installations where the LANs are used for traffic between processors. Because transmission is non-electrical, it is ideal for hazardous environments such as

chemical plants, oil refineries and gas storage installations. The end units themselves use DC power transferred via a composite cable. Installation is easy, the laser heads being provided with telescopic sights for line-up and both a signal meter and a plug in phone for testing the laser link channel.

The 10mW lasers use infra-red light with a wavelength of about 810m. According to CASE, the low power means that there is no risk to safety — you would have

to stare directly into the laser for a considerable time in order to do your eyes any damage.

Because the link is maintained even when 98% of the light is lost, the laser is unlikely to be affected by poor weather conditions, such as fog. On a very foggy morning, the chance of signal loss is about 0.01%. In high winds, CASE believe that their units are more secure than telephone lines.

Contact: 0923 58000.

MAKING SENSE OF VEHICLE CONTROL

Lucas Automotive Ltd has created a new business unit to supply high-technology sensors to the automotive industry, as part of a move into the market for electronically controlled vehicle suspension, braking and chassis systems.

Vehicle control systems are made up of three elements — sensors, electronic control units (ECUs) and actuators. Many vehicles will have up to six separate ECUs to control separate functions.

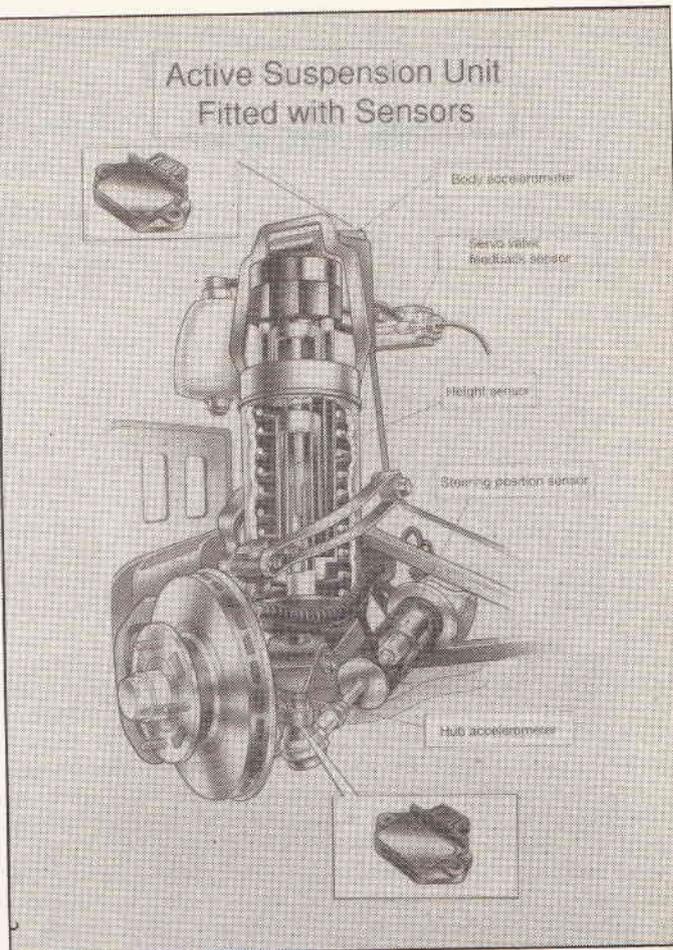
Chassis system control covers the steering, suspension and braking control units, with sensors measuring position, speed or acceleration. An active suspension assembly at each corner will probably require up to five sensors — body accelerometer, height sensor, hub accelerometer, hydraulic servo-valve feedback sensor and load cell. There may be additional accelerometer and yaw rate sensors on the chassis.

Sophisticated electronic control needs rugged and accurate position sensors, both linear and rotational. The Lucas linear sensor operates in stroke lengths of 5mm to 500mm and can be used to control ride height, suspension, transmission, steering, clutch and seat position. The rotational sensor operates over a range of more than 100° and can be applied to steering position,

ride-height control and rotary actuator position feedback. These non-contact sensors use an inductive circuit which incorporates sensing coils, driven by a high frequency oscillator, with a conductive "spoiler". Movement of the spoiler changes the amount of eddy current damping in proportion to the engagement of the coil and spoiler. The resulting inductance change provides a sensor output proportional to displacement. The "Digital Autoplex" interface IC is used to provide an output signal suited to automotive system use.

Speed sensors can be made in different technologies depending on the application. Lucas manufactures a variable reluctance speed sensor used in crankshaft speed/position applications; this unit may be adapted for use in advanced braking systems. The newly developed magneto-resistive wheel speed sensor provides a useful signal at near-zero wheel speed, with application in traction control and anti-skid braking. During the past two years an optical speed-over-ground sensor, using the technique of spatial filtering, has been developed and successfully tested under a wide range of climatic conditions for the measurement of absolute vehicle speed.

The introduction of accelerometers will give rise to the greatest



innovation in control of vehicle suspensions. The silicon accelerometer sensing element consists of a micromachined silicon mass suspended by multiple beams from an external silicon frame. Stress-sensitive Piezo-resistors within the beams change their resistance as the

motion of the suspended mass changes the stress in the beams. The associated circuitry processes this signal into that required by the vehicle's ECU system. Micromachined silicon technology provides the most versatile approach to low cost accelerometers.

LOW VOLTAGES, HIGH TECHNOLOGY

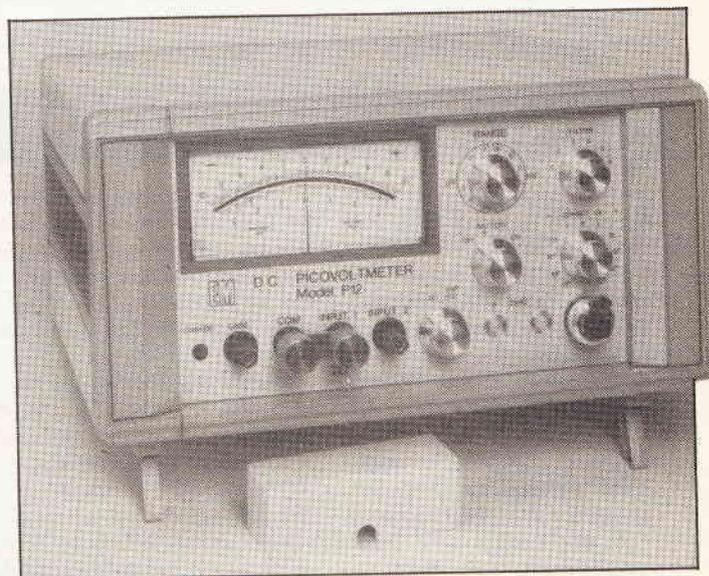
It's not just big companies that make outstanding technological achievements. EM Electronics, a three person organisation, received a Queen's Award for Technology this year.

The company was formed in 1979 as a design consultancy, specialising in measurement of extremely low DC voltages. Following three years of research, EM Electronics developed a nanovoltmeter.

Subsequently the National Physical Laboratory required even lower levels of voltage measurement in for more accurate determination of the

basic unit of electrical current, and so the first EM DC Picovoltmeter was produced. Later projects included the conversion of AC to DC for an amplifier which would detect very low levels and provide a high degree of linearity. EM measuring techniques can also be applied to the quantized Hall effect for accurate determination of basic resistance.

EM Electronics now produce a range of instruments which include detection down to a few picovolts, linearity to better than one part per million and a nanovoltmeter which, whilst remaining at room temperature, can effi-



ciently measure a source at cryogenic temperatures.

For further information

contact EM Electronics, telephone 0590 22934.

BYPS HOP INTO MASS MARKET

BYPS Communications, the Barclays, Philips and Shell Telepoint consortium, are to market their Telepoint service under the brand name "Rabbit". As a result of market research, BYPS decided that marketing Telepoint on the basis of inaccessible technical brand names was more likely to close the door on the mass market.

John Dodds, Communications Manager at BYPS says "The business man, family or individual considering a Telepoint purchase wants simplicity, not jargon — hence Rabbit." BYPS believe that the new name will give them an edge over the jargon-ridden competition.

The findings of BYPS's market research are published in a report "Tomorrow Calling Today." The research predicts that 11 million people in Britain will be using some form of portable communications by 1995.

Until now, portable communications have been used almost exclusively as a business tool and each of the services such as cellular have been marketed as such. According to "Tomorrow Calling Today", the report published by BYPS, the Telepoint phone will be the first portable phone to be accessible to the wider mass market.

The report shows that there will be a massive expansion in the entire portable communications

field. The business sector will be the first to adopt new technology such as Telepoint but also predicts that changing lifestyles combined with reduced cost of the new technology will make Telepoint attractive to the consumer, producing the first mass market for portable phones.

Cellular and PCN will be higher cost and utility forms of portable communications. Telepoint will not compete with these, but will serve the mass market. BYPS intends to have 7,000 base stations in the UK by the end of this year.

BYPS believes that in the long term, the consumer rather than the business market will account for 75% of Telepoint users. By 1995, portable communications handset costs for Telepoint may fall to as little as a quarter of their current level.

People are now more active in their leisure time and communicating with their friends and family much more often. Cordless phones are increasingly popular for people performing additional activities both within and away from the home. Telephones will increasingly become the property of individuals rather than one number referring to a particular household. In the increasingly mobile 1990s, families will want to check up, receive reassurance, request services and make domestic arrangements



using a portable telephone.

Flexibility and reliability of communications will play a key role for women returning to work, but requiring personal communications tools to remain in touch with family and friends without disrupting work. Concern about personal security may also lead to a greater use of portable phones by women.

By 1995, there will be more than 3.5 million self-employed,

who will continue to be prime users of portable communications. Also, 53% of the population would like to work for some of the time from home. By 1995, around 390,000 full-time and 12 million part-time workers could be working from home. Improved information technology and communications will be key to this development.

NEURAL NET ON A CHIP

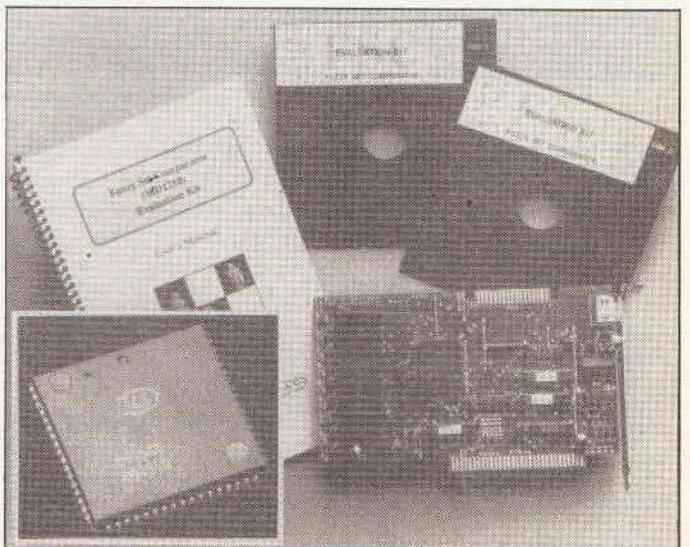
The MD1210 Fuzzy-Set Comparator is a low-cost integrated circuit incorporating a digital hardware neural network optimised for pattern recognition. The device can be taught to recognise new patterns without the use of application specific programs. It is intended for real time application in vision systems; voice radar, telecoms and sensory signal processing; robotics, security and surveillance systems.

A single chip can simultaneously compare eight unknown serial data streams with one known, or one unknown with up to eight known. Data is learnt or compared at rates of 20 MHz

and results are processed by the neural network in five clock cycles. An in-built expansion capability lets you network as many as 32 chips allowing comparison of 256 stored data patterns.

An FSC Evaluation Kit is available for the MD1210. It comprises a PC plug in card, evaluation software running under MS Windows and a users manual with board schematics. The board contains an MD1210, a low cost frame grabber and the necessary PC interface.

The kit costs £499, and is available from Tubb Research, Petersfield. For more information



contact Ian Collins on 0730 60256.

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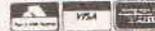
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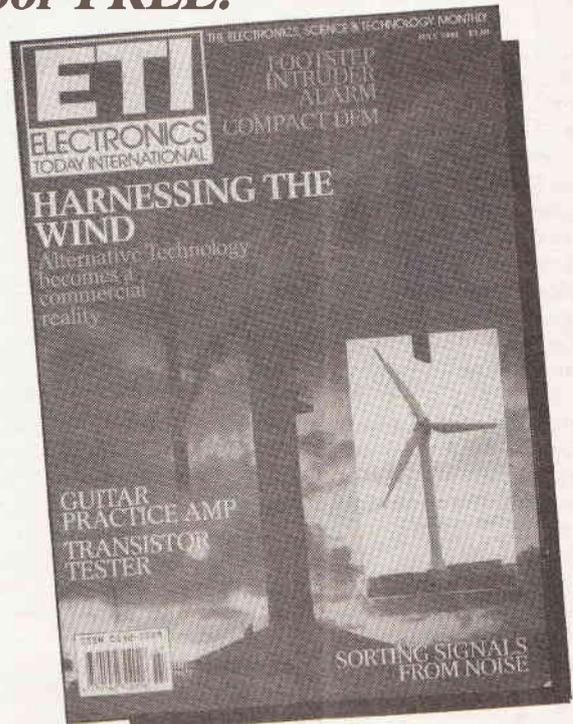


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TK FOR KITS

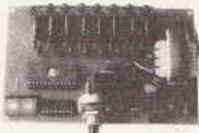
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One of the best burglar deterrents is a guard dog and this kit provides the barking without the bite! Can be connected to a doorbell, pressure mat or any other intruder detector and produces random threatening barks. Includes mains supply and horn speaker.

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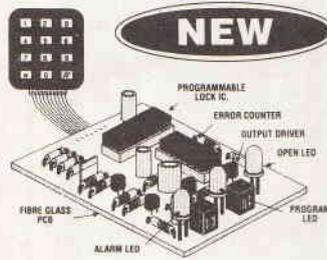
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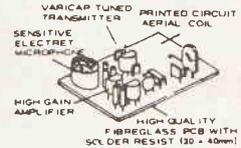
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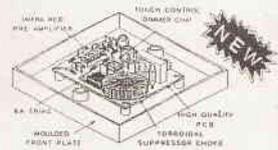
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Designed for use with the XK132 and comes complete with a pre-drilled box. A PP3 9 volt battery is required.
MK 6 £4.95



XK136 TOUCH DIMMER KIT £12.96

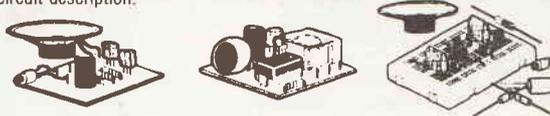
VERSATILE REMOTE CONTROL SYSTEM

These kits can switch up to 16 pieces of equipment on and off or control 16 functions depending on the keyboard selected for the MK18 transmitter. MK12 receiver has 16 logic outputs and operates from 12 to 24V dc, or 240V ac, via the transformer supplied. The MK18 requires a 9V battery and keyboard. Great for controlling lights, TVs, garage doors etc.

MK12 IR Receiver £19.55
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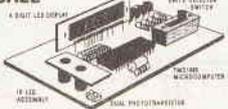
SK1 DOOR CHIME plays a tune when activated by a pushbutton **£4.50**

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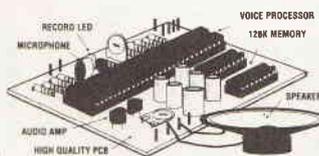


Kit contains a single chip microprocessor. PCB, displays and all electronics to produce a digital LED readout of weight in Kgs or Sts/Lbs. A PCB link selects the scale-bathroom/two types of kitchen scales. A low cost digital ruler could also be made.
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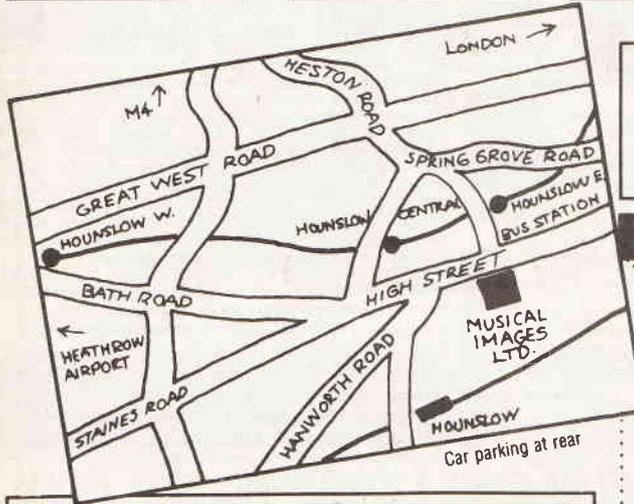
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Roxburgh SDC 021 2 amp mains RFI filter. Has an extra wide frequency range of 150 khz to 30 mhz. Can type, solder lug connection. Quality manufactured to BS 613 standards. Dims 1-1/2"D x 1-3/4"H..... **£3.95 or 3 for £10 (A) 10 for £28 (B)**

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12 volts 12 volts 3 amp/hours **£13.95 (A)**

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NOT suitable for IBM or Clone type colour monitors.

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TEC Starwriter Model FP1500-25 daisywheel printer renowned for its reliability. Diablo type print mechanism gives superb registration and quality. On board microprocessor gives full Diablo/Quume command capability. Serial RS-232C with full handshake. Bidirectional 25 cps, switchable 10 or 12 pitch, 136 cpl in Pica, 163 in Elite. Friction or tractor feed. Full ASCII including E sign. Font and ribbon Diablo compatible.....**£199 (E)**

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150-SN up to 9.5" paper.....**£155.00 (E)**

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Specify whether serial or parallel required.

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-Electronics-

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THE RTC MONITOR II

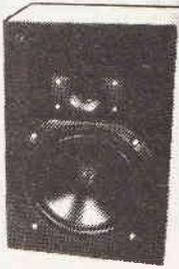
100 WATT SPEAKER KIT £60.00 + £3.50 P&P (pair)
RESPONSE: 55Hz-20kHz
BASS POLYMER CONE D: 22cm
DOME TWEETER: 14mm

OVERALL SIZE
(HWD): 382,252,204mm

RECOMMENDED AMP POWER:
10-100 watts per channel

The performance standard achieved in this compact design is distinctively superior to anything else available at the price. The drive units used are of sophisticated design and have been carefully integrated with a Complex Crossover. Stereo performance is exceptionally good with a well focussed sound stage and sharp resolution of detail. Distortion throughout the frequency range is low even at quite high power input and this gives a great sense of dynamic range and openness especially when used in bi-wired mode.

Supplied with:— 2 READY CUT BAFFLES, ALL CROSSOVER COMPONENTS, 2 BASS MID-RANGE, 2 DOME TWEETERS, HOOK UP WIRE, GRILLE CLOTH, SCREW TERMINALS AND SCREWS.



ROSS MULTI TESTER

As new condition but have been returned by customers or shops so they may need some attention. Hence the price of **£3.50** each plus **£1.60 P&P**. Order five and get the sixth one free. Postage **£5.40**.



LCD DIGITAL MULTI TEST METER AC DC
Volts resistance and DC Amps. Most of these units are new but have been returned or rejected by the store and sold with all faults at **£11.00** each. Postage **£1.00**. (Made by Ross Electronics).

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Mains and battery operated.
High quality VHF/FM,
Medium and Long Wave
reception,
6 pushbutton selected
preset stations.
Fully retractable telescopic
aerial.
Headphone/earphone
jack socket.

Size 230H x 150W x 65D.
Ref RE-5500.
Brand new.
Listed price over **£30.00**.

Price **£14.95 + £2.80 P&P**



SHURE HIFI STEREO MAGNETIC CARTRIDGE Fitted with an elliptical diamond stylus supplied with fitting kit and instructions. A good quality unit made to sell for well over twenty pounds due to scoop purchase, we are able to offer these at a fraction of the manufacturers price. All units are brand new and boxed. **£7.20** each. If you order in multiples of five you get one free. Postage **£1.30** (Made in U.S.A.)

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TV SOUND TUNER KIT



In the cut-throat world of consumer electronics, one of the questions designers apparently ponder over is "Will anyone notice if we save money by chopping this out?" In the domestic TV set, one of the first casualties seems to be the sound quality. Small speakers and no tone controls are quite common and that really is quite sad, as the TV companies do their best to transmit the highest quality sound. Given this background a compact independent TV tuner that connect direct to your Hi-Fi is a must for quality reproduction. The unit is mains operated. This TV SOUND TUNER offers full UHF coverage with 4 pre-selected tuning controls. All parts including Varicap tuner, mains transformer, PCB with IC's, capacitors and coils etc., to build the unit illustrated above; without case and scale.

£11.50 + £2.30 P&P

Case as illustrated **£6.90 + £2.00 P&P**

MAIL ORDER £1 BARGAIN PACKS BUY 20 GET 1 FREE

Please state pack(s) required

No.	Qty.	per pack
BP015B	1	30W dome tweeter. Size 90x66mil JAPAN made
BP016	6	2200µf can type Electrolytic 25V d.c. computer grade made in UK by PHILIPS
BP017	3	33000µf 16V d.c. electrolytic high quality computer grade UK made
BP019	20	20 ceramic trimmers
BP020	4	Tuning capacitors, 2 gang dielectric a.m. type
BP021	10	3 position, 8 tag slide switch 3 amp rated 125V a.c. made in USA
BP022	5	Push-button switches, push on push off, 2 pole change over. PC mount JAPAN made
BP023	6	2 pole 2 way rotary switch
BP024	2	Right angle, PCB mounting rotary switch, 4 pole, 3 way rotary switch UK made by LORLIN
BP025	4	3 pole, 3 way miniature rotary switch with one extra position off (open frame YAXLEY type)
BP026	4	4 pole, 2 way rotary switch UK made by LORLIN
BP027	30	Mixed control knobs
BP029	6	Stereo rotary potentiometers
BP030	2	10k wire wound double precision potentiometers UK made
BP031	6	Single 100k multitune pots, ideal for varicap tuners UK made by PHILIPS
BP032	4	UHF varicap tuner heads, unboxed and untested UK made by PHILIPS
BP033	2	FM stereo decoder modules with diagram UK made by PHILIPS
BP033A	4	6" x 3/4" High grade Ferrite rod. UK made
BP034	3	AM IF modules with diagram PHILIPS UK made
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BP034B	1	Hi-Fi stereo pre-amp module inputs for CD, tuner tape, magnetic cartridge with diagram. UK made by MULLARD
BP035	6	All metal co-axial aerial plugs
BP036	6	Fuse holders, panel mounting 20mm type
BP037	6	In line fuse holders 20mm type UK made by BULGIN
BP038	20	5 pin din, 180° chassis socket
BP039	6	Double phono sockets, Paxolin mounted
BP041	3	2.8m lengths of 3 core 5 amp mains flex
BP042	2	Large VU meters JAPAN made
BP043	30	4V miniature bulbs, wire ended, new untested
BP044	2	Sonotone stereo crystal cartridge with 78 and LP styli JAPAN made
BP045A	2	Mono Cassette Record and play heads
BP046A	2	606 Mains transformers, PCB mounting. Size 42x33x35
BP047	1	24V 0.3VA mains power supply. Brand new boxed UK made by MULLARD
BP047A	1	25V DC 150mA mains adaptor in black plastic case with flying input and output leads new units made for famous sound mixer manufacturer. Size 80x55x47
BP049	10	OC44 transistors. Remove paint from top and it becomes a photo-electric cell (ORP 12) UK made by MULLARD
BP050	30	Low signal transistors n.p.n., p.n.p. types
BP051	6	14 watt output transistors. 3 complimentary pairs in T066 case (Ideal replacement for AD161 and 162s)
BP052A	1	Tape deck pre-amp IC with record/replay switching No LM1818 with diagram
BP053	5	5 watt audio ICs. No TBA800 (ATEZ)
BP054	10	Motor speed control ICs, as used with most cassette and record player motors
BP055	1	Digital DVM meter I.C. made by PLESSEY as used by THANDAR with diagram
BP056	4	7 segment 0.3 LED display (red)
BP057	8	Bridge rectifiers, 1 amp, 24V
BP058	200	Assorted carbon resistors
BP059	1	Power supply PCB with 30V 4VA transformer, MC7818CT IC & bridge rectifier. Size 4"x2 3/4"
BP061	5	6.35mm Mono jack plugs
BP063	5	6.35mm stereo switched jack sockets
BP064	12	Coax chassis mount sockets
BP065	1	3mtr Euro-mains lead with chassis socket

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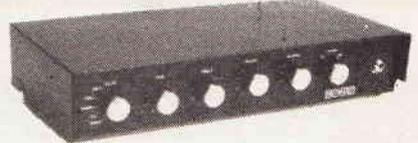
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30+30 WATT AMPLIFIER KIT



An easy to build amplifier with a good specification. All the components are mounted on the single P.C.B. which is already punched and backprinted.

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 - CD/Aux, tape I, tape II, tuner and phono inputs.
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- Size (H.W.D.): 75 x 400 x 195mm
Kit enclosed: case, P.C.B., all components, scale and knobs **£36.80**. post **£3.50**
(Featured project in *Everyday Electronics* April 1989 issue). Reprint Fee with kit.

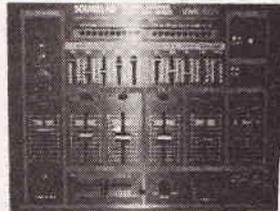
AMPHONIC 125+125 POWER AMPLIFIER



125 watt per channel stereo power amplifier with independent volume controls, professional 19" rack mount and silent running cooling fan for extra reliability.
Output power 125W RMS max. per channel
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Power 220-240V a.c. 50Hz
Chassis dim 435 x 125 x 280mm

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5-channel stereo disco mixer in racking case which can handle up to a total of 10 phono, line and mic inputs, switchable on front panel. Twin 5-band graphic equalizer with insert/bypass switch. Cross fader between channels 1 and 2. Mic channel with low Cut filter and talkover switch. Separate L and R master controls. Output for amp, tape and headphones.
Input Mic 0.3mV 600ohms
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Outputs: Amp & Tape 1.2V
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Equalizer control frequencies 60, 250, 1k, 3.5k, 12kHz
Equalizer control range ±12dB boost or cut
Size 350 x 280 x 90mm

£118.90 + £5.80 P&P

BELT-DRIVE QUICKSTART VARISPEED DISCO TURNTABLE

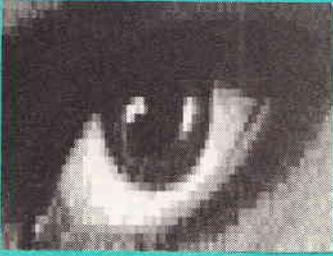
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With a 5.5v at 0.5A mains input 110-240. Size 90 x 105 x 75 fitted with copper screening band; made for famous HIFI Co. **£6.50** each. Postage **£2.80**. It's weight is 2.7kg! Brand new and unused condition.



ELECTRIC EYE



"Reading" a digital newspaper.

Helen Oughton reports on new technology to provide blind people with easier access to written information.

For most people, access to information has never been easier than today. We take for granted many forms of written information such as books, magazines, newspapers and letters, yet it is hard to imagine life without them. (No ETI each month, for a start!).

But for someone who is blind or partially sighted, written information is much less accessible. There are nearly quarter of a million adults registered blind or partially sighted in the UK, and it is estimated that nearly a million are eligible for registration. Often, the only answer is to ask family or friends to read aloud to them. At best, this reduces the person's independence. At worst, it becomes an intrusion into privacy. Who wants their friends to read all their personal correspondence? Many major banks now offer statements printed in Braille, but this is the exception rather than the rule.

Some blind people are also deaf, denying them the media contact afforded by listening to television and radio. For these people, access to all types of information is very difficult.

However, things are getting better. Over recent years, developments in information technology, text processing and data communications have revolutionised media and business environments. Digital communications, scanners and character recognition

software are now symbols of the high-tech, high-flying business world.

Now the thoughtful application of the same technology could bring a further revolution, giving easier access to newspapers and other written information for those who are blind or partially sighted.

Newspaper Over The Air

Technology — albeit rather old technology — already provides blind people with a newspaper service — in the form of weekly extracts on cassette tapes. More immediate information of individual interest can be obtained only by asking friends to read the paper aloud.

But now a new system will allow daily newspaper to be transmitted over the air, and stored on the recipient's computer disk. Items of interest can be picked out and made available in a way which suits the user.

In a pilot scheme, currently running for six months, the text of The Guardian is broadcast nationally over the independent television network by AirCall Teletext Ltd. It is transmitted on the day of publication, and is received in the blind persons home using a decoder card in a personal computer. 'Read

and Search' software, developed by the RNIB Technical Development Department, allows the user to read the paper using a speech synthesiser, Braille printer or a transient Braille display.

The cost to the user is likely to be about £1200 for the PC, decoder, voice synthesiser or printer. It is hoped that the information will be provided free by several newspapers, as The Guardian is currently doing.

This system has several advantages over listening to news on TV, radio or cassette. Firstly, it allows the user to obtain information in the same way that a reader of a newspaper would do, that is, by scanning through headlines to see what is interesting, by selecting those items which catch their eye, and by reading items at leisure. Secondly, it allows people who are both deaf and blind to obtain this information by means of a Braille display or printer.

The pilot scheme with The Guardian newspaper started in mid-March and will run for six months. If it is successful, the project may be extended to three or four national newspapers. So far, the reaction has been favourable.

Digital Newspaper Technology

Most newspapers now use computers for composition, and many convert the articles to a database format. It is this format which is used for digital distribution. The Guardian's text is sorted into five sections — home news, foreign news, financial news, features and sport. The sorting process also strips out the formatting and graphics characters and special indicators (eg for headlines) are inserted. At this stage, symbol characters like $\frac{2}{3}$ are converted to pronounceable words ('two-thirds') for use by voice synthesisers.

The files are sent to AirCall Teletext using packet switchstream, a data communication network.

The data is then transmitted by AirCall Teletext over the television network. This uses similar technology to other forms of teletext, with the data being transmitted alongside video information. However, the data is available only to subscribers, and is encrypted. The data is not in a suitable form for display on a television screen, but for processing by the PC. A typical issue of The Guardian is 100,000 words and takes about an hour to broadcast.

The Screen Electronics decoder card, installed in the user's PC, performs several functions. It is a tuner which demodulates the signal and decodes then encrypted data. It is connected to the TV aerial and, on receipt of a start signal, begins data capture and stores the text as separate files on the hard disk of the user's terminal.

The special software for the service has been written by the RNIB Technical Development Department. There is a screen display for sighted people, but all screen output can be directed to a voice synthesiser or Braille display. For partially sighted users, the screen displays extra large characters. The software allows the user to skim through the headlines, select an article to read, and move easily between articles. As well as the reading facility there is a comprehensive searching capability. It is possible to search the whole paper for up to ten keywords in under four minutes — far quicker than a sighted person could do it. The system is designed to be easy to use. A blind person with only limited experience of a keyboard should be able to learn to use the system in under two hours.

Braille Displays

A Braille display can be thought of as the Braille equivalent of text on a computer screen. The display

consists of plastic pins, which are raised to form a line of up to 80 Braille characters. As some Braille characters represent whole words, a line of 80 characters may contain quite a lot of information.

