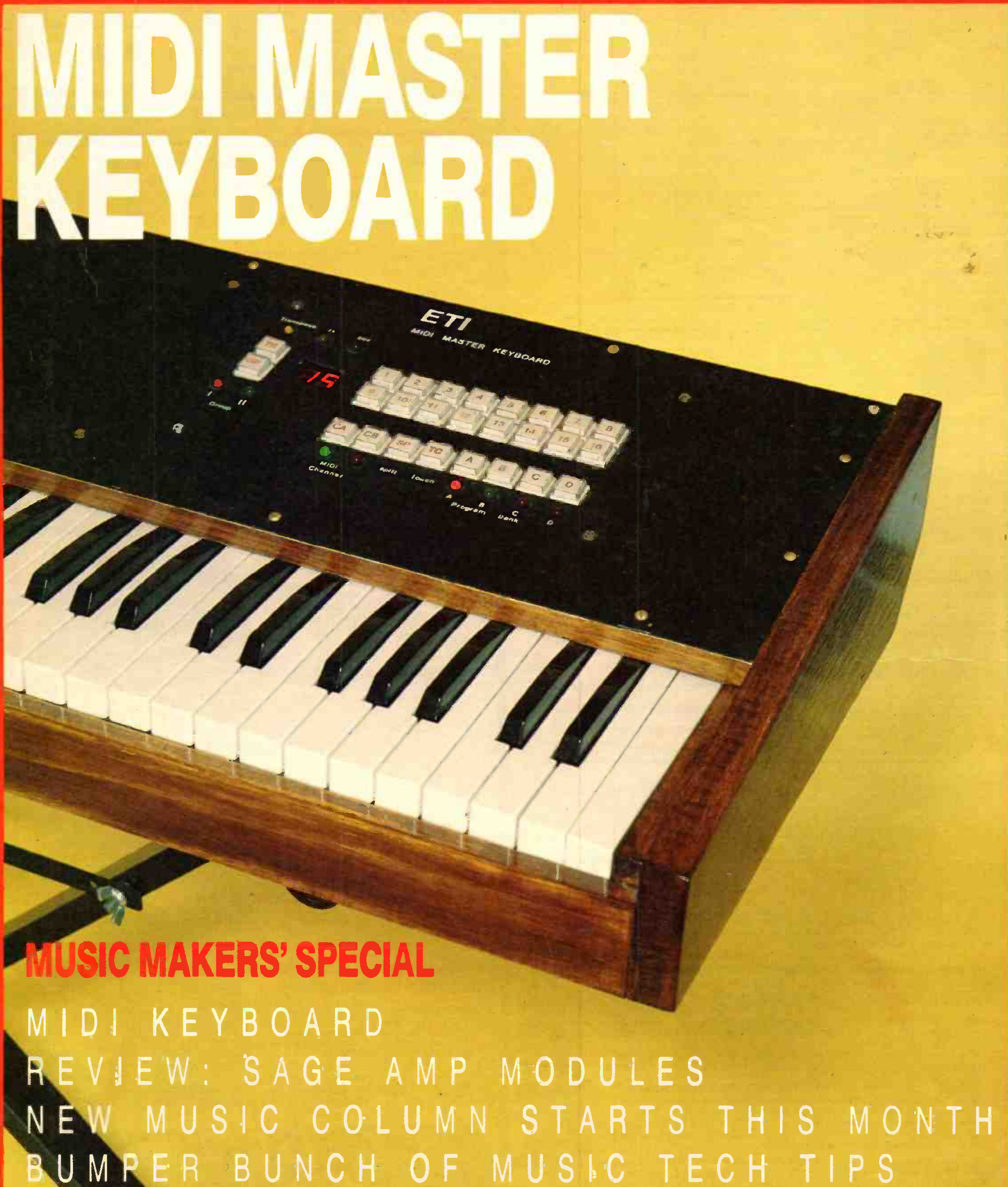
AN ARGUS SPECIALIST PUBLICATION

electronics today

INTERNATIONAL MAY 1987 £1.30

MIDI MASTER KEYBOARD



MUSIC MAKERS' SPECIAL

MIDI KEYBOARD

REVIEW: SAGE AMP MODULES

NEW MUSIC COLUMN STARTS THIS MONTH

BUMPER BUNCH OF MUSIC TECH TIPS

..AUDIO....COMPUTING....MUSIC....RADIO....ROBOTICS..

electronics today

INTERNATIONAL MAY 1987 VOL 16 No.5

EDITORIAL AND ADVERTISEMENT OFFICE
1 Golden Square, London W1R 3AB. Telephone 01-437 0626.
Telex 8811896.

FEATURES

PROJECTS

REGULARS

PUBLISHED BY:
Argus Specialist Publications Ltd.,
1 Golden Square, London W1R 3AB.
DISTRIBUTED BY:
Argus Press Sales & Distribution Ltd.,
12-18 Paul Street, London EC2A 4JS.
(British Isles).
TYPESET BY:
Project Three.
PRINTED BY:
Adlard & Son Ltd, The Garden City Press.
COVERS PRINTED BY:
Loxley Brothers Ltd.

ISSN 0142-7229 ABC **Member of the Audit Bureau of Circulation**

■ Subscription Rates. UK: £18.10. Overseas: £22.50. USA: $29.50. Airmail: £49.50.

01-208 1177 TECHNOMATIC LTD 01-208 1177

BBC Micro Computer System

BBC Master Series
AMB15 BBC MASTER includes one free ROM cartridge .... £385 (a)
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Database Management Systems, Word Processors, Languages, Spreadsheets, Utilities
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EX1000 .... £579 (a)
EX1000 .... £579 (a)
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LQ1000 (136 col) .... £589 (a)
JX80 4 colour .... £229 (a)
FX800 .... £329 (a)
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TAXAN KP815 (80 col) NLQ .. £269 (a)
TAXAN KP915 (156 col) .... £369 (a)
NATIONAL PANASONIC KXP 1080 (80 col) .... £159 (a)
STAR NL10 (IBM interface) .... £209 (a)
STAR Power Type (Daisy) .... £229 (a)
JUKI 6100 Daisy Wheel .... £259 (a)
BROTHER HR20 .... £329 (a)
INTEGREX Multicolour .... £525 (a)
HITACHI 672 A3 Plotter .... £459 (a)

Paper:
2000 Sheets Fanfold:
9.5" x 11" .... £13 (b)
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Labels: (per 1000)
3.5" x 17/16" Single row .... £5.25(d)
27/16" x 17/16" Triple row .... £5.00 (d)

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EPSON
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LX80 Sheet feeder .... £49.00 (b)
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8132 Apple II .... £60.00 (c)
8165 IEEE + cable .... £65.00 (c)
8177P NLQ (FX80+/FX100+). £99 (d)
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Ribbons: RX/FX 100/100+ .... .00 (d)
RX/FX 80/80+ .... £4.00 (d)
LX80 .... £4.50 (d)
Spare pens for H180 .... £7.50/set (d)
FX80 Tractor Attachment (c)

TAXAN CANON
RS232 Interface + 2K Buffer .... £63 (c)
Ribbon KP810/910/815/915 .... £6.00 (d)

JUKI:
RS232 Interface .... £65 (c)
Spare Daisy Wheel .... £14.00 (d)
Ribbon .... £12.00 (d)
Sheet Feeder .... £182 (a)
Tractor Feed Attachment .... £149 (a)

Sheet Feeder .... £239 (a)
Tractor Feeder .... £116 (a)
Ribbons Carbon or Nylon .... £3.00 (d)
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BBC Printer Lead:
Parallel (1.2m) .... £6.00 (d)
Serial (1.2m) .... £7.00 (d)
Printer Leads can be supplied to any length.

DISC DRIVES

These are fully cased and wired drives with slim line high quality mechanisms. Drives supplied with cables manuals and formatting disc suitable for the BBC computer. All 80 track drives are supplied with 40/80 track switching as standard. All drives can operate in single or dual density format.

PD800P (2 × 400K/2 × 640K 40/80T DS) with built in monitor stand .... £249 (a)
PD800 (2 × 400K/2 × 640K 40/80T DS) .... £229 (a)
TD800 (as PD800 but without psu) .... £199 (a)
TS400 1 × 400K/1 × 640K 40/80T DS .... £114 (b)
PS400 with psu 1 × 400K/1 × 640K 40/80T DS .... £129 (b)

3.5" DRIVES
1 × 400K/1 × 640K 80T DS
TS35 1 .... £75 (b)
PS35 1 with psu .... £119 (b)
2 × 400K/1 × 640K 80T DS
TD35 2 .... £135 (b)
PD35 2 with psu .... £187 (b)

3M FLOPPY DISCS

High quality discs that offer a reliable error free performance for life. Each disc is individually tested and guaranteed for life. Ten discs are supplied in a sturdy cardboard box.

5¼" DISCS
40T SS DD £10.00 (d) 40T DS DD £12.00 (d)
80T SS DD £14.50 (d) 80T DS DD £15.50 (d)

3½" DISCS
80T SS DD £20.00 (d)
80T DS DD £25.00 (d)

DISC ACCESSORIES

FLOPPICLENE Disc Head Cleaning Kit with 20 disposable cleaning discs ensures continued optimum performance of the drives ... 3½" £16 (d), 5¼" £14.50 (d)
Single Disc Cable .... £6 (d)
10 Disc Library Case .... £1.80(c)
40 Disc Lockable Box .... £8.50 (c)
Dual Disc Cable .... £8.50 (d)
30 Disc Case .... £6 (c)
100 Disc Lockable Box .... £13 (c)

MONITORS

All 14" monitors now available in plastic or metal cases, please specify.

MICROVITEC: 14" RGB
1431 Std Res .... £179 (a)
1451 med Res .... £225 (a)
1441 Hi Res .... £365 (a)

14" RGB with PAL & Audio
1431 AP Std Res .... £199 (a)
1451 AP Med Res .... £259 (a)

Swivel Base for Plastic 14" Microvitecs .... £20 (c)

20" RGB with PAL & Audio
2030CS Std Res .... £380 (a)
2040CS Hi Res .... £685 (a)

TAXAN SUPERVISION 620 12" High Resolution .... £279 (a)
TAXAN SUPERVISION III with amber/green option, BBC & IBM .. £319 (a)
MITSUBISHI XC1404 14" RGB Med Res IBM & BBC Compatible .. £219 (a)
PHILIPS 8501 RGB Std Res .... £139 (a)

TAXAN KX 1201G Hi Res 12" Etched Green Screen .... £85 (a)
TAXAN KX1202G Hi Res 12" Long Persistence (P39) .... £95 (a)
TAXAN KX 1203A Hi Res 12" Etched Amber Screen .... £95 (a)
PHILIPS BM7502 12" Hi Res Green Screen .... £75 (a)
PHILIPS BM7522 12" Hi Res Amber Screen .... £75 (a)
Swivel Base for Taxan Monochrome fitted with Digital Clock .... £21 (c)

MODEMS

— All modems listed below are BT approved

MIRACLE 3000:
MIRACLE WS2000 V21/23 Manual .... £95 (b)
MIRACLE WS4000 V21/23. (Hayes Compatible, Intelligent, Auto Dial/Auto Answer) .. £149 (b)
MIRACLE WS3000 V21/V23 As SW4000 and with BELL standards and battery pack up for memory .... £295 (b)
MIRACLE WS3000 V22 As WS3000 V21/V23 but with 1200 baud full duplex .... £495 (b)
MIRACLE WS3000 V22 bis As V22 and 2400 baud full duples .... £650 (b)
MIRACLE WS3022 As WS3000 but with only 1200/1200 .... £395 (b)
MIRACLE WS3024 As WS3000 but with only 2400/2400 .... £570 (b)
DATA Cable from Ws series/PC or XT . £7 (d)

DATATALK Comms Package 'if purchased with any of the above modems' .... £70(c)
PACEL Nightingale Modem V21/V23 Manual .... £75 (b)

SPECIAL OFFER

2764-25 .... £2.50
27128-25 .... £2.75
6264LP-15 .... £2.80

ATTENTION

All prices in this double page advertisement are subject to change without notice.
ALL PRICES EXCLUDE VAT
Please add carriage 50p unless indicated as follows:
(a) £8 (b) £2.50 (c) £1.50 (d) £1.00

Serial Test Cable
Serial Cable switchable at both ends allowing pin options to be re-routed or linked at either end using a 10 way switch making it possible to produce almost any cable configuration on site.
Available as M/M or M/F £24.75 (d)

Serial Mini Patch Box
Allows an easy method to reconfigure pin functions without rewiring the cable assy.
Jumpers can be used and reused. £22 (d)

Serial Mini Test
Minitors RS232C and CCITT V24 Transmissions, indicating status with dual colour LEDs on 7 most significant lines.
Connects in Line. £22.50 (d)

GANG OF EIGHT
INTELLIGENT FAST EPROM COPIER

Copies up to eight eproms at a time and accepts all single rail eproms up to 27256. Can reduce programming time by 80% by using manufacturer's suggested algorithms. Fixed Vpp of 21 & 25 volts and variable Vpp factory set at 12.5 volts. LCD display with alpha moving message. £395(b).

SOFTY II

This low cost intelligent eprom programmer can program 2716, 2516, 2532, 2732, and with an adaptor, 2564 and 2764. Displays 512 byte page on TV — has a serial and parallel I/O routines. Can be used as an emulator, cassette interface.
Softy II .... £195(b)
Adaptor for 2764/2564. £25.00(c)

UV ERASERS

All erasers with built in safety switch and mains indicator.
UV1B erases up to 6 eproms at a time .... £47(c)
UV1T as above but with a timer .... £59(c)
UV140 erases up to 14 eproms at a time. £68 (b)
UV141 as above but with a timer .... £88 (b)

CONNECTOR SYSTEMS

I.D. CONNECTORS
(Speedblock Type)

No of ways	Header Plug	Receptacle	Edge Conn.
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS
No of Ways

	9	15	25	37
MALE:				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	-
FEMALE:				
St Pin	100	140	210	380
Ang pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	-
St Hood	90	95	100	120
Screw Lock	130	150	175	-

TEXTOOL ZIF
SOCKETS
28-pin £9.00 24-pin £7.50 40-pin £12

EDGE CONNECTORS

	0.1"	0.156"
2 × 6-way (commodore)	—	300p
2 × 10-way	150p	—
2 × 12-way (vic 20)	—	350p
2 × 18-way	—	140p
2 × 23-way (ZX81)	175p	220p
2 × 25-way	225p	220p
2 × 28-way (Spectrum)	200p	—
2 × 36-way	250p	—
1 × 43-way	260p	—
2 × 22-way	190p	—
2 × 43-way	395p	—
1 × 77-way	400p	500p
2 × 50-way(S100conn)	600p	—

EURO CONNECTORS

DIN 41612	Plug	Socket
2 × 32 way St Pin	230p	275p
2 × 32 way Ang Pin	275p	320p
3 × 32 way St Pin	260p	300p
3 × 32 way Ang Pin	375p	400p
IDC Skt A + B		400p
IDC Skt A + C		400p

For 2 × 32 way please specify spacing (A + B, A + C).

MISC CONNS
21 pin Scart Connector 200p
8 pin Video Connector 200p

AMPHENOL CONNECTORS

	Solder	ZDC
36 way plug	500p	475p
36 way skt	550p	500p
24 way plug IEEE	475p	475p
24 way skt IEEE	500p	500p

PCB Mtg Skt Ang Pin
24 way 700p 36way 750p

GENDER CHANGERS
25 way D type
Male to Male £10
Male to Female £10
Female to Female £10

RS 232 JUMPERS
(25 way D)
24" Single end Male £5.00
24" Single end Female £5.25
24" Female Female £10.00
24" Male Male £9.50
24" Male Female £9.50

4-way 90p 6-way 105p
8-way 120p 10-way 140p

RIBBON
(grey/metre)

10-way	40p	34-way	160p
16-way	60p	40-way	180p
20-way	85p	50-way	200p
26-way	120p	64-way	280p

DIL HEADERS

	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
18 pin	60p	-
20 pin	75p	-
24 pin	100p	150p
28 pin	160p	200p
40 pin	200p	225p

TECHNOLINE VIEWDATA SYSTEM
Using 'Prestel' type protocols for information and orders phone 01-450 9764. 24 hour service, 7 days a week.

● **Fifteen per cent of Britain's top 500 electrical and electronic companies are trading at a loss, according to business information company Jordans. A recent survey revealed that large firms with diverse interests are doing reasonably well but smaller more specialised companies are under pressure from increased competition. Japanese companies operating in this country are among those affected with Mitsubishi Electric and Sanyo Marubeni both showing losses and Sony UK only just remaining in the black.**

● Space Systems sell ex-rental computers which have been fully-refurbished and checked to manufacturers specifications. Among the items currently available are IBM PCs from £680 and a full range of Intel development systems at very low prices. Copies of the catalogue can be obtained free-of-charge from Space Systems Division, Coach House Complex, Old Street, Upton Upon Severn, Worcestershire, Tel. (06846) 3626.

● *RDM sell test equipment manufactured by Fluke, Hitachi, Digitron and Kent among others. The range extends from multimeters, oscilloscopes and wattmeters through to more specialised equipment for measuring temperature, humidity, car engine speed and acidity/alkalinity. For a copy of the free 8-page catalogue contact RDM Test Equipment Company, Unit 74, The Maltings, Stanstead Abbotts, Nr. Ware, Hertfordshire SG12 8HG, Tel. (0920) 871 231.*

● Recorded cases of computer system penetration have more than doubled in the last three years, according to a survey carried out by BIS Applied Systems. The increased use of distributed processing and networking has made system security more difficult to achieve, opening up the way for computer pirates who wish to gain access to other people's data. The trend is analysed in the Computer Crime Casebook which costs £50 and is available from BIS Applied Systems Ltd, 20 Upper Ground, London SE1 9PN, Tel. 01-633 0866.

● **The STC Multilayer Ceramic Capacitor catalogue is aimed principally at OEMs and similar industrial concerns but it includes a wealth of information which will be useful to other users of capacitors. In addition to technical specifications it provides guidance for design and production engineers on type selection, handling and soldering. STC Components Ltd, Capacitor Division, Stoke Holy Cross Road, Arminghall, Norwich, Norfolk NR14 8SQ, Tel. (0603) 29721.**

A New Computer From Uncle

The Sinclair name is back behind a new computer, if not actually on the front.

The Z88 is a portable Z80-based machine which costs £230 and will be marketed by Sir Clive's new company, Cambridge Computer. The rights to previous Sinclair computers and the Sinclair name were bought by Amstrad last April.

The Z88 is about the size of an A4 pad and features an 80 column, 8 row display and 32K of RAM. The keyboard is full-size but is made of rubber like the keyboards on previous Sinclair products. Despite his earlier much-vaunted dismissal of LCD displays (in favour of flat-screen CRTs) and BBC Basic (in favour of various dialects), Sinclair has equipped the Z88 with an Epson LCD and used the Z80 version of BBC Basic as the programming language.

The micro has three cartridge ports for connection of 32K and 128K RAM and EPROM cartridges. There are no interfaces for disk, cassette or even microdrives, all storage being made to the EPROM cartridges which are programmable by the computer and eraseable with an optional ultraviolet eraser (costing £30). The Z88 is also provided with an RS232 interface and an expansion bus.

The Z88 uses four penlight batteries providing 20 hours of use and a mains adaptor is available for £10.

Further details from Cambridge Computer Ltd, Sidney House, Sussex Street, Cambridge CB1 1PA. Tel. (0223) 312 216.

Chinese Slant On Multimeters

Two new multimeters from Hung Chang represent the best value on the market according to the company which imports them, Cirkit Distribution.

The HC 5010 EC measures AC and DC voltage and current plus resistance and features a continuity tester giving both audible and visual indications. It has three capacitance ranges which can handle values from 1pF to 20uF and there is also a diode and transistor tester and a temperature range. The HC5010 comes complete with leads and probes and costs £52.50 plus VAT.

The HC775 is a pocket-sized multimeter which is fully autoranging and features both AC and DC current ranges and a memory mode. It has a 3½ digit 10mm high display and offers a basic accuracy of ±0.75% + 1 digit. It too is supplied with leads and probes and costs £33.50 plus VAT.

The HC5010 EC and the HC775 are available from Cirkit Distribution, Park Lane, Broxbourne, Hertfordshire EN10 7NQ. Tel. (0992) 444 111.

DAT Controversy

The first digital audio tape (DAT) recorders will go on sale early this year in spite of objections from record companies.

The Technics SV-D1000 will be sold only in Japan for the time being.

It uses the rotary head R-DAT system and features 16-bit linear conversion at a sampling rate of 48kHz. The programming and selection facilities are similar to those found on CD players and in fast search mode the tape runs at about 200 times the normal playback speed.

Tapes for the SV-D1000 will go on sale at the same time and will be about half the size of existing campact cassettes. They will be available with playing times of 120, 90, 60 and 46 minutes and are single-sided, providing the full playing time without having to be turned over half-way through.

The introduction of DAT recorders is going ahead in spite of heavy lobbying by the International Federation of Phonogram and Videogram Producers (IFPI), the body which represents the world's major record companies. They are asking the Electronic Industries Association of Japan (EIAJ) to fit some kind of encryption system to DAT recorders so that direct copies cannot be made from compact discs. They are also seeking to delay the introduction of DAT equipment until CD has established itself more firmly.

One of the delegates at a recent IFPI/EIAJ meeting, Nesuhi Ertegun of WEA Records, has been quoted as saying that DAT should not be launched for three or four years by which time CD players should be in use in about 30-40% of homes. At present only around 10% of homes in developed countries have CD players.

Ertegun says that WEA will not be ussuing pre-recorded tapes in the new format and urges other record companies to boycott it too.

Thorn EMI has also issued a statement urging both the British government and the EEC to ban import and sale of DAT equipment until agreement is reached on a standard system to prevent direct taping.

However, the Japanese argue that use of an encryption system would impede future development and cripple moves towards all-digital audio systems. In a statement issued after the IFPI meeting, the EIAJ expressed its belief that such a system would hinder domestic users without preventing commercial piracy. It opposed any legislation restricting the availability or provision of features on DAT products.

Micro Power Beats Power Cuts

Engineers at Bath University are developing a model of the national electricity grid on one of the most powerful microcomputer systems ever built.

Rod Dunn and Richard Daniels of the University's School of Electrical Engineering have been working for some years on the model using relatively slow 16-bit processors.

Now, with the aid of grants from the CEGB and the Science and Engineering Research Council, they are developing a faster model using 12 microcomputers in parallel, each with a 32-bit processor. The resulting system will be at least seven times more powerful than the original design.

When complete, the model will be used by CEGB engineers both as a training aid and to help in the prediction of faults on the national grid. The university hopes that suitably modified versions can be sold to other countries.

New Centre to Help Industry

The increasing reliance of British Industry on computer automation has led to the setting up of a national communications standards centre.

Known as ComCentre, it will work closely with the major national and international bodies responsible for communications standard setting and maintain a database of standards and information. Companies will be asked to pay a membership fee in return for which they will receive on-line access to the database and immediate telephone advice when required.

The centre will be operated by the Production Engineering Research Association (PERA).

Initial funding has come from the Department of Trade and Industry which provided £1 million to cover the first three years of operation. At the end of that time it is hoped the centre will be self-financing.

Speaking at the launch of ComCentre, Industry Under-Secretary John Butcher argued that Britain must use the latest manufacturing technology in order to remain competitive. ComCentre would help make companies aware of the technology available and its capabilities.

ComCentre, PERA, Melton Mowbray, Leicestershire LE13 0PB. Tel. (0664) 501 501.

A New Twist To Screwdriving

Dura-Drive is a four-in-one screwdriver with a unique lever action to shift stubborn screws.

It provides two slot-head and two cross-head blades which cover most DIY and maintenance requirements and is made from tough Dupont plastic.

The Dura-Drive differs from most multi-blade screwdrivers in that the various blades are permanently attached and simply fold out of the handle when required. This removes the risk of losing blades and cuts down the time and effort required to change from one to another.

The lever action is achieved by folding one of the unused blades out to 90° from the handle (see picture). Difficult screws can then be tightened or removed with very little effort.

The Dura-Drive is available by mail-order at an all-inclusive price of £8.57 from Electronic and Computer Workshop Ltd, 171 Broomfield Road, Chelmsford, Essex CM1 1RY. Tel. (0245) 262 149.

BK Imports Vari-Speed Turntable

Audio equipment specialist BK Electronics has added a high-quality variable speed turntable to its range following an exclusive agreement with an overseas manufacturer.

The turntable will be sold in the UK under the OMP brand name and will be known simply as the Vari-Speed.

It uses a high-torque DC motor with electronic servo control and offers standard speeds of 33⅓ and 45 RPM as well as the separate variable speed function. The die-cast platter is belt driven and the rim is illuminated with a strobe prism to enable the speed to be checked.

Other features include a precision balanced S-shaped tone arm, a universal cartridge head-shell and a viscose damped cueing lever.

BK says the turntable offers an unsurpassable price/performance ratio and expects it to prove popular in disco and studio applications. The unit should also be of interest to those building domestic hi-fi systems.

The OMP Vari-Speed turntable costs £53.99 including postage and VAT and can be obtained from BK Electronics, Unit 5, Comet Way, Southend-on-Sea, Essex SS2 6TR, Tel. (0702) 527 572.

- **The IBA has recently completed six weeks of test transmissions in preparation for the UK's first radio teletext service. The system will be used to transmit up-to-date financial information using techniques already well-established in the USA but not previously employed over here. The initial period of testing has been carried out in the London area on 97.3MHz VHF/FM and a further series of tests will begin shortly on 95.8MHz using the IBA's other VHF/FM transmitter in London.**

- *Kit News is a small leaflet which describes the range of products available from Cambridge Kits. Many of the items have a strong amateur radio bias but there are also kits for a sound meter, a rugby clock and various items of test gear plus some useful hints and tips on construction and fault-finding. Cambridge Kits, 45 Old School Lane, Milton, Cambridge CB4 4BS, Tel. (0223) 860 150.*

- A wide range of reed and mercury-wetted relays is described in a 20-page, two-colour catalogue from Hamlin. Among the types listed are miniature and subminiature relays in DIL and single-in-line packages plus multi-pole devices and various high voltage and other special types. Contact Hamlin Electronics Europe Ltd, Park Road, Diss, Norfolk IP22 3AY, Tel. (0379) 4411.

- **A new era in board games is about to begin, according to certain national newspapers and magazines. One of the star exhibits at the recent Toy Fair in London was a revolutionary microchip device which is all set to replace a traditional element of many games — the dice. The idea is apparently regarded as rather novel and games firm Waddingtons is amongst those taking a close interest. Odd, really, when you bear in mind that ETI published an electronic dice circuit as long ago as 1976 and has published several more since. Then again, perhaps they don't appreciate the benefits of electronics: as the Daily Mail sees it, the principal benefit of the new dice is that it is unlikely to roll under furniture and get lost!**

- *At just under 400 pages the 1987/88 Philips Test And Measurement catalogue is definitely the thickest ETI has received this month. It includes all the usual types of test equipment plus microcomputer development systems, microwave test equipment and specialised items for television and video testing. Copies are free from Eleanor Bullett, Pye Unicam Ltd, York Street, Cambridge CB1 2PX, Tel. (0223) 358 866.*

NEXT MONTH

AN ARGUS SPECIALIST PUBLICATION
electronics today INTERNATIONAL

THE TELEPHONE SYSTEM

Ever wondered what happens at the other end of the telephone line? Is there any truth in the rumour that the only reason the system suffered no major breakdowns during the recent engineers' strike is because it's all run on carrier pigeons anyway? ETI reveals all.

FLAT ALARM

Not a warning for punctured tyres but a simple, low cost, but remarkably effective alarm system for a flat, maisonette or small house.

RIAA EQUALISATION

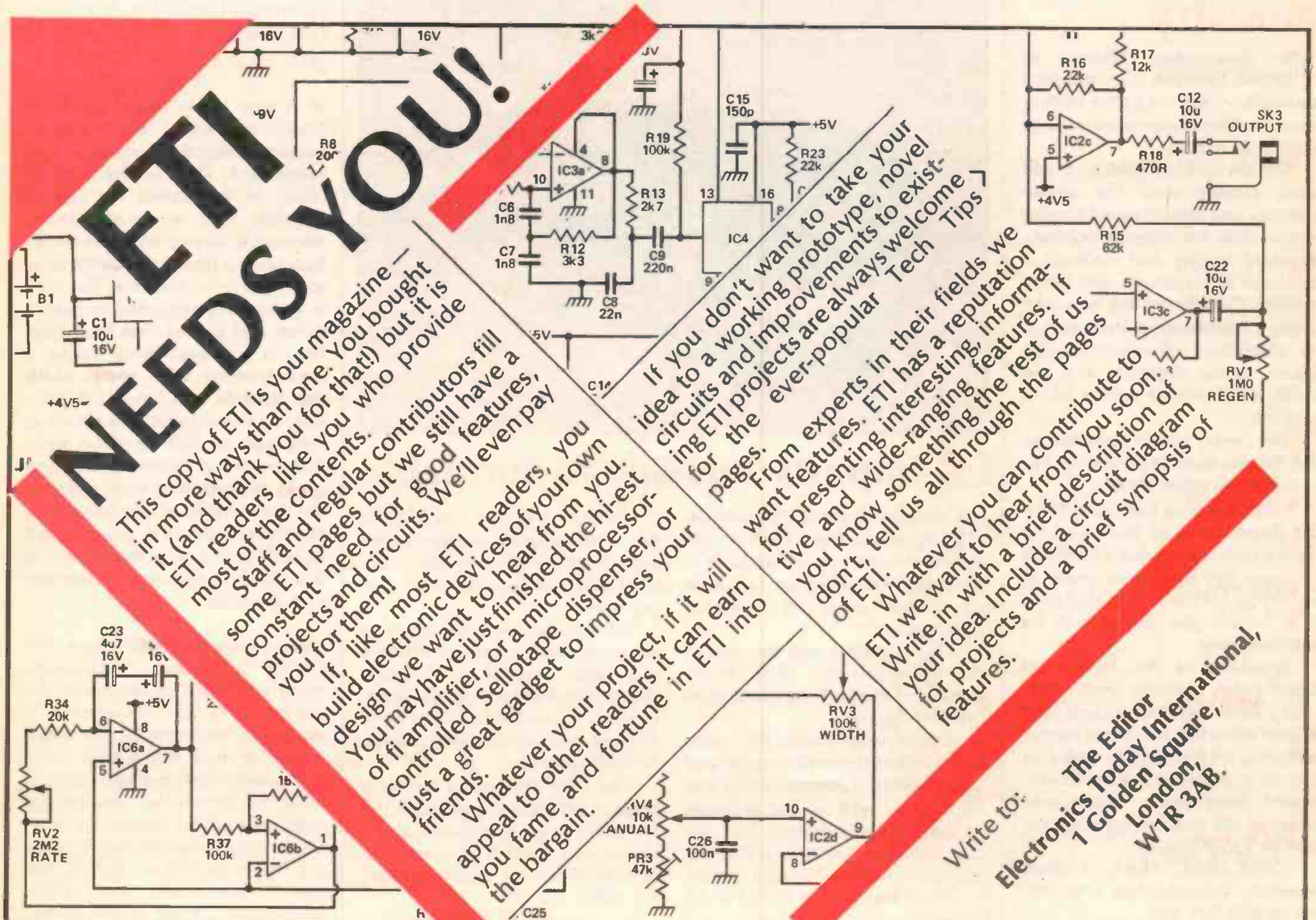
All amp designs equalise but some are more equalised than others. RIAA equalisation is required for all record preamplifiers (remember records? They're those large, black things that work a bit like CDs only not so well). It's not as simple as it's often assumed to be so we take a lingering look at designing amp stages that *accurately* follow the RIAA curve.

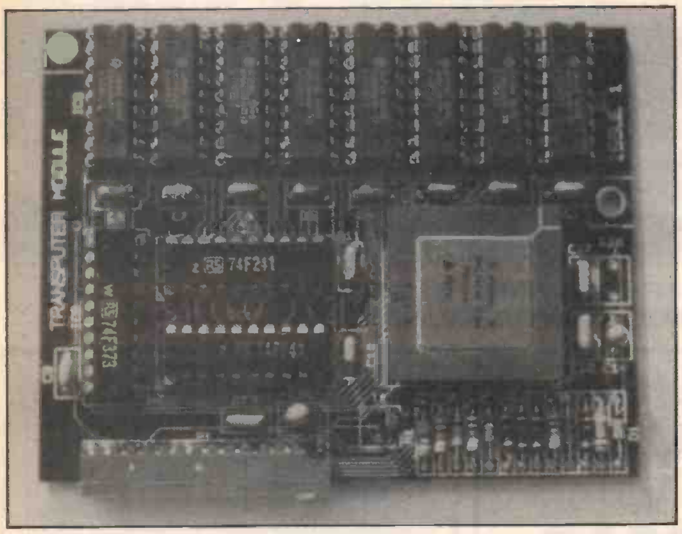
NOT ONLY BUT ALSO

Plus there's the next part of the MIDI Master Keyboard to build, the hi-fi version of the audio power meter and all your usual favourites — news, diary, Tech Tips, letters, readers' ads, and so on.

THE JUNE ISSUE OF ETI — SNAP IT UP ON 1st MAY

All the articles listed are in an advanced state of preparation but circumstances beyond our control may prevent publication.





Low-Cost Parallel Processing

The TMI Transputer module offers educational establishments and other users an opportunity to evaluate the Inmos Transputer chip at relatively low cost.

The module consists of a small, four-layer PCB which carries a T414-15 transputer and 256K of high speed DRAM. The T414-15 is capable of 7.5 MIPS (millions of instructions per second) but for more demanding applications the module can be supplied with a T414-20 capable of 10 MIPS.

The module can be used on its own or with an existing system by means of a suitable interface. All connections are made via one 15-way connector and an interface board for use with IBM PC-compatible systems will be available soon.

A compact, powerful parallel-processing system can be built by using several TMIs together. Up to eight can be accommodated on a single Eurocard, giving anything up to 60 MIPS from a system small enough to be held in one hand.

The basic TM1 module fitted with a T414-15 Transputer costs £600 for a single board and £457 when six or more are purchased. Details of other quantity discounts can be obtained from the manufacturers.

Concurrent Technology, 30 Baldslow Road, Hastings, East Sussex TN34 2EY, Tel. (0424) 714 790.

News On The Cortex Newsletter

We got it wrong last month when we said the Cortex newsletter had ceased publication.

As countless readers have since pointed out, the newsletter is still available. It comes out six times a year and the annual subscription is £5. For details contact the editor, Tim Grey, at 1 Larkspur Drive, Featherston, Wolverhampton, West Midlands WV10 7TN.

We have also received a call from Anthony Rowell who wrote the Basic programme for the Cortex and was involved in the design of the hardware. Anthony says he will be happy to give advice to anyone who is having problems with a Cortex and he is also willing to blow ROMs for the machine. His address is 11 Manor Close, Irchester, Northamptonshire NN9 7ED.

- **Need an unusual character on your printer? Butler & Tanner will take daisy wheels, golf-balls and other impact type-heads and replace redundant characters with new signs and symbols. Astronomical, mathematical, biological and meteorological signs are among those available plus musical notation, fractions, foreign alphabets and any other type face or alphabet not usually available on a print-head. The company will also produce print characters from original drawings. Butler & Tanner Ltd, The Selwood Printing Works, Frome, Somerset BA11 1NF, Tel. (0373) 449 967.**

- Rohde & Schwarz are celebrating over 50 years of precision voltage measurement with the publication of a 20-page, full-colour catalogue. It lists the characteristics, capabilities and main technical features of a wide range of voltmeters and accessories. Rohde & Schwarz UK Ltd, Roebuck Road, Chessington, Surrey KT9 1LP, Tel. 01-397 8771.

DIARY: DIARY: DIARY: DIARY: DIARY: DIARY: DIARY: DIARY:

Digitally implemented Radios — April 1st
The IEE, London. Colloquium. Contact The IEÉ at the address below.

Fibre Optics in Communications — April 2nd
University of Cambridge, 7.00pm. Lecture organised by the IEEIE. For details 'phone 01-863 3357.

The Role of Alternatives in The World Energy Scene — April 7-9th
University of Reading. See March '87 ETI or contact the IEE at the address below.

Frequency Control and Synthesis — April 8-10th
University of Sussex. Conference. Contact the IERE on 01-388 3071.

Reliability '87 — April 14-16th
Birmingham. See April '87 ETI or contact the Institute of Quality Assurance on 01-584 9026.

Electricity And The Body — Friend Or Foe? — April 23rd
The IEE, London. See April '87 ETI or contact the IEE at the address below.

The Audio/Visual Show — April 27-30th
Wembley Exhibition Centre, London. Exhibition aimed principally at trade users but open to anyone. Contact Emap-McLaren Exhibitions on 01-686 9200.

The Electronic Data Interchange Conference — April 28-29th
The Barbican Centre, London. See February '87 ETI or contact Online at the address below.

British Electronics Week — April 28-30th
Olympia Exhibition Centre, London. See February '87 ETI or contact the Evan Steadman Communications Group on (0799) 26699.

Digital Audio Tape Recording — April 30th
The IEE, London. See March '87 ETI or contact the IEE at the address below.

Tool Kits And Sneaky Tricks — May 15th
The IEE, London, 2.00pm. Discussion meeting. Contact the IEE at the address below.

TV Displays: The Next Ten Years — May 20th
The IEE, London, 2.00pm. Discussion meeting. Contact the IEE at the address below.

Computer North — May 27-29th
G-Mex Complex, Manchester. Business computer show. Contact Cahners on 01-891 5051.

UK Telecommunications Networks: Present & Future — June 2-3rd
IEE, London. Conference. Contact the IEE at the address below.

CableSat '87 — June 2-4th
Metropole Hotel, Brighton. Exhibition and conference. Contact Online at the address below.

International ISDN Conference — June 15-18th
London. Conference on the Integrated Services Digital Network. Contact Online at the address below.

Networks '87 — June 16-18th
London. For details contact Online at the address below.

Condition Monitoring For Safety — June 25th
Regent Crest Hotel, London. Seminar and Exhibition. Contact ERA Technology on (0372) 374 151.

Satellite Communication Systems — July 26-31st
University of Surrey. Vacation school organised by the IEE. Contact them at the address below.

Designing For Electromagnetic Compatibility — September 13-18th
University of Sussex. Vacation school organised by the IEE. See address below.

Design Engineering Show — September 15-18th
NEC, Birmingham. Exhibition and conference covering all areas of engineering including electronics and CAD/CAM. Contact Cahners on 01-891 5051.

IDEX '87 — September 21-23rd
Metropole Exhibition Halls, Brighton. See April '87 ETI or contact Nutwood Exhibitions on (04848) 25891.

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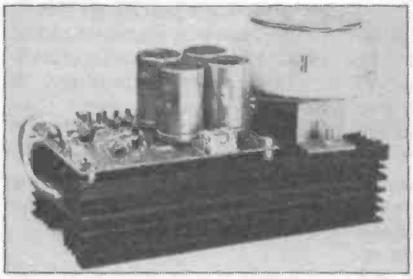
POWER CRAZY



240W HIFI AUDIO POWER AMPLIFIER KIT NR. K2587

The introduction of MOSFET transistors in poweramplifiers opened a new area in this field.
Wide power bandwidth, low drivingpower, high output power and an almost ideal transient response are only a few of the advantages.
This kit is based on this technology. Apart from the power-amplifier, it also includes the powersupply, heatsink and transformer. Once assembled, its ready for use and can easily be housed. Only 2 final adjustments are required and only needs a multimeter.

Some applications:Discobars and discotheques - Orchestra or theatre - DC coupled powercontrols.
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- Intermodulation distortion: 0.0%
- Input impedance: 33K.

Price £184.80 + p&p

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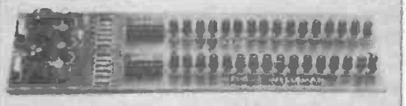
K2532	ADAPTOR SOCKET FOR TMS2532 TO K2578	39.45
K2543	ELECTRONIC TRANSISTOR IGNITION	13.13
K2545	UNIVERSAL CRYSTAL 50HZ TIMEBASE	18.65

LED LEVEL



STERO LED VU-METER KIT NR. 1798

Two rows of 16 Leds each and a 'spot' indication instead of a 'Baragraph' makes up for the difference between this kit and the mono VU-meter. Thanks to an adjustable input amplifier matching to almost any kind of pre- or power amplifier can easily be made.
- 2x16 Leds.
- Supply:12VDC.
- Input impedance: 10kOhm.
- Input sensitivity: adjustable between 100mV to 10V full scale.
- Power consumption: 50mA.

Price £25.02 + p&p.

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K2623	LAB POWER SUPPLY 0-24V 3 AMP	38.41
K2625	DIGITAI RPM METER	31.00
K2626	27640/27128 ADAPTOR KIT FOR K 2578	38.30
K2632	HARDWARE EXTENSION KIT FOR K 2603	22.08
K2636	AC MOTOR CONTROL	20.30
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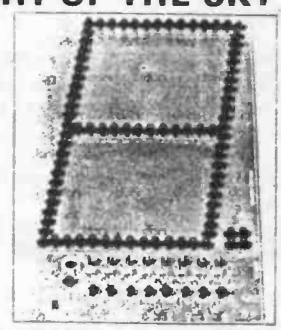
GIANT VU METER KIT NR. K2620

Several circuits providing different light effects, from the simple lightrogan to real 'lightcomputers', have already appeared on the market.
This kit is something new... a giant VU.meter with 240V bulbs. The 12 bulbs are mounted as a lightcolumn which varies according to the sound level.
The input is galvanically seperated and the sensitivity is adjustable, so there is no danger when connected to a pre-amplifier or to a power amplifier.
- 12 triac outputs: 400W each (non-cooled).
- Input impedance: ca. 20 Kohm.
- Input sensitivity: adjustable from ca. 100mV to 3V at full scale.
- Power supply: 9 VAC/0,5A.

Price £36.85 + p&p

LIGHT UP THE SKY



20CM DISPLAY 'COMMON ANODE' KIT NR. K2567

This kit contains a 7-segment display consisting of 12 leds per segment and 4 leds for the decimal point. With the aid of a supplementary power supply, it is possible to connect this kit to any existing circuit equipped with common anode displays of any brand and any dimension.
If the digit and segment drivers of the circuit can supply sufficient current, it will be possible to connect in parallel two or more displays, or even, leave the small display of the circuit in place and connect the 20cm display in parallel. This latter will not effect the brightness of the 20cm display due to the specila concept of the driver circuit.
- Common anode.
- Power supply: 22 to 26VDC non-stabilized.
- Minimum anode input voltage (on): 2V.
- Maximum anode input voltage (off): 1.2V.
- Segments input impedance: 10K.
- Segment current: static (R6=00):+40mA multiplex (R6=220hm): +75mA.
- Total current consumption in static mode: maximum 400mA.
- Maximum power (U=22V): 8.8Watt.

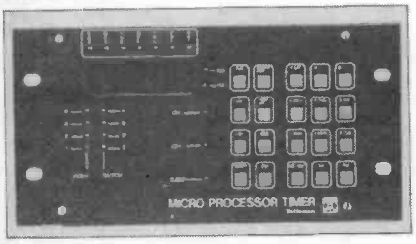
Price £30.26 + p&p

20CM DISPLAY 'COMMON CATHODE' KIT NR. K2568

This kit is in terms of appearance and application identical to K2567 'COMMON ANODE'.
As far as specifications are concerned; read cathode for anode.

Price £31.93 + p&p

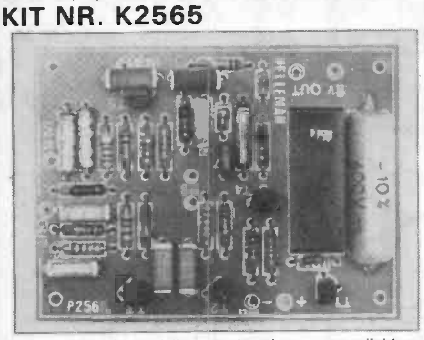
MICROPROCESSOR UNIVERSAL TIMER KIT NR. K1682



This unique timer is in principle a 24-hour clock provided with 4 relay-switched outputs and a programmation period of 1 week. 20 switching programs can be memorized and via the membrane keyboard be programmed. Outputs or timing periods can be selected at random.
All program steps are indicated be leds.
A printed alu frontplate is included in the kit, making building-in of this timer a simple affair.
This microprocessor timer was primarily designed for industrial and labo purposes, but the amateur can use it in dozens of applications as well.
- 20 daily- or weekly programmable timerfunctions.
- Memory display of programmed timer functions per output or per day.
- 4 independent relay outputs (1 relay included).
- Dispaly of: day of week - AM/PM - output - clock.
- ON/OFF - sleep.
- The timer is based on the TMS 1122 microprocessor.
- Transformer 12VAC/1A (not included).

Price £75.85 + p&p

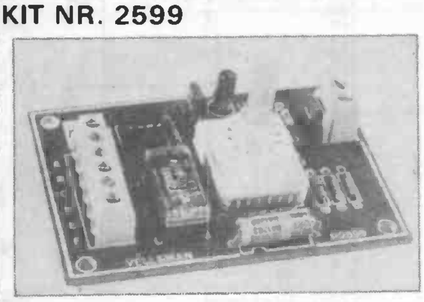
TAPE/SLIDE SYNCHRONIZER KIT NR. K2565



Actually, alot of tape/slide synchronizers are available on the market. The price of these devices varies from expensive to very expensive.
Those owning a tape- or cassette recorder can with this simple and inexpensive device, record synchronizing pulses and use these pulses to control automatic slide projectors.
The circuit is small in sized and can easily be housed.
- Power supply: 9 to 13VDC.
- Current consumption: 40mA.
- Output frequency (tone):+1.5KHz.
- Output amplitude:+250mV.
- Input sensitivity A: minimum 1.5V peak to peak.
- Input sensitivity B: minimum 100mV.
- Oscillator: AMV type.
- Input Impedance (B): 1 KOhm.
- Output impedance: 15 KOhm.

Price £12.75 + p&p

SCREEN WIPER ROBOT KIT NR. 2599



Three different time intervals may be selected by using a multipole rotary switch. With small component changes, the intervals may be varied.
Some applications: windscreen wiper delay - diaprojector control - hazard warning via the brakinglights of the car.
In the manual you will find a complete description how to build this kit in a car, with wiring instructions to connect it to the existing wiper installation.
- Power supply: 12-15V DC.
- Intervals: 5-10-15-seconds.
- Relay output: 240V/2x3A.
- Relay output with two change-over contacts.
- Current consumption:
- Output 'OFF': 25mA.
- Output 'ON': 100mA.
- Dimensions:82×56×41mm.

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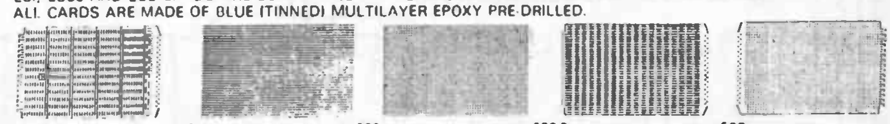

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HARDWARE DESIGN CONCEPTS

Mike Barwise looks at the design of the main board of his pulse generator.