When the user has finished reading the line, he or she presses a refresh button. The previous line is erased, and a different arrangement of pins is raised to form the next line of characters. Cursor keys allow the user to scroll through a document or message.

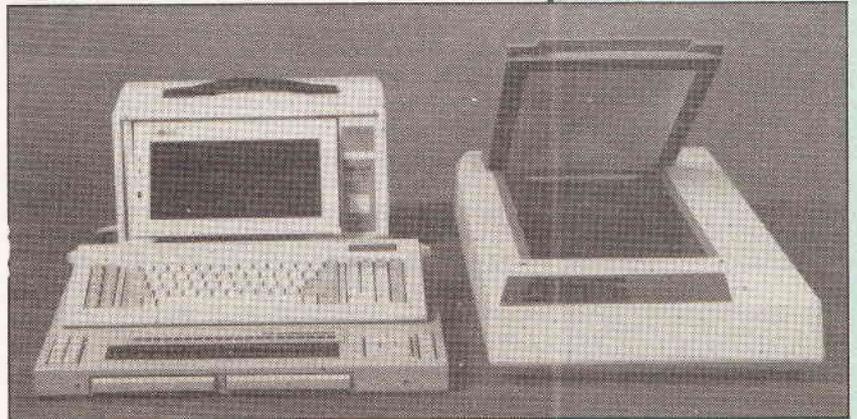
Though very high quality voice synthesisers are now available, many users may prefer a Braille display as they are fast to read, and can be used by people who are both deaf and blind. However, Braille displays are still very expensive.

Blind Leading The Sighted

Several newspapers were approached by the RNIB regarding this project, but The Guardian was the most enthusiastic and also has its information stored in files of a structure appropriate to the project. At present, The Guardian is giving this service free, and hopes to continue this free contribution if the pilot is successful.

Ian Wright, managing editor of The Guardian, gives two reasons for their involvement in the work. Firstly, they are glad 'to be able to co-operate with competent people on a project that will improve the situation of others. We're pleased it's gone as well as it has. We've been enthused by the enthusiasm of the technical department at the RNIB'

Secondly, this new technology may have further applications in the future, as a method for transmitting and distributing written information to all readers. This method has certain advantages over conventional newspaper distribution. A reader could print out only those pages which he or she wanted to read, and scanning the paper for items of interest is actually far quicker than with a conventional paper. For example a reader could request all stories covering events in Eastern Europe. This technology could be advantageous to the sighted as well as the blind. Wright describes it as 'the blind leading the sighted.'



There is considerable interest from other European countries in this project; a number of other countries are now working on similar lines. The first digital newspaper was in Sweden, using very different technology from that used in the UK system. The EEC Concerted Action on Technology and Blindness has set up a project to co-ordinate these activities, and RNIB Technical Development Department has been given the responsibility of leading this project.

Document Readers

Digital distribution may be an answer for newspapers and other widely distributed material, but blind people also need access to other types of document.



Adhoc Reading System with Braille Display.

The combination of three newly established technologies enables a personal computer to read aloud from any printed material. The printed page is first scanned and converted to a digital image. Advanced character recognition software is then used to read the page into text information. The text is then output to a high-quality voice synthesiser. The text could also be sent to a Braille display or printer.

With the voice synthesiser, such a system is useful not only to the visually handicapped, but to people with other sorts of reading difficulties, such as dyslexia.

Several organisations now supply the hardware and software for these reading systems. One supplier is Arkenstone, a non-profit organisation dedicated to providing technical solutions to charitable needs. Arkenstone aims to supply the hardware and software at significantly less than retail prices. Similar systems include the Xerox/Kurzweil PC/KPR, and the Ad Hoc Reader from Alphavision, of which about 20 to 30 systems are being used daily by blind people in employment.



Kurzweil Personal Reader with Flatbed and Hand Scanners.

The Arkenstone Reader uses the Truescan scanner recognition card from Calera Recognitions Systems. Truescan is able to read a very broad range of everyday documents (though no recognition product can read everything — yet).

The card is inserted into a PC-AT or PS/2 (or compatible), and converts the images scanned by an image scanner into text information. This information is typically transferred to the PC as a file: either in ASCII or in formats suitable for about forty PC applications, such as WordPerfect, Microsoft Word or Lotus 1-2-3.

Truescan allows the user to capture all the information on a page in one pass, regardless of the page's complexity. Early character recognition software was only really effective on single column, typed pages. However, recent recognition software provides much more than character recognition, and is often described as document recognition. This includes automatic decolumnization of complex pages, and preserving layout information like paragraph breaks, tables, columns and lists.

Early character recognition software required new fonts or typefaces to be taught to it before it can recognise them. However, the intelligent character recognition software in the Arkenstone reader teaches itself new fonts.

A document can be placed in the scanner in a landscape or portrait orientation. A blind person can often tell which way up a document should be by the

position of staple holes, etc. However, if the document is inserted upside down in the scanner, the user will soon know because there is no output. An optional extra provides a speech synthesised message to warn the user if the paper is in an unrecognisable orientation.

These document readers can be set up to meet individual needs. Within recommended configurations, the user can choose the Personal Computer, the speech synthesiser, Braille display or printer, application software and image scanner, that best meets his or her needs and budget.

The charitable organisation, Arkenstone, has a discount on the Truescan as long as it is for disabled or for similar charitable purposes. They can also sell scanners at a discount, and are customising software for the needs of the visually impaired. The organisation is extended to the UK and Europe, making use of suppliers with high standards of technical expertise who are prepared to offer technology at affordable prices.

Personal Readers

Though a PC-based reader provides a flexible approach to document reading, some users may prefer a more compact dedicated unit such as the Kurzweil Personal Reader. Like the PC readers, it scans and reads single sheets or bound documents.

Output is through a speech synthesiser: a DECtalk model is used. The Personal Reader may be used with a flatbed scanner or hand scanner. With the hand scanner, the surface is certainly easier to move around than a PC based system, though at over 20 lbs, 'luggable' seems a more appropriate description than 'portable'.

The Writing On The Wall

Will such systems ever be able to recognise handwriting? David Sullivan, of the RNIB's Employment Development and Technology Department, thinks that such an achievement is some way off.

Some work is currently going into recognising handwriting. Current software can recognise very neat, clear handwriting, provided that the letters are not joined up. It may be possible to extend this to teaching software to recognise one person's handwriting — that of a member of a blind person's family might be useful. Software to recognise a range of handwriting may be four or five years away.

However, developing new technology is only part of the story. At present, the technology described here will be beyond the pockets of most individuals, and is more likely to be used in schools, libraries and institutions. It is equally important to ensure that existing technology is applied in the right way, and can be afforded by those who need it. And that will only happen if more high-tech companies stop turning a blind eye.

Addresses:

Royal National Institute for the Blind, 224 Great Portland Street, London, W1N 6AA. Telephone: 071 388 1266.

Arkenstone, Inc, 540 Weddell Drive, Suite 1, Sunnyvale, CA 94089, USA. UK Supplier: Sensory Vision Aid, Cameron House, 12 Castlehaven Road, London NW1 8QU. Telephone: 081-485 4485.

Kurzweil products are available from: Sight and Sound Technology Ltd, Qantel House, Anglia Way, Moulton Park, Northampton, NN3 1WD. Telephone: 0604 790969.

Ad Hoc products are available from: Alpha Vision, Seymore House, Copyground Lane, High Wycombe, Bucks, HP12 3HE. Telephone 0494 30555.



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MODERN DIODE CIRCUITS

3

Ray Marston looks at zener diode circuits in this penultimate part of his mini-series.

The first two episodes of this mini-series looked at the basic characteristics of the junction diode and associated devices (zeners, varicaps, photodiodes, LEDs, and then showed a whole range of practical applications of ordinary diodes and rectifiers. This part looks at practical applications of one of the 'associated' devices mentioned above, the zener diode.

Zener Diode Circuits

If a silicon diode is increasingly reverse biased, a point is eventually reached where its reverse current suddenly starts to increase, and any further increase in V_r causes a sharp rise in I_r . The voltage at which this action occurs is known as the avalanche or 'zener' value of the device, and is very sharply defined. Zener junction diodes are specially manufactured to exploit this effect, and are of great value as 'reference voltage' generators.

to about 100V) and power ratings (typically 500mW, 1.3W, 5W, and 20W), and usually have a basic voltage tolerance within $\pm 5\%$ of their specified value. Other important parameters of a zener code is its temperature coefficient (indicating the effects of thermal variations on output voltage) and its dynamic impedance (indicating the effects of zener current variations on output voltage). Figure 3 shows the typical parameter values of 500mW zeners with standard voltages in the 2.7 to 16V range.

Figures 4-7 show some practical variations of the zener voltage reference circuit with performance details based on the parameters listed in Figure 3.

Figure 4 is a basic 10V reference circuit, using a single zener diode and powered from a 15 to 20V input. R1 is given a value of 1k5, to set the zener current at 5 mA at an average supply voltage of 17.5V. The zener has a 5% tolerance, so the actual output voltage will be between 9.5 and 10.5V. Variations on supply voltage (15-20V) cause the zener current to vary by ± 1.6 mA and, since the 10V zener has a dynamic impedance of 25R makes the zener output voltage vary by an additional ± 40 mV (the supply rejection factor). Since this zener has a temperature coefficient of $+7$ mV/ $^{\circ}$ C, the output will vary by an additional ± 140 mV when the temperature is varied by $\pm 20^{\circ}$ C about a $+20^{\circ}$ C room temperature value.

Figure 5 indicates how the above circuits thermal regulation can be improved by using two series-connected zeners with opposing temperature coefficients, to act as a 'composite' zener with a nominal value of 10.1V (giving an actual voltage in the range 9.4-10.5V) and a temperature coefficient of only 0.6 mV/ $^{\circ}$ C (a variation of only ± 12 mV over the $\pm 20^{\circ}$ C range). This 'zener' has a dynamic impedance of 127R and thus gives a supply rejection factor of ± 203 mV.

Regulation of the above circuit can be improved by fitting it with a pre-regulating zener stage (Figure 6 ZD1), this holds the R1-R2 junction within ± 265 mV of a nominal 13V value over the full span of supply-voltage variations, thus giving a final supply rejection factor of ± 53 mV and a thermal rejection factor of ± 12 mV over the full temperature range. R2's value is chosen to give a '10V zener' current of about 5mA, and R2's value will supply a current greater than this

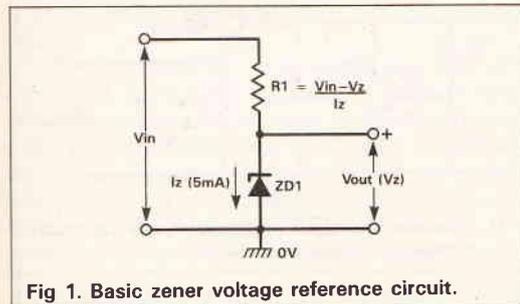


Fig 1. Basic zener voltage reference circuit.

Figure 1 shows how a zener diode can be used to generate a fixed voltage by passing a modest current through it from the supply line via limiting resistor R1. The zener output voltage is not greatly influenced by sensible variations in the zener current value (caused by variations in supply voltage or R1 value), and the output thus acts as a stable reference voltage. The R1 value is found from the formula:

$$R1 = (V_{IN} - V_z) / I_z$$

In most applications I_z should be set at about 5mA.

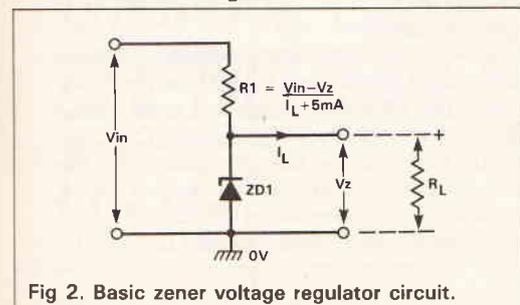


Fig 2. Basic zener voltage regulator circuit.

Figure 2 shows how the above circuit can be modified to act as a simple voltage regulator supplying output currents of a few tens of milliamps to an external load. Here, the R1 value is selected so that it passes the maximum desired output current plus 5mA. So when the specified maximum output load current is being drawn, the zener passes only 5mA. When no load current is drawn, the zener passes all the current and thus dissipates maximum power. The zener's power rating *must not* be exceeded under this 'no load' condition.

Practical zener diodes are readily available in a variety of voltage values (ranging in steps from 2.7V

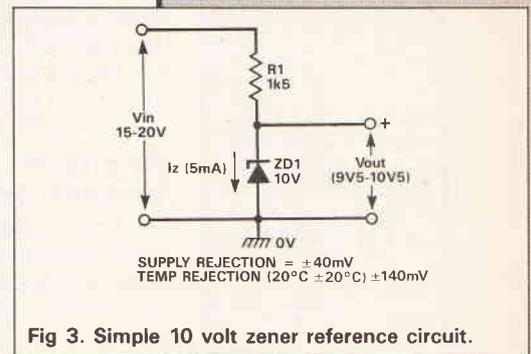


Fig 3. Simple 10 volt zener reference circuit.

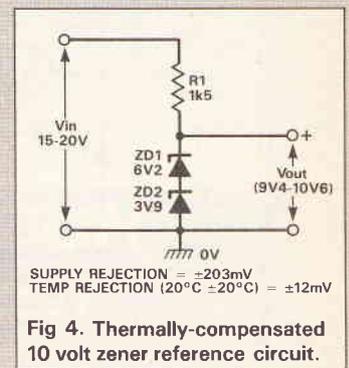


Fig 4. Thermally-compensated 10 volt zener reference circuit.

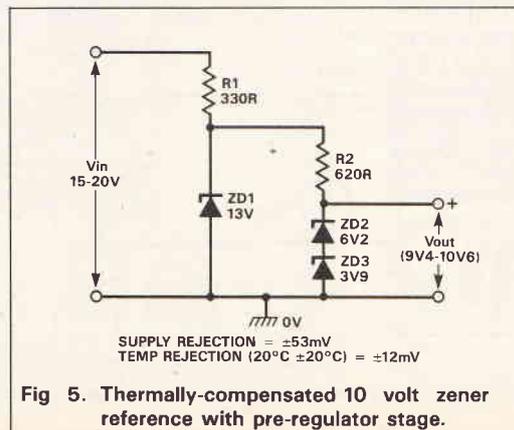


Fig 5. Thermally-compensated 10 volt zener reference with pre-regulator stage.

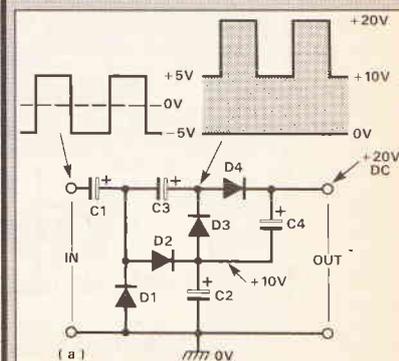


Fig 9a. Corrected from last month.

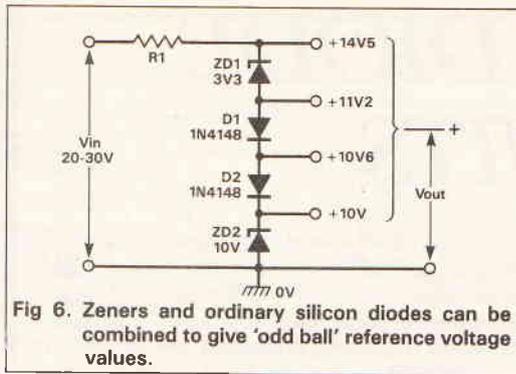


Fig 6. Zeners and ordinary silicon diodes can be combined to give 'odd ball' reference voltage values.

when V_{IN} is at 15V. ZD1 does not cut off under this condition.

Finally, Figure 7 shows how zeners and ordinary silicon diodes can be wired in series to give non standard reference voltage values. Each silicon diode drops about 600mV at a forward current of 5mA, and has a temperature coefficient of $-2mV/^{\circ}C$. The supply (V_{IN}) voltage must be much greater than the largest output reference voltage (14.5V).

Regulator Current Boosting

The simple voltage regulator circuit Figure 2 can be used to supply output load currents up to a maximum of a few tens of milliamps. Greater output currents can easily be obtained by wiring a current-

boosting emitter follower buffer or 'series pass' stage between the zener output and the load Figure 8. This simple circuit reduces the zener current loading by a factor of about 100, the current gain of Q1. The output voltage is about 600 mV less than the zener voltage (equal to Q1's base-emitter voltage drop). This latter snag can be overcome either by wiring a silicon diode in series with the zener diode to boost Q1's input voltage by 600 mV, as shown in Figure 9, or by wiring Q1 into the feedback loop of a precision op-amp voltage follower stage Figure 10.

The output load current of each of the above three circuits is limited to about 100mA by the power rating of Q1; higher currents can be obtained by replacing Q1

with a power Darlington transistor.

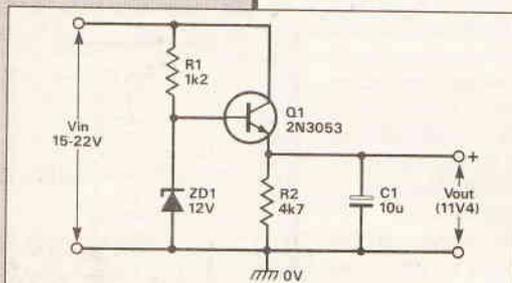


Fig 7. Zener voltage regulator with current-boosting series-pass output stage; nominal output voltage is 11.4 volts.

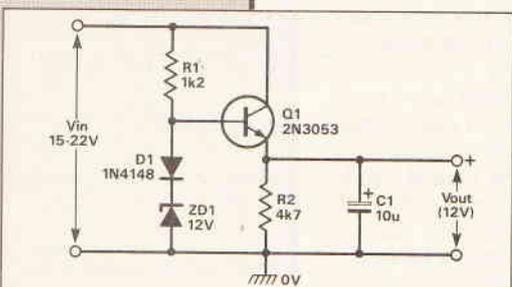


Fig 8. This modified series-pass circuit gives an output of 12 volts.

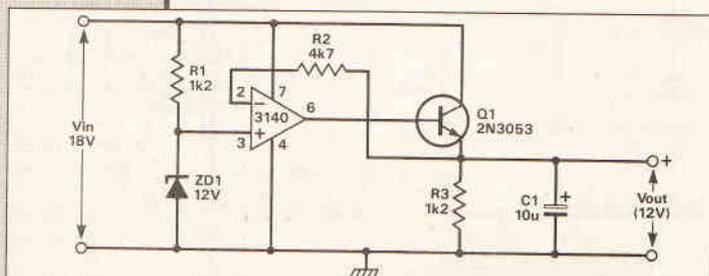


Fig 9. 12 volt regulator incorporating an op-amp in its series-pass network.

Variable Voltage Circuits

Figures 11-13 highlight various ways of generating zener-derived variable reference or regulator voltages. In Figure 11, Q1 is wired as a modified common emitter amplifier, and gives an output of (take in sum) times Q1's base-to-ground voltage, which equals the sum of Q1's base-emitter junction voltage (600 mV) and the ZD1 voltage (6.2V), making 6.8V in total. The output of this circuit is variable from 6.8 to 13.6V via RV1. Q1's base-emitter junction has a $-2mV/^{\circ}C$ temperature coefficient

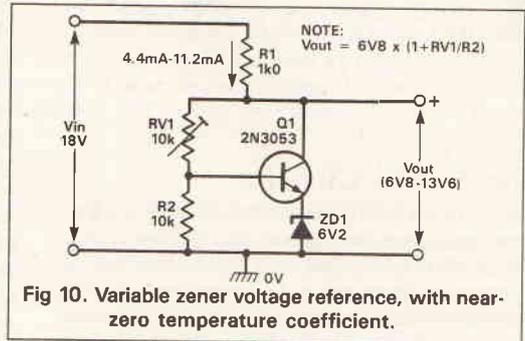


Fig 10. Variable zener voltage reference, with near-zero temperature coefficient.

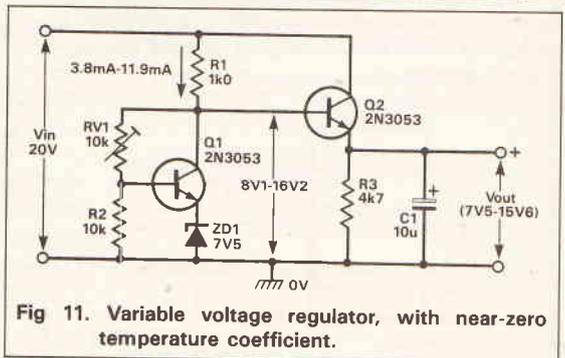


Fig 11. Variable voltage regulator, with near-zero temperature coefficient.

and ZD1, a $+2mV/^{\circ}C$ one, and so they cancel each other to give a final near-zero temperature coefficient at the circuit's output.

Figure 12 shows how the above circuit can be modified for use as a variable voltage regulator to give a current-boosted output via a series-pass transistor Q2. In this case, ZD1 is a 7.5 volt type and has a temperature coefficient of $+3.7mV/^{\circ}C$, giving an 8.1 to 16.2 voltage with a $+1.7mV/^{\circ}C$ coefficient to the base input of Q2. This gives an output that is 600 mV and $-2mV/^{\circ}C$ less than this, thus giving a final output of 7.5 to 15.6V with a near-zero temperature coefficient.

Figure 13 is a simple way of generating a stable 0 to 12V output via RV1 and the Q1 current-booster stage. Note that D1 boosts the effective zener voltage by 600mV, to counter the 600mV loss of Q1's base-emitter junction. The final output impedance of this circuit is fairly high (typically a few tens of ohms) being roughly equal to the output impedance of RV1 slider divided by the current gain of Q1.

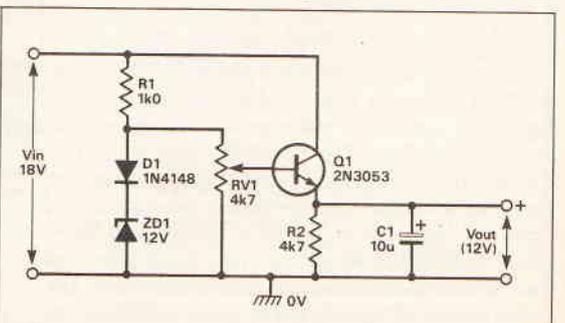


Fig 12. Wide-range (0-12V) voltage reference/regulator circuit.

Miscellaneous Zener Circuits

To complete this look at the zener diode, Figures 14 to 18 show a miscellaneous collection of useful application circuits.

Figure 14 demonstrates how a 6.8 volt zener can be used as a voltage dropper to enable a 1000µ 6V electrolytic capacitor to be used with a 12V DC supply. The zener must have a large enough power ($V \times I$) rating to handle C1's ripple currents; a 5W rating is adequate for most purposes.

A 5.6V zener can be used as a voltage dropper to enable a 6V relay to be used with a 12V DC supply (Figure 15). This circuit also help improve the relay's effective on/off ratio. Suppose the basic relay normally turns on at 5V and off at 2.5V, giving a 2:1 on/off ratio; This circuit will turn on at 10.6V and off at 8.1V, giving a 1:3:1 on/off ratio.

Figure 16 shows how a resistor and zener diode can be used as a half-wave limiter in an AC circuit. The positive halves of the waveform limit at ZD1's rated voltage value, and the negative halves, its 600 mV 'junction diode' value.

Figure 17 indicates how a resistor and two inversely series-connected zener diodes can be used as a full-wave limiter in an AC circuit. In this case, the positive halves of the waveform are limited by the sum of ZD1's voltage value and ZD2's 600 mV 'diode' value, and the negative halves by the sum of ZD2's voltage value and ZD1's 600 mV 'diode' value.

Finally, Figure 18 demonstrates how a zener, a multiplier resistor (R1) and a 1mA FSD moving coil meter can be used to made a suppressed-zero meter, that spans the range 10-15 volts. The zener sets the minimum voltage reading of the meter (10V), and R1 is given a value of 1000R/V to set its span of 5V and thus its FSD value of 15V.

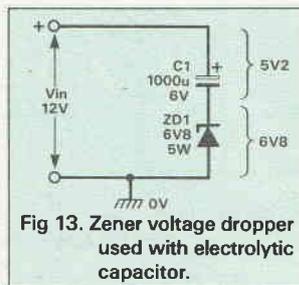


Fig 13. Zener voltage dropper used with electrolytic capacitor.

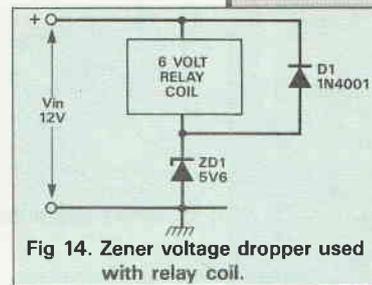


Fig 14. Zener voltage dropper used with relay coil.

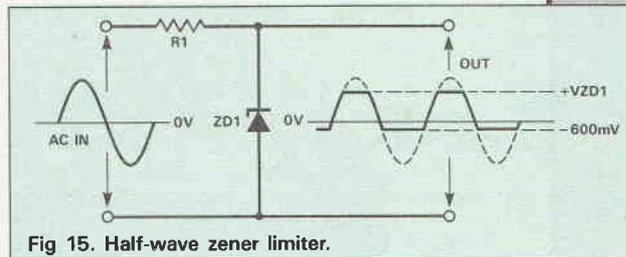


Fig 15. Half-wave zener limiter.

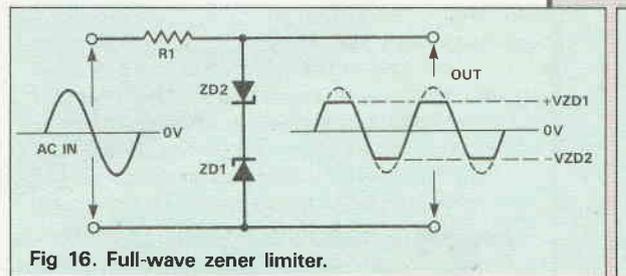


Fig 16. Full-wave zener limiter.

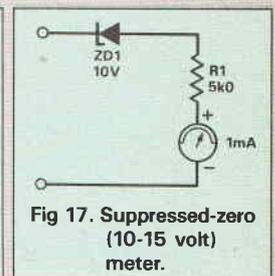


Fig 17. Suppressed-zero (10-15 volt) meter.

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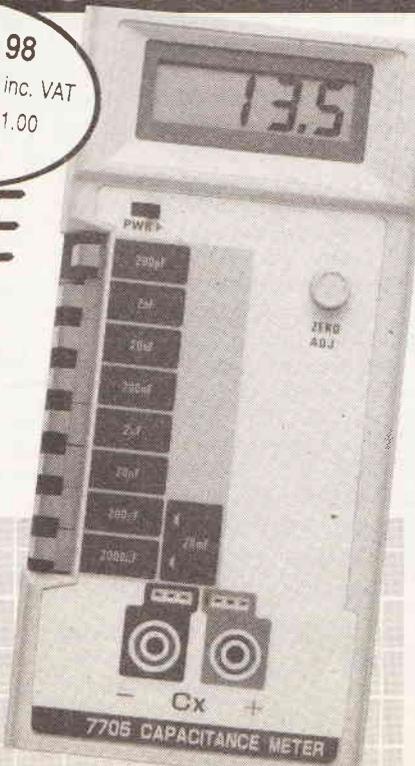
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Specification

ranges	res.	accuracy
200pF	0.1pF	+ (0.5% + 1 digit + 0.5pF)
2nF	1.0pF	+ (0.5% + 1 digit)
20nF	10pF	+ (0.5% + 1 digit)
200nF	100pF	+ (0.5% + 1 digit)
2µF	1.0nF	+ (0.5% + 1 digit)
20µF	10nF	+ (0.5% + 1 digit)
200µF	100nF	+ (0.5% + 1 digit)
2000µF	1µF	± (1.0% + 1 digit)
20,000µF	10µF	+ (2.0% + 1 digit)

Overload protection	0.25A 250V fuse
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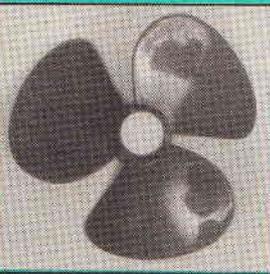
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TEMPERATURE CONTROLLER



Geoffrey Heys builds this project for keeping you cool when it's hot, and warm when it's cold!

PROJECT

This versatile temperature controller unit was originally designed to control inductive loads, such as mains operated fans or heaters over a temperature range of 0 — 40° Centigrade. It can be used to switch either inductive loads of 5A at 240V AC or non-inductive loads of 13A at 240V AC. These include fans, heating elements and lamps used for heating purposes. With modifications, the unit can also be used to control lower voltage devices.

The temperature sensors are thermistors which are arranged in a bridge circuit. The bridge is balanced by a 10-turn potentiometer attached to a 10-turn dial. The potentiometer arrangement is accurate and easy to use. You could substitute the potentiometer for a standard type of the same resistance if lower accuracy temperature setting would be acceptable.

The controlled device can be switched either on or off at a pre-set temperature, for example, heating devices switched off or cooling devices switched on. This depends on which arm of the bridge the thermistor is positioned. Devices can also be turned on or off by a difference in temperature existing between two thermistors. In this case, a difference in temperature between them can be detected over a very wide range of temperatures, far wider than the temperature range possible using a single thermistor.

Terminals are provided on the front panel which connect across the relay coil. 12V appears across these terminals when the relay is actuated, and this voltage could be used for event recording if the instrument is being used in conjunction with a chart recorder or data logger. An LED is also turned on when the relay actuates.

The bridge can be unbalanced and the relay actuated by switch SW1 without altering the setting of the bridge balance control. You can turn off the controlled device without switching the unit off, by using a switch on the 13A output socket.

If the device you want to control is not mains operated, the unit may be modified by using a smaller

relay and suitable output connection. Some alteration to the relay wiring will also be necessary. If a different relay is used, make sure that it operates on 12V DC and that it has contacts of a sufficient rating to control the load used.

Capacitors C2 and C3 are included to dampen arcing across the relay contacts. (This can be particularly troublesome when inductive loads are being switched on and off and can lead to erosion of the contacts.)

A multi-purpose switch on the front panel allows you to vary the hold-on period of the relay after actuation or hold-off after turning off. Hold-on time is shortest when the switch is in the open circuit position.

Resistances R2 and R3 are included to reduce the current in the thermistors and so minimise self-heating effects.

Construction

The PCB is simple and should present little problem to constructors. The points to be careful about are wiring the bridge balance potentiometer and relay correctly.

The unit was made in a plastic case with a sloping aluminium front panel. This panel takes all the components mounted on the outside of the case and must be large enough to accommodate a 13A socket. Earth the front panel using a tag soldered to mains earth. Position the PCB at the back of the case. The wire connecting the relay contacts and the 13A socket should be capable of carrying 13A at 240V AC. Again, 13A cable should be used for a mains connection. Lead this through the case with a grommet or cable gland.