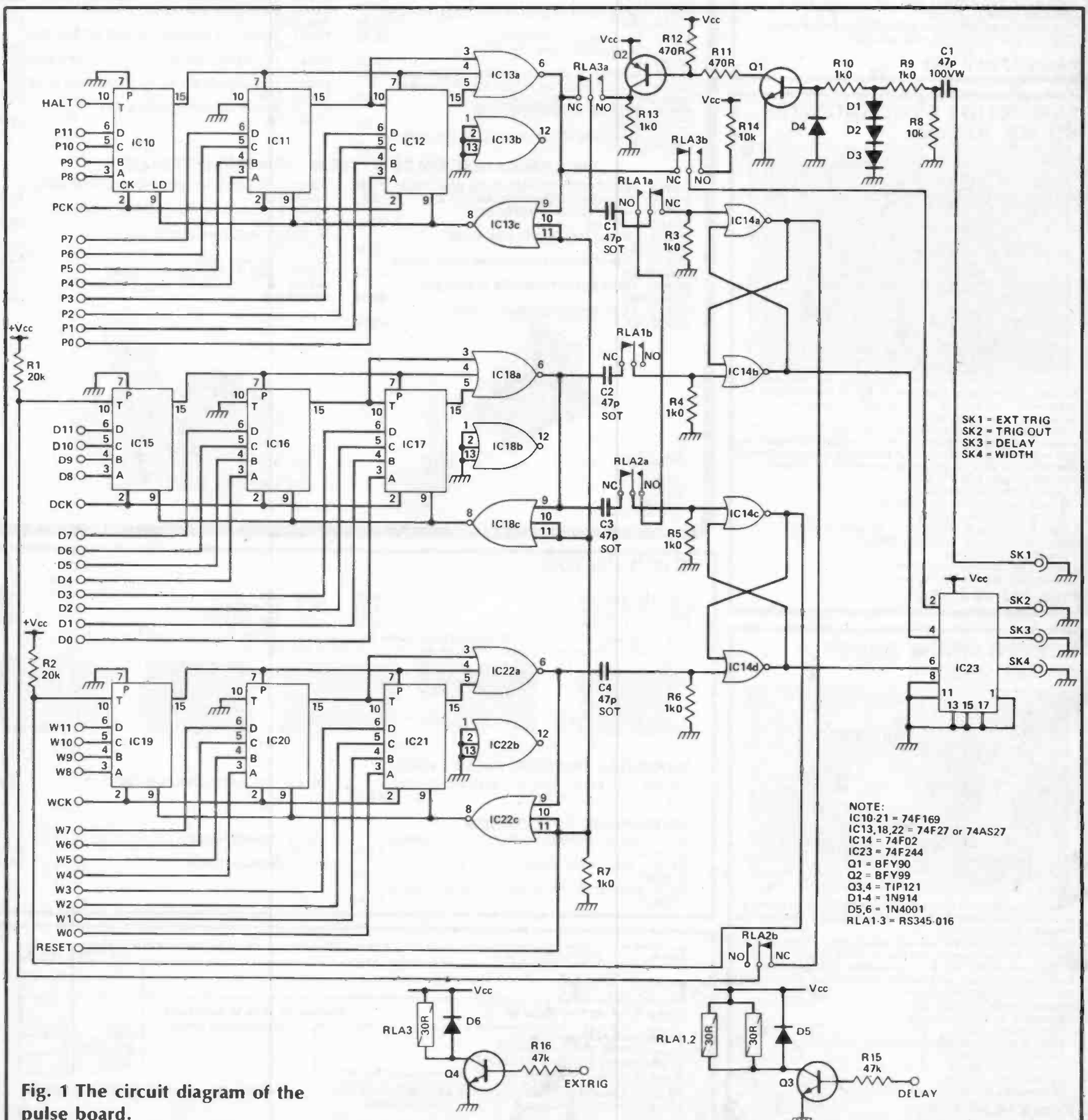


Fig. 1 The circuit diagram of the pulse board.

This month we look at the pulse generator proper from a purely practical standpoint. The final theoretical schematic (ETI March 1987) leaves out one or two minor but desirable features. These are:

- The ability to generate pulses using period and width only, ie no delay.
- The option of triggering the pulse generator from an external source rather than driving the experiment from the pulse generator trigger output.

There is also a minor functional enhancement which is worth describing — the conversion of the control flip-flops to edge triggered operation.

All these details appear in the full circuit diagram (Fig. 1), so let's look at them in order.

Without Delay

To generate a 'no-delay' pulse, we simply have to eliminate the delay stage from the system so that the period stage directly unlocks the width stage. To do this with extra gating would slow the system down, so we use relays.

The total requirement is for four pole, two way switching, but for cheapness we are using two pole, two way telecomms relays together (RLA1/RLA2). Contacts RLA1a and RLA2a perform the switching out of the delay stage and, just as a precaution, RLA1b and RLA2b together with pull down resistors R3 and R4 and pull up resistor R1 disable the isolated delay stage to stop it free running.

The external triggering option is again switched by a relay (RLA3). This simply disconnects the period (free running) stage from the delay and/or width stages and connects a front panel socket instead.

Again as a precaution, the TRIGGER OUT front panel socket is taken permanently high while using external trigger. This is because we cannot easily stop the disconnected period stage without complicating the programming job at the microprocessor control section.

Optionally, if you want an additional rate controlled pulse source in external trigger mode, you can omit R14 and jump across RLA3b but this will require a software modification to allow independent trigger rate programming and external trigger selection.

Protection

The really crafty part of the external trigger system is the input protection circuit, for which I am indebted to Richard Cripps, a technician in the Department of Metallurgy at Oxford.

The need for some kind of protection is self-evident. A 12V trigger would completely zap the whole generator. This solution is more than average elegant, and it's very safe. It was designed for a rig I installed at Oxford, to be completely student proof. OK, so how does it work?

The input capacitor, C1 (which *must* be a high voltage type) passes only fast edges and its small size limits the amount of power that can be passed across it to the transistors and diodes. Q1 is normally off (as the capacitor is discharged by R8) but turns on when the voltage at its base is about 0.6V.

As soon as the voltage on the capacitor rises to about 1.8V, the forward biased diode chain D1-D3 turns on and clamps the voltage to very near ground. This both limits the output pulse and protects Q1 against over voltage.

Q1 is only on (conducting) during rising inputs between 0.6V and 1.8V. The output of Q1 is a short negative going pulse starting at the 0.6V threshold of the positive going input edge, and ending at the 1.8V threshold.

Any negative going input is clamped at —0.6V to D4 to avoid destruction of Q1. The second transistor is a re-inverter stage so that positive inputs yield positive outputs. With the specified components the circuit is extremely fast (we measured about 7 to 10 nanoseconds propagation delay) and will respond to any signal with a positive going rise time of 1V/microsecond or faster.

The output pulse width is, of course, input risetime dependent. Any logic-adequate square wave (CMOS or TTL) will trigger the circuit. We tested the circuit on 50Hz 240V mains and, although it did not trigger (too slow a risetime), it survived. However, note that this is not a recommended user test!

What this does mean, though, is that you can trigger one-shot pulses from, say, an RS232 channel under test or most other available system signals.

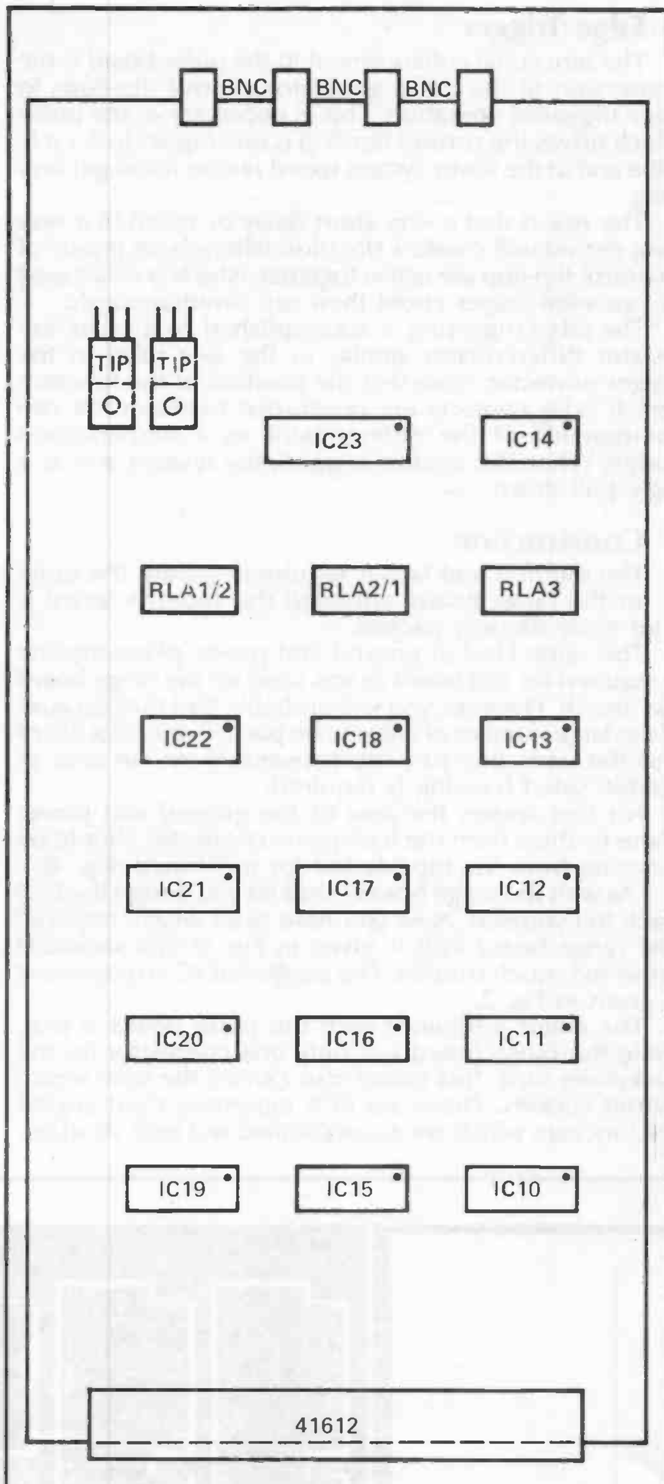


Fig. 2 The recommended component layout for the pulse board.

Edge Trigger

The functional enhancement to the pulse board is the conversion of the pulse generator control flip-flops to edge triggered operation. This is necessary as the pulse which drives the control flip-flop is one input clock cycle wide and at the lower system speed ranges it can get very long.

The risk is that a very short delay or width in a very long period will create a situation where both inputs of a control flip-flop are active together, which is disallowed as cascaded stages could then run simultaneously.

The edge triggering is accomplished by a capacitor/resistor differentiator similar to the one used in the trigger protector. Note that the position of the function switch relay contacts are positioned between the two components of the differentiator as a simplification dodge. When the contact is open, the resistor acts as a logic pull down.

Construction

The method and layout requirements are the same as for the range board, although this month's board is a lot more densely packed.

The same kind of ground and power plane topside is required for this board as was used for the range board last month. However, you will probably find that because of the large number of chips to be packed onto this board and the wide bus running between them, an area of double sided tracking is required.

For this reason the area of the ground and power plane furthest from the backplane connector should be removed from the topside foil for this board (Fig. 4).

As with the range board I shall let you design the PCB track foil yourself. Now you have seen what's required (the range board PCB is given in Fig. 5) this shouldn't prove too much trouble. The suggested IC arrangement is given in Fig. 2.

The major difference with the pulse board is that, while the range board has only one connector (to the backplane bus), this board also carries the user input/output sockets. These are PCB mounting right angled BNC sockets, which are an established test gear standard.

Pin	A	B	C
1	+5V	+5V	+5V
2	KEYCK	PROCK	—
3	WCK	—	—
4	DCK	—	—
5	PCK	—	—
6	—	—	—
7	—	—	—
8	W10	W11	—
9	W8	W9	—
10	W6	W7	—
11	W4	W5	—
12	W2	W3	—
13	W0	W1	—
14	D10	D11	—
15	D8	D9	—
16	D6	D7	—
17	D4	D5	—
18	D2	D3	—
19	D0	D1	—
20	P10	P11	—
21	P8	P9	—
22	P6	P7	—
23	P4	P5	—
24	P2	P3	—
25	P0	P1	—
26	EXTRIG	—	—
27	HALT	DELAY	—
28	RSYNC	RESET	—
29	WR0	WR1	—
30	DR0	DR1	—
31	PR0	PR1	—
32	GND	GND	GND

— not used by the range board or the pulse board.

Fig. 3 The backplane connector pinout used by the range and pulse boards.

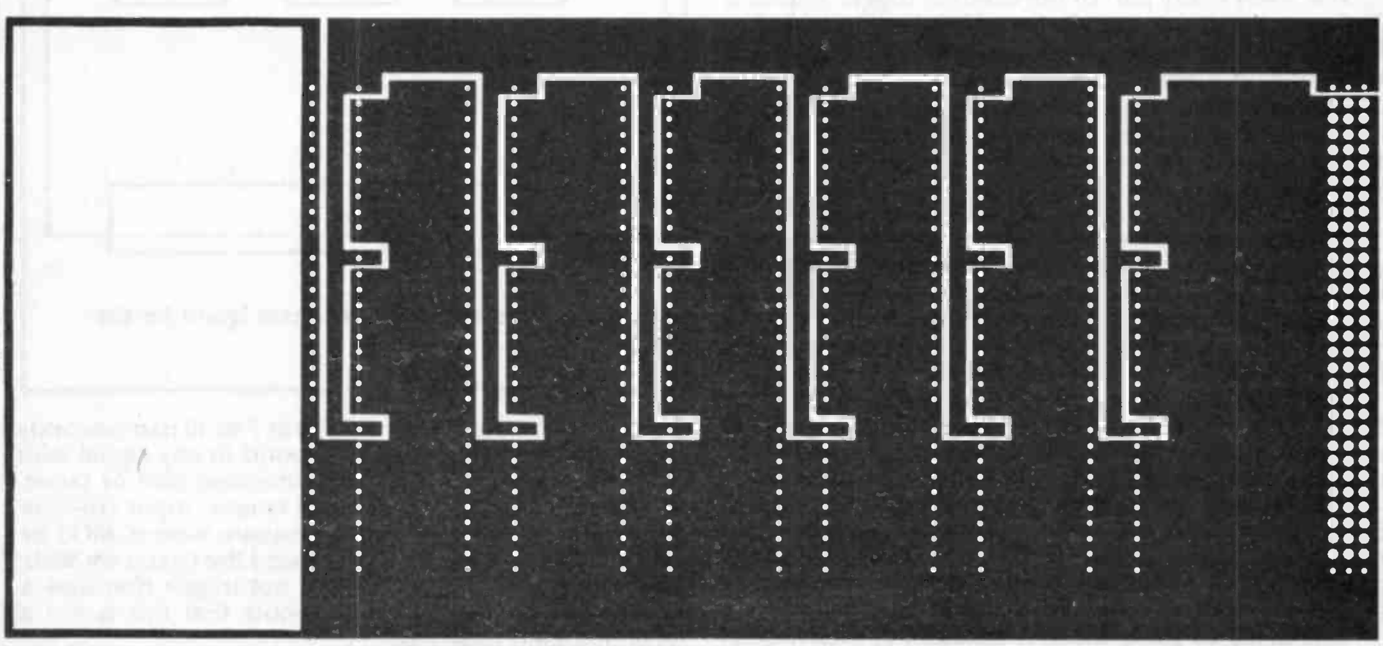


Fig. 4 The topside foil used for the pulse board.

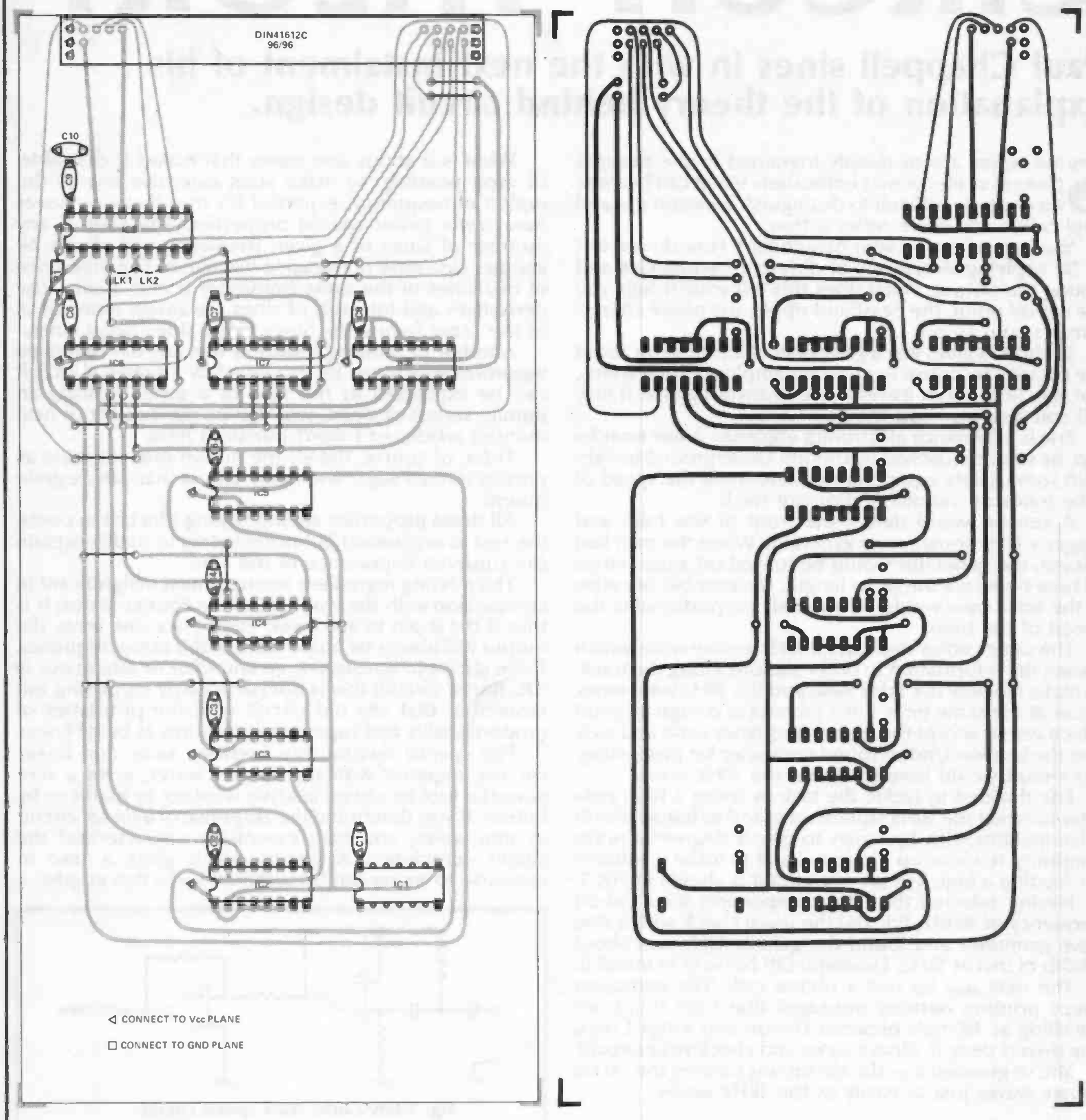


Fig. 5 The trackside foil and the component overlay for the range board looked at last month (approx 80% full size).

You will find that this board *needs* a front panel, whereas it is optional for the range board. The reason is that constant twisting and pulling at the BNC connectors will eventually cause board failure. The front panel screws to the subrack metalwork as well as to the board, so it prevents a lot of wobble.

The front panel holes do not have to fit the BNC sockets closely: in fact they may have to be considerably oversize to accommodate the BNC plug nose, depending on how near the edge of the board the sockets are mounted. This does not matter, as the rigidity is imparted by the brackets coupling the board corners to the panel.

These are the sort of details you have to think of as you go along in systems design, otherwise bits start falling off in service. Figure 2 shows the bus pinout extended to include all the new signals we have added this month.

That's about all for now (and certainly enough to be going on with). Next month we will discuss how to control and program the whole pulse generator, at which point we should be able to define a formal performance specification.

ETI

CIRCUIT THEORY

Paul Chappell sines in with the next instalment of his explanation of the theory behind circuit design.

Sine waves are so deeply ingrained in the thought process of electronics enthusiasts that it can become exceedingly difficult to distinguish between a useful application and mere reflex action.

You have a filter on your breadboard. How do you test it? By applying sine waves of different frequencies and noting the output. What does this tell you? It tells you the cut-off point, the passband ripple, the phase characteristics, and so on.

In short, it gives you a great deal of information about the circuit's response to constant amplitude sine waves, but very little about its response to anything else. It may tell you less than you think.

Eric is a freelance electronics engineer. A few months ago, he was approached by London Underground to help with some safety equipment to determine the speed of tube trains on various sections of track.

A sensor would detect the front of the train and trigger a 1kHz square wave generator. When the train had passed, the generator would be turned off again. Since all tube trains are the same length, the number of cycles of the 1kHz wave would be inversely proportional to the speed of the train.

The same cables also carry a 10Hz square wave, which passes the information to other stations along the track. To make life easy the 1kHz wave and the 10Hz wave never occur at the same time. Eric's job was to design a circuit which would accept the higher frequency wave and pass it to the London Underground computer for processing. His circuit would have to ignore the 10Hz wave.

Eric decided to tackle the task by using a high pass filter to reject the 10Hz square wave and to follow it with a comparator with hysterisis to give a degree of noise immunity, to clean up the signal and to make it suitable for feeding a logic circuit. His circuit is shown in Fig. 1.

Having selected the filter components for a cut-off frequency of 100Hz, Eric did the usual check with a sine wave generator and found the gain at 10Hz was about 1/100th of that at 1kHz. Excellent! Off he went to install it.

The next day he had a phone call: 'The computer keeps printing warning messages that tube trains are travelling at 180mph between Euston and Kings Cross. The drivers deny it. Please come and check your circuit!'

You've guessed it — the circuit was passing the 10 Hz square waves just as easily as the 1kHz waves.

Bandwidth

The point of this little story is that bandwidth, frequency response, and so on, are *sine wave* concepts. How much they tell you about anything else depends on your skill at relating sine waves to other waveforms. Any naive attempt to transfer sine wave concepts directly to other waveforms will lead to 180mph tube trains!

What could square wave bandwidth possibly mean? A square wave will be distorted to a greater or lesser extent by any practical circuit. A high-pass filter will distort it in both the sine wave pass-band and the sine wave stop-band, but the sine wave stop-band certainly won't stop it!

Perhaps we could say that a square wave pass-band is where the distortion is not too bad and the stop-band is where it's awful?

What is it about sine waves that makes it desirable, or even possible, to make such extensive use of the notion of frequency response? It's true that sine waves have some rather special properties. The sum of any number of sines of a given frequency will always be another sine wave of the same frequency. The difference of two sines of the same frequency is also a sine. The derivatives and integrals of sines are always more sines of the same frequency. Sines begat sines begat sines.

Another interesting feature is that any old repetitive waveform which can be produced by a practical circuit can be expressed as the sum of a series (usually an infinite series) of sines. This will be the subject of next month's article, so I won't pursue it here.

Then, of course, there's the notion that sines are as pure as refined sugar and more natural than whole-grain muesli.

All these properties are interesting (the last to poets, the rest to engineers) but none seems to totally explain the supreme importance of the sine.

The missing ingredient seems almost insignificant in comparison with the wonders of the Fourier series. It is this: if the input to any linear circuit is a sine wave, the output will always be a sine wave of the same frequency. If the circuit in question is an amplifier or attenuator (a 'DC linear' circuit) this is not particularly surprising but remember that any old circuit with the properties of proportionality and superposition counts as being linear.

The special relationship between sines and linear circuits, together with the Fourier series, gives a very powerful tool for circuit analysis whether by maths or by tuition. If you determine the response of a linear circuit to sine waves, you have essentially characterised the circuit completely. A circuit which gives a sine in response to a sine can be summed up in two graphs —

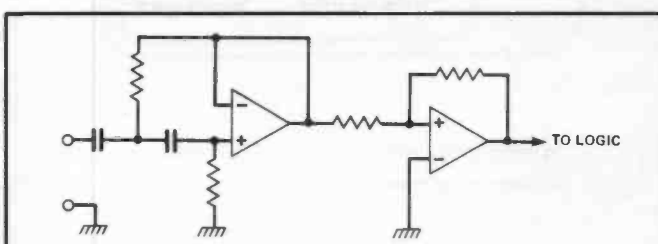


Fig. 1 Eric's tube train speed circuit.

one of the amplitude response, one of relative phase.

Imagine the complications if a sine wave came out distorted in a way dependent on frequency, just as a square wave would. How would you then describe the frequency response of the circuit? You'd have to draw the output waveform at each frequency as well as determining its amplitude and phase, or devise some horrendous mathematical expression to sum it all up — it just wouldn't be worth the effort.

If sines didn't give rise to sines in linear circuits, Fourier would be nothing more than a mathematical curiosity.

Notionally, one way to analyse the response of a linear circuit to a given waveform is to split the waveform into its sine wave components, determine the response to each component individually by means of the amplitude and phase response curves and then add up the individual responses for each sine wave to determine the response to the composite wave.

This is rarely carried out in practise, but an understanding of the relationship of a waveform to its sine components can give rise to some very useful general principles and insights.

Superposition

The last step in the notional analysis process is justified by superposition and is the universal and 'unquestionable' application of the principle that I referred to last month. You may not recognise it from my description, but any statement such as 'the capacitor removes the high frequency components of the signal' is actually an assertion of faith in superposition — that the individual components of a waveform can be dealt with individually and independently.

It's important to remember that all this applies only to *linear* circuits. Try adding up the individual responses from (say) a log law circuit and you'll end up with rubbish. Superposition doesn't work.

To show how general reasoning based on sines and superposition might work in practise, I'll take a simple example.

Amplitude Modulation

Since ETI has not published any AM radio circuits for as long as I can remember, I'll skim through the basics of AM transmission for anyone who may have missed it. The radio transmitter produces a high frequency sine wave known as the 'carrier' — this is the signal you tune your radio set to. The sound signal to be transmitted varies the amplitude of the carrier. At the receiver the sound can be recovered by rectifying the amplitude modulated signal and filtering out the remains of the carrier. This, in a nutshell, is AM radio transmission. Figure 2 shows the various stages involved.

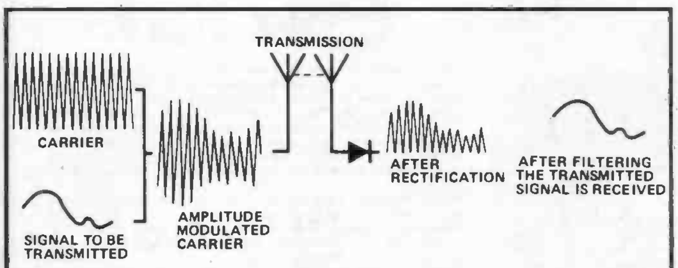


Fig. 2 The essential steps in AM radio transmission.

The receiver selects the radio station by means of a tuned circuit. Commercial radio receivers will usually have several tuned stages, but for our purposes we'll make do with one.

By suitable choice of coil and capacitor, the tuned circuit can have various degrees of 'sharpness' of tuning. Naturally, we would like the tuning to be selective enough to reject other radio stations broadcasting on adjacent frequencies but is there a limit to how sharp the tuning should be made? As any text book will tell you, the answer is 'yes', and it depends on some mysterious entities called sidebands.

If you wanted to transmit a 1kHz sine wave on a 1MHz carrier, there are several ways you could go about it. The most direct method would be to alter the gain of some amplifying stage in the path of the carrier in proportion to the 1kHz wave.

Another possibility would be to generate three sine waves — one at 1.001MHz, one at 1MHz, the third at 0.999MHz. By adding these together in suitable proportions (equal amounts of each will do) you'll get a 1MHz signal amplitude modulated at 1kHz (Fig. 3). Exactly the same signal as by the gain control method.

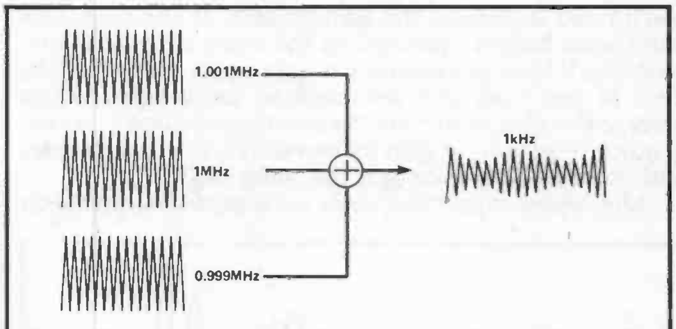


Fig. 3 Three constant amplitude sines add up to one amplitude modulated wave.

I'm not suggesting either of these as practical methods to produce an AM wave. The point to fasten on to is that the AM wave is equivalent to the sum of three constant amplitude sine waves. The 1MHz wave is called the carrier, the 1.001MHz wave the upper sideband and the 0.999MHz the lower sideband.

Look at the radio's tuned circuit again. The principle of superposition tells us that if we determine its response to the carrier, the upper sideband and the lower sideband individually and then add together the results, we will have found its response to the amplitude modulated wave.

It follows that if the tuning is so sharp that the sidebands are lost, all we are left with is the constant amplitude 1MHz carrier. The 1kHz wave (which is what we were trying to transmit) has gone for good and cannot be recovered.

Sine On The Line

I wouldn't blame you if you are not particularly happy with that argument. It seems to be in direct conflict with common sense. The frequency of the AM wave is always 1MHz, the tuned circuit is tuned to 1MHz, surely it should pass with no trouble? Common sense says 'yes', sidebands and superposition say 'no'. Which is right?

The special relationship between sine waves and linear circuits requires that the sine waves should be of constant amplitude. The frequency response curve for the tuned circuit would be drawn up for a practical circuit by applying constant amplitude sine waves at various frequencies and plotting the outputs. We now know the response of the tuned circuit to sine waves but this tells us *nothing* about how the circuit will respond to any *other* waveform, no matter how much like a sine wave it appears to be.

Does the amplitude modulated sine wave have very much in common with a steady sine wave anyway? If you have a signal generator you could set it to produce a 1MHz sine wave and then, just by varying the output level control, make your own amplitude modulated wave (Fig. 4a). You haven't set the waveform control to anything different, you haven't altered the frequency setting so the output must still be a 1MHz sine wave — right?

Let's see how far your credulity will stretch. I think you'll agree that on a fairly low frequency setting you could, just by jiggling the output level control, produce something similar to Fig. 4b. You haven't altered the frequency or waveform setting, you've just altered the output level, so this too is a sine wave — right? Or not?

If you are prepared to believe that Fig. 4b is a sine wave, how about Fig. 4c? To produce this amplitude modulated sine wave is a highly skilled job and takes years of practice. This is how you start. Set your signal generator to produce a 0.1Hz sine wave, connect the output to a 'scope', then adjust the gain control constantly so that the trace moves upwards at 45°. Where the sine wave crosses the axis you'll need unity gain; beyond that you'll need to reduce the gain steadily as the unmodulated wave bulges upwards. As the wave approaches its peak you'll have to increase the gain again, fairly quickly, until at the peak you are back to unity again. Then reverse the procedure for the downward slope — a fairly quick reduction in gain followed by a slower increase, and so on. You'll soon get the hang of it.

After years of practice, daily wrist exercises, and with a low inertia output level control you may eventually manage it at 1MHz! So — a triangular wave is nothing more nor less than an amplitude modulated sine wave, if you choose to look at it that way.

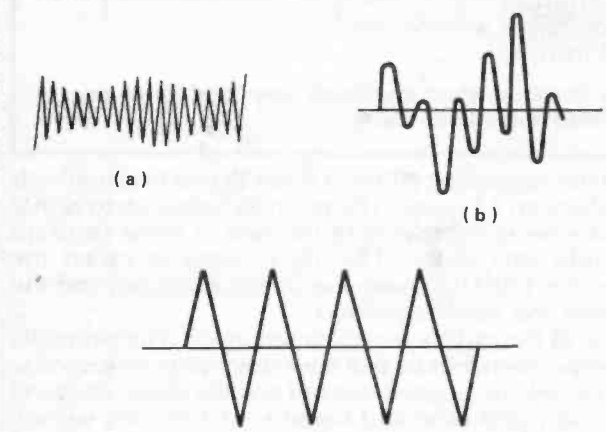


Fig. 4 Three amplitude modulated sine waves (?).

Since the tuned circuit's response to sine waves, which we know about in great detail, tells us nothing about the response to anything else (and I hope you'll now agree that the AM wave is in the 'anything else' category) where do we go from here? The answer is that we regard the AM wave as being the sum of three sine waves. It *is* three sine waves in the sense explained earlier — if you add the three waves together, you get the AM wave.

Now we can determine the response of the circuit to each of the three sine waves — we know all about that. It's what we draw in the frequency response curve. The final stage is to apply the principle of superposition. If the three sine waves are applied all at once (in the form of the AM wave) then the output will be the sum of the responses to the individual sine waves. And there we have it. All we need now is the maths!

To analyse linear circuits, then, we need three things — a way of splitting up arbitrary waveforms into sine waves, a way of determining the response of the circuit to sine waves, and a way of adding the sine waves back together afterwards.

This process is rarely carried out in total — it's more important to have a clear understanding of the principles. However, the methods of determining a circuit's response to sine waves can come in very handy at times and Fourier analysis is very useful for passing exams so next month I'll begin on the maths behind it all. **ETI**

THE TRUTH ABOUT HI-FI

Andrew Armstrong separates fact from fiction in this, the real life guide to designing and choosing audio equipment.

The subject of hi-fi is one which engenders more confusion in normally commonsensical people and has more infernal twaddle written about it than most others. Hi-fi is an area in which art meets science. Perhaps this is why commentators endeavour to screw up the inscrutable while providing a superficially acceptable definition of the whichness of what.

I shall try to demystify the subject and stimulate a critical appreciation of bunkum (including any which I may inadvertently perpetrate).

Distortion

The ideal of hi-fi is to provide the closest possible approach to the original recorded sound. The first requirement of any amplifier or preamp is that its transfer characteristic is linear over the audio range and that its frequency response is flat (or very nearly so) over the dynamic range of any likely programme material. Noise, (hiss, hum and so forth) should be low enough to be inaudible at normal volume settings. An amplifier which simply meets this specification is likely to give good sound quality, but will have some second order defects which slightly undermine the effect.

An amplifier which falls down seriously on any of the above would be barely usable. And yet I remember reading recently that harmonic distortion was not as significant as — what was it? — distortion caused by the crystalline structure of the wire ...

Frequency response figures extending well into the RF region are also not helpful. In fact too wide a response can be a disadvantage. That should stir things up a bit! According to research carried out at Aston University, significant ultrasonic components in the final output can cause headaches, so if such signals are present in the signal source it is preferable to attenuate them.

Transient intermodulation distortion (TID) on the other hand is a genuine distortion from which simple amplifiers may suffer. An amplifier may respond perfectly to any sinewave signal in the audio range but not to complex waveforms. Some of these may have slew rates (rate of change of voltage) significantly greater than the greatest slew rate of the highest frequency sinewave in the audio band. In amplifiers which use a lot of overall feedback across several stages, the feedback may not keep up with a really fast edge, even though it is adequate to cope with a full amplitude sinewave at the top of the audio range.

If TID occurs the amplifier may produce a high distortion for a short period. This effect can be missed in a short listening test but over a long period there is a sense that the sound is not completely clear.

So there is virtue in the amplifier responding without distortion to frequencies significantly above the audio range. This also prevents unwanted frequencies driving the amplifier into non-linear regions and affecting audio frequencies. However, while it is an advantage for the active circuitry to respond accurately to high frequencies, it is even better to exclude them with a gentle rolloff filter that does not cause response ripples inside the audio range. If a passive filter is used on the input of a preamp it should also virtually eliminate RF pickup on the inputs. This will be a step towards immunity to CB radios, fridge thermostats, etc.

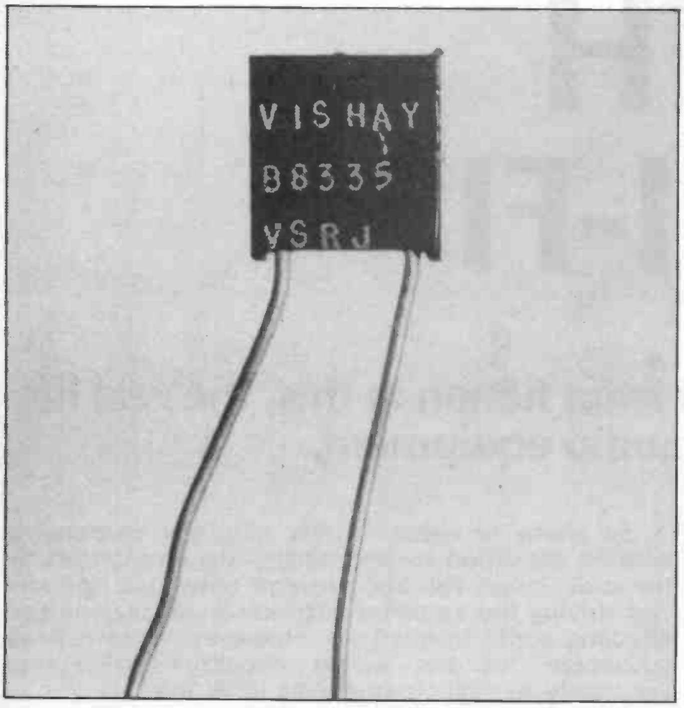
When TID was first discovered there was some scepticism but the effect can be shown both in prolonged listening tests and by measurement. Different circuit design techniques used in valve amplifiers make them less prone to TID than transistor amplifiers.

Most current commercial designs avoid TID so it is no longer a red hot issue but it still appears as a bug in less rigorous designs.

Coloured Wire

Don't laugh! I have encountered, in otherwise

Certainly not hi-fi, but what's the difference?



The ubiquitous bulk foil metal resistor. High temperature stability certainly but are they worth several pounds a time?

reputable places, the theory that the colour of the plastic insulation of internal wiring affects sound quality. If I remember correctly the message was to always use grey loudspeaker wire, because coloured dye will migrate into the copper and make the current flow non-linear. The writer did seem to be serious.

There is a current theory that the crystalline structure of any wire used in hi-fi equipment affects the sound quality, and that only linear crystal wire should be used. Linear crystal wire probably does carry current in a slightly different way on a microscopic level and this may lead to tiny variations in the graph of current against voltage for the particular wire. Such a variation might make a difference in the quantity and type of noise generated by the resistance of the wire. Accepting this for the sake of argument, the noise contribution of the wire could be about, oh, −100dB relative to the other noise ...

I have also seen criticism of the use of screened lead on the grounds that the dielectric loss in the capacitance between inner and outer could cause attenuation of high frequencies. This is true for RF but for audio it is far fetched. In any case, a well designed system will not use high impedances on long cable runs such that the self capacitance of the cable is significant.

I would criticise screened lead on another count. The screening is not always adequate. I noticed this effect recently on an electric guitar lead, where a standard coiled lead picked up buzzing from a fluorescent light while a top quality non-coiled lead picked up no untoward noise, even though it was longer.

In the few instances where ordinary screened lead is insufficient, I recommend the use of the thin PTFE insulated RF co-ax. This is expensive and rarely necessary. The screened lead used to connect the recent audio switcher project to its input sockets was quite ordinary, but there is no interference because the whole project is in a metal case. The only result of using ordinary screened lead is that if an unconnected input is selected and the volume turned to maximum there is just-audible crosstalk from an adjacent input. If something is plugged into the selected input (even a tuner which is switched off) no crosstalk is detectable. To put this further into context, the cables are tied tightly together and the crosstalk is audible at a volume control setting above the pain level for an active input.

Resistors

The types of resistor used in audio circuits, particularly in preamp circuitry, can be significant. Carbon resistors generate a lot of noise and it is better to use metal film in almost all cases. In general, if ordinary 1% metal film resistors are used, the semiconductors in the circuit will dominate the total noise and the contribution made by the resistors will be insignificant.

In cases where the ultimate performance is needed (for instance with a very low output cartridge) there may be some advantage in using high precision metal film resistors or even wirewound types. These should give a noise level not too much above the theoretical thermal noise.

However, in no case is the voltage coefficient of the resistor significant. Any non-linearity introduced by this effect will be negligible when compared with other circuit non-linearities, and indeed with the quality of any available signal source.

Capacitors

In a well designed circuit the capacitors will be deployed in such a way that minor deviations from the theoretical capacitor do not matter. Electrolytic capacitors should always be polarised in the correct direction and should not be asked to do anything except couple or decouple. If an electrolytic couples a signal from one stage to the next, its value should be high enough that the alternating voltage across the capacitor at the lowest frequency is negligible. For example, the impedance of a 100μ capacitor at 20Hz is 85 ohms, so if a capacitor of this value is used to couple into a stage having 100k input resistance only a small proportion of the signal will appear across it. Indeed, less than you think because the capacitive impedance is 90° out of phase with resistance. The change in overall impedance due to the addition of the capacitor is the square root of the sum of the squares — good old Pythagoras.

If the capacitance is slightly dependent on the voltage across the capacitor, the effect of this is minute. The same applies to any unwanted inductance or resistance in a supposedly pure capacitance and, for that matter, to any question of dielectric loss and non-linearity in different types of electrolytics. If the circuit is designed sensibly and a suitable value of capacitor is chosen, any effect on frequency response or linearity will be too tiny to measure. When I say such an effect can be neglected, I mean it is smaller than other unavoidable system defects.

There are times when the quality of capacitor is important. For example, in a tone control or filter there is inevitably a significant proportion of signal across the capacitors. In particular, some types of capacitor have a significant voltage coefficient — the capacitance depends on the voltage across the capacitor. Ceramics have been the worst offenders. On the other hand some polyesters and all polypropylene and polystyrene types are very good. The least consistent polyester capacitor I have measured had around 0.1%/V change in capacitance, while I have found ceramic types which show over 1%. As a general rule, it is safe to use polyester capacitors in filters or tone controls so long as a good brand is used and not one out of the junkbox.

Quality is also significant in decoupling. There the capacitor should not have a significantly higher impedance at higher frequencies, or high frequencies impressed onto the power supply may cause slight cross coupling between stages. High value electrolytics are often offenders due in part to self inductance. There is an argument for using local low value electrolytics or, if appropriate, tantalum bead capacitors to decouple sensitive stages. Tantalum beads have an excellent high frequency performance as decouplers although they also have a significant voltage coefficient. Some pundits suggest the use of film capacitors in parallel with the main power supply reservoir capacitors. This is not always a good move because the inductance of the electrolytic can resonate with the capacitance of the film capacitor and worsen the effect.

Power Supply

With an oscilloscope it is easy to check whether power supply lines have any stray signal on them, by using AC coupling and a sensitive range. If little or nothing shows up when a full amplitude signal at say 15kHz is fed in then the decoupling is sound. A small amount of stray signal may not cause any problem.

Practical circuitry will of course be slightly sensitive to power supply ripple or noise, but this effect should be minimised. A good way to do this is to use wide bandwidth low noise op-amps in preference to transistors in low level signal processing. If devices with good power supply rejection ratio (PSRR) and common mode rejection ratio (CMRR) are used, only a low level of hum will result with even a volt of ripple on the power supply. The use of voltage regulators should make hum inaudible at maximum volume setting with all signal sources switched off. To exceed this performance is clearly not necessary.

However, it is still necessary to use local decoupling capacitors on the power supply because the CMRR and PSRR are reduced at higher frequencies, as is the ability of the regulator to maintain a steady power supply voltage in the presence of a fluctuating load.

A good choice of voltage regulator for use in a preamplifier is the LM317 (and its negative counterpart the LM337). If the adjust terminals and the outputs are decoupled with 10μ electrolytic capacitors, the power supply noise is significantly less than than with 7800 and 7900 series regulators.

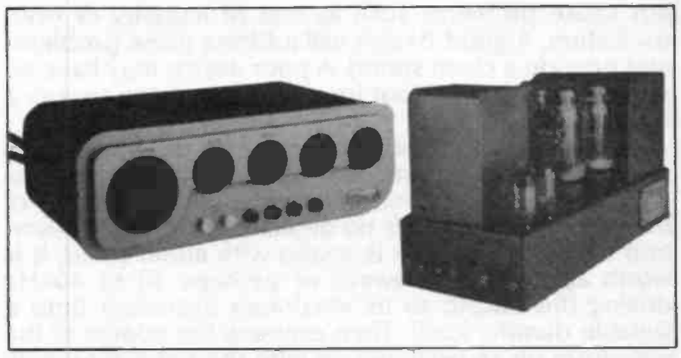
In a power supply for a preamplifier, the transformer should keep the voltage on the reservoir capacitors high enough to operate the regulators even if the mains is 15% below nominal. Then the sound will remain good even if the mains is a bit low. The regulators will then have perhaps six volts across them, in a circuit designed to supply ±12V.

In this case, the regulators will need small heatsinks and the power drawn from the transformer is significantly greater than that drawn by the preamp circuitry. Because the wattage rating of a transformer with a rectifier/capacitor load is about ⅔ of its VA rating, a transformer with a VA rating of at least double and preferable triple the preamplifier wattage should be used. More than this is unlikely to be beneficial, and can cause hum by its greater stray magnetic field.

To give an example, a 15V 6VA transformer would be suitable to operate a small preamplifier running on regulated supplies of ±12V.

Semiconductor Choice

There is a myth that only discrete transistors are suitable for quality audio, and that op-amps are inferior. This idea had some truth when the 741 was young, but nowadays it is outdated. The right choice of op-amps can outperform any discrete design. Unless, of course, you use a very complicated circuit of transistors lovingly matched by hand on a curve tracer. This would be a discrete op-amp!



The famous Quad II valve amplifier. The valve amps of old had specifications far from the standards of modern transistor amps and yet many are still held in awe today.

One reason why op-amps work so well in audio circuits is that the very high gain gives negative feedback effects which all but eliminate harmonic distortion. However, high levels of overall negative feedback mean the possibility of TID, so it is important to consider an op amp's ability to handle the highest slew rate which it will encounter.

It also helps if the internal design of the op-amp does not have any serious non-linearity. The 741 design used to have an unbiased class B output stage, and the feedback was therefore called on to correct for severe crossover distortion which it could not handle at the high end of the audio range. A load resistor connected to one of the power supply rails on the output of the op-amp was an effective way to improve its performance by preventing the output from crossing over at all. More modern designs do not suffer from this problem.

Some modern op-amps have a noise figure lower than ordinary discrete transistor circuits. The 5532 dual or 5534 single op-amps, which have been around for some time, give sufficiently low noise for most audio applications. There are newer and better designs worth consideration for very low signal levels. The OP37 is one but its price rules it out for applications in which its improved performance is no real advantage.

The choice of circuit techniques for power amplifier stages is rather different. Where the signal input level is much higher than that of a preamplifier, noise is no longer a problem. The voltage level of the output signal precludes the use of op-amps directly, though an op-amp could be used in an early stage. However, there is little to be gained because most op-amps do not perform well in larger systems with overall feedback round the whole circuit.

Power amplifiers often use long tailed pairs in the early stages with various output configurations. In general it is better if each stage of an amplifier has enough local negative feedback to make it fairly linear, so that the overall feedback is not called on to correct for too much. This reduces the likelihood of significant TID. It is also important that the output stage should have adequate gain. A well designed complementary output stage may have three transistors in each half because the gain of power transistors normally drops considerably at high currents. Excessive amounts of gain must be provided at low power levels to avoid unreasonable demands on the driver stage at high output power levels.

It is difficult to ensure that the gain change of the output stage over the cycle of the output signal does not cause problems such as loss of linearity or even oscillation. A good design will address these problems and provide a clean sound. A poor design may have no simple faults but will not be pleasant to listen to over a long period.

Some significant faults are not easy to identify with simple tests using a sinewave generator and an oscilloscope but the use of extreme tests can dig up some of the problems. If there is no detectable crossover distortion when an amplifier is tested with audio tones, it is worth applying a sinewave of perhaps 30 or 40kHz driving the output to its maximum excursion (into a suitable dummy load). Then examine the middle of the waveform on an oscilloscope with the input sensitivity set to show a range of a few volts. Amplifiers designed a little close to the limit may exhibit just detectable crossover distortion under these circumstances, which would suggest the possibility of TID on some signals.

MOSFETS

There is a real argument in favour of using class A to minimise the problems of designing a completely clean output stage. If crossover does not occur, a possible source of distortion is removed. Also, the effects of gain change are much reduced when neither transistor reaches zero current.

Another fashionable technique is to use power MOSFETS in the output stage. The gain change due to current change is lower and the crossover region is spread over a greater voltage range so the feedback which linearises it does not have to work so fast.

The disadvantage of power MOSFETs is that they often have a very high gate capacitance and can be difficult to drive without sacrificing speed, limiting the overall bandwidth or reducing the phase stability margin of the amplifier. It is easier to design a clean power amplifier using power MOSFETs, but a design using ordinary transistors need not be worse. If the circuit is properly designed to give clean performance it does not matter what devices are used in the output stage.

To sum up my thoughts on hi-fi circuit design, some factors affecting sound quality are surprising but everything significant is amenable to measurement. Not everything that matters is currently measured. Consider TID. This rather obscure effect was not discovered for a long time partly because measurements on hi-fi amplifiers were not designed to detect it. Once the theory arrived, the effect was detected. Anything which is literally incapable of being measured is most unlikely to produce an effect detectable by the human ear.

Damping factors

An amplifier's damping factor measures how well the amplifier damps out spurious loudspeaker cone vibrations. As the cone vibrates, the movement of the coil in the magnetic field generates a voltage. If the coil is deliberately shortcircuited and the cone vibrated, the response will be very soggy and any cone resonance will be damped. Ideally the amplifier output should look like a short circuit to any currents arising from spurious vibrations. A low output impedance gives a high damping factor.

It is not worth chasing extremely high damping factors in selecting a commercial amplifier because its effects will be reduced by other factors such as the resistance of the loudspeaker cables (even where good quality thick cables are used). The crossover unit in the loudspeakers will also reduce the level of damping seen by the loudspeakers.

As consideration of the damping factor has as much to do with choosing as with designing a hi-fi system, this is a good place to move onto other 'choice factors'.

General Criteria

Before worrying too much about the technical specifications, you should work out how and where your hi-fi will be used. If you have a special listening room, soundproofed and lined with acoustic tiles then it is worth aiming for a very high specification with the lowest possible noise level and distortion.