Cut the thermistor leads to about 5mm and

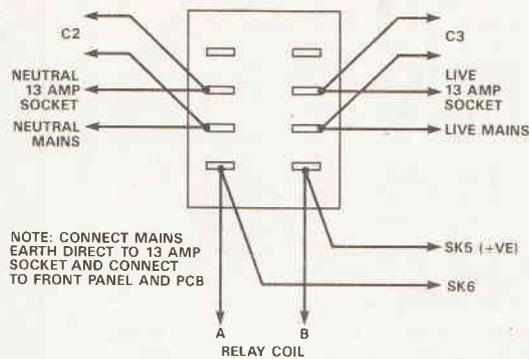


Fig. 3 Connections To Relay

temperatures between which the unit operates also depends on the value of the resistance substituted for a thermistor in the bridge, a lower value resulting in lower temperature operation. To calibrate the unit, use heated water placed in a vacuum flask and determine its temperature with an accurate mercury-in-glass thermometer. Immerse the thermistor in the water and rotate the dial to find the position where the relay actuates. Do this for about six different temperatures and draw a graph of dial-setting against temperature. The unit should be able to control temperature to within about half a degree Centigrade.

If two thermistors are used in the bridge, the unit will operate as a result of a difference in temperature between the thermistors for a wide range of ambient temperatures, the bridge having been balanced with the two thermistors at the same temperature. The unit will turn the relay on or off depending on the initial setting of the bridge balance control and the thermistor which is heated. For example, if both thermistors at the same temperature and the bridge is balanced so that the relay is just turned off, heating the thermistor in arm B-B will turn the relay on. If the bridge is balanced so that the relay is just turned on, heating the thermistor in arm A-A will turn the relay off.

HOW IT WORKS

The circuit consists of a bridge containing thermistors as temperature sensing elements. The bridge is fed into an operational amplifier which has positive feedback applied. With positive feedback or with the feedback loop in open circuit, the amplifier is very sensitive to changes of voltage polarity at its input. A slight change in input polarity will cause the output voltage to swing from full output of one polarity to full output of the other. The circuit has been arranged so that a negative voltage at the amplifier input will cause a power transistor to conduct as a result of a positive voltage appearing at its base, thus actuating a relay.

If a thermistor is placed in the bridge arm B-B in the circuit diagram, a rise in temperature will lower its resistance and present a negative voltage at the input of the operational amplifier. This means the relay is actuated as a result of a rise in temperature. However, if a thermistor is placed in arm A-A, a rise in temperature will present a positive voltage at the input of the amplifier and the relay will turn off. The temperature at which these events occur depends on the setting of the bridge balance control, which is a ten-turn potentiometer, fitted with a dial so that the required temperature for relay actuation can be pre-set. For example, for heating thermistors in arm A-A, lower dial settings represent lower temperatures.

The feedback loop contains various selectable resistance values giving some control of the hysteresis shown by the circuit. This has the effect of varying the hold-on period of the relay after actuation or hold-off after turning off. Relay chatter is prevented by placing a high value capacitor across the coil.

BUYLINES

All the components used in this project are available from RS Components. Tel: 0536 201234, or their mail-order business, Electromail. Tel: 0536 204555.

The RS stock numbers for some of the components are: Case, 509-276; Mains transformer, 196-303; Relay, 348-447; Thermistor, 151-029; Capacitors C2, C3, 114-519.

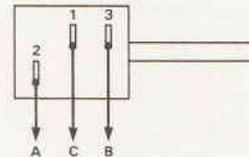


Fig. 4 Connections To Potentiometer

Cooling the opposite thermistors will produce the same effect.

Figure 2 is shown at 90% of actual size and is a guide for positioning components only.

PARTS LIST

RESISTORS (all 1/4W unless otherwise stated)

R1	1k8 metal oxide
R2,3	12k 1% metal oxide
R4	1M0
R4	1M0
R5	470k
R6	330k
R7	180k
R8	100k
R9	1k 1W
R10	2k2 1W
TH1, 2	RS Components Type GL23
RV1	20k 10-turn potentiometer, linear

CAPACITORS

C1	1000µ 25V DC WKG, axial electrolytic
C2, 3	10n 250V AC WKG
C4, 5	4700µ 25V DC WKG, axial electrolytic

SEMICONDUCTORS

IC1	741
Q	TIP31A
D1,2,3	IN4001
LED1,2	red LED

MISCELLANEOUS

T1	12V-0-12V secondary, 6VA
RLA	12V coil, see text
SK1,2,3,4,5,6	4mm sockets
SK7	13A mains socket
SW1	miniature single pole, single throw switch
SW2	6-position rotary switch
SW3	single pole, double throw switch, suitable for 240V AC
FS1	0.5A Slow blow, 20mm fuse

PCB case, 10 turn dial knob for SW2, mounts for LEDs, heat sink for Q1, 13A cable and 13A plug, rubber grommet, 20mm fuseholder, rubber feet, earthing tag, wire, 4BA screws and nuts, socket for IC1

CONSTANT CURRENT CIRCUITS

Constant current circuits (as their name implies) provide a direct and constant current that is not related to the impedance or resistance of their load, though in reality, the current will vary slightly within the limits of the circuit used.

This article looks at various circuit topologies and their applications. It should be noted here that for some low current applications constant current diodes are available. They are selected JFETs with their gate and source connected. The circuit symbols for a constant current source or sink are given in Figure 1.

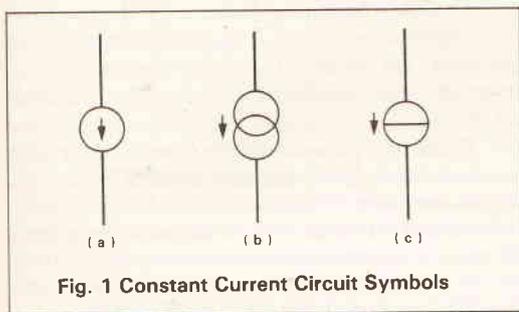


Fig. 1 Constant Current Circuit Symbols

Why Use Constant Current Circuits?

We can derive a linear response from some circuit elements only by keeping the current constant rather than the voltage, and an easily predictable linear response is often what we require.

For example, we require all the LEDs in a block to be of equal brightness. For the same brightness the forward voltage drop of one LED varies considerably from another due to internal resistance. However the current required by definition is almost equal for all the LEDs.

When charging batteries such as NiCads, we require a constant current because the low internal resistance of the batteries. A constant voltage would cause destructive initial current to flow.

For timing and comparator applications, for example generating an output pulse width proportional to an input voltage, any capacitor used must be supplied with constant current to generate a linear voltage across it.

Shunt regulators may be needed to sink current in situations where the output is off load, and the voltage has risen above a certain limit. This does not give as good voltage regulation as a normal voltage regulator but is more efficient as power dissipation decreases with an increase in loading of the supply.

Now we've discussed some areas where we need a constant current circuit, let's have a look at the circuits themselves.

Circuit Topologies

The first and simplest circuit is shown in Figure 2(a). This uses an n-channel JFET with its gate and source linked. With the voltage between gate and source V_{GS} at zero and the voltage between gate and source V_{DS} at a few volts or greater, the drain current is reasonably constant. The saturation drain current I_{DSS} spread is quite wide, so it is not possible to predict an accurate

current value. This circuit is also subject to considerable temperature drift (as is the improved version shown in Figure 2b).

As an example, let's look at the JFET 2N3437. For this device, I_{DSS} varies from 0.8 to 4.0 mA when V_{DS} is 20V and V_{GS} is zero. The output characteristic curve shows that the typical I_D varies from 1.4 mA when V_{DS} is 2V to 1.6mA when V_{DS} is 14V.

The addition of this circuit of a resistor between the source and gate (at 0V), enables the current to be adjusted, especially if a potentiometer is used. The resistor provides feedback, which increases the output

David Nightingale explains constant current sinks and sources, and suggests some circuit ideas.

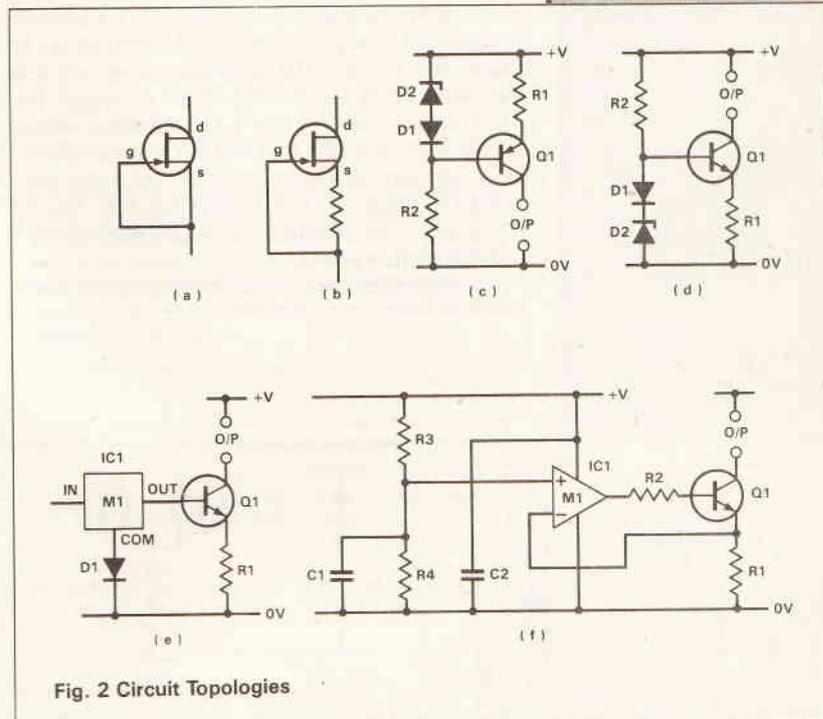


Fig. 2 Circuit Topologies

impedance making it a better current source. The I_D against V_{DS} curves also tend to flatten out as V_{GS} becomes more negative.

More advanced circuits are shown in Figure 2(c) and Figure 2(d). This is a much more accurate and predictable circuit. To a large extent it is independent of the transistor characteristics and can be used for much higher currents. The diode (D1) connected to the base of the transistor, compensates for the V_{BE} temperature drift of Q1. The voltage across R1 is therefore determined by the voltage of the zener diode (D2). The bias current for D2 is set by voltage drop across resistor R2. The two main causes of variation in this circuit are supply voltage changes and the bias current and thermal characteristics of the zener diode. The transistor chosen should have a large h_{FE} , so that the base current will be negligible compared to the zener diode bias current.

For example, suppose we require a constant current supply of approximately 30mA to operate on a 15V supply. The circuit can be based on a transistor of the type BC182, which has a minimum h_{FE} of 200, and for which I_b is 15 μ A when I_c is 30mA. D1 should be a 1N4148 which has a forward bias characteristic similar to that of Q1's V_{BE} , and D2 should

be a 3.1V zener diode.

To choose R1:

$$3.1V/0.03A = 100R.$$

To choose R2, where 5mA is a typical D2 bias current:

$$15V - (0.6V + 3.1V) = 11.3V$$

$$11.3V/5mA = 2k2.$$

In fact this circuit will give 31mA and checks should be made to ensure that with component variations the current will be within acceptable limits.

Figure 2(e) shows a transistor circuit with its reference derived from a voltage regulator, which is used as an accurate voltage source that is largely independent of temperature and supply rail variations. D1 is added to compensate for V_{BE} variations of Q1. Thus the current is determined by M1 and $V_{out}/R1$.

Figure 2(f) shows a circuit using an op-amp. It is configured as a voltage follower with Q1 and R2 inside the feedback loop. This automatically compensates for the characteristic variations of Q1. R2 is inserted as a current limiting resistor which also prevents oscillations due to parasitic capacitance in the circuit. The voltage across R1 is maintained by the op-amp to that of the reference voltage, which in this case is derived from the potential divider R3, R4. The circuit shown assumes a well regulated voltage supply. If this is not the case then R4 may be replaced by a bandgap diode, or alternatively a precision voltage-reference IC may replace R3, R4. R3, R4 could also be replaced by a potentiometer if adjustment is required.

Capacitors C1 and C2 are for decoupling. Some example values are listed here:

R1 1R0

R2 100R

R3 5k1

R4 5k1

C1 100n

C2 100n

Q1 TIP 121

M1 LF358 (dual op-amp, single supply rail operation)

V+ 5V

With these values, the constant sink current would be 2.5A.

Circuit Applications

Figure 3 shows some of the many uses for constant current circuits.

Figure 3(a) shows a constant current circuit as an electronic load, for example, as a constant current variable load for use in test equipment. The circuit shown in Figure 2(f) is suitable for this application and if we derive V+ from the collector of Q1, then we have a constant resistance load. If the power supply voltage increases, the op-amp V_{ref} also increases in direct proportion and therefore so does the current through Q1, R1.

Figure 3(b) shows how a constant current is used as a linear ramp generator. The circuit of Figure 2(c) can be used here. A capacitor is placed between Q1 collector and 0V, which may be discharged by a transistor also connected across these two points. Since $Q = It$, we can see that the capacitor must charge linearly with time (T) if current (I) is constant.

Figure 3(c) shows an LED current sink, which ensures constant brightness even with supply voltage variations. We can use the circuit of Figure 2(e) here. D1 may be omitted as M1 could be a 5V regulator for some logic circuit, and the LEDs may be powered from some higher voltage unregulated supply.

Figure 3(a) shows the tail in a long tailed pair differential amplifier. This application can use the circuit of Figure 2(b) to replace the emitters' resistor and to increase the effective resistance, taking the common mode gain much closer to zero.

Figure 3(e) shows a voltage controlled pulse generator where the circuit of Figure 2(c) is used to charge C1. When the voltage across C1 reaches that of the input voltage (V_{in}), the comparator output goes low. C1 is discharged by a short pulse on Q2. Thus the output pulse width is proportional to the input voltage level, within the limits of the peak-to-peak ramp voltage. (We have here the basis of a pulse width modulator.) The narrow pulses may be easily generated, for example using a NE555 timer IC as the oscillator.

Figure 3(f) shows a battery charger which again uses the circuit of Figure 2(c) as the constant current source. The mains AC voltage is stepped down by TR1, rectified by four diodes arranged as a bridge rectifier, and smoothed by C1. The D1 voltage appears across R2, setting the charge current to 14.1mA. D2 compensates for the V_{BE} of Q1, and R1 sets the bias current for D1. The charge current chosen should be within the safe continuous charge rating of the battery, and the battery manufacturers' recommended charge time should be observed. Care should also be taken to ensure that the voltage across Q1 collector-emitter does not, with the charge current, cause excessive power dissipation in Q1. TR1 should not be a miniature type as these tend to run hotter than normal types. In general, as the unit may be left running unattended for some time, the cooler it runs, the greater the reliability and safety. Remember that mains power is dangerous.

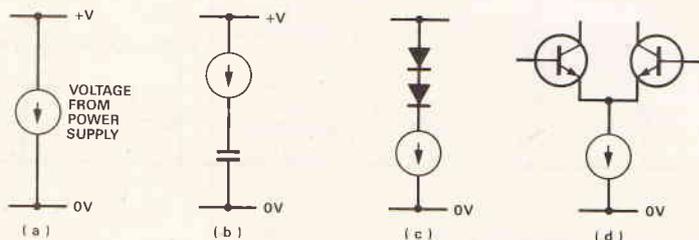


Fig. 3(a) Electronic Load Fig. 3(b) Ramp Generator Fig. 3(c) LED Current Sink
Fig. 3(d) Differential Amplifier Current Sink

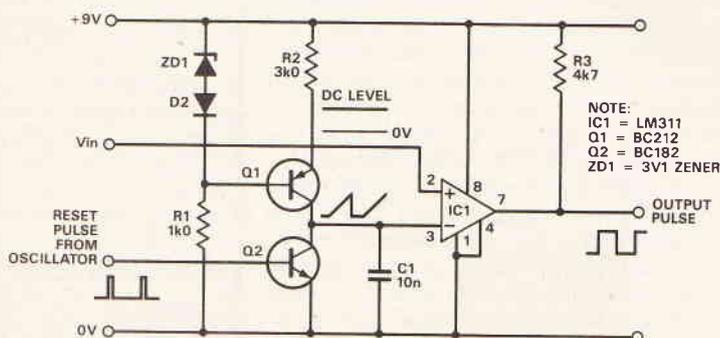


Fig. 3(e) D1, D2, R1, R2 & Q1 form a constant current circuit. C1 is reset (shorted out) by Q2 when a narrow oscillator pulse is applied to its base. C1 charges linearly due to the constant current. When C1 voltage rises above the V_{in} the output of the comparator goes low. C1 and R2 values will depend on the reset frequency.

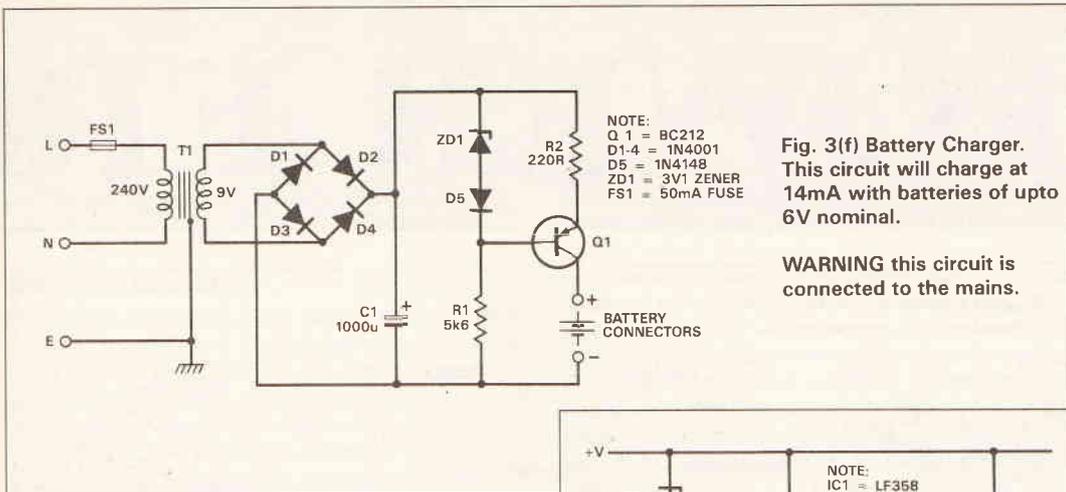


Fig. 3(f) Battery Charger.
 This circuit will charge at 14mA with batteries of upto 6V nominal.

WARNING this circuit is connected to the mains.

Figure 3(g) shows a shunt load. If the supply voltage exceeds the zener voltage, the difference voltage appears across R1, determining the shunt current. Here a current is sunk in proportion to the difference between +V and the voltage of ZD1. This is useful where a voltage rail would rise to excessive limits when off load, but where a continuous resistive load would exceed the full-load current supply available or where the excessive power dissipation is to be avoided.

Now that this article has whetted your appetite for current sinks and sources, perhaps you will use them in your own circuits!

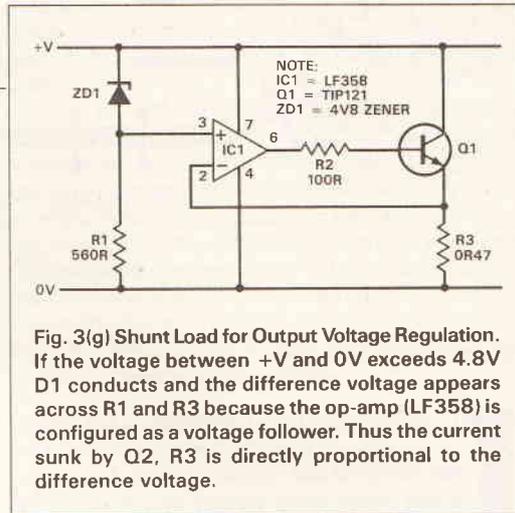
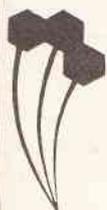


Fig. 3(g) Shunt Load for Output Voltage Regulation.
 If the voltage between +V and 0V exceeds 4.8V D1 conducts and the difference voltage appears across R1 and R3 because the op-amp (LF358) is configured as a voltage follower. Thus the current sunk by Q2, R3 is directly proportional to the difference voltage.



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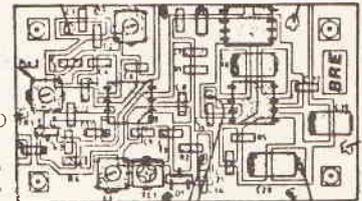
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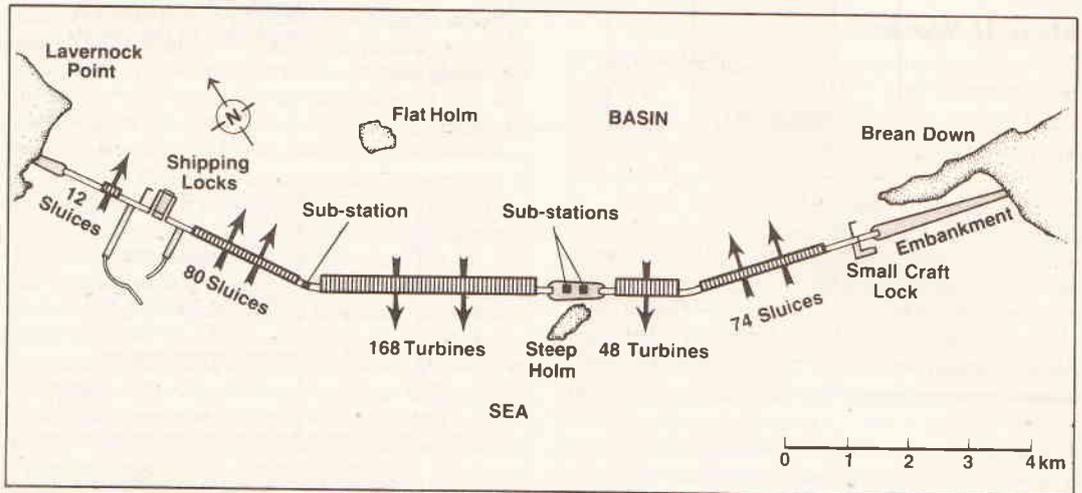


Fig. 1 Plan view of barrage.

Paul Freeman looks at tidal and wave electricity generation, and explains why these projects are all at sea.

If you have ever been impressed by the power of sea waves along the coastline in winter or wondered at the movement of a huge sea-going vessel being pushed up and down by water, then it might seem equally surprising that this energy has never been harnessed and converted into electric power. It might seem a shrewd move in the light of today's energy and environment conscious world, for this untapped power appears to have no direct pollution effects when used to generate electricity. No carbon dioxide, sulphur dioxide, carbon monoxide nor any dust and dirt comes from the dynamics of water. What is not so clearly understood though, is what change a large-scale tidal barrage would have on the local environment, or indeed on the ecosystem as a whole. It is even more difficult to predict any change in the ecosystem from taking energy from waves.

Many ideas have been put forward over the years for taking energy from the motion of water. The most conventional has been from the action of water flowing downhill under gravity. The greater the distance the water has to fall, the greater potential for changing its power into another form. Hydro-electric schemes have been constructed around the world using this simple idea. The water is allowed to flow through simple or multi-bladed propellers giving shaft rotation to electrical generators.

More recently, thoughts have been turned to the bulk movement of water around the world by tidal motion and to harnessing the power of the waves.

Tidal Power (The Severn Barrage)

The commercial prospect of damming the tidal shift of water for electrical power generation has also been around for some time. Several areas around Britain have been suggested (Figure 2) but there are two areas of particular interest that could support such a project. These are on the estuaries of the rivers Severn and Mersey.

The River Severn is well known to the locals for its large changes in water level between low and high

tide. Studies have shown that the optimum position for a barrage to be built would be from Cardiff to Weston-Super-Mare (Figure 3) where tidal changes can cause a shift in water level of up to 11m. The near twice daily cycle would produce a maximum period of generation between ebb and flood tides.

Tidal cycles are determined by the rotation of the earth and the moon's orbit around the earth and are not synchronised to the 24 hour day. The shift in generated output means that power is available at different times each day. This contrasts to our everyday lifestyle where we habitually use electricity at the same times of the day.

The mismatch of supply and demand can be ironed out by using other forms of generated power such as conventional coal/oil-fired or even wind power stations.

The Severn Barrage Development Project, set up by the government, the Central Electricity Generating Board and Severn Tidal Power Group (a consortium of several big companies) spent £4 million over 2 years from 1987 to investigate several aspects of this important civil engineering exercise. They looked at how much the whole project would cost to operate and build, reassessed it economically, explored the environmental effects and reported on further work which must be done before they can recommend whether to go ahead with the project.

The findings estimate the total construction time to be seven years with a further two years to completion and full electrical output. Another five years has been allowed before construction for financing and organising the whole project.

Table 1 shows some of the proposed data for the project. The total potential electrical output per year is equivalent to 7% of present electricity consumption in England and Wales. This would save 8 million tonnes of coal every year if the electricity was generated from a coal-fired station and a corresponding amount of carbon dioxide liberated to the atmosphere would also be saved. The calculated cost of electricity to the consumer would be comparable to or below today's prices. This could be from 1.7 pence per kWh to 7.2 pence per kWh.

FROM THE SEA

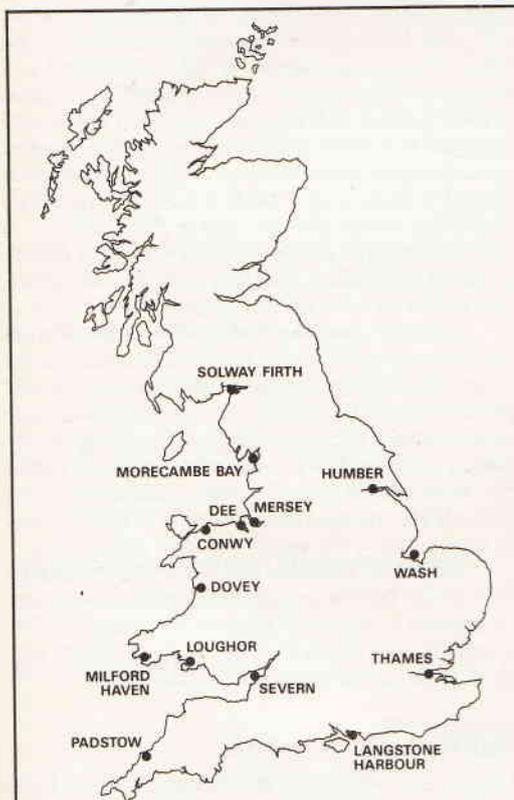
How It Works

The outline operation of the Severn Barrage can be followed from Figure 1. Major shipping and small craft pass through locks seen on either side. Generation of electricity depends upon the number and size of turbines used. The turbines need to be located in deep water and so are situated in mid stream. Studies have shown that a 9m diameter propeller is practically possible for the River Severn to maximise the energy extracted from the waterflow. The turbines are axial flow types and are similar in shape to a ship's propeller. The generator is cased in a water-tight steel shell (Figure 9). The generators would start up about 3 1/2

hours after high tide by lifting a control gate and would continue running for a period of about five hours (Figure 4) with the water flowing out to sea.

The design allows the generators to be used as pumps at times when it could be advantageous to pump water from the sea into the basin when flow is small. This occurs around high tide. Generated output would go via transformers to substations on the barrage.

By its very nature, a barrage cannot supply a steady output. The two tides a day give two peaks with a maximum output of 8000MW. This is typically the output of four large power stations. During the ebbing process when water is discharged through the barrage, the head of water continually changes and if not compensated, the flow rate would change through the turbines and alter the electrical output. In order to overcome this and maintain a constant frequency of output, the water flow is controlled by guide vanes and/or adjustable runner blades.



	Mean tidal m	Barrage length m	Installed capacity MW	Annual energy output GWh	Approx cost of energy p/kWh
Mersey (line 1a)	6.5	1750	620	1320	3.6
Severn - Inner line	7.0	16000	8000	17000	3.7
Conwy	5.2	225	30	57	4.0
Loughor	3.6	220	9	17	4.3
Morecambe Bay	6.3	16000	3040	5400	4.6
Solway Firth	5.5	30000	5580	10050	4.9
Dee	5.95	9500	800	1250	6.4
Humber	4.1	8300	1200	2010	7.0
Wash	4.45	19000	2760	4690	7.2
Thames	4.2	9000	1120	1370	8.3
Langstone Harbour	3.13	550	24	53	5.3
Padstow	4.75	550	28	55	4.2

Fig. 2 Locations of potential barrage schemes.

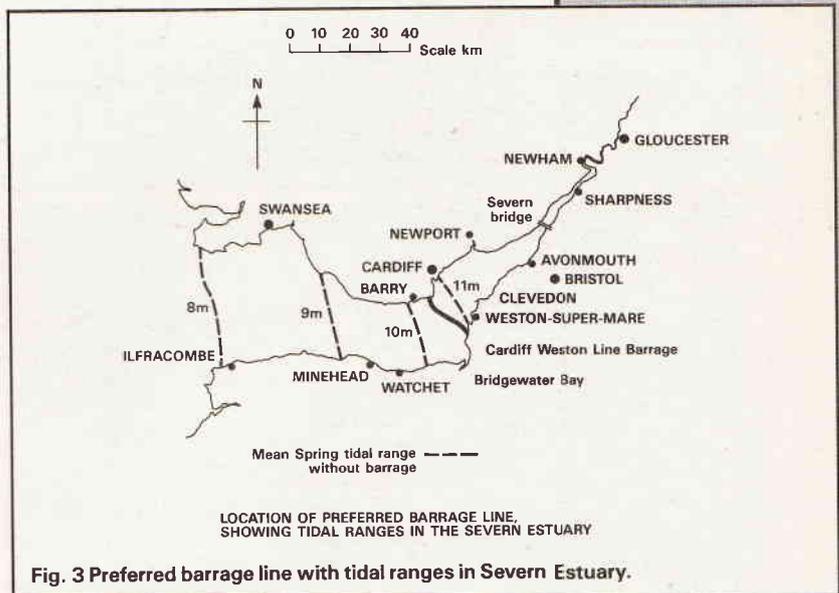


Fig. 3 Preferred barrage line with tidal ranges in Severn Estuary.

Environmental concerns

The project could stand or fall on the environmental issues that are still to be resolved. Present research has shown that mean water levels will rise if the project goes ahead. Levels will be higher than existing low tide values and slightly lower at high tide points upstream from the barrage. According to the development project, currents in the estuary would change to half those at present landward of the barrage and there would also be a slight reduction on the seaward side.

Sediment is controlled in the basin by natural water currents and so any change in the current would mean a change in the movement of sediment and sediment suspension. The report indicates that more sediment would settle giving clearer water and more light penetrator making it more biologically productive. The salinity of the estuary and the concentration of pollutant is not expected to alter.

Many questions still remain unanswered though

about where the sediment will end up and what effect a higher mean level will have on the ecology of the estuary. Further studies are required to give a more accurate picture.

Inevitably, even if the majority of factors favour such an enormous capital project, it remains to be seen whether it is actually built using government funding, private investment or both. If the government funding hoped for by the Severn Tidal Power Group is not forthcoming, then private contractors will surely go to a smaller cheaper alternative, an obvious candidate being the River Mersey Barrage Project.

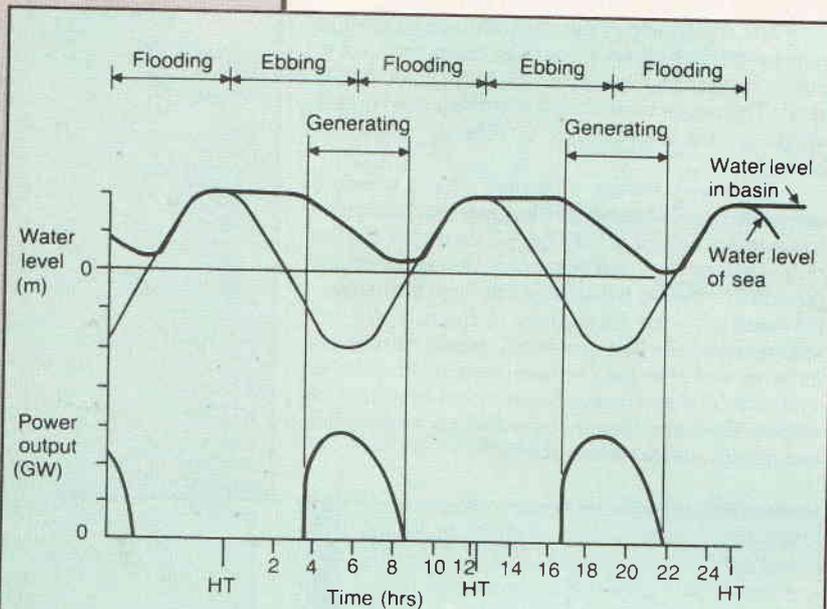


Fig. 4 Water levels and electrical output over the tidal cycle.

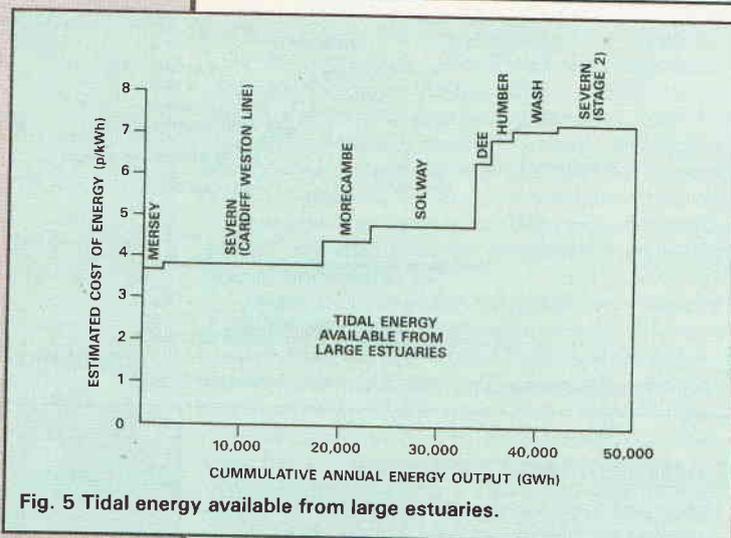


Fig. 5 Tidal energy available from large estuaries.

Wavepower

Interest in using the waves for creating electricity has been up and down, very like the waves themselves. In 1982 the government abandoned investment in wavepower because it appeared that the technology for such schemes developed at that time was not and, as it appeared, never would be, cost effective. The chances of achieving a cost below 8p/kWh was not good, the government maintained. But since then other research programmes, including a small shoreline project in Norway, have shown that targets of 4p/kWh might be achievable. Renewed government interest in 1988 has resulted in a new study of wave power, the findings of which will be published next year.

Wave energy machines for turning moving water into electricity have been tested over several years. The 'duck' was an invention by Professor Stephen Salter of Edinburgh University. A series of eccentric shaped floats bob up and down in the water. The 'ducks' are attached to a rotatable shaft via a ratchet mechanism. A long enough chain of floats would provide continuous motion to a gearbox and generator. Another idea is to have rotating cylinders held underwater and driven by underwater wave currents.

A Norwegian idea, later developed by others, is the tapered channel. This is sited on the shoreline. It is a slope that progressively narrows towards the top. Waves from the shore rise up the channel and increase in speed owing to the taper. The water pours into a reservoir at the top, and then returned to the sea via a turbine (Figure 6). Rising tapered channels occur naturally within coastal rocks and cliffs and could possibly incorporate an electrical generating system.

Another concept called the Oscillating Water Column (OWC) allows rising water from wave motion to rise up a tall column through a hole in the bottom. The water acts like a piston in a tube increasing the pressure of air. The air flows through a turbine generating electricity. The downward movement of the water reduces the pressure at the seaward end and draws the air back again to turn the turbine once again. A Wells turbine, as it is known, has been specifically designed by a team at Queens University Belfast to rotate the same way whichever way the air flows. The Shoreline Rock Gully System is a combination of an Oscillating Water Column and a Wells turbine. A 180kW prototype is being built on the island of Islay in the Inner Hebrides. This type of small-scale generator would be used for small island communities.

Further investigations on small-scale projects are to continue into the 90s for further evaluation, but for major tidal projects like the Severn barrage the next years are crucial. Emotions can run high over large scale changes to the environment, sometimes for irrational reason. Environmentally concerned visitors may prevent such plans if holiday or leisure stamping grounds are changed even where local opinion may be favourable to the wealth creation it may bring.

The project is feasible within the scope of existing technology, but the prospect of current government investment in large tidal projects looks remote. The stakes may be just too high for private groups to take the plunge into otherwise unknown waters.

Acknowledgements

Thanks to the Energy Technology Support Unit, Harwell Laboratory, Oxford for the provision of illustrations used in this article.

Table 1

Number of turbine generators	216
Diameter of turbines	9.0m
Operating speed of turbines	50rpm
Turbine generator rating	40MW
Installed capacity	8640MW
Number of sluices, various sizes	166
Total clear area of sluice passages	35000m ²
Average annual output (10 ⁹ kWh=1TWh)	177TWh
Operational mode	Ebb generation with flood pumping
Total length of barrage	15.9km
Area of enclosed basin at mean sea level	480km ²
Estimated design life	120 years
Estimated total capital cost	£8280m

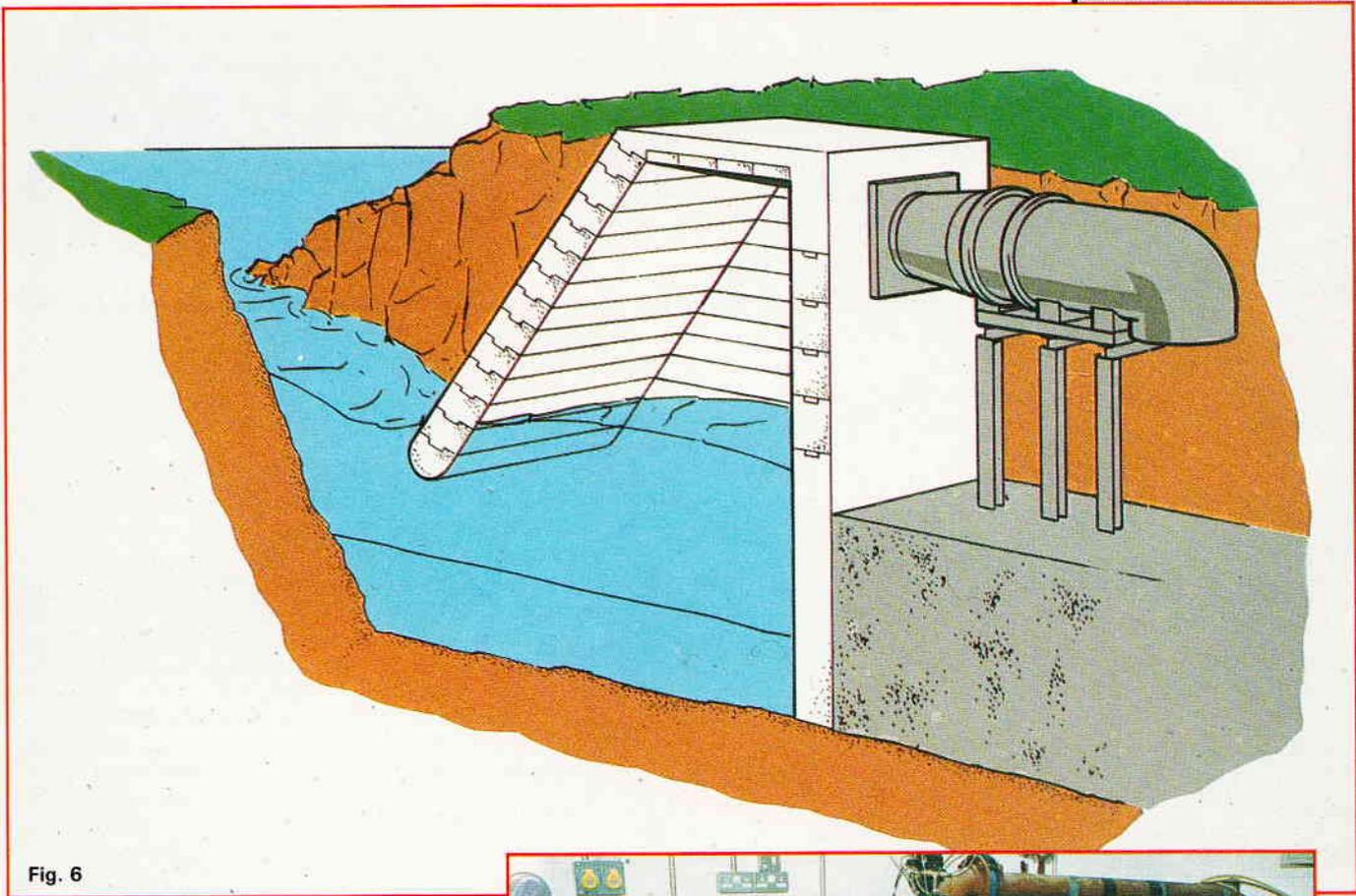


Fig. 6

Fig. 6 Shoreline device at Islay.

Fig. 7 A Wells Turbine of 1 metre diameter.

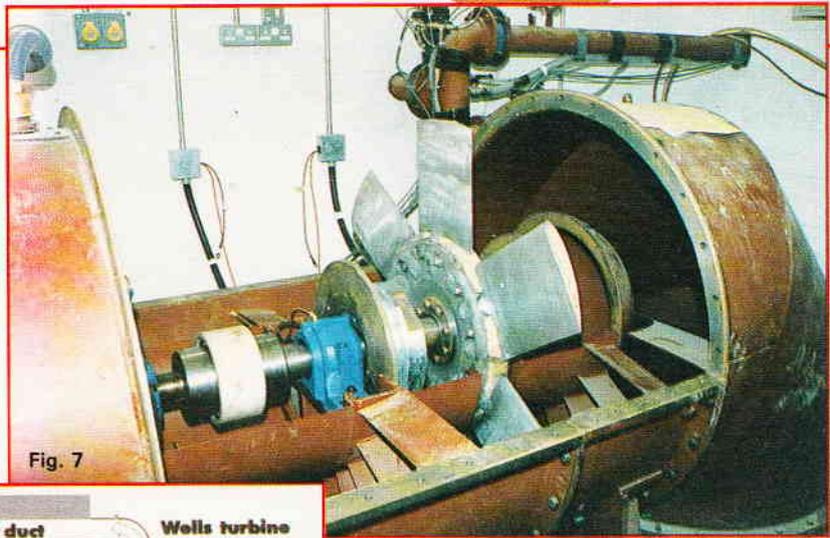


Fig. 7

Fig. 8 Diagrammatic operation of shoreline device.

Fig. 9 Turbine caisson layout.

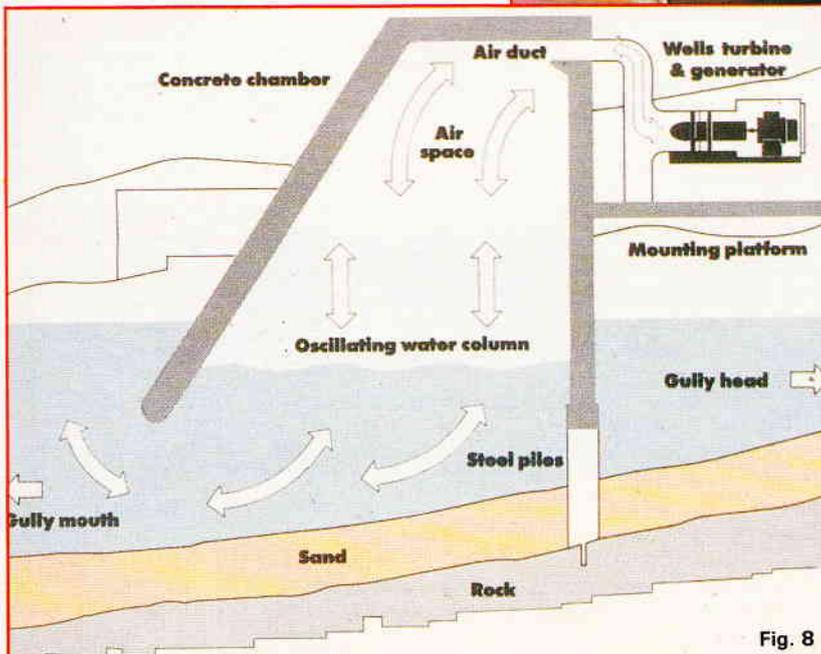
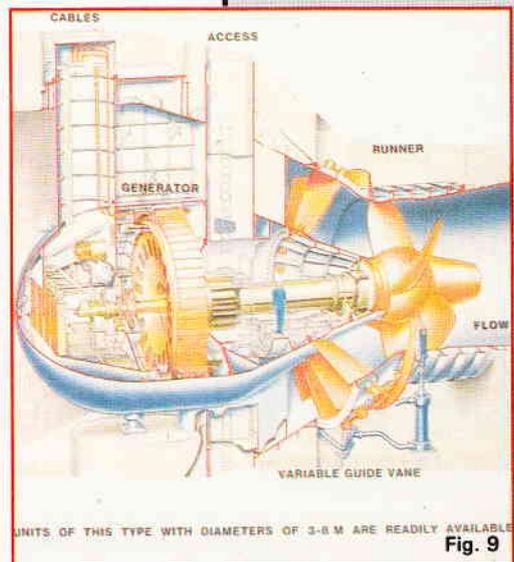


Fig. 8



UNITS OF THIS TYPE WITH DIAMETERS OF 3-8 M ARE READILY AVAILABLE
Fig. 9



NEWS



If you can't afford the SY77 synthesiser from Yamaha then perhaps the budget SY22 keyboard suits your pocket. It contains the now familiar FM tone generation system and a whole host of sampled sounds with facilities to bend each sound with all manner of control envelopes. A joystick, called a vector control, allows realtime mixing of the two sound generating systems. The internal memory

contains 128 preset sampled sounds and 256 preset FM sounds. Internal RAM gives you 64 user voice positions to store your own created effects from scratch or by modifying existing sounds.

Optional plug-in voice memory cards will store any extra sound that cannot be accommodated in the internal memory. The SY22 retails at £799.



A new British development is now available for receiving NICAM Digital Stereo Television Transmissions in the UK — the SACHS NICAM AD9000 Digital Stereo Receiver.

Area coverage of digital stereo is being continually increased and SACHS NICAM has produced an add-on unit for existing TV. The unit can be connected to a Hi Fi system, Hi Fi stereo video or video recorder. The unit can record video as well. Quality is said to be 'comparable to Compact Disc'.

NICAM Digital Stereo (Near Instantaneous Companded Audio Multiplex) is transmitted on a separate 6.552MHz sub-carrier. It is modulated using QFSK techniques (quadrature phase shift keying). The

stereo sound is coded digitally using the NICAM system. The audio is sampled using 14 bits, then compressed digitally to 10 bits for transmission. After being received, it is expanded back to the original 14 bit format.

Stereo listening on TV is in its infancy in the UK, whereas in Europe viewers have had stereo broadcasts for some time. This has proved useful, as British engineers have been able to evaluate all systems. This has resulted in a higher quality NICAM system, which is now being adopted in many other countries, including some European countries, such as Denmark, Sweden, Norway and Spain.

NICAM stereo is particularly noticeable when heard with a feature film, where the sound experience may be compared with that of a cinema.

The recommended retail price of the AD9000 receiver is £199.95.

Roland's M-12E 12-Channel Mixer provides 12 input channels with equalization in a compact 2U rack-mountable unit.

Specification for the M12E equals that of the M16E and M24E, the 16 and 24 channel mixers.

Each channel contains a sensitivity control which allows adjustment level from -60dBm to +4dBm. A peak/signal indicator is also included for each channel which helps to prevent overload and distortion. All channels are equipped with a two-band EQ for precise tonal adjustment. The high EQ is 10kHz shelving with a range of 15dB and the low EQ is 100Hz shelving with a range of 15dB.

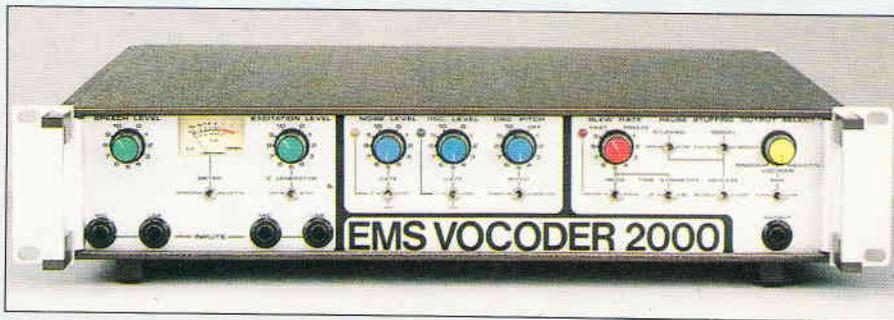
The M-12E's Master section features a Peak Level Meter and Pre Master Fader signal indicator which allows you to monitor levels, and includes Effect send and Aux controls. The Aux send can be set to either Pre or Post fader position allowing you to use the Aux to set an independent monitor mix or as a second effect send. Two sets of stereo returns are included as well. Additional effects can be connected to the Insert jacks which are provided for channels 1-4.

Bus In jacks allow an additional M-12E to be connected to the unit to operate both units as single 24-channel mixer that occupies only four rack spaces. The M-12 costs £599.

If you thought vocoders, those machines very often heard on early ELO records are dead and buried, you'd be wrong. Vocoders are still available from a company called Electronic Music Studios (EMS) who originally designed them in the mid 70s.

At a very basic level, the vocoder uses one sound to manipulate or modulate another. With the input of speech in one input and the sounds of musical instruments on the other, the music can take on a speechlike quality.

The EMS 2000, just one of the range, uses a bank of 16 analysis filters to sort out the signal into different frequency bands. The voltage outputs control the gain of the



synthesis filterbank covering the same frequency bands. An excitation signal (could be music) is fed into the synthesis filters, and speech from the analysis filters modulates the

music.

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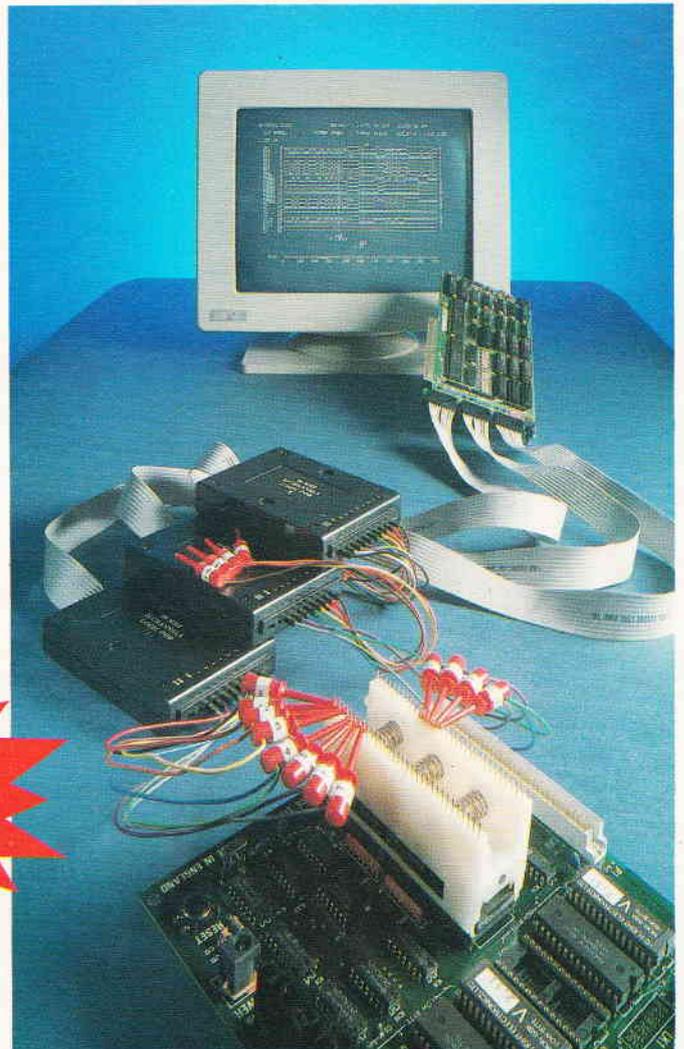
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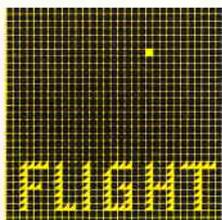
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CLK-27100	250Hz to 100MHz 250kHz to 50MHz	Channel 0-5 Channel 0-23	16K 4K	1MΩ ≤ 5 pF	2 Independent settings -8 to 14V	3 Channels 0-50MHz	16 Levels "0", "1", "x"	12 Channels "0", "1", "x"	= 150V	100MHz
CLK-2400	100MHz 25kHz to 25MHz	Channel 0-5 Channel 0-23	4K 1K	12KΩ ≤ 15 pF	1 Setting -10V to 10V	1 Channels 0-25MHz	1 Level "0", "1", "x" 100MHz "0", "1" only	1 Channel "1"	= 25V	25MHz
CLK-12100	100MHz 25kHz to 50MHz	Channel 0-11 Channel 0-23	2K 1K	1MΩ ≤ 5 pF	TTL	0-50MHz	1 Level "0", "1", "x"	NO	= 10V	50MHz
CLK-2450	25kHz to 50MHz	Channel 0-23	1K	1MΩ	TTL	0-50MHz	1 Level "0", "1", "x"	NO	= 10V	50MHz



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SY77 MUSIC SYNTHESIS



In the 20 years since Walter Carlos' pioneering synthesizer album 'Switched On Bach', new sound generating technologies have evolved in ever-shorter development cycles, the American giants of electronic instrument design have been born, lived and died (ARP, Moog, Sequential, Oberheim) and the Japanese industrial success story has given us today's manufacturing giants: Yamaha, Roland, Korg and Kawai. The sophistication of modern electronic instruments has increased exponentially during the 1980s whilst at the same time, the price for this musical and sonic power has fallen equally radically. At the start of the 1980s, an instrument with less than 10% of the features of the Yamaha SY77 would have cost between £5000 and £10000. For that price, you would have got a fairly impotent synthesis capability, certainly no recording capability, and an onboard digital effects unit was unheard of! Touch sensitivity wasn't guaranteed, and 8 notes of polyphony (the number of permitted simultaneously sounding notes) was about the maximum available, that is if you had money to burn. Today, the same figure would buy 5 SY77s which each include probably the world's most powerful commercial synthesis engine, and all the peripheral components required to write, record and mix a piece of music.

What is the SY77?

In perhaps uncharacteristic measured restraint, Yamaha has innocuously badged the SY77 as a 'Music Synthesizer'. Since this term could equally apply to every synthesizer ever made, it is appropriate, before discussing the historical details of SY77's birth, and the technical details of how it actually works, that we should be clear about what the instrument actually is. Depending on who's trying to sell you the instrument, it is an RCM Synthesizer, a Performance Keyboard, a Workstation, a Complete Production System, and a very nice modern Piano! Well actually, it is all those things, but leans towards some of them more than others. For myself, the whole ethos of the instrument is about synthesis and manipulating sound rather than manipulating music. It is a synthesizer first and foremost, with a reasonably sophisticated musical sketchpad in the form of an onboard sequencer, and

enough MIDI facilities to make it a passable Master Keyboard for controlling other MIDI devices/tone generators in a MIDI studio.

The SY77 has a 61 note, velocity sensitive keyboard with channel aftertouch, 128 preset voices (sounds), 64 user programmable voices, and 4 Megabytes of 16-bit linear waveform data sampled at 32/48kHz. It has twin (16-part multi-timbral) tone generators using both FM and sampling technology



Mike Barnes takes us through the complexities of the latest in synthesizer technology.

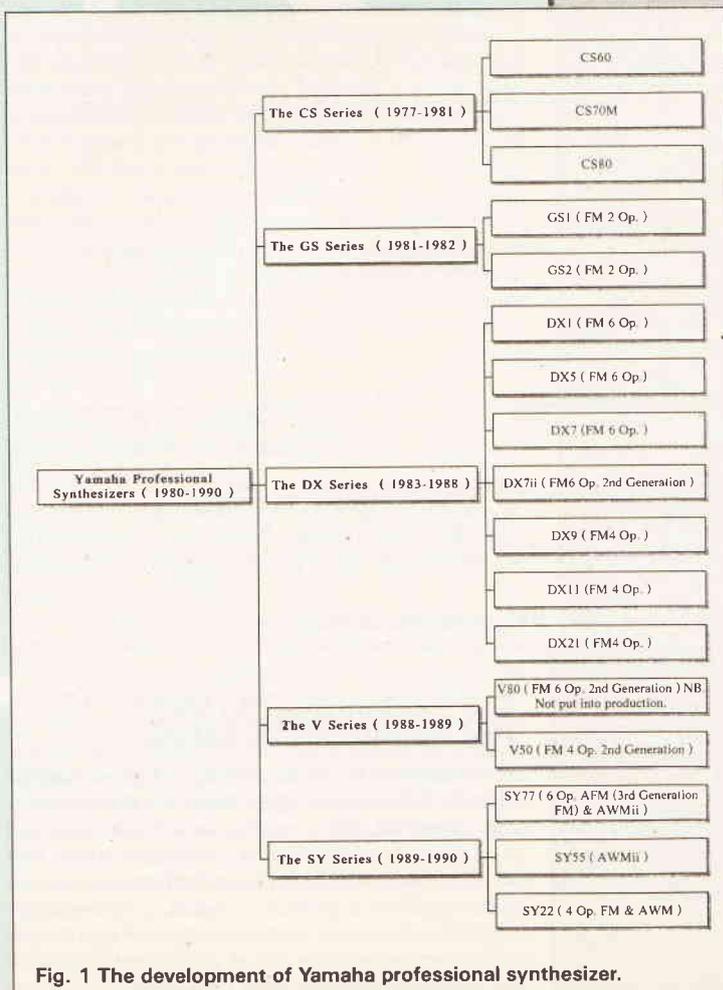
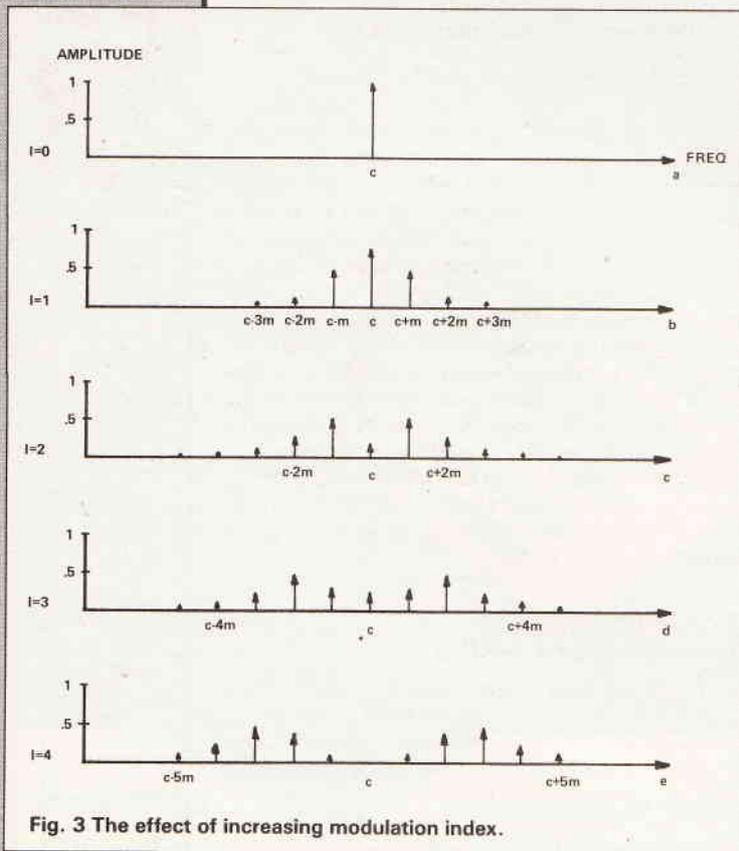
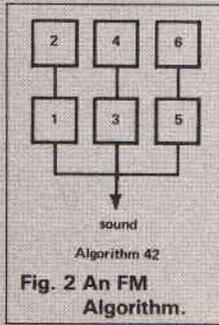


Fig. 1 The development of Yamaha professional synthesizer.



(explained later), up to 8 resonant realtime-controllable digital filters per voice, and 4 Yamaha digital signal processing LSIs for 40 different reverb and modulation effects. (So far so good, it's a powerful synthesizer!) It has two sets of stereo outputs with dynamic panning control, a 16-track 16000 note sequencer for recording your music, a 3.5" disk drive for storing voice and sequence data, and a large 240x64 pixel backlit LCD display for viewing information. It has 2 external card slots for inputting new Voice and wave data, 5 rear panel MIDI controller inputs, and 2 front-panel user-definable wheels for real-time MIDI control. It costs £1999 (RRP).

If all this music technology jargon doesn't mean very much yet, hopefully some of it will by the end of this article. The important point to grasp is that this is the first time so many powerful facilities have been put into one musical instrument. (I am excluding machines like the Synclavier & Fairlight which are really very expensive computers masquerading as instruments!) However, the technologies involved in SY77 are not completely new. It is their development to the point of interaction that is. The technologies involved have been nurtured through several phases by Yamaha and represent the state-of-the-art in the same way as the 68030's and 80486's represent the latest advances in the computer world. To understand SY77 means firstly understanding technologies.



The Background To SY77 . . . : The Infamous DX Series

Any musicians in the readership will know that the Yamaha DX series really heralded the age of affordable, powerful, digital synthesizers which could not only create a vast palette of traditional weird and wonderful special effects, but for the first time respond dynamically to a musician's touch, and moreover passably mimic both the response and the timbre of real instruments. Not only that, the DX series were the first series of synthesizers to implement a universal

keyboard communications protocol which has radically changed forever the way that modern music is made. This interface was an innocuous set of female 5-pin DIN sockets called the Musical Instrument Digital Interface. MIDI now graces the rear panel of all professional keyboards made by any manufacturer and is truly a universal, international standard.

The DX7, launched in 1983, became (and still maintains) the title of the world's best-selling synthesizer. Up until 1983, the 'affordable' polyphonic keyboards such as the SCI Prophet 5 were all variations on 'Analog' (Subtractive) synthesis where a crude static waveform such as a sawtooth wave was filtered using a Low or High Pass Filter to modify the frequency spectrum of the waveform. The DX series made a complete departure from this inherently restrictive synthesis method by adopting a new technique that had been pioneered on the (£10,000+) Yamaha GS1 and GS2 keyboards of the early eighties. This technique was economical, relatively cheap, and offered vast scope for timbral variation and real-time control. This synthesis technology, developed over 10 years by Yamaha in association with Dr. John Chowning (Director of the Centre for Computer Research and Musical Acoustics at Stanford University, USA), was known as Frequency Modulation (FM).