Unless you use headphones, the ultimate hi-fi will sound no beatter than average equipment in most living rooms. Traffic noise and so forth will prevent you from hearing the difference between 80dB and 90dB signal to noise ratio. Room colouration will alter the frequency response enough to render a totally flat response pointless.

Loudspeakers

The loudspeaker is probably the major factor in sound quality. Loudspeakers are often the weakest link in the chain and a good place to invest real money. When looking at loudspeakers, reject immediately those which do not have a solid, non-resonant cabinet. If it sounds like a box when you tap it with your finger, it will sound like a box when you play music through it. The duller the tap, the better. Concrete cabinets are probably the best but impractical for most people!

Generally, the more drive units a loudspeaker has the more carefully it must be designed to benefit. A really cheap three unit design should be viewed with suspicion. When you have rejected unsuitable speakers, listen to the serious contenders critically. Choose music you are familiar with and which is demanding of loudspeaker performance. Also, listen to speech through the speaker before you buy it. Close your eyes and see if you could imagine a person speaking, rather than a wooden box. Because the human voice is so familiar it can betray defects which are not otherwise obvious.

When a possible loudspeaker has been chosen, a suitable amplifier is the next requirement. This must have sufficient power output to produce an adequate sound level from the chosen speakers, but (ideally) not enough to blow them up. Most well designed power amplifiers will perform so the human ear can detect no flaw but choosing a reputable make is an added insurance.

A preamplifier should be chosen to provide low noise and all the inputs you need. Nothing is worse for the equipment or the user than to be constantly plugging and unplugging connectors at the back. There is a fashion to eschew tone controls on expensive preamps, but I think they are to be preferred. However, it is important there is a clearly marked neutral position which you can trust or, even better, a tone defeat switch. This will allow you to listen to your best recordings without unwanted modification.

If you intend to play records a scratch filter is a good idea. A choice of frequencies is also an advantage, to clean up the sound while losing as little music as possible.

When you listen to the system so far, set the volume as loud as you ever expect to want it and then turn off the signal source. Can you hear any hiss? If you can hear much then reconsider your choice of preamp.

Sources

Choosing signal sources is complicated. Perhaps the easiest one to deal with is CD. The majority of CD players nowadays are so good that most people cannot hear any deficiency. The facilities offered by each one are different, as is the standard of assembly. Some of the newest machines offer better error correction than earlier designs, but only in more expensive models. This can be useful as worse scratches can be tolerated without losing sound quality.

Reject any machine which seems mechanically flimsy then choose one which you feel happy with. The chances are you *will* be happy with it. Don't worry about the last ounces of performance. If the noise and distortion are below the level you can hear in your living room, halving them won't produce a dramatic improvement.

Although vinyl discs will decline in popularity as CD takes over they will probably be around for decades. If you want to play records then buy a good deck. To put it simply, the turntable should be heavy and solid and the arm should be light, free moving and capable of precise adjustment. Evidence of mechanical precision in all parts is a good sign.

Cartridges are often priced from tens of pounds to around a thousand. There are good, inexpensive ones, but they do give slightly different tonal balances so listen for one which sounds right to you. Spending £500 on a cartridge is barmy because the quality of the best pressings is nowhere near the quality available from a CD player.

Tuners are a big subject in themselves, so I will just say that the performance varies significantly between models. Among other things is the ability to reject strong out of band signals while receiving a weak station in stereo. Listen critically to a number of different stations.

Dolby

In cassette players there is enormous variation in the quality of reputable brand machines. Both the mechanics and the electronics have to be well designed and assembled to provide reasonable performance.

Before switching on, look at the facilities. If the machine sports Dolby C, check that fine adjustments can be made for individual tapes. If the flat frequency response cannot be tweaked to the correct level when recording, Dolby C will multiply up response errors much more than Dolby B. Dolby C gives a dramatic reduction in noise but it cannot do its job well unless the machine is first class.

The mechanics should be solid. Tape heads on a slide made of a thin piece of bent metal are useless. Even if the line up is accurate when the machine is new, this will not last. Small head alignment errors of only a few minutes of arc can have a seriously deleterious effect. A good test for head stability is to make a mono recording of the interstation hiss from an FM tuner and then play it back in mono. If the head alignment shifts at all, the left and right channels will have a time difference and weird phasing effects will result.

Access to the heads and the capstan pinchwheels for cleaning is vital. If the machine is impractical to clean don't buy it. Sooner or later you will play a tape with a dirty pinchwheel and it will stick to the wheel and be mangled.

In conclusion, when you have put together a good hi-fi system, keep it clean. I cannot say this too strongly. There is little point in cleaning the pickup after it has damaged your favourite LP or cleaning the pinchwheel after it has ruined a tape. Nothing distorts quite so thoroughly as a recording with a hole in it.

Happy listening.

ETI

THE BATLITE

Andy Armstrong's Batlite checks batteries, alternators and wiring thus preventing darkness in the Batcave.

This is a simple project which can give advance warning of a number of possible problems with a car's battery, alternator or wiring. The Batlite could also be used to indicate voltage changes in other situations.

The battery voltage is shown with a simple colour display made from an array of bi-colour LEDs. This alters colour from red, through orange, and green according to the voltage present on the supply line. Keeping an eye on the Batlite mounted on a car's dashboard can give early warning of several potentially disastrous problems.

Construction And Testing

All the components except the LED display are mounted on the PCB. R4, for which no value is given, should be omitted at this stage. There should be no difficulty fitting the other components to the PCB. The display should be connected using wire links directly on the pins, or on a piece of stripboard, in the manner shown in Fig. 1. The display should then be connected to the PCB for testing.

At this stage a bench power supply is highly desirable. Set the supply to 11V and connect up. If all is well the display should light up red. If any segments are not red, then reverse the connections to them. If it's all green then reverse the whole display.

BUYLINES

The LED array is, to our knowledge, only available from Farnell. Non-account holders should contact Trilogic, 29 Holm Lane, Bradford who will supply Farnell products at a cost. Alternatively, there is nothing wrong with making your own array using four bi-colour LEDs — Maplin UF96E or QY83E types, for example. The LM358 is available from Electromail (stock no. 632-871) and the PCB will be available from our PCB Service.

HOW IT WORKS

IC1a forms an oscillator in which C1 is alternately charged and discharged via R6. The charge and discharge times of C1 are modified by the contribution from the potential divider comprising R3, R4, and R5, This effect is dependent on the battery voltage and so the mark to space ratio depends on the battery voltage.

The square wave output from IC1a is inverted by IC1b and the signal and its inverse are fed to opposite sides of the display with a current limiting resistor in series. The apparent colour of the display depends on the relative length of time for which the red and green LEDs are on, and hence on the mark to space ratio of the oscillator (Fig. 2).

The extra voltage drive afforded by the second op-amp is necessary because of the high voltage drop of four LEDs in series.

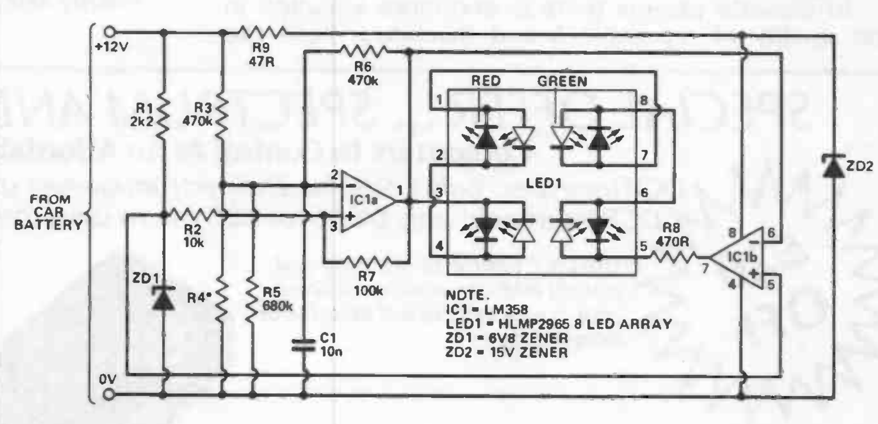


Fig. 1 The circuit diagram.

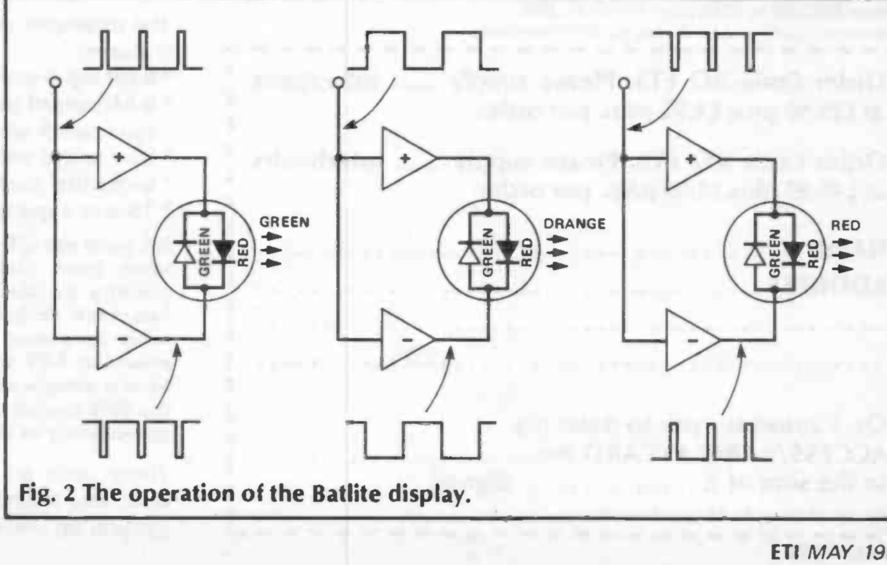


Fig. 2 The operation of the Batlite display.

Increase the voltage until the display shows all green and no red. If this happens at about 14V then R4 is not needed. If, on the other hand it happens at a lower voltage, the addition of a high value resistor for R4 should correct the situation. A good value to start with is 3M3, and then test again to find out if a higher or lower value is needed.

If you are using the Batlite for purposes other than car battery monitoring, you will have to establish for yourself a suitable value for R4 and R5.

Operation

The gadget should be connected to a point in the car's wiring which maintains the same voltage as the battery. That is to say, not at the end of a long thin wire with a variable load on it. A thick wire on the ignition switch is a good bet.

If you should connect it the wrong way round, then ZD2, whose normal function is to absorb spikes, will conduct in a forward direction, and protect the op-amp. Under these circumstances R9 will smoke mightily.

Once you are used to how the Batlite responds to normal conditions, the alteration of response due to a fault should be very obvious. If the display remains orange even when the engine is running fast, then the alternator has probably failed.

If it only turns orange when the headlight or rear heater are on, then the fan-belt may be slipping. A battery in bad condition will cause the colour to change to red rapidly when the engine slows to idle, at red traffic lights.

Keep an eye on it. A prototype of the same device warned me that the brushes in my alternator had failed when there was no other symptom — nor would there have been until the lights dimmed and the engine stopped.

PARTS LIST

RESISTORS ¼W 5%.	
R1	2k2
R2	10k
R3, 6	470k
R4	* See text
R5	680k
R7	47R
R8	470R
CAPACITORS	
C1	10n polyester
SEMICONDUCTORS	
IC1	LM358
ZD1	6V8 400mW zener
ZD2	15V 400mW zener
LED1	HLMP2965 (Hewlett Packard LED, available from Farnell)

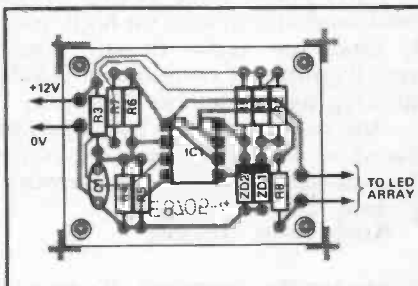


Fig. 3 Component overlay.

ETI

READ/WRITE

Reviews Review

I feel I should compliment you on a couple of recent articles — Gareth Connor's CAD review (March 87) and Barry Porter's article on balanced lines (February 87). I found Gareth's comments refreshingly unbiased. I use the Analyser II package on my IBM PC clone along with the EC-ACE package from the US. Both are excellent.

Barry Porter rates as one of the most readable writers on high quality analogue audio design. Apart from a couple of component values missing his article was excellent.

Any further articles by Barry will always be welcome as will any more reviews along the lines of Gareth's.

Tony Crane
Kings Lynn, Norfolk.

Thanks for the comments. It's nice to feel wanted! We shall continue to feature Barry porter's articles and to review relevant micro packages when we can.

Bird Brained

Your new column 'Bird's Eye View' looks like it's going to be great! You ought to double its size immediately.

Do tell us. Who is this fella John Bird who stands in judgement of all other contributors?

S.R. Thackery
Ripley, Derbyshire.

I was sitting by the glowing log fire reading my action-packed March copy of ETI (back to front as I usually do) when I spotted a new name — John Bird's eagle-eyed views on a parcel of back issues of ETI.

I am delighted Mr. Bird agrees the standard of features and circuits is very high with few exceptions. However, Mr. Bird does feel most ETI projects have no engineering content. He finally gets round to this conclusion in column two. Why he bothers heaven knows — is the Editor short of projects I ask myself. I do hope he will enlighten us how many ETI projects he has built since 1972. I have successfully built 27 but back to the facts...

I can find no fault with the presentation of projects in ETI. Generally the engineering content is sufficient for the construction and build-up and in some three part series the engineering content is remarkable.

I have also compared ETI with other electronics magazines which arrive on my desk daily. ETI always wins. The features are more balanced and interesting and the projects have that little extra thought which lets you know the circuit is well tested, proven and can be easily built with good results.

Perhaps ETI readers would prefer a project rather than another chunk from Mr. Bird!

Keith Lawrence
Ilkley, West Yorkshire

John Bird has been a mainstay member of the British electronics industry for many years. More than that he is (understandably, perhaps) reluctant to reveal.

However, he has constructed many of the projects in ETI and even contributed a few (under suitable pseudonyms of course). Yes, some of his own projects he holds to be lacking in engineering content! It is *electronic* engineering which John Bird feels is lacking and not mechanical details. He thinks too many projects are jigsaw compendiums of standard building blocks.

We are delighted that Keith Lawrence disagrees with this and yes, we do need more projects! Anyone with experience of 27 successful ETI projects can surely come up with a few novel ones for the rest of us...

Monitoring The QL

My main interest is computing for a hobby and for word processing. Your magazine is of great interest to people like myself who need to interface odd pieces of equipment.

The 'Foreign Ports' article in the March ETI was excellent and I am now looking forward to the follow-up ETIFaker.

I have a QL which requires a 'special' monitor. At present I use a Philips black and white TV set. Can you advise what is necessary to convert the TV set for use as a monitor? There must be many people in this position who would welcome such a project.

L.E.G. Lettice
Alresford, Hampshire.

It is not possible for us to specify the modifications required for every TV set around. Moreover, the gain in quality with a monochrome set is very small anyway. The QL can be used with many 'normal' RGB monitors and we would advise you try some of these first. We are planning a generalised TV-to-RGB monitor conversion project but this will only cover colour TVs.

Air Conditioner

My immediate neighbour recently bought a Sony TV and, although their two previous sets required no filtering of any kind against my transmissions (I am a radio amateur), the new unit did. The antenna down lead was filtered with *four* ferrite rings in an effort to remove the interference but a complete cure was not effected until I fitted an ETI mains conditioner (September 1986 issue).

From observations I have gained the impression that Sony sets are very prone to interference and suffer from a general lack of gain. Do you have any comments?

R.C. Parnaby (G2DPA)
Beverley, East Yorkshire.

As far as we are aware, Sony sets are no better or worse than any others with regard to interference.

At the risk of teaching Granny to suck eggs, there are a few comments to make on the subject of dealing with interference. If the set is fitted with a pre-amplifier, any filtering must come *before* the amplifier.

It can be a damn nuisance to place the filters correctly if a mast-head pre-amp is fitted, but it's got to be done.

After following your natural instinct to filter the aerial lead, it's as well to look around for any other source of pickup. Any old length of wire can inject unwanted signals into the set. The mains lead is no exception. If TVs have much resistance to interference entering via the power supply it's as often as not by accident rather than by design.

Fitting a mains filter is always a sensible precaution and we are pleased to hear that the ETI design proved effective.

ETI welcomes letters from readers on any topic. If you want to put us to rights, air your views or just want to see your name in print, put pen to paper (or finger to keyboard) immediately and let us all share your ideas.
Write to:
Electronics Today International,
1 Golden Square,
London, W1R 3AB.

ETI

MIDI MASTER KEYBOARD

John Yau shows how all manner of MIDI instruments can be controlled from the ETI master keyboard.

The Musical Instrument Digital Interface (MIDI) is now the universally accepted standard for communication between synthesisers, drum machines, music computers and other musical peripherals. Probably the most common MIDI application is to link synthesisers together in a way that permits a single keyboard to play all the other units attached to it via MIDI, as shown in Fig. 1.

This project is a six octave velocity sensitive keyboard designed to be a central controller for any number of connected MIDI synthesisers.

MIDI information transmitted by the keyboard controller includes note on/off events, program changes, pedal hold on/off and also pitch bend and modulation information, more details of which will be given later.

A full description of the MIDI standard was given in the January and February 1987 issues of ETI but before embarking on a description of the ETI MIDI Master Keyboard's specifications it is worthwhile giving a brief description of the concept of MIDI channels.

When the controller keyboard is played, the corresponding note information is passed through to all the other synthesisers via the MIDI serial link in a 'daisy chain' fashion. Each synthesiser can usually be programmed to act upon MIDI information transmitted on any one of the 16 possible channels.

These channels do not exist physically (remember the MIDI link is a serial one). As we shall see, the intended channel destination for a MIDI message is conveyed in the form of a number embedded within the message itself. MIDI synthesiser units with programmable channel number reception (virtually all commercial units) combined with a keyboard controller that transmits on a programmable MIDI channel, can provide a very useful and powerful configuration as far as the musician is concerned.

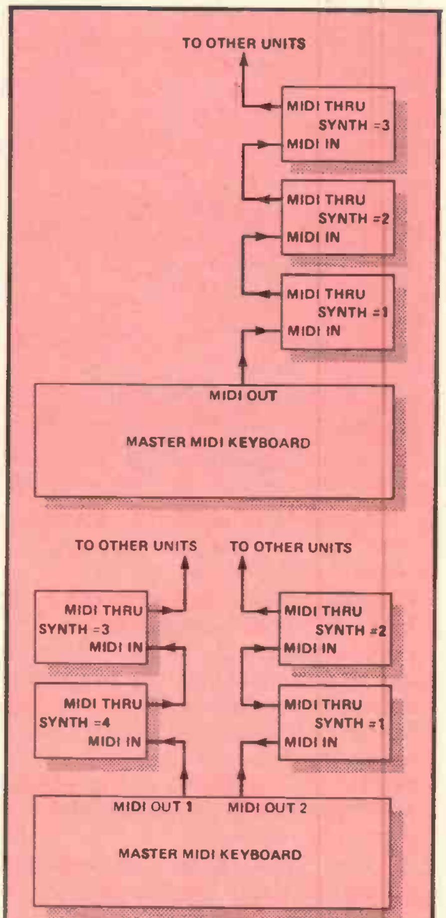


Fig. 1 Using the ETI MIDI Master Keyboard.

From the transmitting keyboard it is possible to select and play any synthesiser in the connected MIDI 'daisy chain'. Alternatively two or more synthesisers can be played in unison if they are selected to receive on the same MIDI channel.

This 'doubling up' of synthesiser voices by playing different modules in unison is a common trick used by keyboard musicians to achieve a richer or 'fatter' sound. Since the average player has only one pair of hands the unison playing implementation offered by using MIDI is more than welcome!

Using MIDI, a single synthesiser keyboard can independently select up to 16 separate slave instruments. In such a system in which the master mother keyboard controls other instruments, the slave instruments may be just MIDI equipped sound modules and need not have keyboards at all. Moreover the mother keyboard itself does not need to have the capability of generating sound of its own accord.

More and more synthesisers are being made available in the form of a black box equipped with a MIDI interface without a keyboard for incorporation into a master mother keyboard system. Examples of such products are Yamaha's TX7 (a DX7 without the keyboard), the rack-mounting keyboardless versions of the Ensoniq Mirage and the Prophet 2000 sampling synthesisers.

The project presented here is a MIDI master keyboard that is suitable for controlling slave instruments in this way. The actual keyboard unit itself does not have its own sound generation hardware but is capable of full MIDI control of any externally connected device.

Specifications

For maximum flexibility the 72-note keyboard is fully touch sensitive. This means that if the slave synthesiser module can respond to key velocity information, the harder you strike a note the louder it will be. For some synthesisers such as the Yamaha DX7, the key velocity information is also used to alter the tonality of the sound as well as the amplitude.

A unique feature of the system is that the touch sensitivity of the keyboard can be varied over a range of 16 different preset settings. This means you have complete control of the dynamic range of the synthesiser module direct from the mother keyboard. For synthesisers that do not feature touch sensitivity, the velocity information transmitted by the mother keyboard is simply ignored.

Most MIDI synthesisers have performance controls which are accessible via MIDI. To accommodate this the mother keyboard system has two joystick controls and three footswitch inputs. The joysticks enable the system to transmit MIDI information relating to pitch bend and modulation. The footswitches enable sustain pedal hold, portamento switch and program advance information to be sent.

MIDI information is transmitted in two output streams, called channel A and channel B. The default setting is that channel A transmits on MIDI channel number one and channel B transmits on channel number two. However, the output streams can be independently assigned to any of the possible 16 MIDI channels.

The main purpose of having two MIDI output streams is to facilitate a split point on the keyboard. A split point can be programmed to be anywhere on the keyboard. Any notes played to the left of (and including) the split point key are sent to the MIDI channel assigned to the channel A output stream while notes to the right of the split point are assigned to channel B.

Using this facility two separate synthesiser modules can both be played from the mother keyboard with each synthesiser assigned to either side of the split point.

For the average piano player, transposing a written piece of music whilst playing can be a bit of a nightmare, especially when a lot of flats and sharps are involved in the key signatures. When playing synthesisers with the MIDI Master Keyboard an easy way out is offered to the musician fed up with mentally juggling semitones whilst playing.

The transpose feature in the master keyboard allows note information to be transposed before it is transmitted. So it is possible to play in a fixed key in relation to the physical keyboard while the actual notes played and transmitted through MIDI can be of any key signature.

This facility is especially useful when playing keyboards to accompany singers. The music can be instantly transposed at a touch of a button to suit the singer's range.

An additional feature incorporated into the mother keyboard system is the ability to independently transpose the keyboard at either side of a programmed split point. The main use of this feature is to transpose voices independently over octave ranges. Although one does not relish the thought of two synthesiser modules being played at different key signatures the possibility is there!

The ETI MIDI Master Keyboard project enables the music enthusiast to acquire a high specification MIDI mother keyboard at low cost. Some time and patience is required for the construction, especially within the mechanical construction side. However, the level of finish is up to the individual. You may be content with the keyboard nailed onto a wooden base (the prototype remained in that state for quite a spell!). Alternatively, a professional style cabinet finish may be easily achieved.

Hardware Overview

There are a total of six printed circuit boards making up the guts of the hardware for the ETI MIDI Master Keyboard. This may seem a lot but some consolation can be drawn from the fact that three of them (the keyswitch PCBs) are identical. These three boards are mounted along the length of the keyboard and serve the dual purpose of holding the CMOS multiplexer circuitry and providing the mounting base for the keyswitch springs.

Of all the PCBs the only double sided one is the main CPU board. This board holds the 6502A processor circuitry and all its associated peripheral devices as well as the analogue parts of the pitch bend and modulation joystick circuitry. The fifth board (the front panel board) holds all

LED display circuitry and also serves as a mounting base for the push button switches that form the data entry keypad. Last but not least is the power supply PCB, which provides the necessary power rails for all the boards.

The heart of the system lies within the CPU board as shown in Fig. 2. All the necessary functions for the operation of the MIDI keyboard are directed by the on-board 6502A processor running at 2MHz. Physical tasks to be performed by the processor include scanning the keyboard, scanning the data entry keypad and footswitches, reading the joystick positions, setting the current LED display and finally transmission of MIDI data. All these tasks require a substantial number of peripheral devices to be placed within the address space of the 6502A processor.

Scanning The Keyboard

Perhaps the most critical task performed by the 6502 is the scanning of the keyboard. Each note on the keyboard can be in any one of three possible states — pressed, not pressed and in transition.

Detection of the transition state is required for velocity sensing and necessitates a two bus bar system as shown in the diagram of the keyboard mechanics in Fig. 4.