Basic FM Synthesis: A Guided Tour

Dr. Chowning said in 1984: 'It is a simple way to control complex sound spectra that evolve over time . . . one can reduce a complex spectrum to a set of sinusoids which has some phase drift and some amplitude changes, and recompose the complex signal on the basis of those components.'

Before SY77 synthesis can be investigated in any meaningful way, it is necessary to appreciate the basic principle behind the way FM works, and learn some fundamental terminology. Anyone who understands FM radio transmission will have an inkling of how this might relate to the generation of audio spectra by using signals that are within, rather than outside, the human audio range (20-18000Hz if you're lucky!). Non-radio enthusiasts read on . . . Classical FM Synthesis (as implemented in the DX7) involves the linking of 6 sound generating blocks each containing an oscillator which generates a sine wave. Each of these sound generating blocks is called an 'Operator' and the arrangement and interconnections of the Operators is called an 'Algorithm'. Algorithms are thus preset configurations of operators (the DX7 had 32 of them, SY77 has 45). An example can be seen in Figure 2.

The position of the operators within an Algorithm is critical since their position defines their function and consequently the complexity of the resultant sound. In the above case, there are 3 pairs of operators in vertical stacks. The upper operators are termed *Modulators* and the low operators are termed *Carriers*.

Each of these operators is controlled by its own independent envelope generator which controls the amplitude of that operator over time. Crudely, this means that the envelopes of the carriers are effectively master volume controls, and the envelopes of the modulators are master spectrum controls. The carrier envelopes therefore define whether the resultant sound will sustain or act only as a short transient and if carrier amplitude is zero, nothing will be heard. If, on the other hand, the modulators are turned off, or have zero level throughout their envelope cycle, then all that will be heard is the carrier waveform which is a sine wave. However, if the amplitude of the modulator is made to rise and fall over time, then the sound heard from the output of the carrier is not a

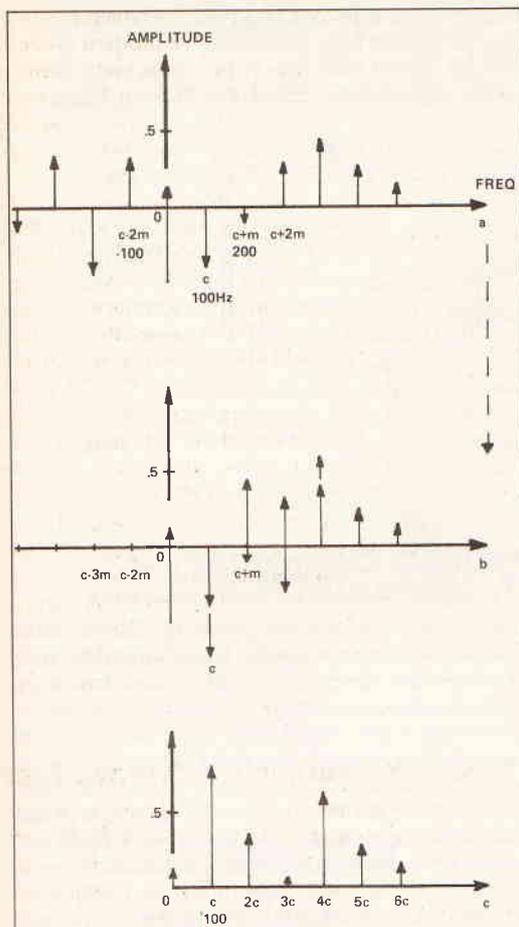


Fig. 4 The reflection of FM sidebands around 0Hz.

simple sine wave but a complex waveform whose individual frequency components are (a) positioned according to the frequency relationship of modulator and carrier, (b) amplified according to the amplitude (or in Yamaha terminology 'Output Level') of the modulator. In order to imagine how this might sound, consider the effect of sweeping the output level of a modulator up and down as being similar to sweeping the cutoff point of a low pass filter over a sawtooth oscillator. The lower the modulator output and cutoff, the fewer the components in the spectrum, the higher the modulator output and cutoff frequency, the greater the number of frequency components. It can be imagined, even at this stage, that if you could somehow control the output of a modulator or series of modulators using keyboard information and how hard the keys are being hit (key velocity), it would be possible to exert control over the final sound spectrum and make it respond dynamically to a player's touch. Of course, by mapping keyboard velocity to filter cutoff, a similar effect can be achieved with subtractive synthesis, so where are the advantages of the FM technique?

The fundamental difference between FM and the filter analogy, is that in FM, microscopic control can be exerted over individual spectral components over a large bandwidth by changing just a few critical parameters (Carrier Frequency, Modulator Frequency and Modulator Output Level), whereas filtering is a macroscopic function which merely removes a whole range of static frequencies according to the slope of the filter. The reason why modulator amplitude envelopes act as controls over the evolution of spectral components is important, and is best explained by resorting to FM theory and showing what occurs in the frequency domain.

The equation for a frequency modulated wave

of peak amplitude A (where both carrier and modulator are sine waves) is:

$$e = A \sin(\alpha t + I \sin \beta t)$$

where:

e = the instantaneous amplitude of the modulated carrier

α = the carrier frequency in rad/sec.

β = the modulating frequency in rad/sec.

$I = d/m$ = the modulation index (the ratio of peak deviation to the modulation frequency)

When $I = 0$ (no output from the modulator), the frequency deviation must be 0 and there is no modulation, we hear only the carrier. However, when I is greater than 0, new frequencies occur above and below the carrier frequency at intervals of the modulating frequency. As I increases above 0 by increasing modulator output level, energy is removed from the carrier and distributed amongst an increasing number of side frequencies called sidebands. The relative amplitudes of the carrier and sideband components are determined by Bessel functions of the first kind and the n th order and are denoted as $J_n(I)$. The Bessel functions give amplitude scaling coefficients for the carrier and sidebands, so that J_0 scales the carrier, J_1 scales the first upper and lower side frequencies etc. . . . As a guide, the total frequency bandwidth is approximately equal to twice the sum of the frequency deviation and the modulation frequency:

$$BW \approx 2(d + m)$$

The effect of increasing modulation index can be represented visually by looking at a frequency domain plot as shown in Figure 3. However, it is clear that on the left hand side of the carrier (c) some sideband components fall in the negative frequency domain of the spectrum. These components are not lost, and moreover, it is what actually happens to these components that gives FM its richness and timbral range. The negative components reflect around 0Hz and 'mix' with the components on the positive side. The 'mixing' process involves inverting the phase of the negative domain components and adding them to the positive domain components so that some frequencies cancel and others are boosted (Figure 4). The ratio of modulator frequency to carrier frequency determines whether the final 'mixed' spectrum will be inharmonic or exharmonic.

From FM to AFM, from AWM to AWMii

'FM synthesis is an efficient, natural way of packing a lot of sonic variability in a neat little box. However, manufacturers' hype notwithstanding, it is only a next step, not a universal solution to all the problems of synthesis.' (Robert Moog, 1985)

The limitations of conventional FM using sine wave oscillations were made more apparent by the introduction of competing products such as the Roland D50 and Korg M1 which used digital recordings of real instruments ('samples') and then subtractive synthesis (ie filtering) to modify the sounds. These newer instruments were not only easier to use (dispelling the 'rocket scientist' myth that surrounded the programming of sounds on the DX7), but were also able to convey far greater realism, if not dynamic response from the keyboard since a carbon copy of the real instrument was effectively being played back. However, the fundamental synthesis limitations of both the instruments mentioned above was that the spectra they generated was a static recording and thus



SYNTHESIS

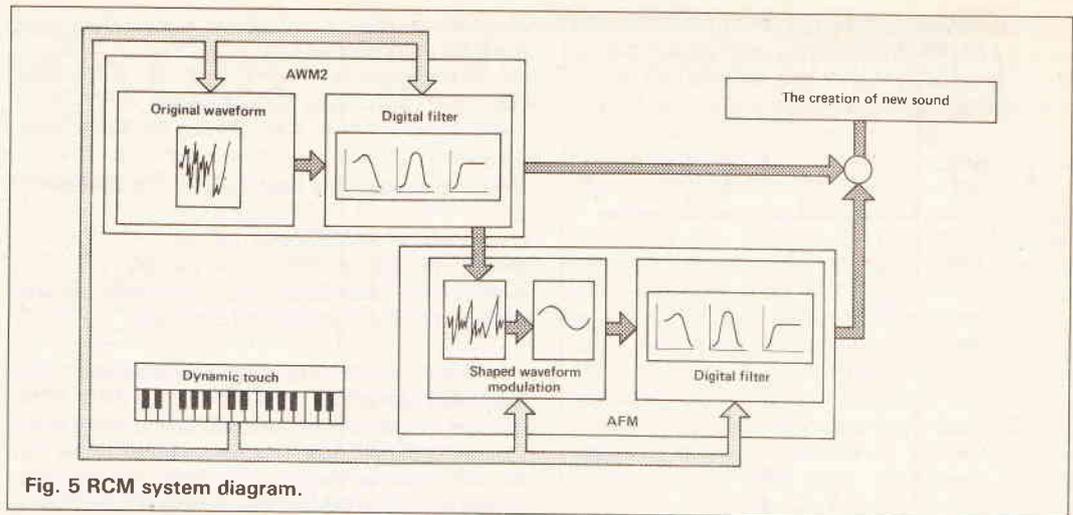


Fig. 5 RCM system diagram.

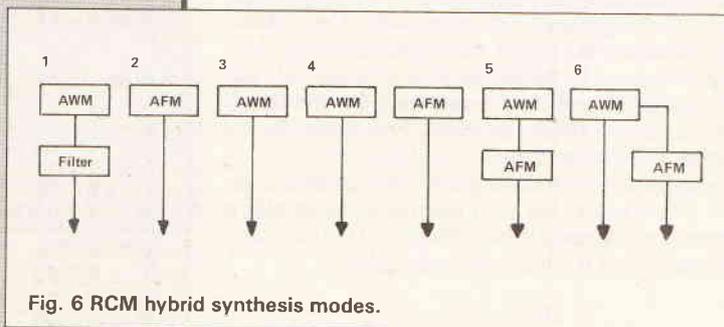


Fig. 6 RCM hybrid synthesis modes.

Realtime Convolution and Modulation (RCM) Synthesis

The term RCM is used to highlight the fundamental parts of the synthesis system. Realtime implies that all calculations are made in realtime as the user plays the keyboard, and that the expressive response is immediate. It also implies that many of the system parameters can be controlled via MIDI in realtime such as the filter section. 'Convolution' refers to the filter theory behind the Time variant IIR (Infinite Impulse Response) digital filters, and 'Modulation' refers to the Advanced Frequency Modulation (AFM) section of the machine. The system diagram is shown in figure 5.

Next month we continue this article by looking at the functional architecture of the SY77.

could only be varied in amplitude, or by carving off sections of the spectrum using a LPF. This in itself was not always a great problem, since the ease of use and quality of sounds on these instruments initially far outweighed the synthesis disadvantages, and in any case, at the time of their arrival at the market place, programming your own sounds had become quite an alien concept after the DX7's introduction of complex programming parameters and the need to understand what you were actually doing when changing the value of the parameter.

Yamaha's reaction to the sampling/sample playback developments made by competing products was not to throw FM away as being an outdated technology, but to develop it further (Advanced FM), in order for it to integrate it within a powerful sound generating system with sample playback and digital filtering technology. Moreover, not satisfied with the 12-bit, sampling resolution of the existing Yamaha AWM (Advanced Wave Memory) technology (seen in Clavinova series of home pianos and TX16W sampler), the 16-bit M3 chip (AWMii) was developed in 1987-1988 alongside the OPS3 chip which contained the new FM technology (AFM). The concept of the SY1 (later to become SY77) was born: it would integrate the two most powerful sound generating technologies in a radical new way which would take advantage of the realism of digital samples and the expressive power of FM. The specification was laid down that to run the two sound generating systems in parallel, or even in series was not enough. They would be made to really integrate: complete AFM generated sounds could be treated as samples and therefore digitally filtered, and samples could be treated as FM operators within an Algorithm so that the user was no longer restricted to using only simple sine waves as carriers or modulators. This specification permitted six different modes of synthesis that were to be carried under the umbrella term 'Realtime Convolution and Modulation' (RCM) synthesis.

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NB. The views expressed here are those of the author and are not necessarily the views of Yamaha Corporation.

Mike Barnes is a postgraduate in Music Information Technology, works for the Yamaha Research & Development Centre, London as MIDI Product Specialist and is currently involved in voicing, sampling and demonstration work for the new SY/TG series.

TO BE CONTINUED

SYNTHESIS

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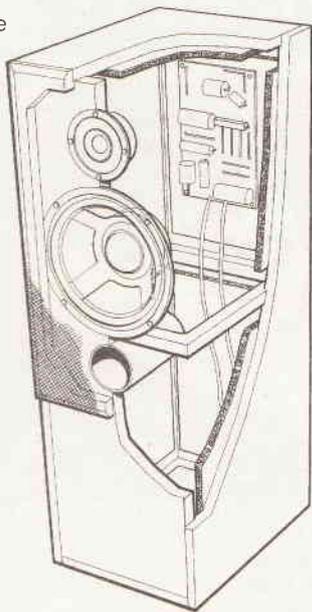


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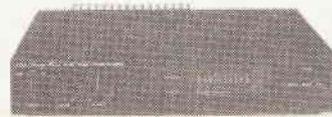


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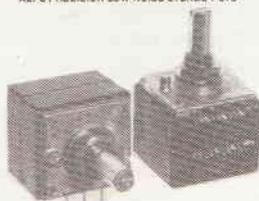
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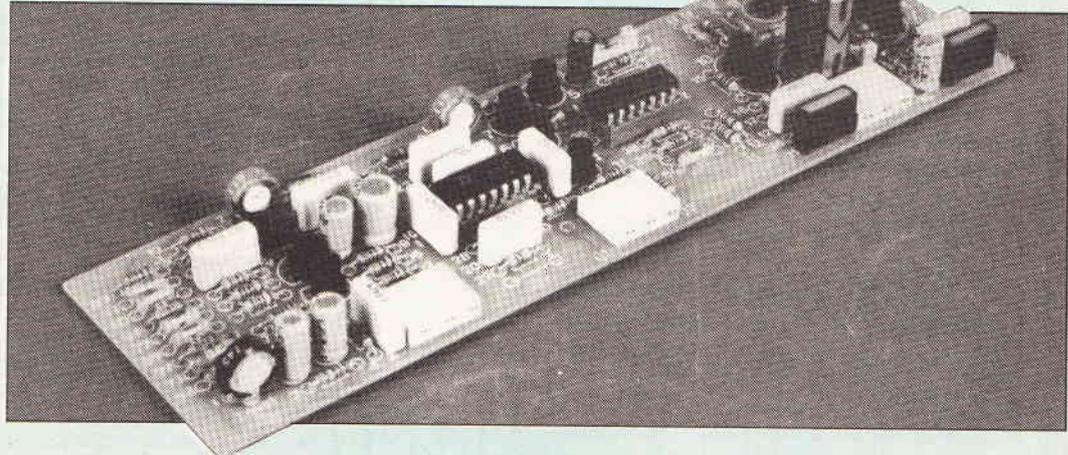
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STEREO DECODER UPDATE



John Linsley Hood has revised the sample and hold stereo decoder featured in ETI.

In February 1987, I described a design for a stereo decoder in ETI, in order to extract the two stereo channels at a good bit less distortion than the typical 0.3% given by the conventional '1310' type PLL IC decoder chip. Although I used this circuit description as an introduction to a new design of low distortion FM receiver, it occurred to me that this particular decoder unit could be added as an improvement to an existing FM tuner.

The signal to noise ratio of any FM stereo decoder is improved if there is an effective input low-pass filter to remove those wide-band noise components of the demodulated signal. These lie on either side of the 114kHz and 190kHz (3rd and 5th) harmonics of the 38kHz sub-carrier frequency. They will otherwise be decoded as audible noise, and added to the AF output signal.

Unfortunately, any input low pass filter of this type will cause some phase shift in the 23-53kHz part of the signal spectrum which provides the left-minus-right part of the stereo matrix, and some compromise

is necessary between the requirements of good signal to noise ratio, and maximum stereo channel separation.

It is possible to improve the performance of the input filter I had used. This was described as an alternative design in a short follow-up article in July 1988.

In the process of constructing an FM tuner/decoder kit from my design, I spent a bit more time thinking about other possible improvements to this circuit. These might be of benefit to other constructors.

The major change which I would suggest concerns the operation of the sample-and-hold FETs, Q8 and Q9. The gate resistors, R11 and R12, have increased to 2M Ω and taken to the 15V line rather than to their sources, as shown in Fig. 1. This gives rather better switching characteristics.

I have also changed the type of filter used in the output buffer stage (Q10/11, Q12/13) from a third-order bootstrap design to a second-order Sallen and Key layout, with 2N5457 input FETs to reduce the resistive loading on the sampling circuit. The use of

PROJECT

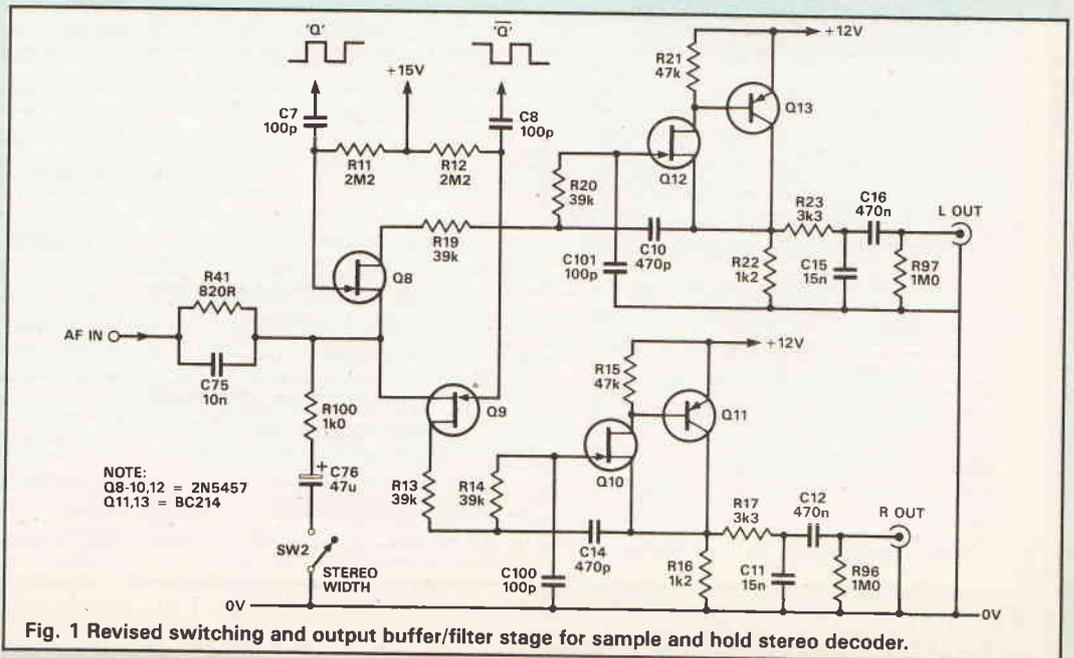
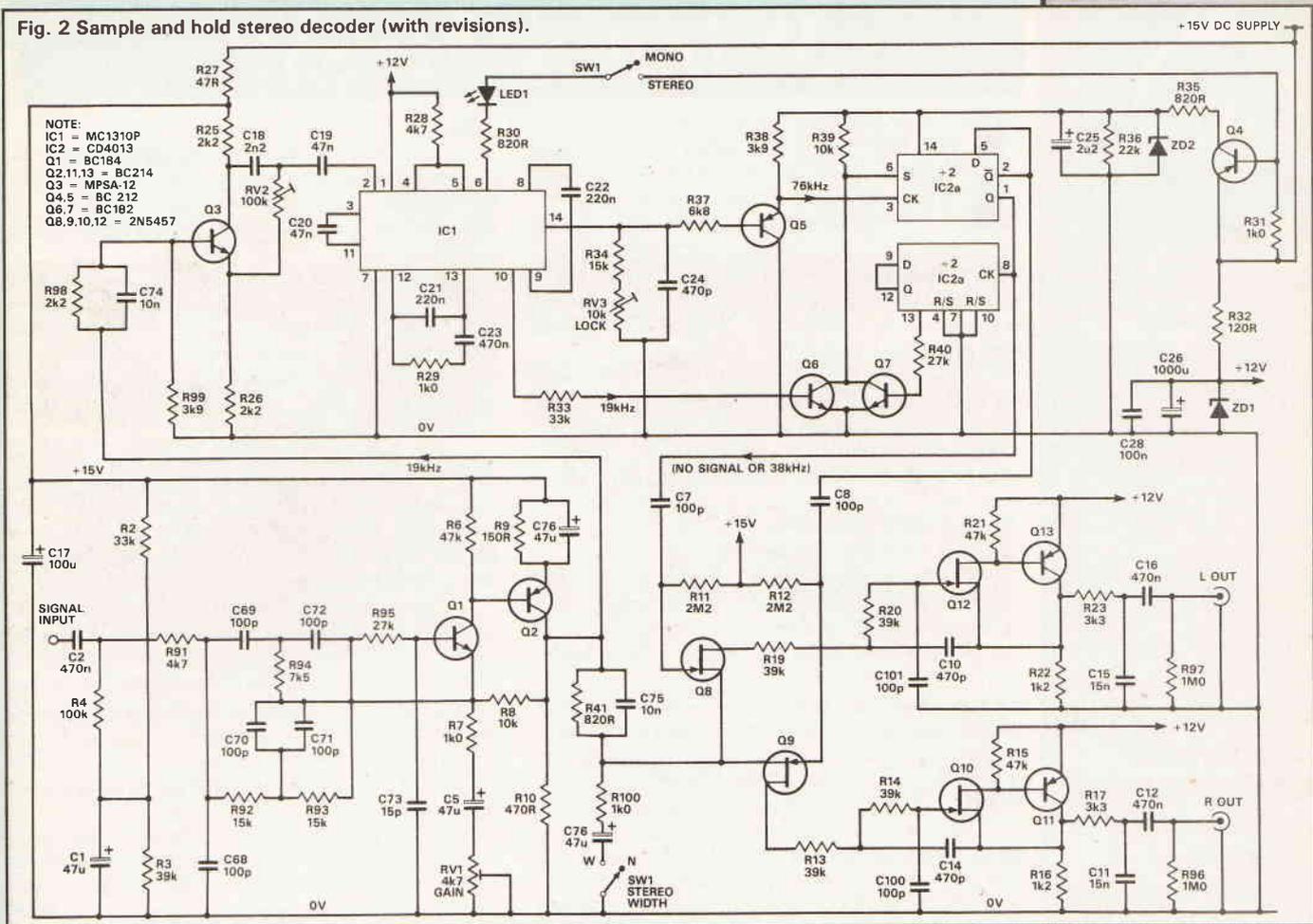


Fig. 1 Revised switching and output buffer/filter stage for sample and hold stereo decoder.

Fig. 2 Sample and hold stereo decoder (with revisions).



the simpler filter circuit allows a more straightforward output de-emphasis RC system, with a 3k3/15n combination to give the required 50µs (actually 49.5µs) high frequency roll-off. I have also added, to correct an original oversight, a pair of output DC blocking capacitors (C16, C12), to remove the standing DC potential otherwise present on the audio output sockets.

The other small change which I would suggest to the decoder is a divider network (C74/R98/99) on the input to Q3, to adjust the DC potential applied to Q3 base. I have for completeness shown the whole revised circuit in Figure 2 and Hart Electronic Kits have

made a new PCB for this circuit design to provide a direct plug-in replacement for the earlier unit.

Three further small changes I would recommend are: the reduction of the values of R79 and R80, in the 'mute' circuit, from 100k to 33k, the joining of pins 6 and 7 on the CA3189 (IC3 in Figure 9 in ETI March 1987) — a simple blob of solder will do this, since everything else remains as it is. If one was building the circuit from scratch, one of the resistors R55/R57 could be omitted and the other reduced in value to 1kΩ — and the removal of the capacitor C42, and the resistor R58 on the AF output of this IC as shown in Figure 3.

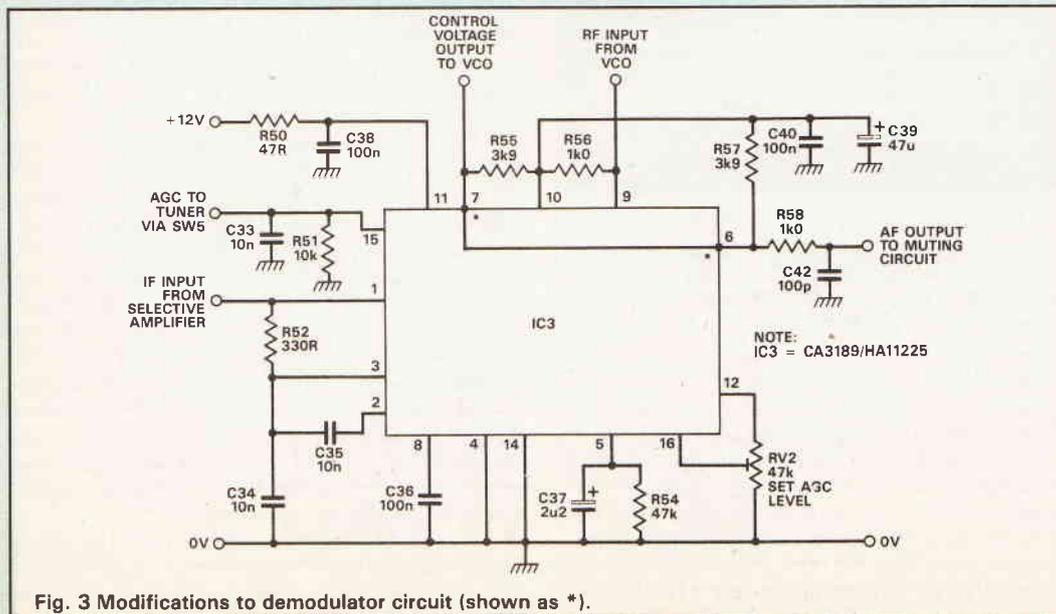


Fig. 3 Modifications to demodulator circuit (shown as *).



*Music correspondent
Darrin Williamson
fills us in on what's
new at the Frankfurt
Musik Messe 1990*

What A Messe!

It's with a mixture of both curiosity and dread that I set foot in one of the world's largest exhibition complexes for my annual download of product data from the music business.

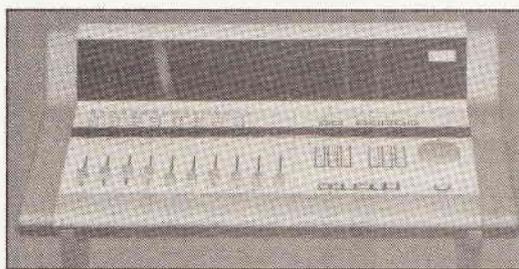
Everybody who's anybody either exhibits or attends Frankfurt. In fact this year there were over 1000 exhibitors from 39 countries showing their wares to over 50,000 visitors within 42,000 square metres of space over six days (phew!). Needless to say, I was kept pretty busy during my week's stay.

A plethora of music software was on show with the lion's share for use with the Atari ST and the Apple Macintosh, with a respectable showing for the Commodore Amiga, and a smattering for the PC. Conspicuous by its absence was the Acorn Archimedes, which promised a lot of good things at last year's show but this year had a presence of zero. Obviously not too fussed about the pro music market after all!

The big development in software this year was direct to disk recording which, put simply, is a hardware/software combination that turns your micro into an enormous 16 bit CD quality stereo sampler which records the sound straight onto a hard disk drive. Sample time is governed by the capacity of your drive. To sample in stereo at CD bandwidth (44.1kHz), you need roughly 10 Mbytes of storage per minute of recording, so a 45 Mbyte hard drive will comfortably handle a 7" or 12" vinyl version of a song.

Tracks can be hacked about and cue lists can be set up so that sections of the sample can be looped and replayed anywhere within the recording. So, a chorus need only be recorded once and triggered after each verse thus saving valuable disk space. Applications for such products spread from straight recording of your own music to constructing remixes of existing tracks to incorporate sound effects onto film or video productions.

San Francisco based software house Digidesign already have a firm stranglehold on the pro end of the market with Sound Tools running on Mac II machines and look set to do the same for Pro Atari users with 24 meg STs. Both versions offer a whole host of features including digital EQ, CD mastering, DAT editing and SMPTE synchronising.



They will also link up with MIDI sequencers allowing the user all his sequencer tracks running the musical instruments, samplers and effects, as well as having two tracks of audio all within the same sequence, so you could have your vocals and guitar licks all stored digitally on your micro.

For the Mac version (retailing for about £3000), Digidesign have gone for Opcode's Vision and on the ST (about £2000), C-Labs Creator/Notator.

Direct to disk isn't territory solely owned by Digidesign, or even America for that matter. Cambridge based D2D Systems have come up with ADAC SE. A similar product in many respects but working on the cheaper Mac SE micros and costing in the region of £499, which include free direct to disk

software!

Support for the Atari shows no signs of letting up, in fact it must be a continual source of amazement to the original system engineers as to what can be achieved with a machine that's rapidly approaching its fifth birthday!

Steinberg have version 2.0 of Cubase, without doubt one of the most professional and complete sequencers on the market. This version offers some nice scorewriting functions which not only allow you to edit tracks but also allows you to output your music to a wide range of printers from the humblest of 9 pin to the most sophisticated of lasers.

Also included is an Interactive Phrase Synthesizer (IPS) which allows musical phrases to be filtered and modulated in a number of ways including Scale Correction, Pitch and Rhythm Modulation. Once a phrase has been tinkered with, it can be transferred into a standard Cubase track for MIDI playback.

Cubase has also been cut down in features and price for those ST owners whose budget doesn't quite stretch to £550 for a piece of software. Cubeat will retail for around £250 and includes much of the same editing flexibility of its big brother but, as one would expect, fewer bells and whistles.

Steinberg have also wasted no time at all in releasing a Synthworks editor/librarian package for the Yamaha SY-77.

On the ST hardware side there's a 16 bit digital to analogue converter for use with their Avalon direct to disk recorder and Midex+ which plugs into the cartridge port to provide four dongle ports, two MIDI INs, four MIDI OUTs and both SMPTE and EBU timecode synchronisation. Two versions of this product will be available, one with and without the timecode sync facilities.

A product for the Amiga is the Fun Lab Music System in which Steinberg have teamed up with Kawai to put together a MIDI package for the education market based around an A500 and a Kawai preset keyboard, speakers, amp and some specially designed 12 track sequencing software which can be used for keyboard players as a sequencer or as a controllable backing band for any other musicians.

Several nice ST products to come from the Netherlands — such as Son from Mopro. Another Direct to disk recorder but with the added advantage of signal processing software allowing the user to add effects such as reverb, echo/delay, and it's even got a software based vocoder in case you want to try your hand at some Jeff Lynne or Herbie Hancock impressions.

Future developments for this system include a Radio Jingle package for broadcasters to use instead of the rather antiquated and sometimes unreliable cartridge systems typically found in studios of this ilk.

Roland (yes, that Roland) has entered the ST software market with TenTrax; not surprisingly a ten track sequencer designed with their Desktop Music System series of sound and utility modules. Tracks 210 are set up for the CM32L (or the MT32/D110) with track one open for whatever other sound sources you have going. Step Edit, Drum Edit and notation facilities are all there, as well as Mixing Desk page allowing control of MIDI volume, stereo panning and reverb modes. Roland plan to sell this both separately and as a package with the CM32L.

On the software side there are editor packages for the Yamaha DX/TX range, the Kawai K4 and Lexicon LXP1 effects processor. On the sound

libraries side, PCM cards or disks for a number of synths including the Korg M1, the Waldorf Microwave, the Yamaha SY77, the Roland D50 and the Ensoniq VFX.

Disc Samples

Sound Sample libraries were all over the place this year. All manner of companies had sounds for you to load into your sample, be it an 8 bit micro-based package or a full fledged 16 bit studio model.

Sounds available cover a wide range of sonic possibilities and appear on a number of different formats varying dramatically in price and flexibility.

At one end of the spectrum you have audio Compact Discs which just offer single notes played at different pitches which you must record and edit yourself on whatever system you have.

Metra Sound have three discs in their range covering percussion, acoustic strings and sound effects. Frohlic have a Sound Sampling Collection volume 15 which includes a mixture of percussion, wind instruments, ensemble sounds (choirs etc), Steinway Grand Pianos and various effects. The BBC now do an 18 disc set from their effect libraries. Masterbits have three and are chock-full of popular synth sounds. Sonic Images have five volumes ranging from percussion to multi-layered pad sounds.

At the other end of this sonic spectrum are CD ROMs. These contain far more samples which are already edited and ready to play, but are confined to professional samplers such as the Akai S1000, the EMU Emax I and II, the DPX1 and the Emulators II and III. These all come from InVision Interactive and although quite good are a bit more expensive.

Music Hardware

Now we move swiftly on to the hardware. Plenty of new stuff there as well.

To kick off, Roland had a new flagship synth, the D70, which aside from having a longer than average weighted keyboard (just over six octaves) which transmits velocity and aftertouch information, also corrects the oversight on the D50 in being multi timbral. Its principal sound source is LA but the system has the added benefit of DLM (Differential Loop Modulation), which allows you to mess around with PCM sounds in a big way, which becomes particularly useful when the sample cards designed for the U110/220/20 are plugged in.

You can have five synth parts plus a rhythm bank all utilising the 30 note polyphony and the internal multi-effects processor.

The MV30 is a wonderful little box which is not only a sequencer but also contains the guts of a U220, tape sync and multi-effects. Eight parts can be recorded internally whilst an additional eight tracks are free for other MIDI devices. Ideal for musicians on the move or for computer owners who want to use their micro for things other than just sequencing. Price yet to be confirmed but should be around the £1500.

On the effects front, Roland's Boss division have come up with six new rack mounted effect units — a 31 band graphic EQ, a two channel version of the same and a two channel 15 band version, a digital reverb, a digital multi echo and a guitar driver.

Akai's big announcement was their top of the range sampler the S1100. A front panel and casing were on show but as yet not guts for the beast. Still, the specifications look mighty impressive: real time Digital Signal Processing, built in SMPTE timecoding and provision for direct to disk recording and a staggering 32 Mbytes of onboard RAM. Price around £3500. Ensoniq were proudly showing the SQ1, a cut

down VFX with 16 track on-board sequencer and effects for about a grand.

Yamaha's big launches were at both ends of the music market. At the budget end was the SY22, which is the first Yamaha keyboard to feature Direct Vector Synthesis which basically means that you have up to four tones to play with (two AFM and two sampled) and a joystick which allows you to mix between the sounds. These mixes can be recorded as macros and used in performance mode, so big, evolving sounds can be created very quickly and to great effect. At around £750 this has got to be this year's hit as far as the budget keyboard market goes.

For the big studios Yamaha also launched the DMR8 which combines an eight track digital recorder, digital mixer, effects, time code locator and automated mixdown all in one neat box not much bigger than a computer. The product is still in its prototype stages so no price has been fixed; however it does look like it'll be over £5000.

Korg had some very similar products to show (not too surprising, as Yamaha own Korg) and the team who came up with the vector synthesis concept for the now defunct Sequential Circuits were taken on by Yamaha and subsequently transferred to Korg — it's an incestuous business you know!

Brother (yes the people that make typewriters, printers, sewing machines, etc) were showing two budget sequencers. The MDI30 offers a 32K workspace and features 2 recording tracks with unlimited merge facilities, so you can record on track one bounce it onto track two as many times as you want. The MDI40 offers identical features but has twice the memory capacity. The emphasis of both these products is portability and I would imagine that sales would be to musicians on the move or those who need to transfer MIDI data with the minimum hassle factor. Its attraction lies far more in its ability to save thing like system exclusive than as a sequencer.

No strangers to the useful little boxes end of the MIDI market are Birmingham-based XRI Systems who had several new additions to their range of MIDI patchbays and SMPTE synchronisers.



XRI also have the Lemi range of MIDI lighting controllers which allows you to control an entire light show from a MIDI sequencer or master keyboard using the MIDI dimmer packs and control desks.

JL Cooper demonstrated their Magi II mixer automation system which consists of a 16 into four remote fader panel, a master unit and however many VCA units you need for your set up. ST and Mac software is available to help in the mixing process which runs on the Mac and now the ST.

For the digitally minded amongst you TOA have tied up a distribution deal with Saori for the Integrated Sound Processor (catchy name guys!) which effectively replaces two 30 band equalisers, two constant directivity horn compensators, two four band notch filters, two four way crossovers and eight digital delays all within the digital domain. As you would expect, the purchase of such a product will require most of us to take on a couple of more paper rounds in order to afford it!

On the loudspeaker front, LA Systems had some very impressive units on show starting with the STE30s — a pair of 30 watt speakers with built in stereo amp. Ideal for small studios or for live work.



REVIEW



The STE60s offer 65 watts of music power with the combination of two satellite speakers and a single sub woofer. This combination really kicks and would be equally at home in a mobile disco set up or as apart of a studio monitoring system.

Finally, LA's flagship speaker system, the STE120 — offering 130 watts of music power and making them ideal for live foldback PA applications or HiFi buffs with deaf neighbours.

If you thought Vocoders were a thing you could only find in the second hand ads then think again. Cornwall-based EMS has just such a system that the likes of Jean Michel Jarre use. They also have another little product for the Jarresque among you called the Soundbeam which is a little box that allows you to trigger MIDI equipment by breaking ultrasonic sound beams. The nearer the transmitter you are the lower the pitch. Great for live performances.

Last, but by no means least (to my mind at any rate) was the most revolutionary product of the show which is to be distributed this side of the Atlantic by Farnham based Plasmec who, up until recently have been best known for their studio jackfields.

Now they have the MIDITap, the first in a range of products using the Medialink networking protocol from US company Lone Wolf.

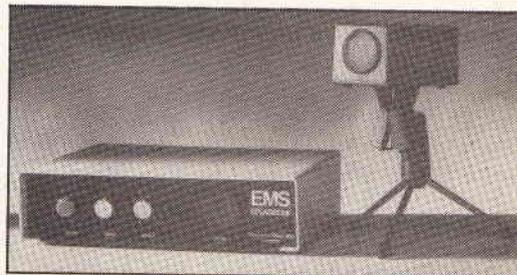
Medialink basically allows all manner of different signals to be shoved down a single fibre optic cable, which not only cuts down the amount of wiring you need but also simplifies the setup and system reconfiguration that becomes such a headache in even the smallest of studios. Medialink employs the Local Area Network concept that is taken for granted in the world of business computing and applied it to the music world.

MIDITap has four MIDI INs and four MIDI OUTs, all of which are fully mergeable and furthermore all MIDI Channels on all outputs are independently addressable by name. So with one MIDITap you can quite happily have 64 separate MIDI Channels running at any one time. If you need more than that then you just add more MIDITap. If you wanted you could have over half a million MIDI channels.

The other nice thing about the unit being fibre optic based is that you're not losing any speed, in fact you could have MIDI devices upto two kilometers away with no timing problems.

The MIDITap also has a serial RS232 port which will allow you to have computers, modems, printers etc all on the same network.

Future products in this range include SMPTETap, SCSI Tap and AudioTap which will allow eight channels of digital audio to be sent round your system along the same cable everything else is coming out of.



It isn't cheap at £2000 per unit, but in terms of flexibility there'll be nothing to touch it for the foreseeable future.

HAM RADIO TODAY

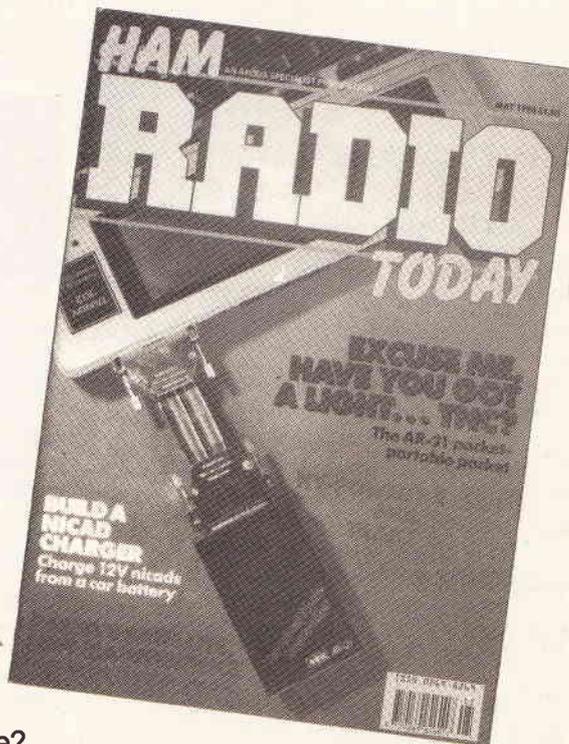
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			E9003-1	Superscope Y1 input board	J
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			E9006-3	Telephone External Bell	D
			E9006-4	Fecko Box	G
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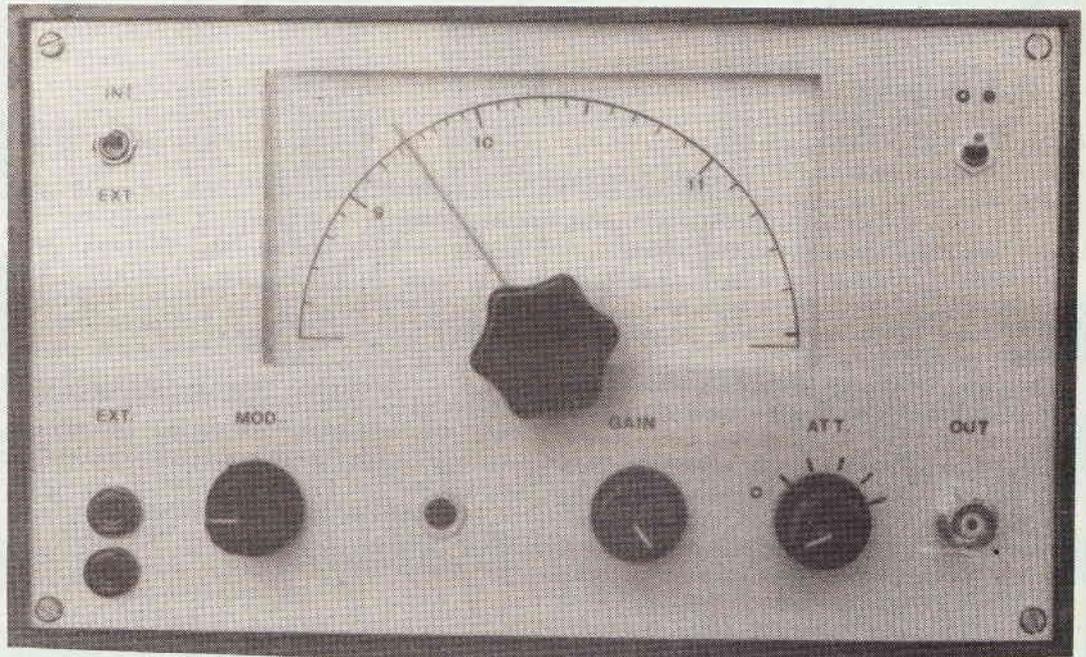
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FM GENERATOR



L. Boullart builds this highly reliable and accurate FM generator.

This project uses more or less conventional circuitry, but it is very reliable and accurate, allowing you to align your FM tuner without problems.

Briefly, the unit consists of a FET HF oscillator, tuned by a double capacitance diode, which in turn is modulated by a 1kHz oscillator. Another FET, used as an impedance transformer, connects the signal to a 50R attenuator. Figure 1 shows a block diagram of this set-up.

between 5.5 and 10 μ H.

The capacitance diode D1 is connected via R10 to RV2, which allows the DC potential to vary between 0.8V and 9.6V. Minimum voltage is adjusted using RV3. Remember that the scale is only 180°, so the maximum voltage at the glider of RV2 will be:

$$\frac{180}{300} \left(V - V_{RV3} \right) + V_{RV3} \approx 9.6V$$

A FET Q1 is used in a well-tried oscillator circuit, justly reputed for its excellent performance. The oscillation amplitude is very nearly constant over the entire frequency range. The output at the drain is of the order of 2V rms, so a potential divider R12, R13 is used to reduce this to a more reasonable level. The signal is then passed on to another FET, Q2, through gain control RV4. Q2 is used as a source follower, with a low load resistance in order to obtain a 50R constant impedance output.

Taking into account the losses in Q2, the signal level at the attenuator will be approximately 100mV. The attenuator SW2 has four successive steps of -10dB each. With a maximum output of 100mV it is possible to use a very loose coupling to the input of an IF amplifier for alignment purposes.

Alternatively, the 10th harmonic is still strong enough to allow tracking adjustment of the HF part of an FM tuner. However, note that the resistors of the attenuator are mounted directly on SW2, without separate screening. As a result, the last step of the attenuator (-40dB) is no longer very accurate, owing to capacitive and inductive losses. Even so, RV4 will allow further attenuation if required.

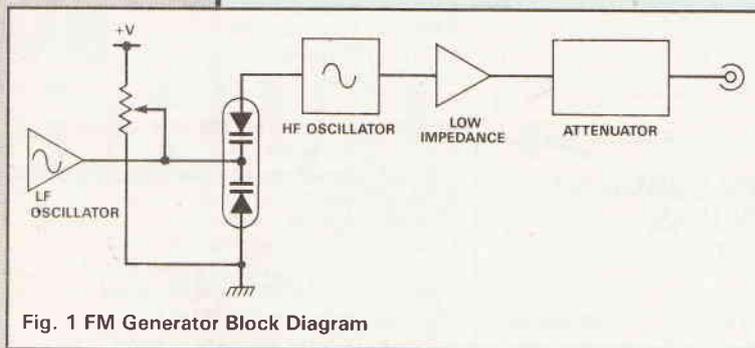


Fig. 1 FM Generator Block Diagram

The HF Oscillator

In order to keep the FM generator as simple as possible only one frequency scale is provided, with a range from 8.6 to 11.5MHz. The 10th harmonic will then cover the complete FM band from 87 to 108MHz. Frequency coverage is accomplished by a double capacitance diode (BB294B or KV1320) together with coil L1. The capacitance variation amounts to:

$$\left(\frac{11.5\text{MHz}}{8.6\text{MHz}} \right)^2 = \frac{1.778}{1}$$

which is well within the possibilities of these diodes.

It is perfectly possible to use a home made coil, adjustable between 7 and 10 μ H. It will take 30 turns (with a tap at 5 turns) of 30 - 36 SWG wire on a 0.25 inch coil form with dust iron core, or alternatively 39 turns on a 5mm coil form. But it is more convenient to use a TOKO KANK 3334R coil. With the two windings in series, the inductance can be adjusted

The Modulator

Low frequency modulation at 1kHz is provided by the oscillator circuit with IC1. This is a conventional Wien bridge oscillator, stabilised with a thermistor RA53. The output waveform is very pure with total harmonic distortion well below 0.003%! The dual IC type NE5532 was chosen because it is readily available, but you could also use the single type NE5534. In that

PROJECT

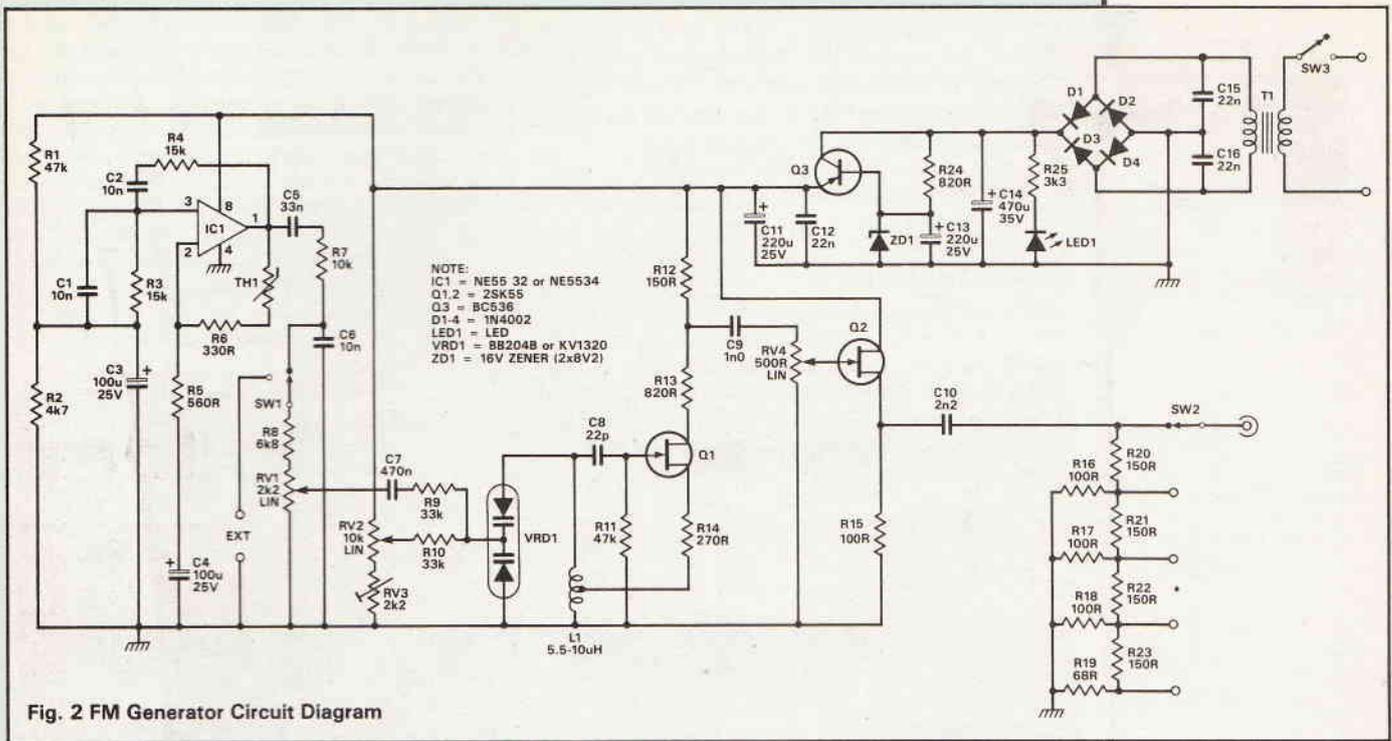


Fig. 2 FM Generator Circuit Diagram

case, the output should be taken from pin 6 instead of pin 1 and +V must be connected to pin 7 instead of pin 8.

The signal output is approximately 1.5V, which is far in excess of what we actually need for a 75kHz deviation. With the HF oscillator at 10.7MHz, a DC voltage of 240mV will cause a frequency shift of 75kHz, so the modulation level should not exceed $240\text{mV}/2.82 = 85\text{mV}$ rms to avoid overmodulation. Therefore, R7 and R8 are included to reduce the output voltage of IC1. R7 and C7 also form a low-pass filter, which reduces the distortion to less than

0.0018%. With the glider of RV1 in maximum position, the signal level reaches 160mV. The potential divider R9, R10 leaves about 85mV at the cathode of D1, as required.

Incidentally, if you are going to adjust a double-tuned FM discriminator circuit for minimum distortion, it's best to reduce frequency deviation to no more than 50kHz (two-thirds of RV1). The extremely low distortion level of the 1kHz signal will then permit a very accurate adjustment of the secondary coil. Of course, you should strictly keep to the recommended values for the complete modulation.

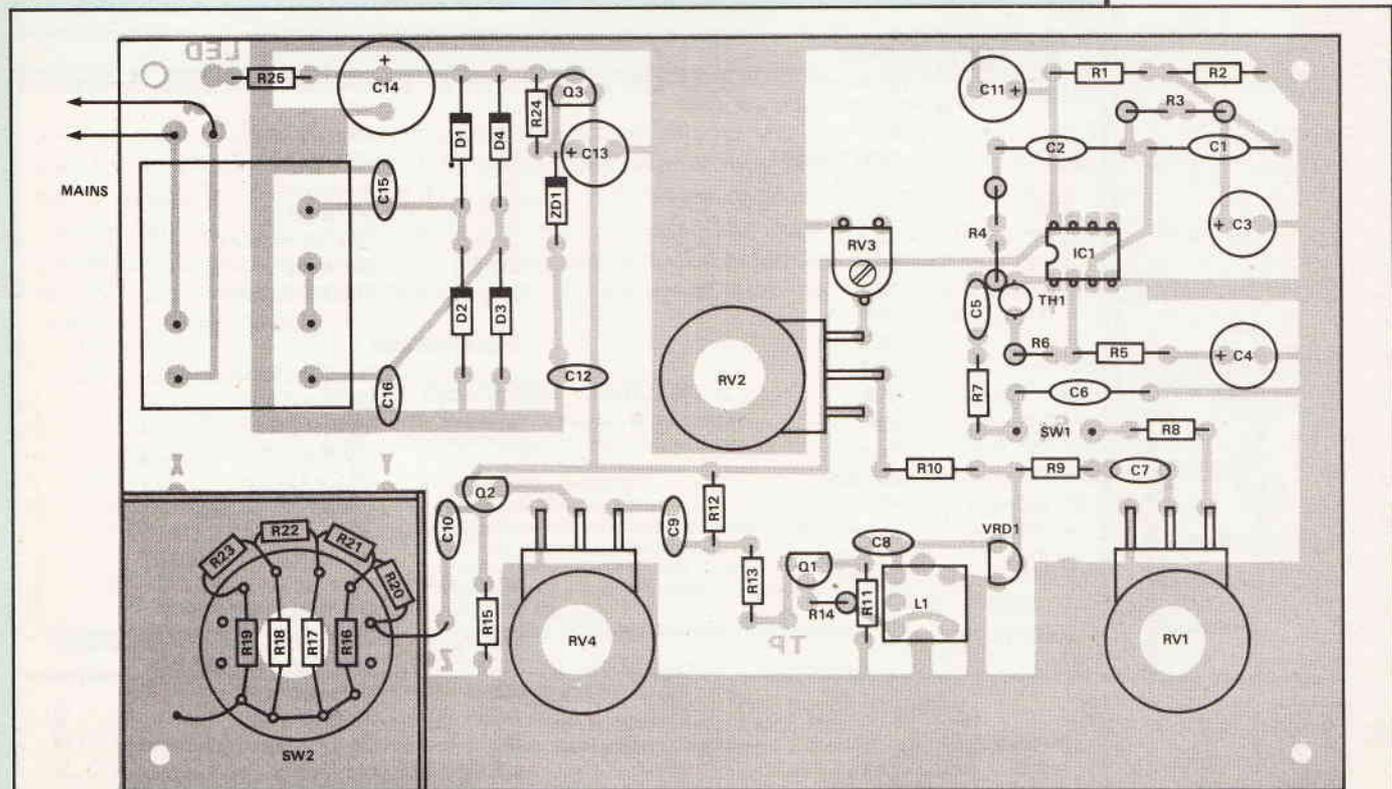


Fig. 3 FM Generator Component Overlay

Power Supply

The demands of the power supply are very modest: 30mA at 15.5V. Voltage stabilisation is achieved by the 16V zener diode D2 together with Q3. D2 could be made up of two 8.2V zeners in series; room is provided on the PCB for this possibility. HF hum modulation is suppressed by C15, C16.

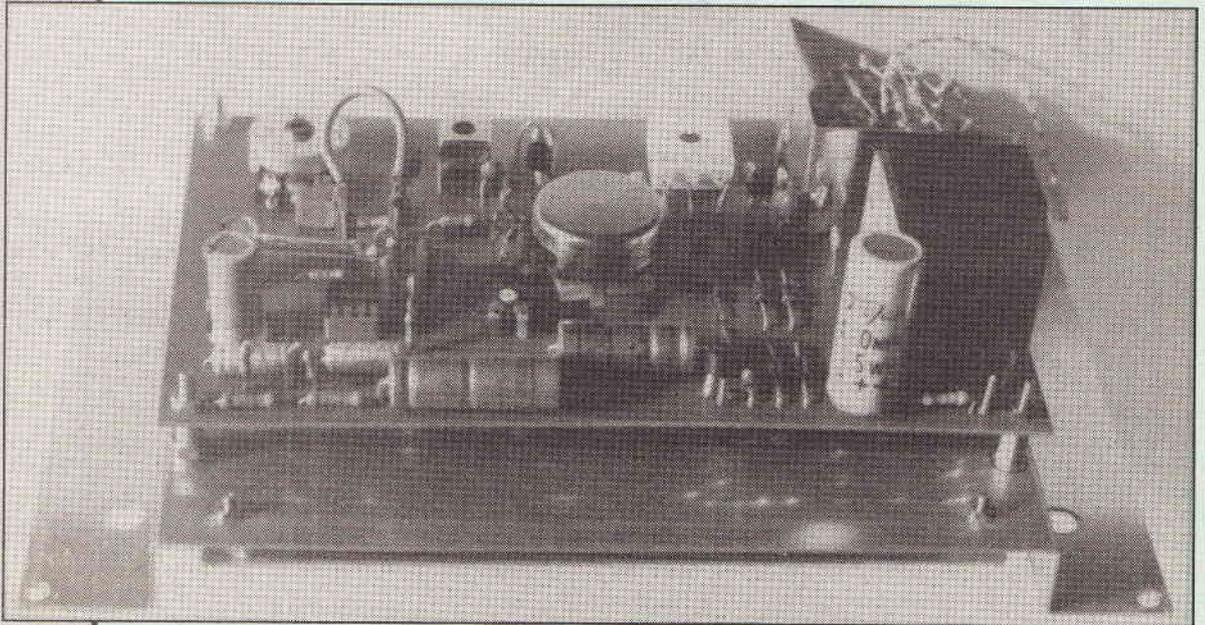
Construction

Except for the input and output connectors, SW1 and SW3, all the components are mounted on a standard PCB (16 x 10cm), which is fixed by means of 4 spacers to a subchassis. This subchassis is then fastened to the frontplate by means of the switches SW1, SW3, as well as the connectors for external modulation and the BNC HF outlet.

As for the drive and scale mechanism, several solutions are possible. The one used in the prototype simply consists of a Jackson SMD6 slow-motion drive for RV2, with its flange bolted to the subchassis. SW2 has a small screening panel, consisting of a folded strip of tin-plate 25mm high. The screening is soldered to three soldering tags at the points X, Y, Z, marked on the PCB. TR1 is a small printed circuit transformer.

The prototype is housed in a plastic TEKO P4 box. Although HF radiation from the assembly is not very obtrusive, it would be a wise precaution to provide internal screening of the box. A metal case would be suitable, but will be more expensive.

Very little initial adjustment is necessary, except for the tracking of the frequency scale. This is carried out by means of L1 and RV3. If a DFM is not available, the 10th harmonics can easily be traced on an existing FM tuner.



PARTS LIST

RESISTORS (all 1/4W 5% unless otherwise stated)

R1,2,11	47k
R3,4	15k91 (15k+90R)
R5	560R 1%
R6	330R 1%
R7	10k
R8	6k8
R9,10	33k
R12,20,21,22,23	150R
R13,24	820R
R14	270R
R15,16,17,18	100R
R19	68R
R25	3k3
RV1	2k2 linear
RV2	10k linear
RV3	2k2 preset
RV4	500R linear

CAPACITORS

C1,2	10n 1%
C3,4	100µ 25V electrolytic
C5	33n

C6	10n
C7	470n
C8	22p ceramic
C9	1n ceramic
C10	2n2 ceramic
C11,13	220µ 25V electrolytic
C12,15,16	22n ceramic
C14	470µ 35V electrolytic

SEMICONDUCTORS

IC1	NE5532 (or NE5534)
Q1,2	2SK55 (or BF256)
Q3	BC536 or similar
D1	BB204B (or KV1320)
D2	16V (2 x 8.2V) Zener
D3-6	1N4002
D7	LED

MISCELLANEOUS

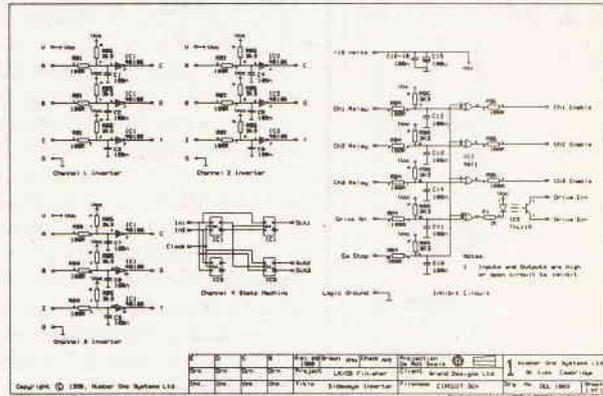
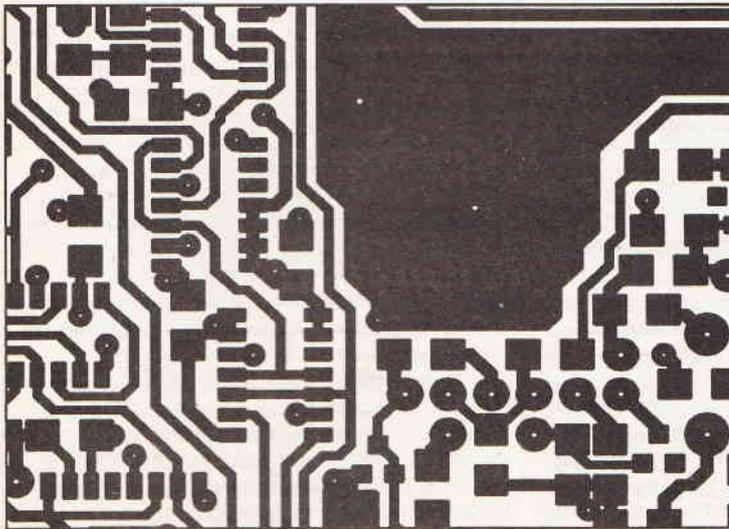
L1	5.5 - 10µH ANK 3334R (Toko)
SW1	SPDT toggle switch
SW2	1-pole 12-way rotary switch
SW3	SPST toggle switch
TH1	Thermistor RA53
TR1	15V, 1.5 VA printed circuit transformer
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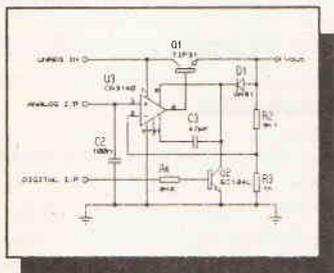
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TESTING, TESTING

Mike Barwise continues his analysis of fault finding techniques, taking a faulty amplifier as an example.