When a note is in neutral or unpressed state its contact spring touches the upper bar. Pressing a note causes the plunger to force the contact spring against the

HOW IT WORKS

Figure 3 shows the circuit of the three keyswitch PCBs mounted along the length of the keyboard chassis.

Both the upper and lower bus bars are tied to +5V via pull up resistors R65 and R66. IC27-35 are 4051 CMOS 8 channel multiplexer devices.

Each device has its data input tied to 0V. The three bit address input presented at pins 9, 10, 11 routes the data input (0V) to one of the eight outputs. However, at any time only one of the CMOS multiplexer devices is selected to be active by IC26, a 4-to-16 decoder (of which only nine outputs are actually used).

With a 7 bit address (four bits for the 4-to-16 decoder, IC26, and three bits for the CMOS multiplexers, IC27-35) a 0V signal can be routed to any one of the 72 keyswitch contact springs that are electrically connected to the CMOS multiplexer outputs.

To examine the state of a key, all that has to be done is to supply the 7 bit address of the key and then read the state of the upper and lower bus bars. If the key were idle the contact spring would be touching the upper bus bar, thereby pulling its potential to 0V (actually not quite 0V due to the resistance of the CMOS switch). Similarly, a key depression would ground the lower bus bar. In the transition state both bus bars would remain at 5V potential.

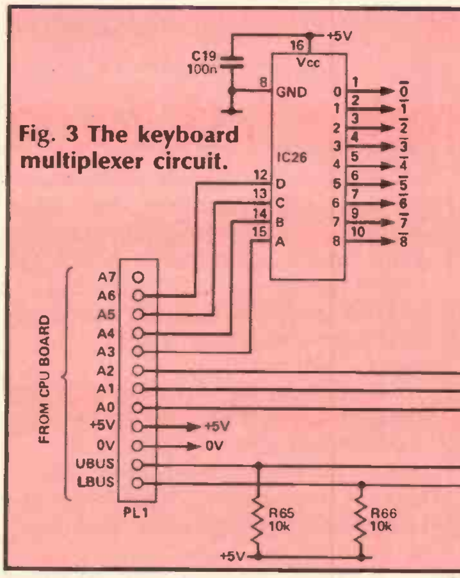
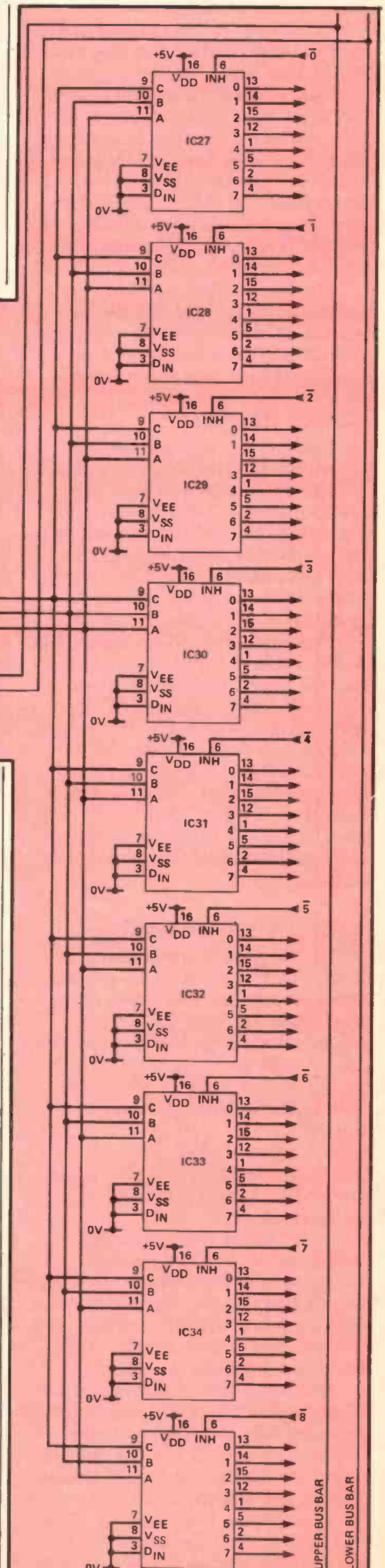


Fig. 3 The keyboard multiplexer circuit.



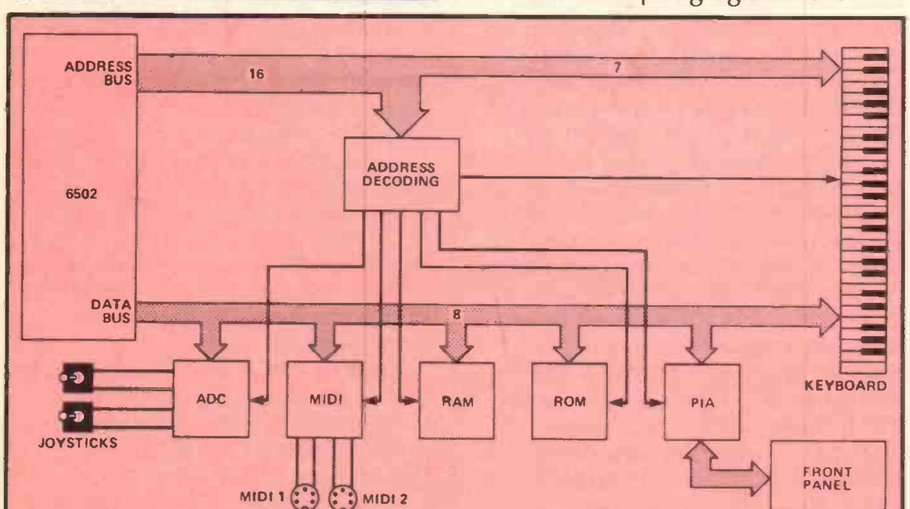


Fig. 2 The MIDI Master Keyboard.

lower bus bar. When in the transition state the contact spring is touching neither the upper nor lower bus bar.

The software examines each key at precise time intervals of 2ms. Velocity sensing is achieved by timing how long a key takes to transverse from the upper to lower bus bar when pressed by counting the number of discrete time intervals that the key spends in the transition state.

For the moment we will concentrate on the hardware aspect of the keyboard scanning with the construction of the keyboard and keyswitch PCBs.

Construction

Some time and patience is required in assembling the MIDI Master Keyboard as there are a fair number of printed circuit boards to be tackled as well as the keyboard mechanical assembly (and cabinet construction, for those who want a professional finish).

The keyswitch PCBs should be made up and incorporated into the keyboard mechanics first. Thereafter the CPU board, the front panel board and the power supply can be assembled separately and wired into the keyboard unit to make up the complete system. The construction of the latter boards will be described in subsequent issues.

Keyswitch Mounting

The keyboard mechanics comes in the form of 72 plastic notes which are mounted on a steel plate chassis. Each note pivots on a flange protrusion from the chassis and has a return spring at the back of the note, pulling it towards the chassis (Fig. 4).

A keyboard with square fronted notes may also be used, the choice being a matter of personal taste.

Attached to the underside of each note is a nylon plunger tab which, when the note is pressed causes the contact spring for that note to move from the upper bus bar and come into contact with the lower bus bar, as shown.

Start with the assembly of the three keyswitch PCBs. Although all three boards are identical the component layout for the middle board (called board B and shown in Fig. 5) is slightly different because of the inclusion of IC26 (the 74LS42 decoder) and the bus bar pull up resistors R65 and R66.

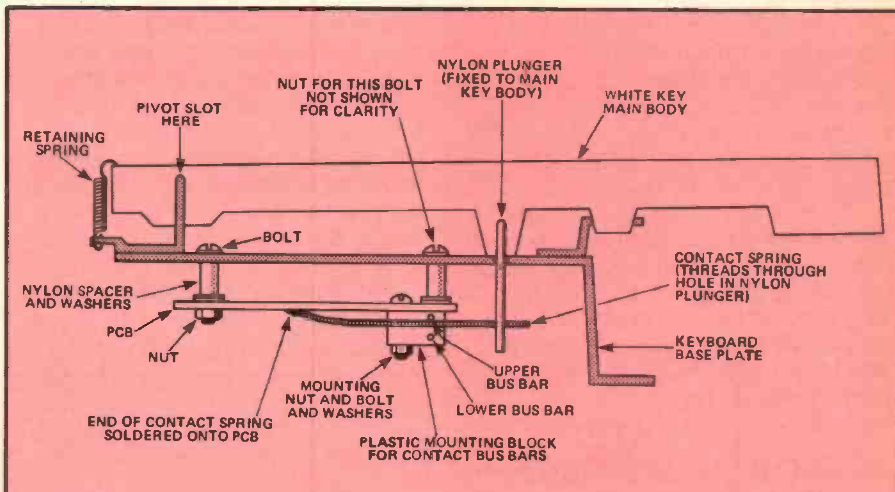


Fig. 4 The keyboard mechanics.

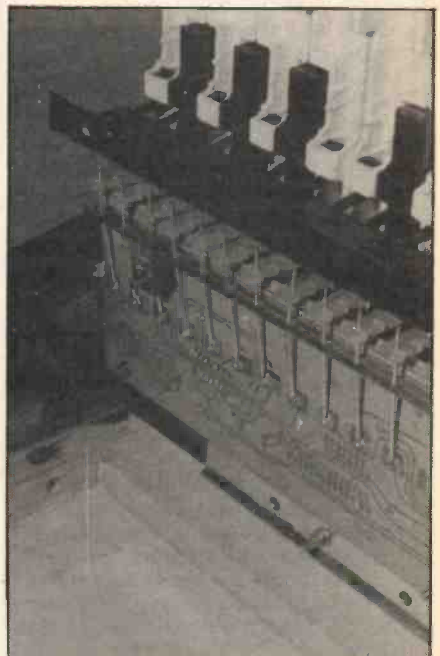
All the jump links should be kept identical on all boards (in fact some links on boards A and C are redundant because of the absence of IC26 and R65, R66, so the keep-them-the-same rule is for simplicity's sake).

It is important to note that the contact springs are *not* to be soldered in at this point. It is better to mount them after the boards have been bolted onto the chassis of the keyboard, in order to ensure best alignment.

A 12-way cable should be fitted to board B around IC26 and terminated with a female PCB multi-way connector. Cable length should be about 50 cm — long enough to reach the CPU board. The 12 way cable should be soldered directly to board B since there is no room for a multi-way connector when the board is mounted on the keyboard chassis (boards are mounted with component side facing the chassis with only about 8mm clearance).

After all the components and links have been mounted, the next task is to mount the upper and lower bus bars. These are gold plated contact rods which run parallel to each other along the whole length of the keyboard. Ready drilled plastic mounting blocks were used. These have two holes spaced a short distance apart in which the contact rods are mounted and a larger single hole for mounting onto the PCB.

Use eight mounting blocks and insert the rods through all of them and space them roughly equally apart. On board A drill holes marked by the letter A, use the B holes on board B and C on board C. Adjust the mounting blocks so they are positioned above these holes and use suitably sized bolts to fasten them to the boards.



The prototype keyboard fully assembled and hinged up in its cabinet to reveal the PCB, contact springs and bus bars.

The three boards are now held together by the parallel bus bar assembly. At this stage, link the three PCB tracks which run parallel along the edge of the boards so that they continue throughout the span of the three boards. Also link the power rail terminations so that they span all three boards.

Wire the bus bars by soldering two wires from appropriate points on the bus bars to the take-off points on board B (lightly tin a small area on each bus bar before soldering the wires). Finally, wire the nine decoder outputs from IC26 to the appropriate terminals on the three PCBs as shown in the component overlay diagram.

Some keyboards are supplied already assembled and mounted on a steel chassis. Buyers of such keyboards should skip the next section.

To mount the keyswitch PCB assembly, drill holes in the keyboard chassis and use a combination of nuts, bolts, washers and nylon spacers to firmly fix the three PCBs in place. The stand-off height of the PCBs is important since it effects the keyswitch action. In the prototype, the stand-off height was about 8mm (see Fig. 4 for details of assembly), but a different height may be required depending on the dimensions of the keyboard mechanics.

It is essential that the stand-off height should be such that when a contact spring is soldered onto the PCB pad and threaded through the lower hole in the nylon plunger (having passed between the bus bars) it is in contact with the upper bus bar with slight tension when the key is neutral and in contact with the lower bus bar when pressed. In order to achieve the optimum position, it may be necessary to fine adjust the height by adding or removing washers.

When mounting the boards onto the chassis some notes on the keyboard will have to be

PARTS LIST KEYBOARD

RESISTORS	
R65,66	10k
CAPACITOR	
C19	100n
SEMICONDUCTORS	
IC26	74LS42
IC27-35	4051
MISCELLANEOUS	
PL1	12 way female multiway PCB connector

PCBs (3 off); 72 note plastic keyboard; 72 spring contacts; bus bars (2 off); 12-way ribbon cable and female multiway connector; plastic mounting blocks for bus bars; metal keyboard base plates; spacers, nuts and bolts.

BUYLINES

The keyboard mechanics are available from Clef Products, 44a Bramhall Lane South, Bramhall, Stockport, Cheshire, SK7 1AH. The prototype used a 73 note keyboard with the rightmost note as a dummy key.

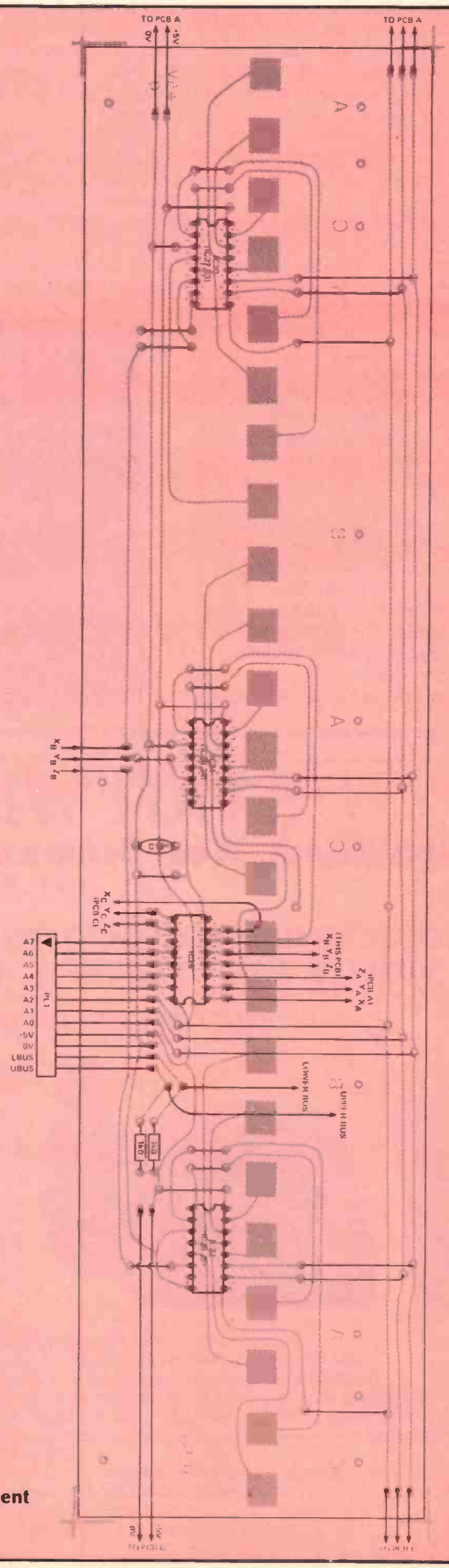


Fig. 5 The component overlay for the keyboard PCBs.

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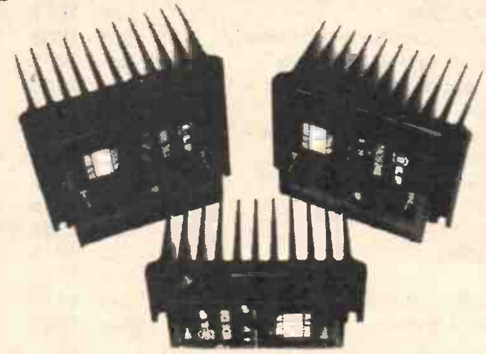

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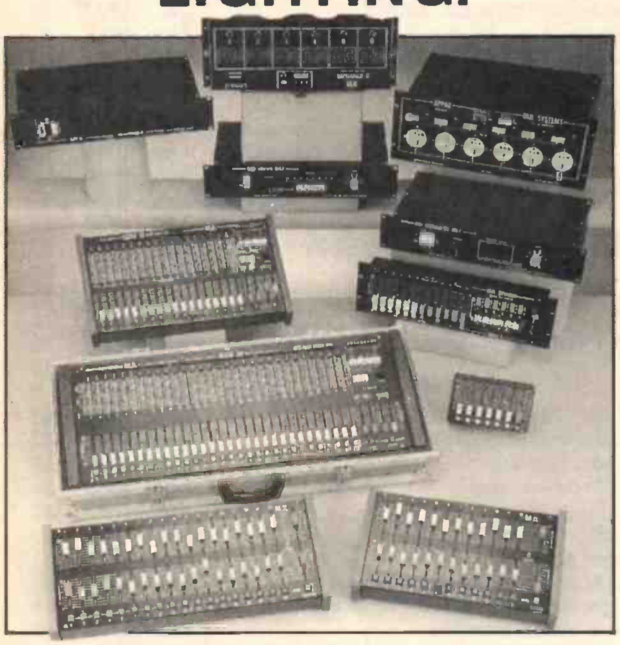

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temporarily removed in order to access the other side of the steel chassis to tighten up the bolts.

Before finally tightening up the bolts make sure that the boards are positioned squarely so that the bus bar edge lies perfectly parallel to the row of nylon plungers in the keyboard mechanics.

The final stage in the keyswitch assembly is to mount the contact springs themselves. When handling the contact springs only pick them up by the bulbous end, otherwise sweat or dirt from your hands can easily impair the spring's conductivity.

Take each spring and tin the bulbous end very lightly with solder. Act very quickly when doing this to avoid flux creeping along the length of the spring and making it stiff.

Tin the copper pad on the PCB and position the spring, by passing it between the bus bars and threading it through the nylon plunger. Find the best position to solder the spring within the copper pad by testing the key action. When the optimum position is found a mere touch with the soldering iron will be all that is necessary to fix the contact spring into place. Check that the spring is squarely in position and that the key action is correct.

Repeat the procedure for the rest of the springs until all 72 notes are completed. When complete, check the overall keyboard action for correct operation.

It may be necessary to lightly clamp each nylon plunger so that the contact springs cannot slip out via the side slot as a result of frantic keyboard playing. If this is to be done, use a light set of pliers and be careful not to let the tool slip and damage the springs.

That completes the construction of the keyboard itself. Next month we shall look at the construction of the main PCB which holds the CPU and the other major sections of the MIDI Master Keyboard. **ETI**

HI-FI POWER METER

Paul Chappell develops a power meter that not only serves your hi-fi but is in itself hi-fi as well.

When faced with the task of designing a power meter for audio amplifiers, the variety of different approaches that can be taken is almost overwhelming.

If the load to the amplifier is known, the power can be derived from the voltage alone. The very simplest method is to assume that the load is a pure resistance, to rectify the output voltage and apply it to a single quadrant square-law circuit, (since power is proportional to the square of the voltage for a given resistive load) and then to smooth the output and use it to drive a meter.

If the meter movement is sensitive enough, the entire circuit can be made from passive components and will divert very little power from the loudspeakers.

This approach relies for its accuracy on two factors. First of all it assumes the loudspeaker impedance is close enough to a pure, fixed resistance for the assumption to be valid. The second assumption is that a reasonably accurate square-law circuit can be made. In practise, reasonable results can be achieved, and this type of design has the advantages of being simple, cheap and reliable. A practical circuit along these lines will be given later on.

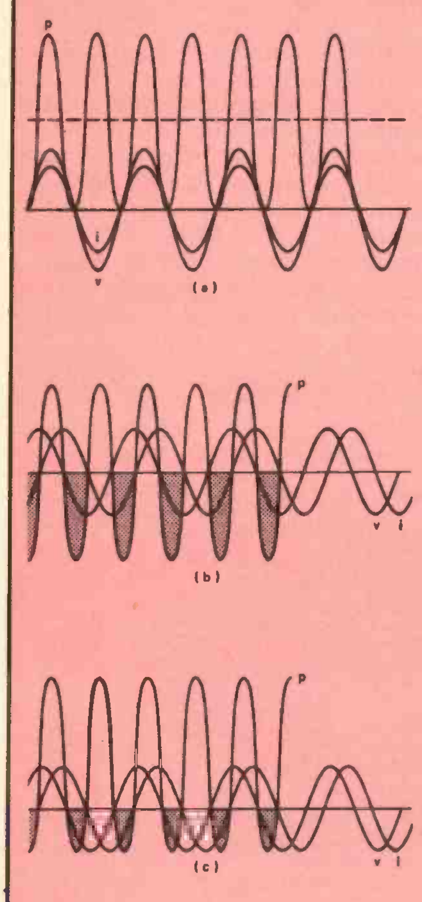


Fig. 1 Voltage, current and power waveforms for (a) a resistive load (b) a pure reactance load (c) a load with both resistive and reactive components.

This is all very well for PAs, music centres and the like but for top flight hi-fi or for accurate power monitoring, something considerably better is called for. If the current is measured as well as the voltage, there is no need to make any assumptions about the loudspeakers. The circuit can take into account the characteristics of the load. But how?

What do we do with the current and voltage signals when we've got them? Multiply them? Find the RMS values and multiply? Find the average and multiply? It depends on exactly what we're trying to measure — which is not as silly a question as it sounds.

Power To The People

For a resistive load there's no doubt about what we want to measure. However, for a load with a reactive component the case is not so clear cut. Figure 1a shows the voltage, current and instantaneous power waveforms for a resistive load with a sinusoidal voltage applied. The power (p) varies from a peak when v and i are both at peak positive or negative values, down to zero when v and i are both zero. However, it is always positive.

The average power delivered to the load is shown by the dotted line. This is the mean value of the instantaneous power curve. It can be calculated by taking the product of the instantaneous current and voltage over a whole number of half cycles and averaging the result, or by multiplying together the RMS voltage and current, or from the mean squared value of the voltage divided by the load resistance, and so on. All these methods give exactly the same result.

Figure 1b shows the situation where the load is a pure reactance — it can be a capacitor or inductor depending on which of the waveforms you take to represent v and which to be i.

In either case the instantaneous power varies symmetrically about zero. On the positive parts of the curve, energy is being stored by the load. On the negative parts it's being returned to the source. The load does not dissipate any energy and the mean value of the power curve is zero.

However, if we multiply the RMS voltage and current in this case we get exactly the same result as for the resistive load. One way of calculating power gives the answer zero, another gives a positive value. Which is correct?

The answer is that it depends on exactly what you are trying to measure. If you want to know the average power delivered to the load (the 'real' power, measured in watts) the answer is zero.

On the other hand, suppose you were to connect a capacitor directly across a mains transformer. The current flow in the windings would have just the same heating effect as for a resistive load. There is a limit to the size of capacitor you can connect directly across a transformer before it burns out! Clearly the 'real' power is not the whole story.

The effect on the transformer is measured by the product of RMS voltage and current. It is called the 'apparent' power and is measured in volt-amperes (VA) — a unit you'll no doubt have come across in transformer specifications.

Figure 1c shows the more general situation where the load has resistive *and* reactive components, as in the case of a hi-fi loudspeaker. Here, the power situation is even worse — we can distinguish three different kinds!

The product of RMS voltage and current still gives the apparent power (VA), the mean of the power waveform will give the real power (watts). Now, the difference between the two gives yet another power reading — the 'reactive' power, measured in 'volt-amperes reactive' (VAR).

The apparent power, then, is made up of two components: the real power delivered to the load and the reactive power which shunts backwards and forwards between load and source. So — what should a power meter measure?

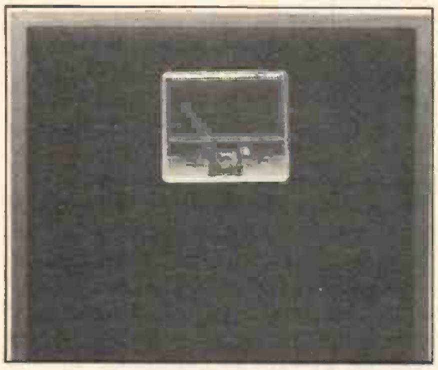
The Old Bill

If we asked the electricity board, we'd get an answer without hesitation — apparent power is the one to go for! It's bigger than either of the other two and the choice can be justified by saying that even if the energy transferred from the generators to the customer's load is less than the meter reading, the 'extra' power shunted back and forth means that heavier gauge wires and bulkier transformers are needed.

The electricity board does indeed charge for apparent power!

As a slight digression, factories are perfectly well aware that they can be charged for energy they haven't used and go to great lengths to apply power factor correction to their supplies.

The most common cause of trouble is large electric motors which have a high inductive component and the solution is to connect a whopping great capacitor across the mains — just like an amplifier's Zobel network but on a much, much larger scale.



As the budget power meter requires no external power supply it can be fitted directly into a loudspeaker cabinet for that 'hi-tech hi-fi' look.

The result is that the factory appears more like a pure resistance to the power supply and the reactive power circulates between the capacitor and the motors.

Unlikely as it sounds, this measure will often give a considerable reduction in the electricity bills!

I should point out that the capacitors used are not the type you buy from your corner shop. They have to withstand continuous mains voltage and huge currents and are therefore very costly and bulky. For household supplies it just isn't worth the time and effort. Also, since different gadgets are being turned on and off at various times, there's no sensible way to compensate for them, so please don't try it.

To return to the hi-fi power meter, the most sensible thing to measure seems to be the power that is actually used by your loudspeakers — the real power. It may not be quite so flattering to your amplifier as apparent power but it's a realistic indication of the power used by the loudspeakers. How much of this actually gets converted to sound rather than heat is a matter between you and your hi-fi supplier!

If you've already read this month's Circuit Theory article then alarm bells should have been sounding for quite a while now. I've slipped into the usual habit of illustrating the principles of power by means of sine waves and there is no reason to suppose that all this applies to any other waveform.

As it happens, some of the discussion applies (in the form I've presented it) only to sine waves. However, the method for calculating real power applies to any old waveform, and this is:

The voltage and current signals are continuously multiplied to give the instantaneous power, then the resulting power waveform is average over a number of cycles to give the mean power.

A four quadrant multiplier is needed because the areas below zero on the power waveform represent energy returned to the amplifier to be dissipated in the output transistors. This must be subtracted from the area above zero which represents the total energy supplied (some of which is returned). This will all be taken care of by a four quadrant multiplier and suitable averaging circuit.

Acceptability

Having decided what we want to measure and how to go about

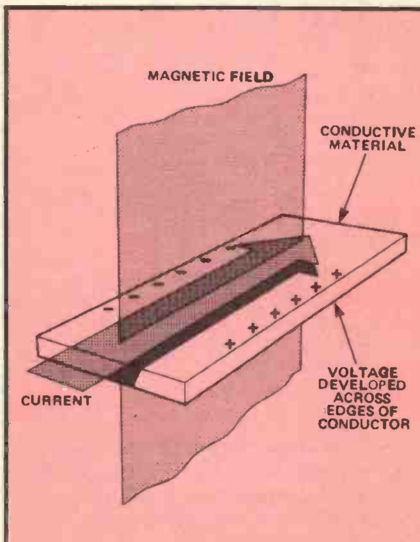


Fig. 2 The Hall effect.

HOW IT WORKS

D1 to D4 form a bridge rectifier which provides drive of a suitable polarity for the meter. The presence of the diodes gives a degree of non-linearity to the current to voltage relationship and with a little imagination we can pretend it's something like a square law relationship.

To make the best of the diode characteristics, the more sensitive the meter movement the better. If you choose a more sensitive type, you should reduce the value of R4 and leave all other component values the same.

The network of resistors around SW1 and SW2 simply pad the voltage divided to cope with different input ranges. The arrangement looks unnecessarily complicated but was devised to avoid the need for a double gang switch in each channel. With the arrangement shown, two DPDT switches can be used for the stereo version. Since the pot settings are not entirely independent, it's important to calibrate the meter in the order described in the text — RV1 first, RV2 next, and so on.

D5 gives protection to the meter movement against the overload.

it, the next question is acceptability. What will hi-fi enthusiasts feel happy to connect to their amplifiers? Not being hi-fi manufacturers, ETI can't be blackmailed into catering for the whims of the more over-enthusiastic of hi-fi buffs. I have made no attempt to align the grain of the wire with the Glastonbury lay-line or whatever is the current 'essential'. My modest aim has been to produce a circuit which will introduce no distortion whatsoever into top-flight hi-fi equipment. Anybody who will be happy with this approach should be more than satisfied with the circuit.

Tapping a voltage reading from the amplifier output presents no particular problem. The main question is how to derive a suitable current signal. Introducing a resistor into one of the speaker leads is the usual solution (see the power meter in ETI, March 1984 for example). However, although the disturbance caused by a 0.1 ohm resistor would be negligible in all but the very finest equipment, a better approach should be sought if possible.

My first thought on the subject was to use a Hall effect device to measure the current. If you are not familiar with the Hall effect, Fig 2 shows the general idea. The rectangle is a strip of some kind of conductive material. A magnetic field at right angles to the strip will produce a voltage at the edges, the polarity of which can be determined by somebody or other's left boot rule!

The effect is exhibited by any conductor whatsoever, even the tracks on a PCB but is generally so small as to be unmeasurable. (Nevertheless, hi-fi over-enthusiasts can hear it and will always align their amplifiers parallel to the earth's magnetic field).

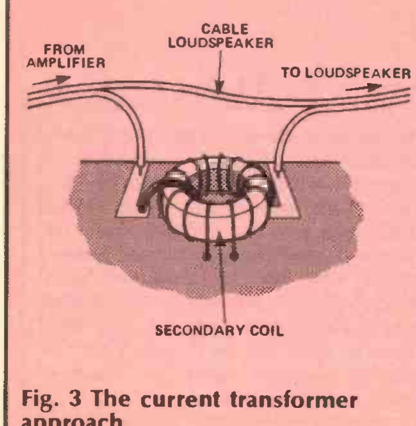


Fig. 3 The current transformer approach.

Some semiconductor materials produce relatively high voltages for fairly modest flux densities and can be obtained in IC form, often with internal amplifiers (for example: stock number 304-267 from Electromail).

One of the loudspeaker leads running alongside such an IC would have been the ideal way to derive a current signal without disturbing the audio signal. Unfortunately, the devices I tried were all far too noisy and insensitive to obtain a clean signal, so it was back to the drawing board.

The Long And Winding Road

The solution that eventually produced excellent results was a current transformer (Fig. 3). One of the speaker leads is broken and forms a half turn around a suitable toroid via a single hoop of wire. The secondary coil is wound around the toroid giving a step-down in current of about 200:1.

For best performance (and to avoid reflecting the slightest suspicion of anything unwanted back into the primary circuit) the transformer must be terminated with a very small resistance — a fraction of an ohm if possible. Since high performance current buffers don't exist in IC form, this approach leads to some interesting problems, about which there will be more next month. For this month, I'll finish with the circuit for the simple, low-cost power meter.

Budget Power Meter

The circuit of the budget power meter is shown in Fig. 4. It depends entirely on the voltage for the readings, and draws a small current from the amplifier output to drive the meter. The rectifiers are used to produce an approximation to a square law, and also to rectify the signal for the meter. Two different speaker impedances can be selected by SW1 and two different power ranges (0-10W and 0-100W) by SW2.

The component overlay for the project is shown in Fig. 5. There is so little on the PCB that it should be almost impossible to make a mistake! If you use the specified meters, the PCBs can be mounted on the back. Otherwise, they can be fixed to the case by means of the screw holes.

The meters we used can be

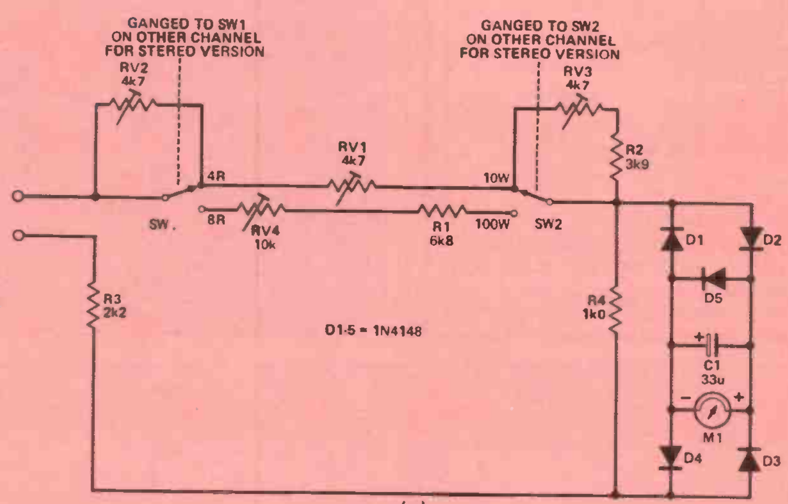
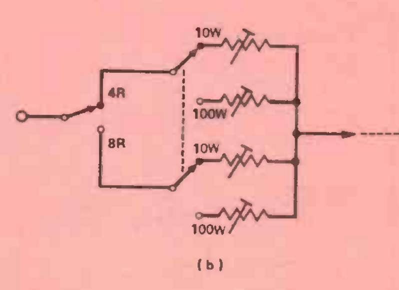


Fig. 4 (a) The circuit diagram of the budget power meter



(b) alternative switching arrangement for totally independent range adjustment.

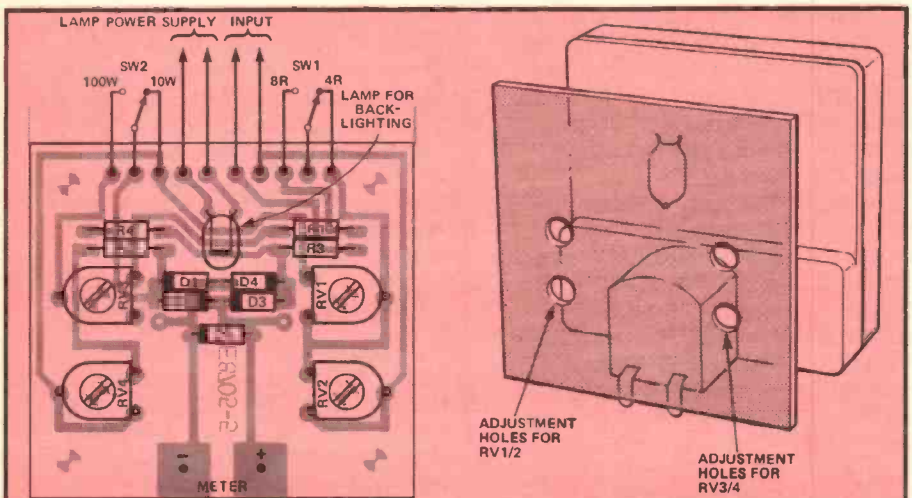


Fig. 5 The component overlay for the budget power meter.

back-lit, but this means giving the meter a power supply it would not otherwise need, so it's up to you whether or not you think it worthwhile. Incandescent bulbs will give better results than LEDs. You can probably get away with using a small transformer driving a few bulbs in series.

PARTS LIST

RESISTORS	
R1	6k8
R2	3k9
R3	2k2
R4	1k0
RV1,2,3	4k7
RV4	10k
CAPACITORS	
C1	33uF 16V elect.
SEMICONDUCTORS	
D1-5	1N4148
MISCELLANEOUS	
PCB; meter movement; optional components for back lighting: bulbs and suitable mains transformer; Case.	

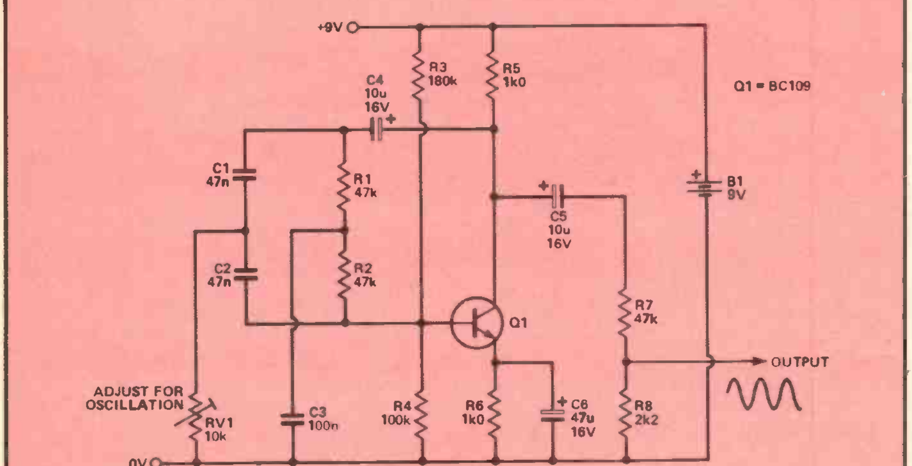


Fig. 6 A simple signal generator circuit for calibrating the budget power meter.

Calibration

You will need a sine wave generator and a multimeter. If you haven't got a signal generator, the circuit of Fig. 6 will do the trick. If you haven't got a multimeter, go out and buy one! (How on earth do you manage to test your circuits without it?).

Disconnect the speakers from your amplifier and connect a 1k0 resistor across the output of one channel instead. Feed the sine wave into a suitable input on your amplifier (the AUX input will probably be best) and connect the power meter across the 1k0 resistor. Connect your multimeter on AC volts range across the resistor too.

Set the power meter switches to 4 ohms, 10 Watts and then adjust the volume control of your amplifier until the meter reads 6.3V. Adjust RV1 until the power meter reads 10W exactly.

Set the power meter to 8 ohms, and adjust the amplifier volume control until the meter reads 8.9V. Adjust RV2 until the meter reads 10W.

For 4 ohms, 100W, set the multimeter to 20V and the power meter to a scale reading of 10 (which represents 100W on this range).

For 8 ohms, 100W, set the multimeter to 28.3V and the power meter to a reading of 10 (which once again represents 100W).

This completes the calibration. There is, of course, no reason why you shouldn't expand the number of ranges and speaker impedances to suit your own purpose, although the PCB only allows for two of each.

Next month I shall investigate the really *hi-fi* power meter which operates without disturbing the audio signal and gives true and accurate power readings.

ETI

BUYLINES

The meter movement can be any fairly sensitive current meter, scaled 0-10. A range of low cost meters is stocked by: Cirkit, Park Lane, Broxbourne, Herts. Their stock number 37-00520 would be suitable. A meter with the legend 'power' scaled 0-10 can be obtained from Specialist Semiconductors, who will also supply a complete parts set. See their advert in this issue for details. The PCB will be available from our Readers Services in due course.

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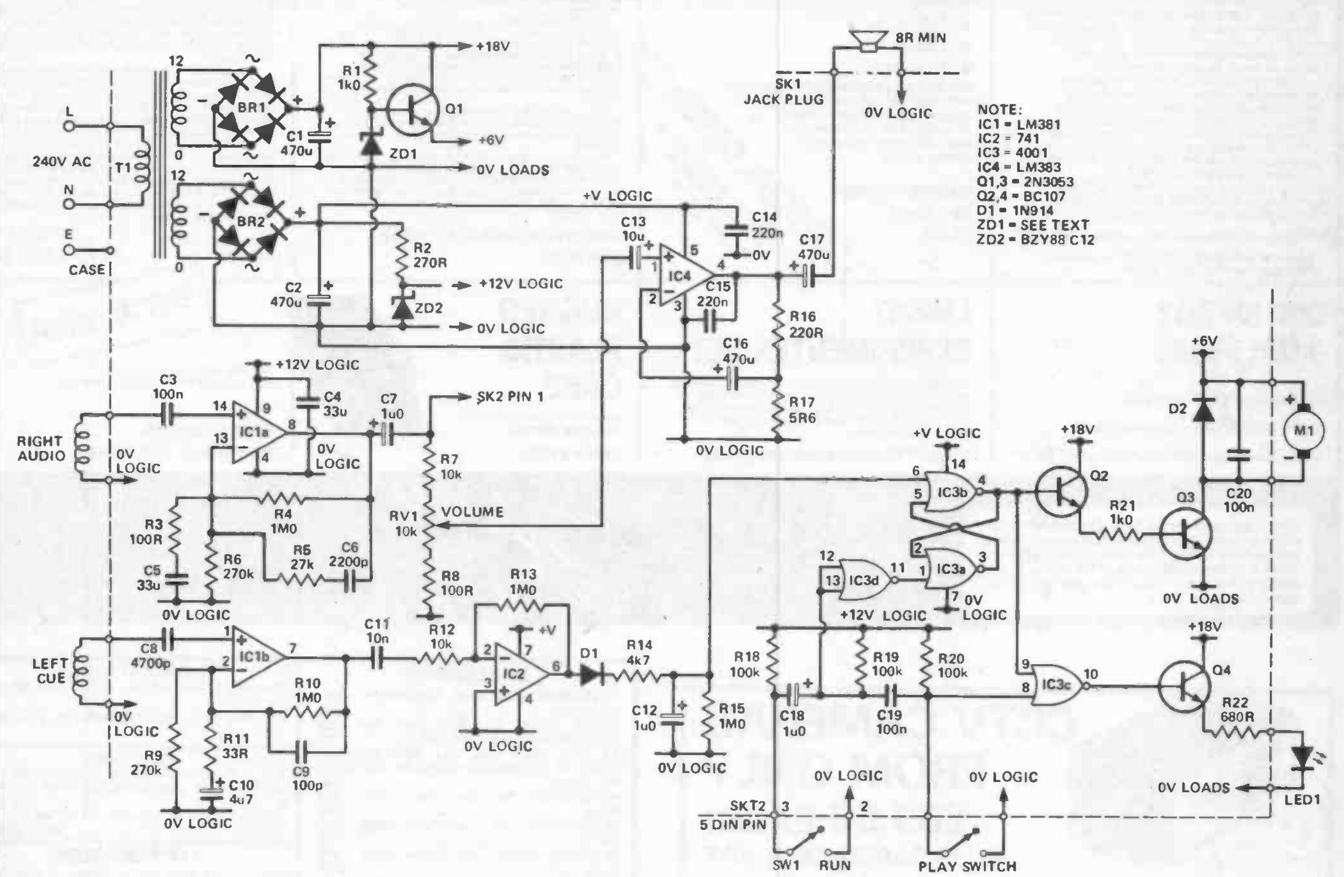


Fig. 1 The circuit of the main Telfax board.

Telfax is a complete system for presenting any kind of recorded message or sound effect at the exact time it is wanted.

After delivering the recording, Telfax automatically re-cues ready for the next.

Telfax uses messages recorded on a normal cassette and has outputs for both an external loudspeaker and an amplifier. The messages can be triggered either with a push button switch built into the unit or by any external contacts such as a door switch or a pressure mat.

Telfax can be used for the quick and accurate cueing of jingles for a disco or hospital radio. It can provide sales information in a shop when triggered by a customer approaching the display. Telfax could provide a calming and instructive message when triggered by a fire alarm, instead

HOW IT WORKS — TELFAX

IC1 is a dual low noise pre-amp IC which is used to amplify the signals from the tape head. IC1a is used to amplify the audio information on the right stereo track. The feedback components are calculated to give the necessary NAB tape head equalisation curve for 1⅞in per second tape speed. The gain of this stage is 56dB at 1kHz.

IC1b amplifies the 1kHz cue tone which is recorded on the left stereo track. This stage has a narrow bandwidth centred on 1kHz and a gain of approx 90dB. The 1kHz cue tone is further amplified by IC2 before being rectified by D3 and integrated by C12.

Operation of the cassette motor is controlled by the condition of the bistable IC3a and b. When the Run contacts are closed, the differentiated pulse produced at R18/C18 sets the bistable to the motor run position. The motor is energised via Q2 and Q3 and the Telfax message is then played.

When the 1kHz cue tone is received via IC1b and IC2, the bistable is reset to the motor stopped condition. D4 and C20 are included to suppress switch-off transients generated by the motor. The Cued LED is then lit via IC3 and Q4.

The output of the audio pre-amp IC1a is fed to the volume control chain R7, RV1 and R8. R8 has been included to give a minimum volume level and may be replaced with a shorting link if the volume is required to be reduced to zero.

R7 is included to give a maximum volume level and was chosen to set the max level just below the point at which self oscillation of the audio chain occurs. IC4 is a power amplifier which can supply up to 4W into a 4 ohm speaker.

of the usual panic-inducing alarm bell. Telfax could even be used to provide a barking dog sound triggered by an approaching intruder as part of a domestic security system.

The possibilities are (almost) endless.

Basic Concept

The audio message is recorded onto the right stereo track of an endless compact cassette and a 1kHz cue tone is recorded onto the left stereo track at the end of the message. The Telfax machine is a compact cassette player with its cassette drive motor controlled by a bistable latch.

The latch is set by a pair of contacts closing. The cassette motor then starts and plays the message. At the end of the message the 1kHz cue tone on the left track of the tape causes the bistable to be reset and the cassette motor is stopped.

If the stop or cue tone is placed near to the start of the message, the Telfax machine automatically cues the tape ready for almost instant play of the message when the start contacts are closed again.

The Telfax machine has its own built-in power amplifier which can supply 4W of audio power to an external loudspeaker. It is also fitted with a line output level DIN socket for connection to a PA amplifier.

Cassette Mechanism

There are a number of suppliers of low cost cassette mechanisms most of which will function satisfactorily with the Telfax circuit. Ideally the motor should be 12V DC although there is provision on the PCB to fit a zener regulator for lower voltage motors. A stereo head is required but no erase head is needed.

It should be pointed out that Telfax calls for the cassette mechanism's pinch wheel to be engaged with the capstan when the motor is stationary. Some manufacturers suggest this can wear flat sections onto the pinch wheel. A cassette mechanism is available from Symot which has a specially formulated pinch wheel for continued engagement with the capstan. The mechanism is ideal for Telfax as it has been designed for use with endless cassette tapes.

However, it should be mentioned that the original Telfax prototype did not use a special pinch wheel and is still functioning well after four years' service.

Construction

Circuit layout is critical, especially the 0V connections and the high gain pre-amp stage. Construction using the printed circuit board layout shown on the foil pages of this magazine is highly recommended as this layout has been thoroughly proven. PCB mounted sockets and transformer are used which considerably simplify construction. The component overlay is shown in Fig.2.

It is better to solder IC1 in place rather than use a socket as the low level signals may be troubled by socket oxidisation after a year or two.

Layout of the circuitry around IC1 should be made compact, keeping the leads as short as possible. C3 and C8 should be bent flat against the PCB so as to minimise hum pick-up. IC1 and associated circuitry should be screened by constructing an

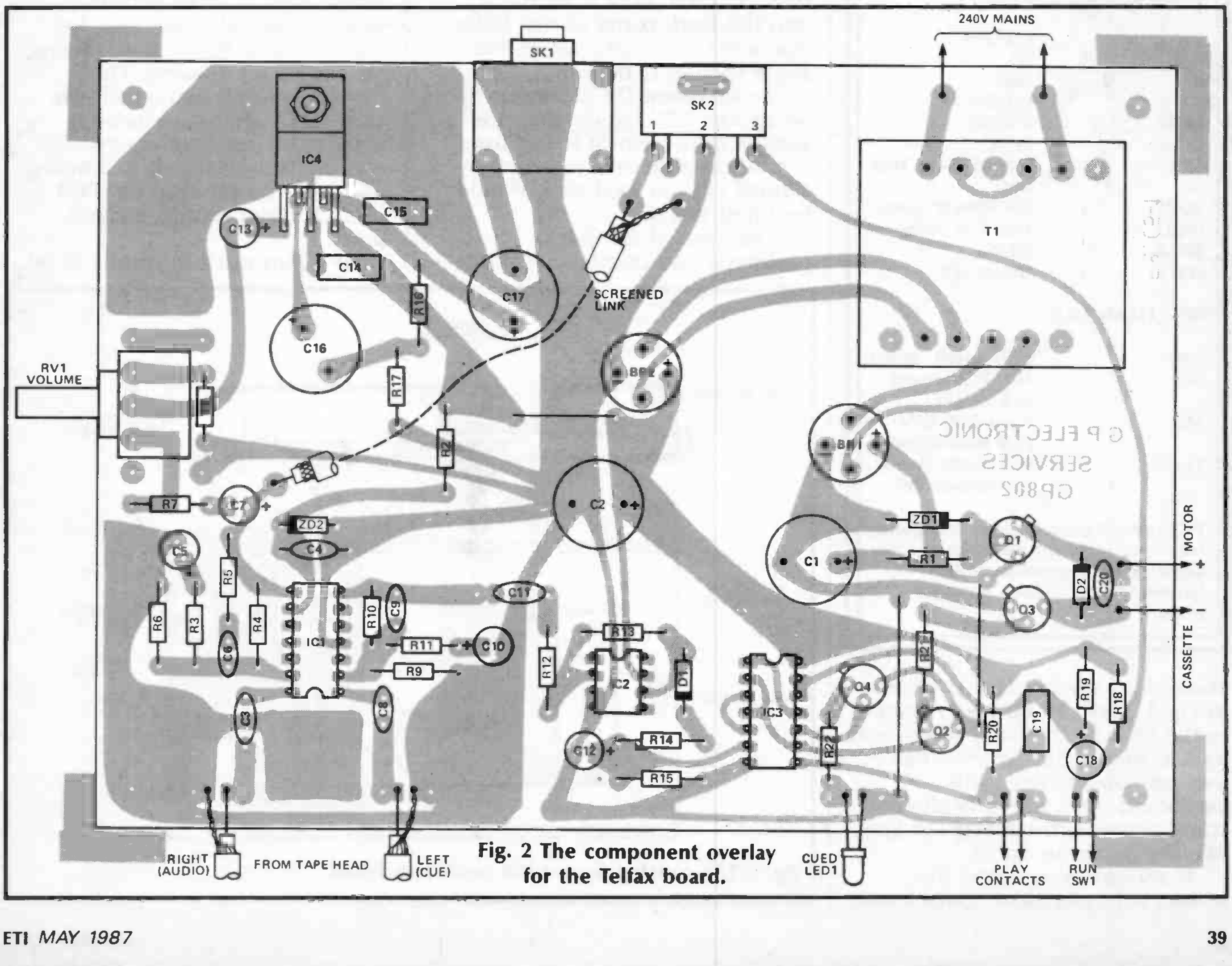


Fig. 2 The component overlay for the Telfax board.