TEST GEAR

In June I left you taking measurements of the working conditions of our megaphone amplifier. Let's recap a little and go over the method together.

How much supply current is drawn?

Before you start testing, ground the amplifier input to prevent 50Hz mains pickup interfering with our DC measurements. The first test is to work out how much power the amplifier should draw from the supply under worst case no-signal (quiescent) conditions, and check whether it actually draws more than this.

Referring to our circuit diagram (Figure 1), we can work through from input to output adding up the currents drawn. Stage one (around Q1) consists of about 65k and 1k6 in parallel, drawing not more than 11mA total. Stage two (around Q2) is identical, so that's another 11mA. If Q3 is fully ON, about 120mA will flow in R13, so our total rises to 144mA. Assuming the biasing of the output stage (Q5, Q6), adjusted by Q3 and VR1, is not grossly incorrect, the worst case current in the output stage will be only a bit more than the feedback current through R5, R4 and VR3. The feedback current is around 10mA, so let's say a total of 20mA, making the grand total 164mA: less than 200mA. This is quite a crude approximation, but we are interested in whether the circuit is drawing amps or is behaving normally.

very much damage. The reading is taken by keeping your finger on the power supply on/off switch and estimating the proportion of the scale swept by the needle. If full scale equals 5A and the needle moves about a third of the way across the scale, the current is about 1.6A. Ideally, using a 5A range, you should see very little movement of the needle (about 1/25 of the scale). If you see this, it is probably safe to keep the power supply on as you change down the meter current ranges until a good reading can be obtained. As a precaution, put a finger on the transistor heat sink to check that nothing is getting hot. Obviously, if you get a significant reading on the high current range, *switch off the power immediately*. The general setup for this test is shown in Figure 2.

Why not use a digital meter here? The risky thing about this measurement is the time during which excessive currents are flowing; the exact value of current is much less important. The digital meter returns a reading about three times a second, and under fault conditions the excessive current is likely to change in value. You therefore have to read and interpret changing digital information, which the brain is not particularly quick at. The spatial information provided by the moving needle is far less precise, but much quicker to assimilate. In fact, it can take as much as 2.5 times as long to obtain a reading from a changing digital display as from an analogue meter needle. In that time, your circuit fault has done more damage.

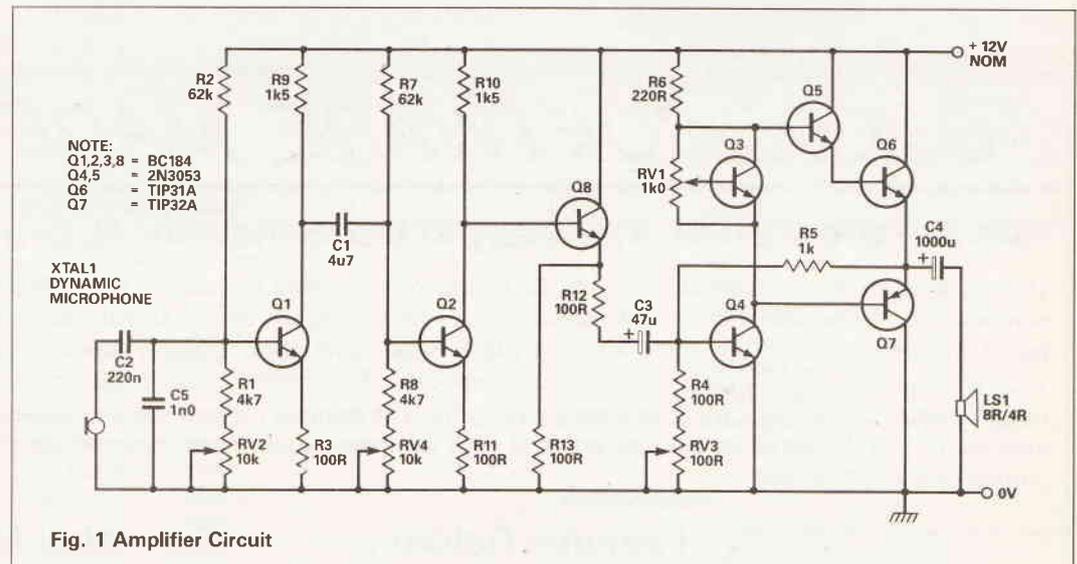


Fig. 1 Amplifier Circuit

The test is best performed quickly (to prevent damage if massive currents are drawn), so a tough instrument with a quick response is needed. The perfect tool is the analogue meter, which should be set to a scale which will protect it against damage: if your power supply can deliver 1A, set your meter to its 5A or 10A range. The meter is connected in series with the supply to the circuit under test before the power supply is switched on.

When power is applied, there will probably be an instantaneous surge current higher than predicted while the capacitors charge up, and the meter needle will overshoot a bit. However, it should be possible to take a reading of adequate precision within 1.5 seconds, which is not likely to be long enough to cause

DC Measurements

Let's assume that in our case the amplifier passes the supply current test, so we can continue taking measurements. The next task is to check the bias adjustment of each stage in turn, comparing the measured results with our predictions of last month. The perfect instrument here is the digital voltmeter. It is precise, practically non-intrusive (10M compared with less than 65K) and quick enough to use, as the measured voltages should not be changing at all. Make no adjustments on the first measurement run. Just check and record what is going on. Table 1 shows the recommended sequence of DC measurements and some results which might be obtained.

Table 1

Q1 collector to GND	6.1V
Q1 emitter to GND	0.39V
Q1 base to GND	1.04V
Q2 collector to GND	5.9V
Q2 emitter to GND	0.41V
Q2 base to GND	1.06V
Q8 emitter to GND	5.25V
Q4 base to GND	0.6V
Q6, Q7 emitter to GND	6.2V
Q5 base to Q7 base	1.1V

Looking at Table 1, we can tell whether the DC conditions of this amplifier are correct. Note that most readings have been taken to two significant digits, and none to more than three. Component tolerances override any greater resolution than this.

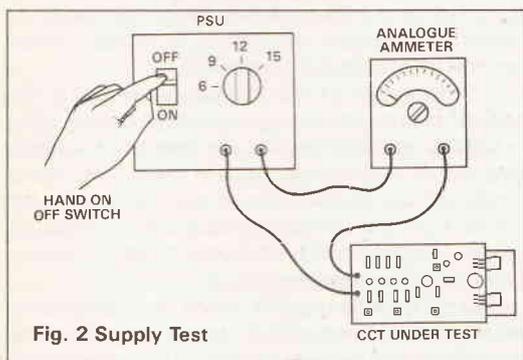


Fig. 2 Supply Test

Note also the logical progression from input to output of the amplifier when taking readings. This is a good idea so that you can keep track of your efforts in case you get distracted.

Let's see whether these readings make sense. Remember that we are trying to achieve mid-rail potential at the collectors of Q1, Q2, and at the emitters of Q6, Q7. Looking at Table 1, we see that our readings are 6.1V, 5.9V and 6.2V respectively. These are all within 5% of the desired 6.0V, so they will do. The Q1, Q2 emitter voltages are also within about 5% of 1/15 times the collector voltages, so they too are adequate. The base voltages of Q1, Q2 and Q4 are all approximately 0.6V more than the emitter voltages, which is what we would expect of silicon transistors with functional base-emitter junctions. Q8 being a voltage follower, its emitter voltage should be V_{be} less than Q2 collector voltage, and it is. The output stage crossover distortion is controlled by the differential base bias developed across Q3. This voltage is a little unpredictable, but should be in the region of two times V_{be} , or just over 1V. Yet again, it is. So all DC conditions are within limits, which implies all transistors and resistors are nominally functional.

AC Measurements

This leaves the AC circuit conditions and AC-only components — the capacitors. You could take them all out and test them, using an ammeter and battery (at least 6V) for short circuit test and a dedicated capacitance meter to check their values, but it is simpler to apply a signal to the amplifier (now you know it won't blow up!) and trace the signal through. First you need to work out a safe input signal. We know the amplifier has an overall AC gain in the region of >1000 ($15 \times 15 \times 10$, less losses), and the peak-to-peak output signal will be about a volt in each direction short of supply rails. An output swing of 9V peak-to-peak off a 12V supply would be a good guess. This would predict a 9mV peak-to-peak signal for a gain of 1000, so let's be safe and say 5mV peak-to-peak in.

It is unlikely that a cheap signal generator will allow you accurate adjustment down to this level, so a better bet is to set-up a reliable signal an order larger (say 100mV peak-to-peak) and reduce it using an external multi-turn potentiometer. The multi-turn pot allows accurate adjustment even when you are reducing by a factor of 10 or 20. If you are poor, a fixed resistor and single-turn pot may be wired up together instead. The alternative rigs are shown in Figure 3.

We must now consider the value of this potentiometer. It must be able to deliver enough current from its wiper to drive our amplifier input without its set up point being dragged around by the load. The general rule is that at least ten times the output current must flow in the potential divider.

Disregarding any series reactance in the input capacitor C2 (that is, assuming the input frequency is well within the flat response area of the amplifier), the first stage input impedance will effectively amount to the parallel combination of R2 and $R1 + VR2$. Why? R2 is connected between input and positive supply and $R1 + VR2$ is connected from input to negative supply. Theoretically, supply rails have zero impedance to ground, and so both supply rails look like grounds. R2 and $R1 + VR2$ are effectively connected between the input and ground, so they are in parallel. The amplifier input impedance can therefore be considered as $1/(1/10K + 1/62K)$ or about 8K6. The average cheap signal generator has a standardised audio output impedance of 600R, and the nearest standard pot value which is not less than this is 1K, near enough not to matter. So you need a 1K ten turn pot across the output of your signal generator, with the wiper supplying your output signal.

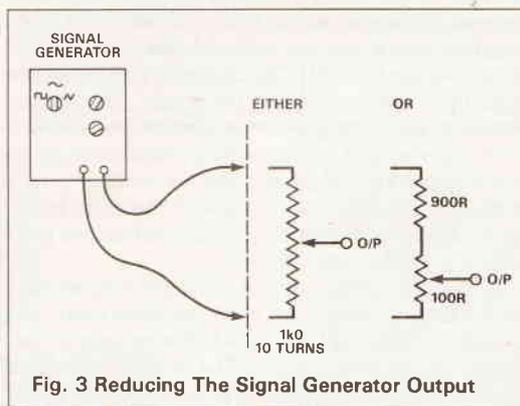


Fig. 3 Reducing The Signal Generator Output

The AC tests all use the oscilloscope as you will be testing the amplifier in the audio frequency range (100Hz to around 16kHz). As you are fault finding, you need to compare what you expect with what happens. The amplifier under test will be traced from input to output, making comparisons between what goes into each stage in turn and what comes out. At each stage, the output of the previous stage is the reference for the next test. So you will use the 'scope in *dual trace mode* with two probes. Channel 1 becomes the input or reference signal channel, and channel 2 the unknown signal channel. There are two display modes when working with dual trace: *chop* and *alternate*. Chop mode time-slices two slow seeps simultaneously, and alternate mode displays trace 1 followed by trace 2. Some 'scopes make the choice for you according to the setting of the timebase, but if you can choose, choose chop, so that both traces appear to be simultaneous at the low scan speeds we are using.

How low are these speeds? Audio equipment is normally tested starting at a standard test frequency of 1kHz. At one cycle per cm (horizontal division) the

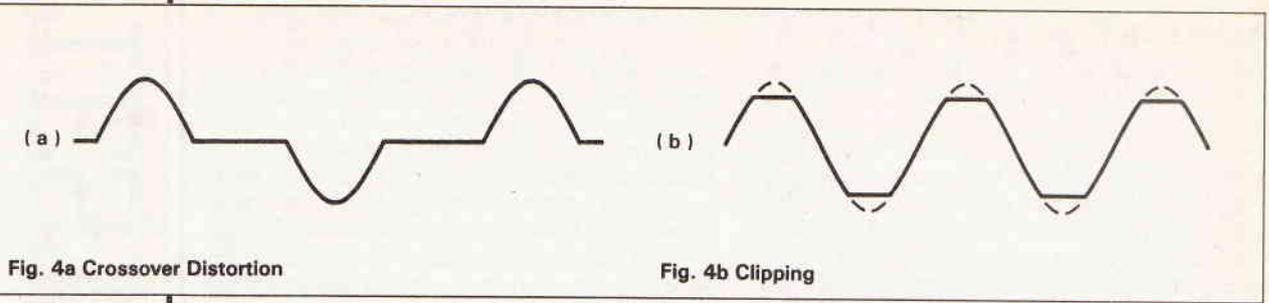


Fig. 4a Crossover Distortion

Fig. 4b Clipping

trace crosses the screen in 10ms, making 100 retraces each second (the same as UK television). However, if you use alternate mode, each trace will refresh 50 times per second, which will result in visible flicker. Apart from the headache you will get, it will also be quite difficult to compare the two traces, as they will fade alternately.

What sort of probe do we need? The general purpose X10 probe with a 10M input impedance has a bandwidth stretching to 250MHz or so, which we don't need. We don't really need 10M either, as the highest impedance in our circuit is the input impedance of less than 10K. However the 'scope needs about 1cm of vertical trace to trigger reliably, and you need about the same to take any sort of meaningful voltage reading. The average 'scope has a maximum vertical amplification of 5mV/cm. The X10 probe would require a 50mV peak-to-peak signal to deliver this to the 'scope input, which you haven't got at the amplifier input, so use two X1 probes.

Now to make our measurements. First set up the input signal on your signal generator before connecting it to the amplifier under test. Set up about 100mV at the signal generator output, using your 'scopes as the measuring tool, and using the most sensitive range you can without losing part of the track. Use the Y POSITION control to shift the whole trace up or down until it fits the screen. The normal 'scope screen has eight vertical divisions, so you will probably use the 20mV/cm setting, displaying a signal five divisions high. Make sure that the continuous trim control (frequently concentric with the main range knob) is in the calibrated position, otherwise your readings will be meaningless.

Measuring the 5mV out of the pot may be quite tricky as you cannot get a display taller than 1cm unless you have a X5 multiplier button on your 'scope. If not, use the ten-turn pot. The large, wire-wound types cost between £5 and £10 and are very linear, so you can set up your signal by just counting turns. The whole pot is across 100mV, so one turn makes a change of 10mV, and your pot wiper will be set one half turn from the bottom. If you have to go for the fixed resistor/single-turn pot setup, the ideal fixed resistor would be 900R in series with a 100R pot. This would put your 5mV at about the mid-point of the pot. The real fixed resistor would have to be 820R + 82R in series, and this rig would be a throw-away after the job was done. Make sure that the output frequency of your signal generator is in the region of 1kHz ($\pm 10\%$ is quite good enough), and that the waveform is sinusoidal.

Apply power to the amplifier before you input your signal. Many devices, particularly high speed ICs, can be destroyed in milliseconds or less by signals in the absence of power supplies. Destruction is most often caused by the forward biasing of diode junctions which are not current limited while the power is off, leading to burn out, or by 'latch up' conditions in which positive feedback locks the circuit into self-destructive saturation. Similarly, in the presence of power, signals should never swing more positive or negative than the respective supply rails. In the absence of power, any

signal will exceed these limits!

Make sure there is no load at the amplifier output, the power on. Attach the 'scope probes to the signal generator pot output and to the input of stage 1 at the Q1 base. Input the signal, preferably by keeping the signal generator switched on and making the connection with a croc clip lead or similar. (This prevents switch-on transients in cheap signal generators wrecking the amplifier).

What do we do with the grounding clips of the probes? For circuits of low gain, one clip would suffice to refer the probes to ground. However, this is a high gain circuit, and voltage drops in the ground circuit could well be amplified to give dodgy results. So connect the ground clip of each probe to a ground reference point on the circuit under test as near as possible to the measurement point.

Look at the two signals. For the best comparison, set the vertical range of both 'scope channels to the same figure and then use the vertical position controls to superimpose the two traces. If they are indential, you should see a single trace. There will, of course be a very slight attenuation due to the potential divider to AC formed by C2 and C5, but the effect will be a reduction of less than 0.5%, so it probably won't show. There will of course be a small DC offset (quiescent base potential).

Next, move probe 1 to the base of Q1 and probe 2 to the collector of Q1. You will need to change vertical range on channel 2, because you've got a stage gain of about $\times 15$. A rough approximation of stage gain will do: you either have a gain of $\times 10$ to $\times 15$ which is OK, or you have vastly less. There will be substantial DC offsets here (virtual ground or mean collector potential is +6V!) so use AC coupling at the 'scope input. Supposing this test result is acceptable, move probe 2 to the base of Q2. The presence of a similar signal minus its large DC offset is proof of functionality.

Now you can move probe 2 to Q2 collector. Again the previous considerations apply. Suppose we see a signal. Move to the output end of R12. Signal present. The next test point is the base of Q4. NO SIGNAL!!

Bingo!

Where do we go from here? Suspect C3 as open circuit. This is not very common, but it happens. Turn off all signals and power, get out the soldering iron, and remove C3 from circuit. In the process, it leaves one of its leads stuck in the board. That's it! The lead must have broken off inside the case. Fit a replacement capacitor and carry on with your tests, repeating the test that failed. Now you have a signal at the base of Q4!

Save yourself some time. As you have found a fault, assume briefly that it's the only one, so your next test will be probe 1 at base Q1, probe 2 at emitters Q6, Q7. You were right! Plenty of signal. Careful measurement now gives you a figure for the gain of about 1400, calculating on the basis of peak-to-peak readings.

Adjusting Crossover

The final task is to operate the amplifier under load, and to adjust the crossover distortion (VR1, Q3) to a minimum. The absolute amount of crossover distortion is determined by the time it takes for the output transistors to turn on or off compared to the slew rate of the signal you are trying to reproduce. Transistors appear to operate slower under greater loads, so it follows that the worst case demonstration of crossover distortion will be under maximum load and high frequency signal conditions. For now we will ignore the inductive component of a speaker, and test the circuit with a purely resistive load. The aim of the test and adjustment is to minimise the distortion by control of VR1 without causing the output stage to dissipate too much quiescent current.

The principle here is as follows: if the output stage transistor pair was not differentially biased (bases at same potential), there would be a midpoint range of signal swing (equal to $2V_{be}$) over which neither transistor was conducting, so the resulting output waveform would look like Figure 4a. Q3 with VR1 acts as a variable voltage drop which will cause the bases of Q6, Q7 to stand at different voltages. The ideal quiescent condition is with the Q6 base above virtual ground by about 0.5V and Q7 base above virtual ground by the same amount. Both transistors will just conduct under quiescent conditions, so that at no time are they both cut off. Excessive differential bias would cause a large quiescent DC current to flow from V+ to real ground via Q6, Q7, heating them up to no purpose and wasting power.

Our first step is to set up a signal near to the maximum frequency the amplifier will pass, and to check that this signal is still at 5mV peak-to-peak. The upper frequency limit of the amplifier is effectively set by the parallel capacitor C5. When the reactance of C5 equals the input imped-

ance of stage 1, the signal will be -6dB (50% amplitude in volts peak-to-peak). The reactance formula is:

$$X_c = 1/(\pi f C)$$

where X_c is in ohms, f is in Hz and C is in farads.

We can call the input impedance 10k, which simplifies the calculation. The result is 15.9kHz, say 16kHz. Since the capacitor reactance provides a roll off of 3dB/octave, a test frequency of 8kHz would give us a good result with about -3dB. The input signal swing can therefore be increased by a factor of 1.4 (-3dB is 0.7 V_{in} peak-to-peak), giving 7mV peak-to-peak in. The amplifier output signal should not be allowed to clip (Figure 4b). The load for this test will be a 4R7 resistor (nearest preferred value over 4R) with a power rating of at least 10W, so that it will not get hot during the tests.

Do not connect the resistive load yet. Set VR1 at mid position, connect the 'scope probes to Q4 base and the emitters of Q6, Q7, switch on the power and apply the input signal. The two 'scope traces should be adjusted until they are about the same size on the screen, and the crossover distortion minimised by adjustment of VR1. Remember that overcompensation will cause excessive output stage quiescent current, so apply just enough bias to eliminate the distortion. Having set VR1 by eye, connect the resistive load to the amplifier output and confirm the level of distortion. It will have increased slightly, and a minor readjustment of VR1 may be needed. However, remembering that this is a public address megaphone (not for music) a degree of crossover distortion is acceptable, as it does not reduce clarity until it is quite bad.

The whole process should have taken about an hour or so. You have now traced and repaired the fault and set up the amplifier for your customer.

TEST GEAR

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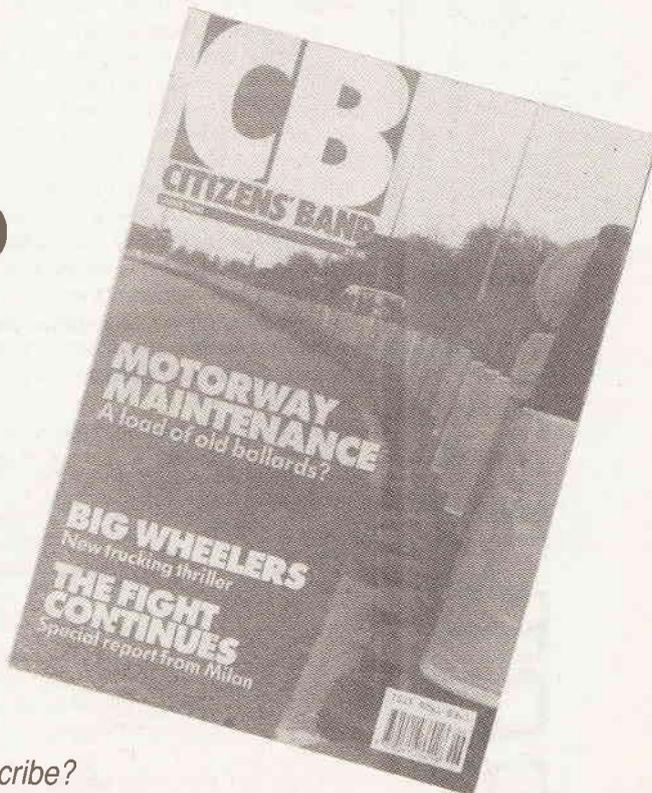
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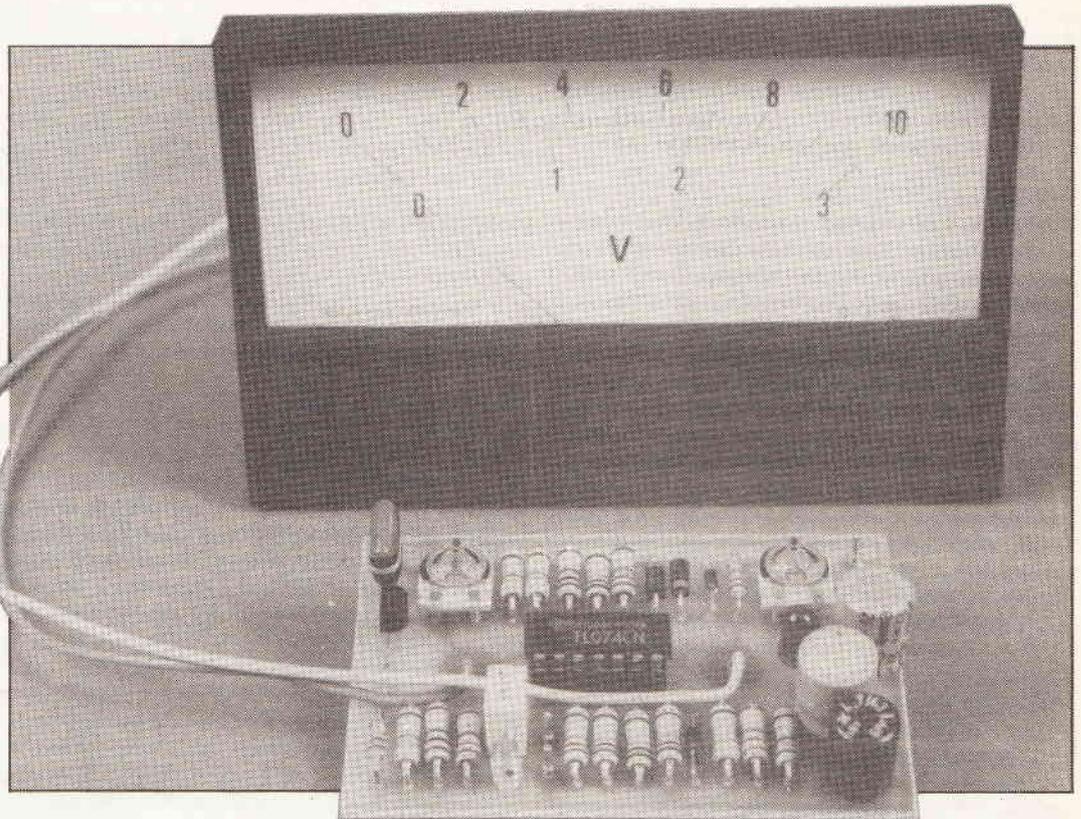
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AC MILLIVOLTMETER



Analogue meters still have their place in a digital world. Steve Bateson provides a project for a high-performance AC Millivoltmeter.

PROJECT

Although most modern voltmeters have digital displays and complete modules are available at a very low price, the analogue meter still has an important place in data presentation; so much so that some digital displays now emulate analogue types by being constructed as 'bargraphs'.

Digital displays have obvious advantages when measuring steady or slowly varying quantities because they are easy to read, have good resolution and do not suffer from non-linearity or hysteresis as do mechanical meters. They are, however, much less effective at displaying dynamic variables such as audio signal level (imagine a digital-display VU meter!) or general trends such as rate of acceleration. They are also quite unsuitable for indicating null adjustments in bridge circuits.

In general, an analogue display is easy to assimilate roughly, but difficult to read exactly. Within these guidelines, the display can be chosen to suit the application.

Frequency Response

Conventionally, AC meters enjoy a 'precision rectifier' configured around an operational amplifier to remove errors due to diode forward voltage drop. This works very well at low frequencies, but is quite inadequate at frequencies above a few kHz. For example, the rectifier of Figure 1(a) reads around 10% low at 60 kHz and 50% low at 200 kHz. This is mainly due to the limited gain-bandwidth product of most operational amplifiers, but also in part to diode and stray capacitance effects. Germanium diodes are often specified for their low forward voltage drop and low capacitance but are actually quite unsatisfactory due to their excessive and highly temperature-dependant reverse leakage. More sophisticated rectifier circuits employing current mirrors are used in true RMS chips and audio circuits such as the NE570 series.

Meter Overload Protection

Another area generally overlooked in conventional meter drive circuits is that of meter protection. The normal implementation is a diode in parallel with the meter movement (Figure 2) but as many voltmeter movements are specified with a maximum overload limit of only 200%, it is clear that this arrangement

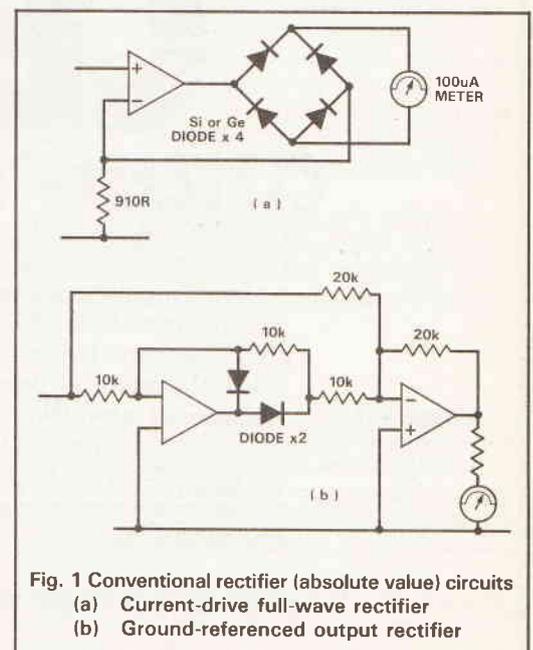


Fig. 1 Conventional rectifier (absolute value) circuits
(a) Current-drive full-wave rectifier
(b) Ground-referenced output rectifier

is adequate. Diodes conduct significantly at forward voltages well below the nominal 'threshold voltage', so we are faced with the unsatisfactory choice of meter non linearity due to diode conduction or inadequate protection. For this project, good meter protection is essential so a simple but very effective system was devised.

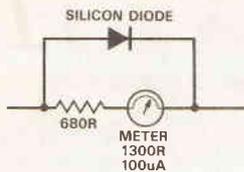


Fig. 2 Typical meter overload protection circuit (parallel diode)

Half-wave, Full wave, RMS, Peak...?

Most meter rectifiers are full-wave arrangements but I decided against this for two reasons. Firstly, full-wave arrangements can compromise high frequency performance, either because the operational amplifier now has two diode forward voltage drops to jump when crossing zero (Figure 3a) or because propagation delays cause the two half-waves to shift out of phase (Figure 3b). Secondly, full-wave rectification is only essential for detecting the peak values of unsymmetrical waves, an important parameter for compressor-limiters but less relevant for instrumentation. This meter driver uses a half-wave average-reading rectifier calibrated for sinewave RMS as usual.

Construction And Testing

The circuit diagram is shown in Figure 4 and the layout in Figure 5. The PCB was designed for use with the RS meter movement type 259-763 but can easily be modified for use with other movements.

As Figure 5 shows, construction is straightforward and the board mounts directly onto the meter terminals. Alternative configurations are possible and you may wish to include a true RMS chip such as the AD636 or omit the rectifier for a protected DC meter. For the most reliable performance however, this PCB layout is recommended. As usual, small components should be mounted first. Pins are convenient but not essential for external connections.

Assuming a multimeter is available, it is a good idea to replace the movement with a 910R resistor while testing, and measure the output voltage of IC1a. Bridge the module input terminals with a short wire, set RV1 and RV2 mid-way, check the supply

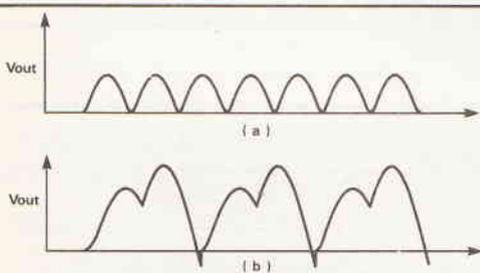


Fig. 3 High-Frequency limitations of simple rectifier circuits

- (a) Slew-limited waveform distortion
- (b) Propagation distortion (phase-shift error)

wiring and apply power. Set the output offset to zero with RV1. Remove the input short, apply a 50mV sinewave signal at about 1kHz and observe the output reading (about 50mV). Increase the input level. At about 150mV output, the LED should light and the output drop suddenly to less than 10mV. Gradually reduce the input until the protection circuit resets; the output should now read about 130mV. This confirms circuit operation. Remove the test resistor and install the meter movement.

Calibration

You can calibrate this meter using an ordinary DC

meter (preferably digital!). The calibration voltage chosen corrects for both the average/RMS form factor and the half-wave rectification.

Firstly bridge capacitor C1 with a short wire. Check that the meter mechanical zero is correct and apply power. Adjust RV1 for zero deflection at zero input. Apply 45mV DC to the input and set RV2 for 100% deflection. Remove the bridge and re-adjust RV1 to zero the meter again. To overcome meter hysteresis it is often necessary to tap the case gently until the reading settles.

Power Supplies

The module consumes relatively little current and the prototype was powered from two PP9 9V batteries. As they supply a similar current, the zero adjustment drifts very little with time. You can of course run the meter from a mains-derived supply, using standard regulators, anything between $\pm 5V$ and $\pm 15V$ will do.

Options

One option which could be included in a mains-operated version is an AC 'wobble' circuit. A common limitation of the mechanical meter is hysteresis due to bearing friction. By adding a suitable AC component to the meter drive signal, the armature can be vibrated to equilibrium at each angular deflection — more elegant than tapping the meter glass! The technique has been used in com-

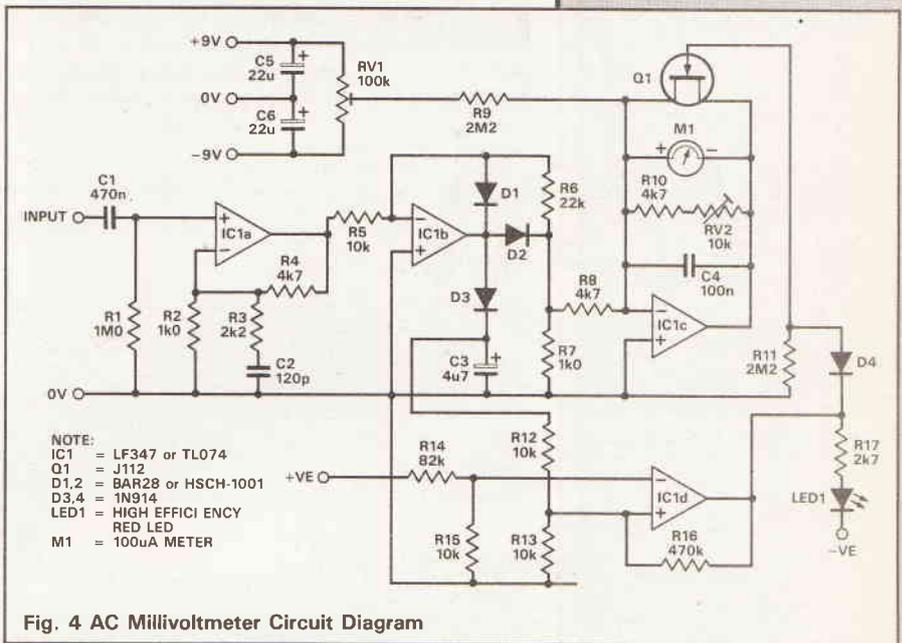


Fig. 4 AC Millivoltmeter Circuit Diagram

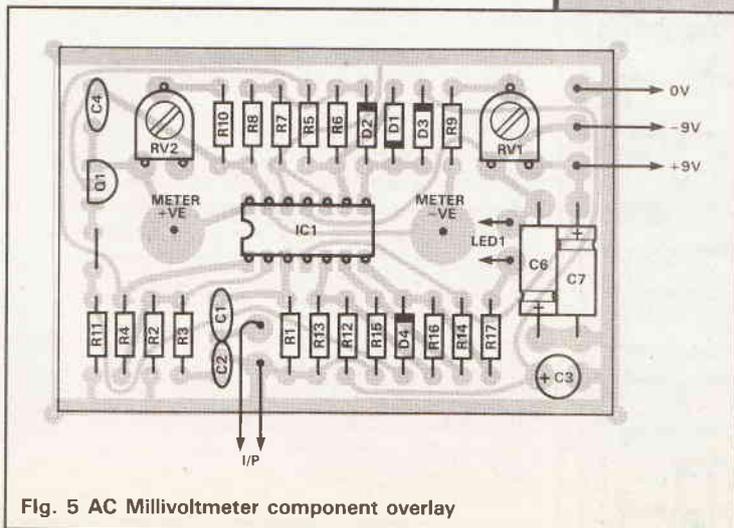


Fig. 5 AC Millivoltmeter component overlay

mercial instruments and published designs. It is easily implemented here with the circuit of Figure 6. Finally, if you wish the meter to respond down to DC, simply replace C1 with a wire link.

Dr Bateson is a senior lecturer at the Instrumentation and Control Division, school of Information Engineering, Teesside Polytechnic.

HOW IT WORKS

The circuit diagram of this instrument is shown in Figure 4. IC1 is a quad BIFET operational amplifier type LF347 which has a relatively high slew rate but needs no compensation.

The first stage is a straightforward AC coupled amplifier with a high input impedance and moderate gain about 6. A small amount of HF compensation is applied to offset the cumulative effects of stray capacitance and op-amp bandwidth, giving an overall frequency response flat to 300kHz. The full-scale input level is 100mV RMS sinewave. If greater sensitivity is needed a preamplifier stage should be built since increasing the gain of IC1a will degrade its frequency response.

IC1b is configured as a precision rectifier using Schottky barrier diodes. These have a low forward voltage drop less than (400mV) and low leakage. However, alone they are insufficient to ensure good HF response; stray capacitance and the circuitry around IC1c degrades the rectified waveform. The rectifier is therefore loaded with a relatively low impedance which shunts capacitive charge to ground. A low stage gain ensures good bandwidth, while the high output level, around 1V peak, reduces low-level offset errors.

IC1c is the current-mode meter driver. A full-scale current of about 120A (average) is partly shunted by the 'sensitivity calibration' preset. Since the LF347 has no offset adjustment, a small offset current is available from the 'set zero' trimmer RV1. Current-mode operation gives fast meter response since the meter movement is undamped, and a small meter bypass capacitor is fitted. This component is essential, not for low-frequency smoothing but rather because of the meter inductance which would otherwise require excessive voltage excursions from IC1c to maintain the meter current at high frequencies.

IC1d and Q1 provide meter protection. IC1d is a voltage comparator fed from the rectifier stage. The comparator threshold and hysteresis are set so that overload protection is tripped at 150% deflection and reset at 130%. Q1 has extremely low leakage normally but when switched on shunts the meter, reducing the sensitivity by about 95%. The meter movement is then protected and heavily damped, but still responds to trends. LED1 flags the overload condition.

SPECIFICATION

Frequency Response 30Hz (or DC) to 300kHz, -1%; (to 600kHz sine, -3dB)

Reading Average-reading meter (ARM) calibrated RMS sine wave

Input sensitivity 100mV RMS

Input impedance 1M / <10pF

Power Consumption

(i) No deflection +8.4 / -8.4 mA
(ii) 100% deflection +9.1 / -8.5 mA
(iii) 30x overload +19.1 / -15.1 mA

Dynamic response bandwidth 0 - 1.4Hz, -3dB (using specified meter)

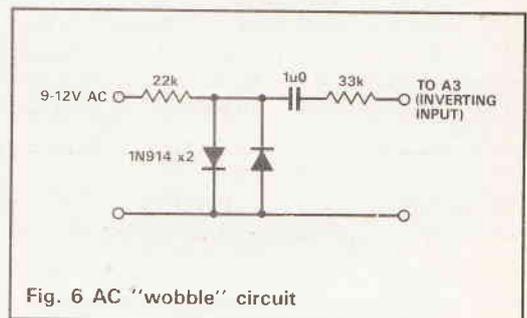


Fig. 6 AC "wobble" circuit

BUYLINES

The meter movement was obtained from RS/Electromail (0536 204555). Any 100µA movement could be used but the PCB terminal holes may not fit directly. All other components are commonly available from sources such as Maplin; any Schottky barrier diodes should work. Other N-channel FETs will also work, although their 'on' resistance may be higher.

PARTS LIST

RESISTORS All 0.6W 1% metal film

R1	1M0
R2	1k0
R3	2k2
R4	4k7
R5	10k
R6	22k
R7	1k
R8	4k7
R9	2M2
R10	4k7
R11	2M2
R12	10k
R13	10k
R14	82k
R15	10k
R16	470k
R17	2k7
RV1	100k cermet
RV2	10k cermet

CAPACITORS

C1	470n miniature polystyrene film
C2	120p miniature ceramic
C3	4µ7 25V radial
C4	100n miniature polystyrene film
C5,6	22µ 16V axial

SEMICONDUCTORS

IC1	LF347 or TL074
Q1	J112
D1,2	BAR28 or HSCH-1001
D3,4	1N914
LED1	high-efficiency Red LED

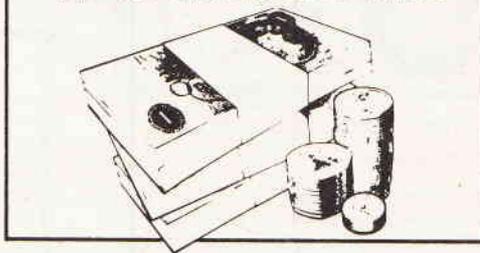
MISCELLANEOUS

Meter	100 µA movement type 259-763 (RS/Electromail)
PCB terminal pins	if required
14-pin IC socket	
PCB	
910R	1% resistor for testing

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Some new corrections . . .

Darkroom Timer (June 1990)

Pin 4 of IC1 should be connected to the main earth line. D1 +ve should be connected to the output F line, and should not connect to C1. The circuit diagram is correct, as are PCBs from the ETI PCB Service. The corrected foil pattern is printed in this issue.

Superscope (March 1990)

On Figs 13 and 14, the polarity of C409, 509 should be reversed.

20 Metre Receiver (January 1990)

On Fig. 4, C34 should be 100n, not 220u.

Smoke Alarm (November 1989)

On Fig. 2, SW2 and ZD1 should not be connected to C4 (0V), but to the 9V rail above C4.

Modern Diode Circuits 2 (July 1990)

Fig. 9 voltage quadrupler circuit. Diagrams a and b should be electrically identical. Drawing b is correct and a has been reproduced in this issue under Modern Diode Circuits 3.

And some we've printed before . . .

Feko Box (June 1990)

The foil pattern is printed at 50% actual size, and component side up. The correct foil pattern is included in this issue.

Elements Of Radio, Part 3 (May 1990)

On Fig. 2, the resistor on the output of F2 should be 1k5, not 10R. On Fig. 20, the top of the CT should be connected to switch SW1b, and the label 6 is missing from L13.

Business Bass Amp (March, April, May 1990)

In March: On Fig. 2 HI and LO inputs are wrong way round. The north button increases volume, the south button decreases it, and both buttons together zeros volume. Hitachi devices are rated for zero temperature coefficient. Q1-4 should be 2SK135.

In April: On Fig. 1, C5 should be 100p. On Fig. 2, Q2 should be PNP. On Fig. 3, the positions of the gyrator board should be:

Z8 Z9 Z10 Z11 Z12 Z7
Z1 Z2 Z3 Z4 Z5 Z6.

In May: On Fig. 2, pin 20 of IC1 also connects to the 5V supply, and C1 is the wrong way round. On Fig. 8, all dimensions except the fan hole are in inches, and should be divided by 10. A symmetrical supply of +63 and -63 should be on C1 and C2.

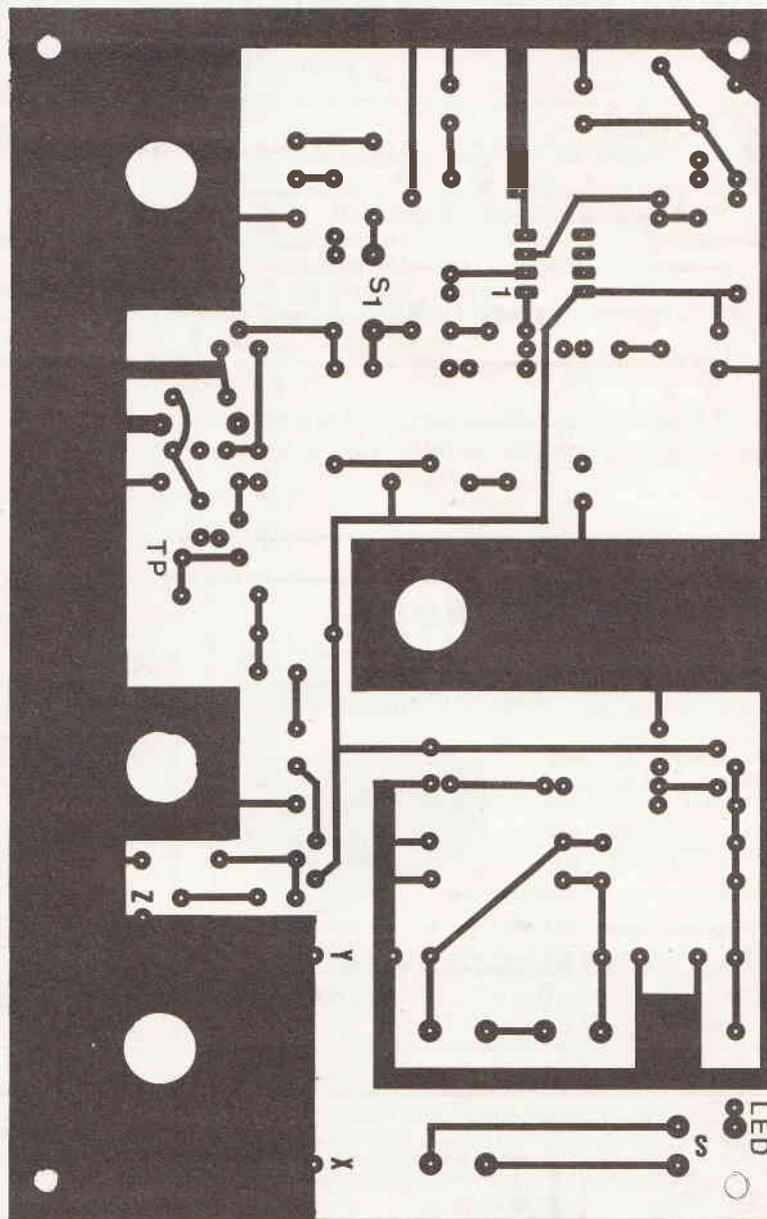
Superscope (February 1990)

Q302, 303 should be BC109C.

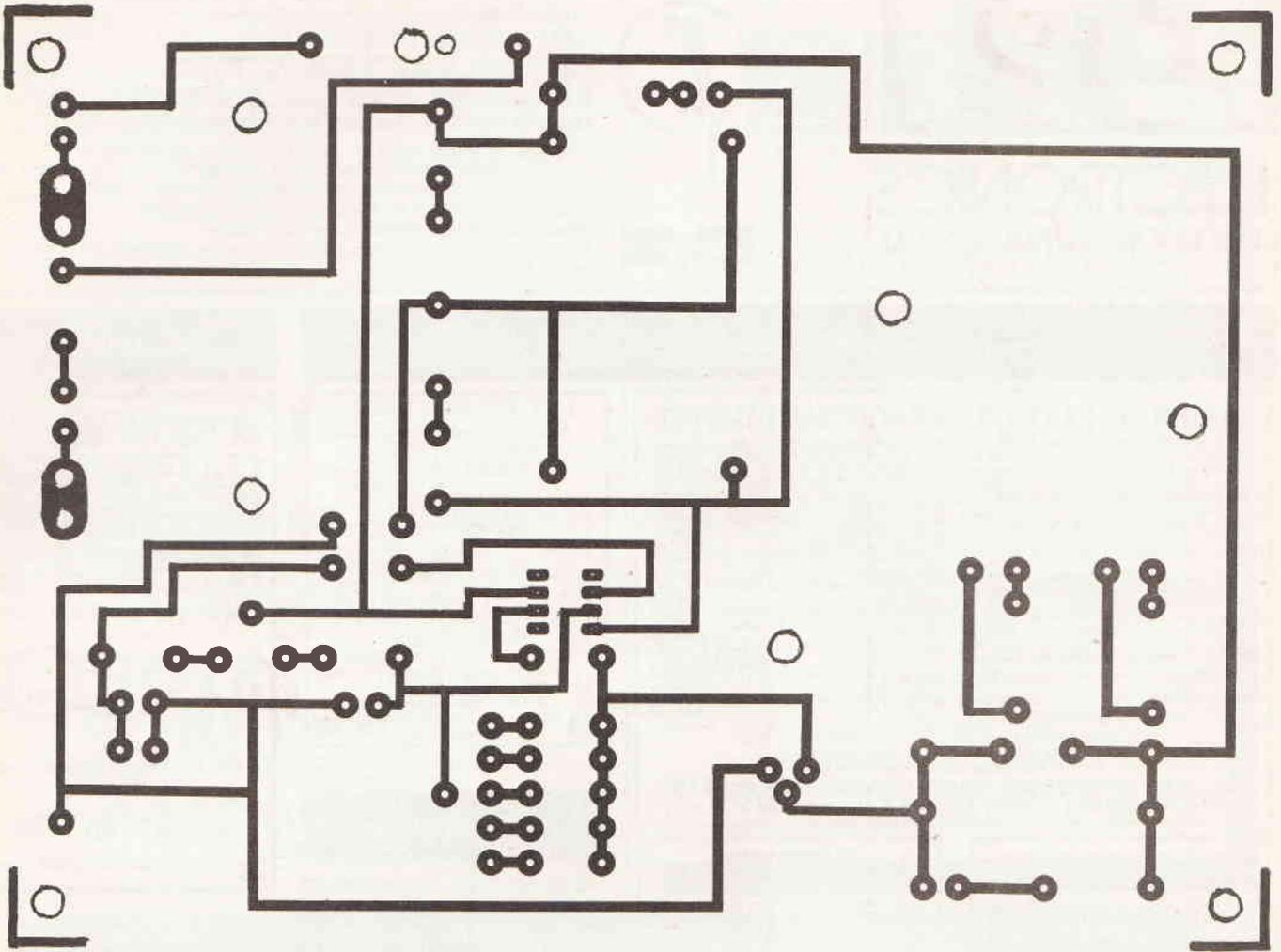
Fig. 3, does not show the polarity of diodes D105,6. The cathodes point up the page. Diodes D304 is a 1N4148. Capacitors in the deflection amplifiers parts list are incorrectly numbered and should be C205, 206, 213 and not C105, 106, 113.

Text refers to inductors L203, 204; these should be L201, 202. Inductors L101, 102, 201, 202 are wound on 100k 0.5W resistors. The value of R201 should be 820R. The PCB track connecting RV301 to R313 should be extended to the pad of link 17. The foil on page 60, for the motherboard is at 95% of full scale. TS2 should have 550 turns, giving 110Vrms.

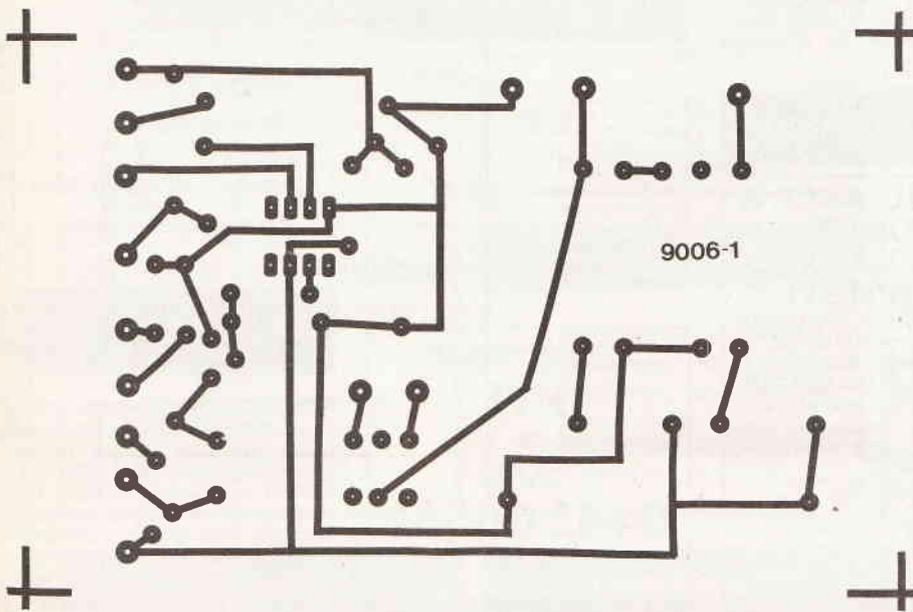
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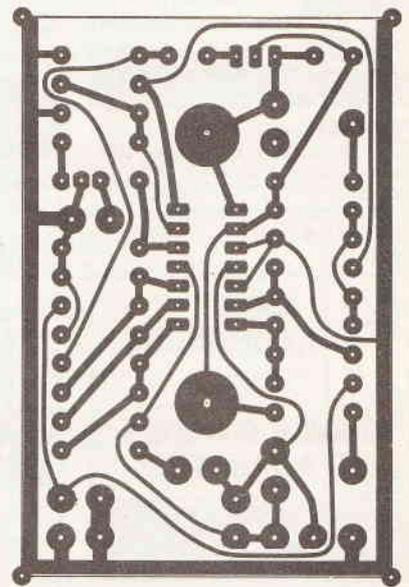
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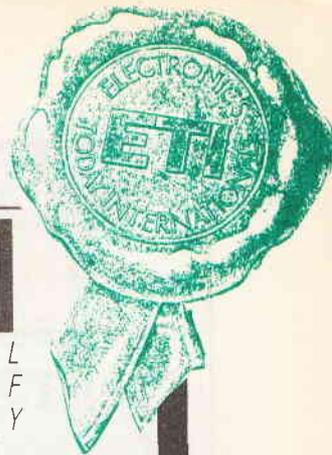
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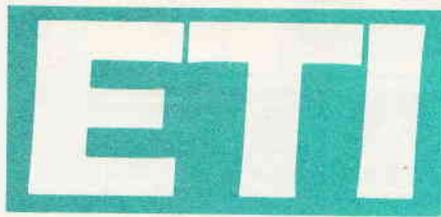
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NEXT MONTH

Once again, our September issue, will contain a mixed bag of goodies to keep you amused through the heat of the summer.

We present a feature on Data Communications to illustrate how our screen information gets from one place to another at high speed.

Also starting will be a series of features and projects based on microwave transmission, a subject kept much in the dark by electronics magazines.

How well does your video cassette recorder keep track of recorded programmes? The answer depends on programming the timer correctly and correct transmission times. Our feature on the subject will tell us that there are other, better ways.

On the projects front, there is slide projector controller to give a more professional presentation including cross fading slides and the ultimate diode tester giving simple clear indications.

All this and more including our final part of the series on diodes and the workings of a modern synthesiser. Order your ETI today and collect it on Friday August 3rd.

The above articles are in preparation but circumstances may prevent publication

LAST MONTH

Subjects covered in the July issue were:

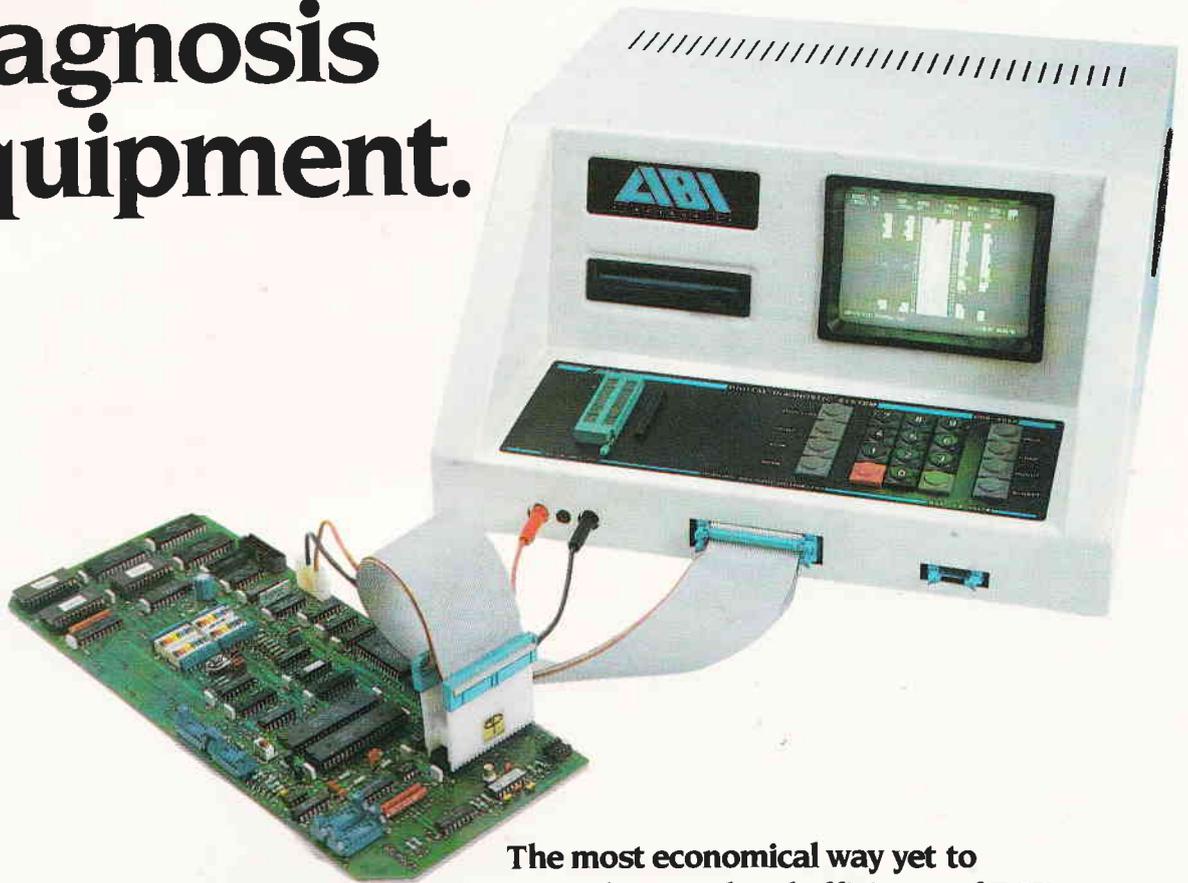
A compact digital frequency meter based on a single chip design. A footstep intruder alarm to protect your property or its destruction. A guitar practice amplifier to keep your melodic creations to yourself and some audio tech tips. Our features included, Harnessing the Wind, a guide to creating electricity from wind energy, extracting signals from noise and a round-up of PCB Design software.

If you missed the July issue, a limited number of back copies are available from Select Subscriptions (address on contents page).

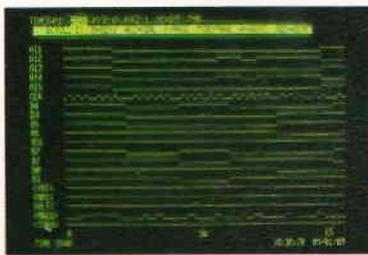
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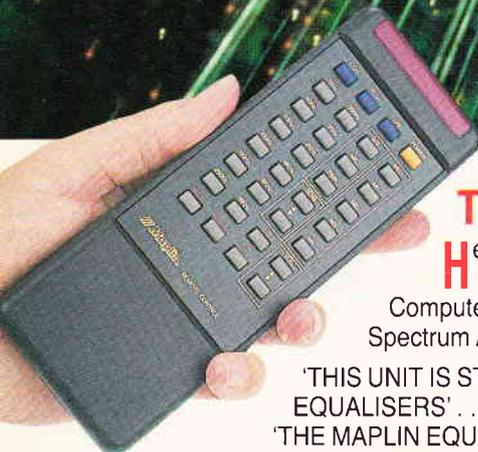
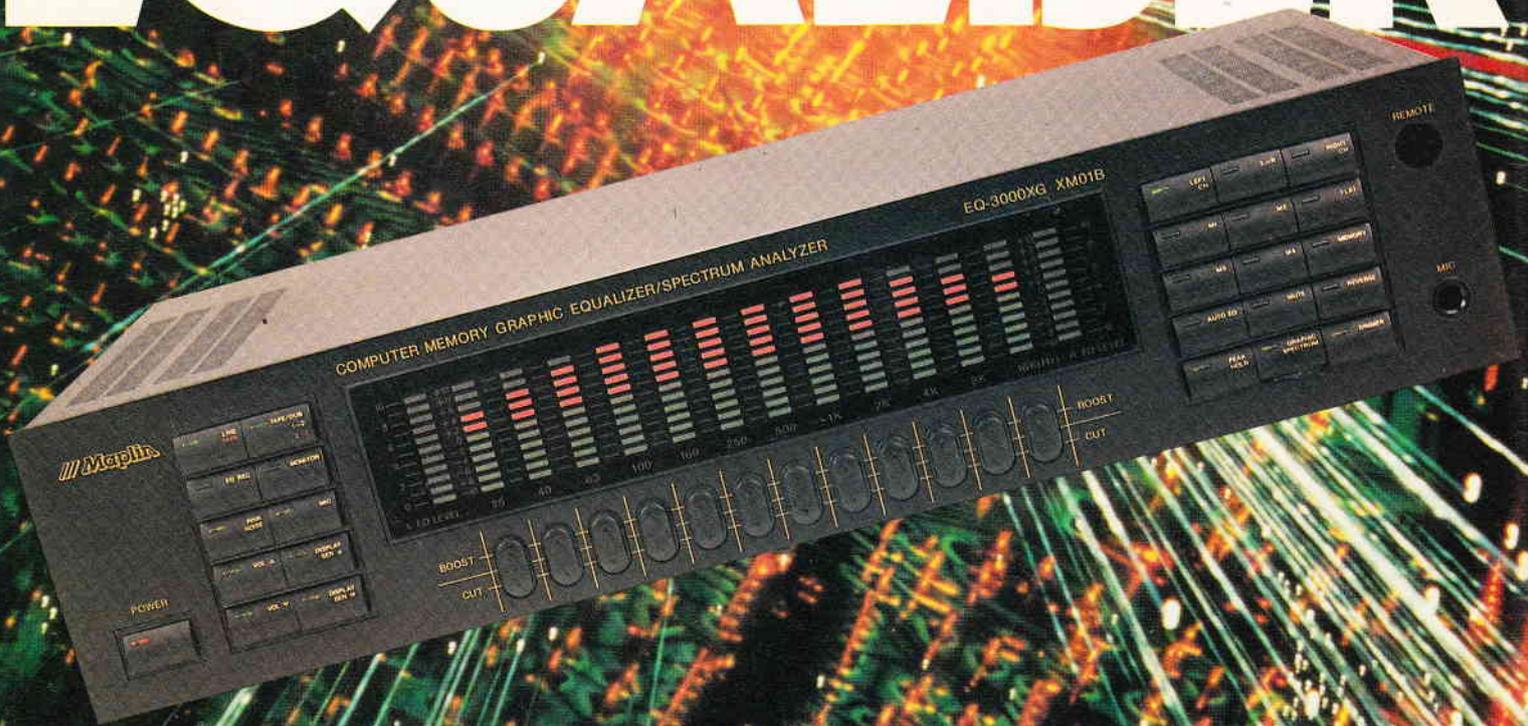
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