PARTS LIST TELFAX

RESISTORS all ¼W 5% unless specified

R1,21	1k0
R2	270R
R3,8	100R
R4,10,13,15	1M0
R5	27k
R6,9	270k
R7,12	10k
R11	33k
R14	4k7
R16	220R
R17	5R6
R18,19,20	100k
R22	680R ½W
RV1	10k log PCB mount pot

CAPACITORS

C1,2,16,17	470µ 25V electrolytic
C2,19,20	100n ceramic
C4,5	33µ 25V
C6	2200p ceramic
C7,12,18	1µ0 24V electrolytic
C8	4700p ceramic
C9	100p ceramic
C10	4µ7 25V electrolytic
C11	10n polyester
C13	10µ 25V electrolytic
C14,15	220n polyester

SEMICONDUCTORS

IC1	LM381N
IC2	741
IC3	4001
IC4	LM383T
Q1,3	2N3053
Q2,4	BC107
ZD1	400mW zener (see text)
ZD2	12V 400mW zener
D1,2	1N914 or similar
BR1,2	WO1
LED1	Green LED

MISCELLANEOUS

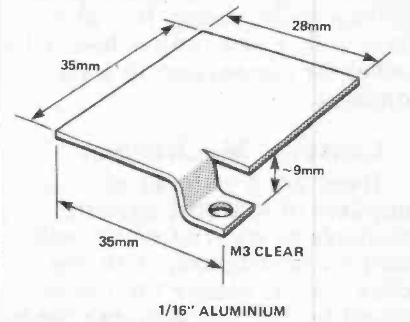
SW1	SPST push switch
SK1	¼in PCB mount jack socket
SK2	5 pin 180° DIN PCB mount socket
T1	0-12+0-12V mains transformer 6VA

PCB; cassette mechanism; fine gauge twin core screened cable; aluminium angle; 1/16in aluminium sheet; hardwood side cheeks; nuts and bolts.

aluminium shield plate as shown in Fig 3. This can be easily bolted to the PCB by its fixing screw next to IC1. Alternatively the screen may be constructed from cardboard onto which is glued some aluminium kitchen foil (just like the Japanese do it).

It should be ensured the screen is in electrical contact with the 0V plane of the PCB. This is easy to achieve as the fixing hole in the PCB penetrates the 0V plane. The screen must not touch any of the component leads of course.

Fig. 3 The screen for the preamp stage.



RV1 is a PCB-mounted volume control which has an integral mounting bracket. However, these are not too easy to find. The same type of pot without the bracket is easier to find (see Buylines). This will suffice but will be less rigid when soldered in place.

The power amp, IC4, is bolted to the PCB through a piece of 20mm aluminium angle section approx 35mm long. This is used to conduct heat away from the IC into the back panel of the Telfax machine's case onto which the angle section is bolted.

Zener diode D1 is chosen to be approx 0.7V higher than the voltage of the motor being used. If a 6V cassette motor is employed a small clip-on heat sink should be fitted to Q1.

The case of the Telfax prototype was constructed from 1/16th inch aluminium as shown in Fig 4. Hardwood side cheeks give the finished case a very professional appearance. The PCB is clamped to the rear of the case via the PCB-mounted jack socket and a 4mm screw through the power amp angle section. 0V connection from the PCB to the case is made via this angle section.

The PCB is also supported on 13mm stand-offs mounted on the base plate of the case. The cassette deck is also supported on stand-offs of a suitable length for the mechanism used.

Very fine gauge twin core screened cable should be used to connect the tape head to the PCB. The left stereo track is the track at the lowest edge of the tape. This track is the cue tone channel and should be connected to the input coupled by C8. The right track is the audio channel and is connected to the C3 input.

Once the connections are made to the tape head, the cable should be anchored to the head supporting assembly so the connections cannot be fractured during movement of the assembly.

If the cassette mechanism being used is fitted with Play switch contacts, these may be connected to the PCB as shown on the layout drawing. These contacts merely extinguish the Cued LED when a cassette is withdrawn from the mechanism and are not essential. A shorting link must be fitted at the PCB input if Play contacts are not used.

If a Run push button is to be

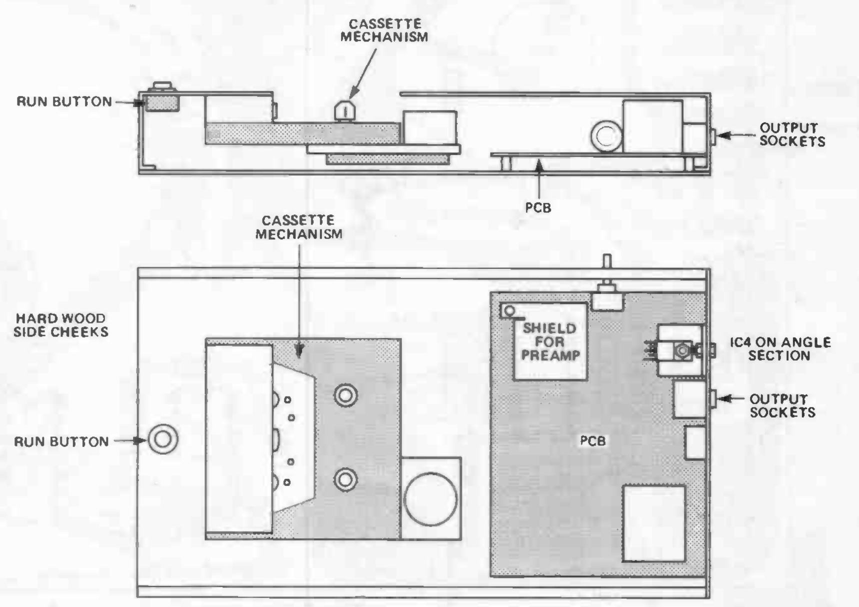
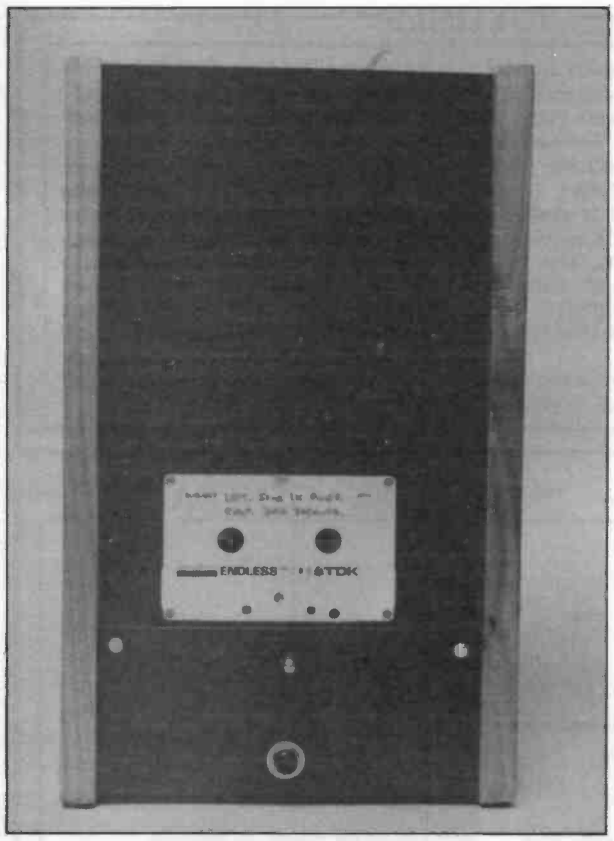
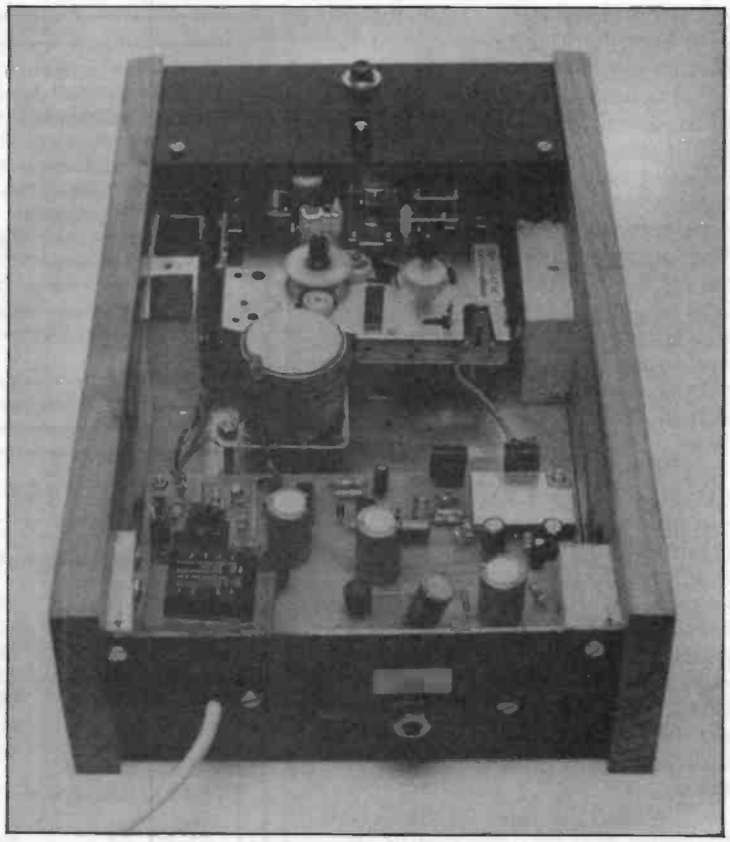


Fig. 4 The construction of the prototype Telfax.





fitted to the machine, this is wired up to the appropriate input on the PCB. Otherwise (or additionally), external Run contacts may be brought into the Telfax machine via pins two and three of the five pin DIN socket.

Message Tapes

No specialised equipment is required to prepare message tapes for Telfax. A good quality stereo cassette recorder is all that is required. Endless cassettes are available from TDK and are ideal for Telfax as the message need only be recorded once. The tape will then automatically re-cue to the beginning of the message. Tapes are available in various lengths ranging from twenty seconds to three minutes.

Conventional cassettes can also be used but the message must be recorded again and again as many times as required.

During early development of Telfax it was found that a reasonably satisfactory cue tone could be generated by simply vocalising the sound DUH into a microphone plugged into the left channel of the recording machine.

A more professional method is to construct a 1kHz cue tone generator which outputs a set

HOW IT WORKS — 1kHz TONE GENERATOR

Figure 5 shows the circuit diagram of the tone generator. The duration of the tone is adjustable by means of a selector switch so the best duration may be found by experiment. The selector switch could be replaced by a link selection arrangement so that, when the best tone length is found, the unit can be permanently wired for that condition.

IC1 and 2 are connected as a 20ms period square wave oscillator which is controlled by the bistable IC1/3 and 4.

The 1kHz tone is generated by IC3 and is fed via an analogue switch IC4 to the jack socket output. When SW1 is pressed, the bistable is set causing pin 11 of IC1 to go high. This enables the analogue switch IC4 allowing the 1kHz tone to pass to the output.

The square wave oscillator is energised at the same time and the decade counter, IC2, counts up the negative edges from IC1/2. Depending upon the setting of SW2 the bistable is reset after a delay of 40,60,80,100,120,140 or 160 ms. The analogue switch is then disabled and the cue tone ceases.

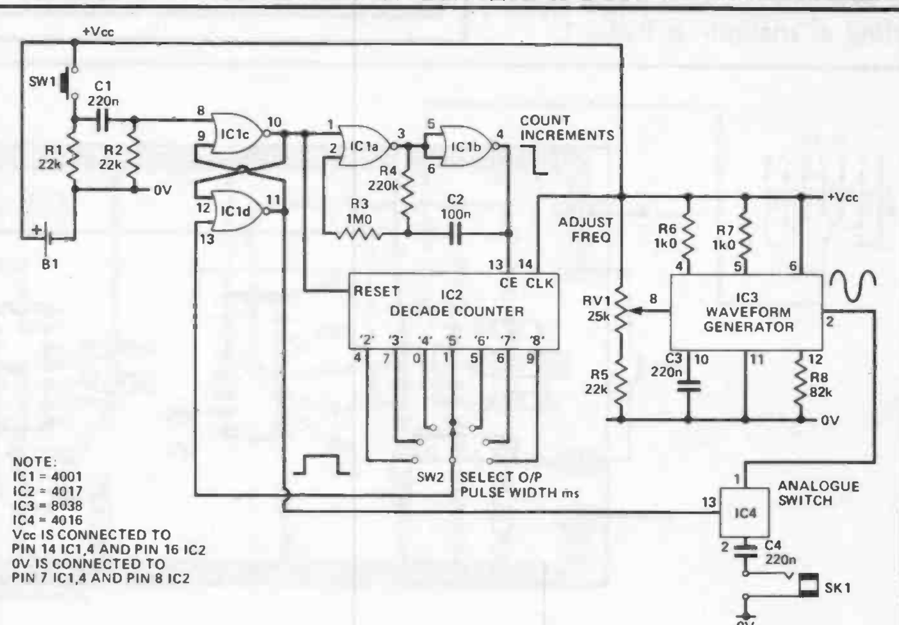


Fig. 5 The circuit of the 1kHz tone generator.

duration 1kHz tone at the touch of a button. A suitable circuit for this is given in Fig 5.

The best duration of tone can be determined by experimentation but it was found that about 60ms was the best compromise between reliability and noticeable crosstalk into the audio channel. The best volume level can also be found by experiment and −3 to 0dB is a good starting point. If you are recording spoken messages it's a good idea to prepare a script and rehearse several times before going for a 'take'.

If you are using endless cassettes, ensure the tape is long enough for your message or jingle. Start the recording machine, press the cue tone button and immediately start your message. If you are recording music, practice your skill at cueing the record for the piece of music required (ask any DJ how to do this), press the cue tone button and immediately start the music.

Transfer the tape to the Telfax machine and test the results. If you have started the message too close to the cue tone you will hear the message 'whine' as the motor is still accelerating up to speed.

If you've placed the cue tone too far away from the beginning of the message there will be an awkward silence after you've pressed the Telfax button. This will not matter too much for sales messages but it spoils continuity in discos and amateur radio stations. With practice you will find that you can have jingle tapes starting as snappily as Radio 1.

BUYLINES

Most of the components should present no problems. Suitable cassette mechanisms are available from Maplins, Henry's, and many other suppliers. The endless cassette mechanism is available from Symot Ltd. (Tel: (0491) 572663).

The PCB mounting pot is available from Electrovalue. The PCB mounting DIN socket (type 473-278), the PCB mounting jack socket (type 477-573) and the transformer (type 207-756) are available from Electromail (Tel: (0536) 204555).

The PCBs for this project are available from GP Electronic Services, 87 Willowtree Avenue, Durham, DH1 1DZ. Prices are £6.99 for the Telfax board and £4.99 for the 1KHz tone generator board. Both prices include VAT and postage.

Separate power supplies are used for the motor circuitry and the audio circuitry. D1 and Q1 regulate the motor supply voltage and the zener is chosen to be approx 0.7V higher than the voltage of the motor used. If a 6V motor is used, Q1 will require a small clip-on heat sink as it would have to dissipate approx 1W during play of the machine. The supply for the dual pre-amp IC is derived by the 12V zener D2.

PARTS LIST — 1kHz TONE GENERATOR

RESISTORS all ¼W 5%

R1,2,5	22k
R3	220k
R4	39k
R6,7	1k0
R8	82k
VR1	22k skeleton preset pot

CAPACITORS

C1, C3, C4	220n polyester
C2	1µ0 polyester

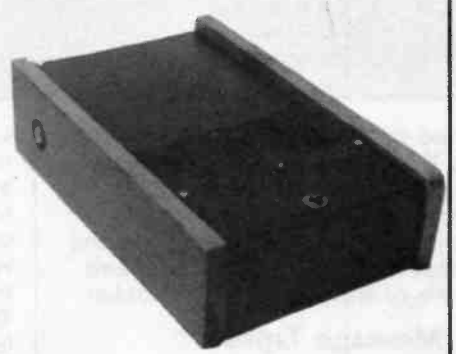
SEMICONDUCTORS

IC1	4001
IC2	4017
IC3	8038
IC4	4016

MISCELLANEOUS

SK1	¼in jack socket
SW1	push button switch

PCB; PP3 battery and holder; case.



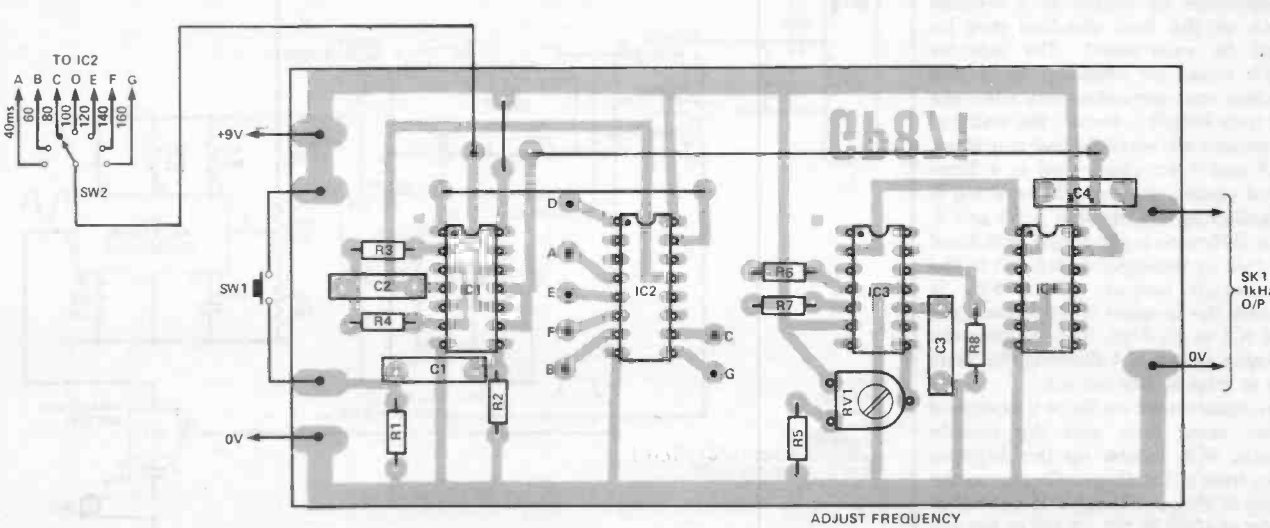


Fig. 6 The component overlay for the 1kHz tone generator.

MUSIC CIRCUITS

Andy Armstrong gets creative with some musical Tech Tips

Metronome

A simple electronic metronome can be made in a number of different ways. For example, a single op-amp or CMOS IC can be used as the oscillator.

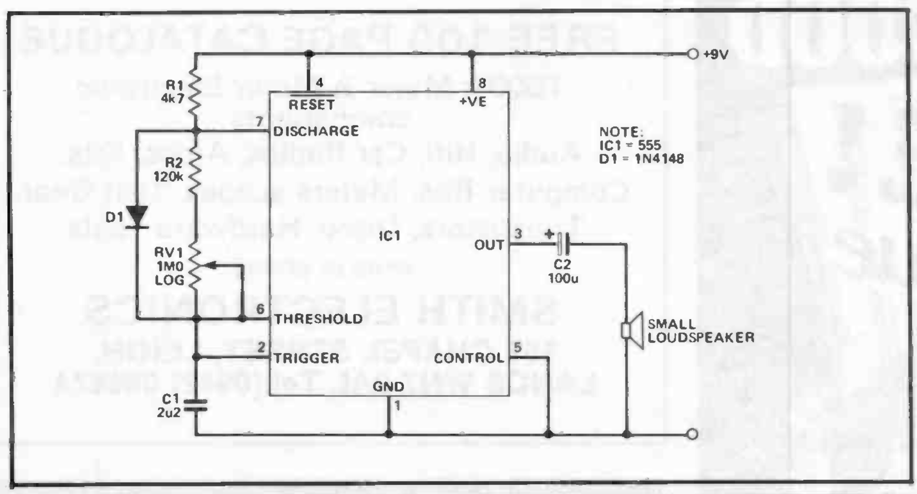
The 555 timer, however, is one of the best ICs for the job because its output stage has a high enough current rating to drive a loudspeaker directly.

The 555 used as an astable can of course be connected to give an almost even mark:space ratio. However, this design uses an extremely uneven mark:space ratio to good effect.

This means that the tick rate is absolutely even, rather than having a slight difference between alternate time periods. Also, the sound output level of the tick is greater than with the nearly even mark:space ratio configuration, because the loudspeaker is fed with a pulse rather than with a single edge.

A frequency range of about 30 to 300 beats per minute should cover most requirements and the component values are chosen to allow this. A *log* pot is specified, connected so that the tick rate increases with anticlockwise rotation. This is the reverse of what you would expect but it does even out the scale usefully.

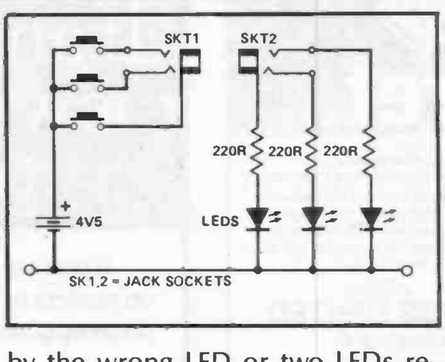
Calibration at 30, 60, and 120 beats per minute is possible with the use of the seconds count on a digital watch (or even an analogue watch's second hand). Other calibration points can be marked by interpolation or by using an oscilloscope to measure the time period of each tick.



Guitar Lead Checker

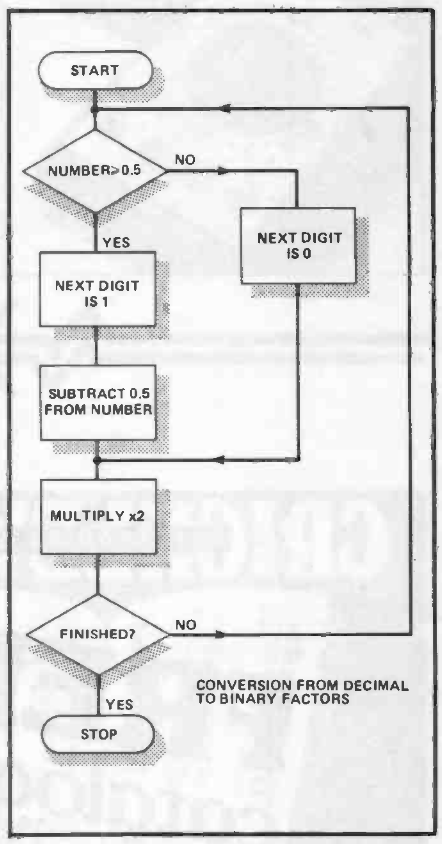
It is sometimes difficult, when under pressure to set up the equipment quickly, to buzz out an apparently faulty lead with a meter or audible continuity checker.

This simple gadget will show open or short circuit leads much more easily. Just plug the two ends of the lead into the two sockets and press each button in turn. The corresponding LED should light when the button is pressed. If it does not the connection is broken. Crossed or shorted connections are indicated by the wrong LED or two LEDs respectively.



If several different types of lead are to be tested, it is convenient to wire the different sockets in parallel.

Electronic Tuning Fork



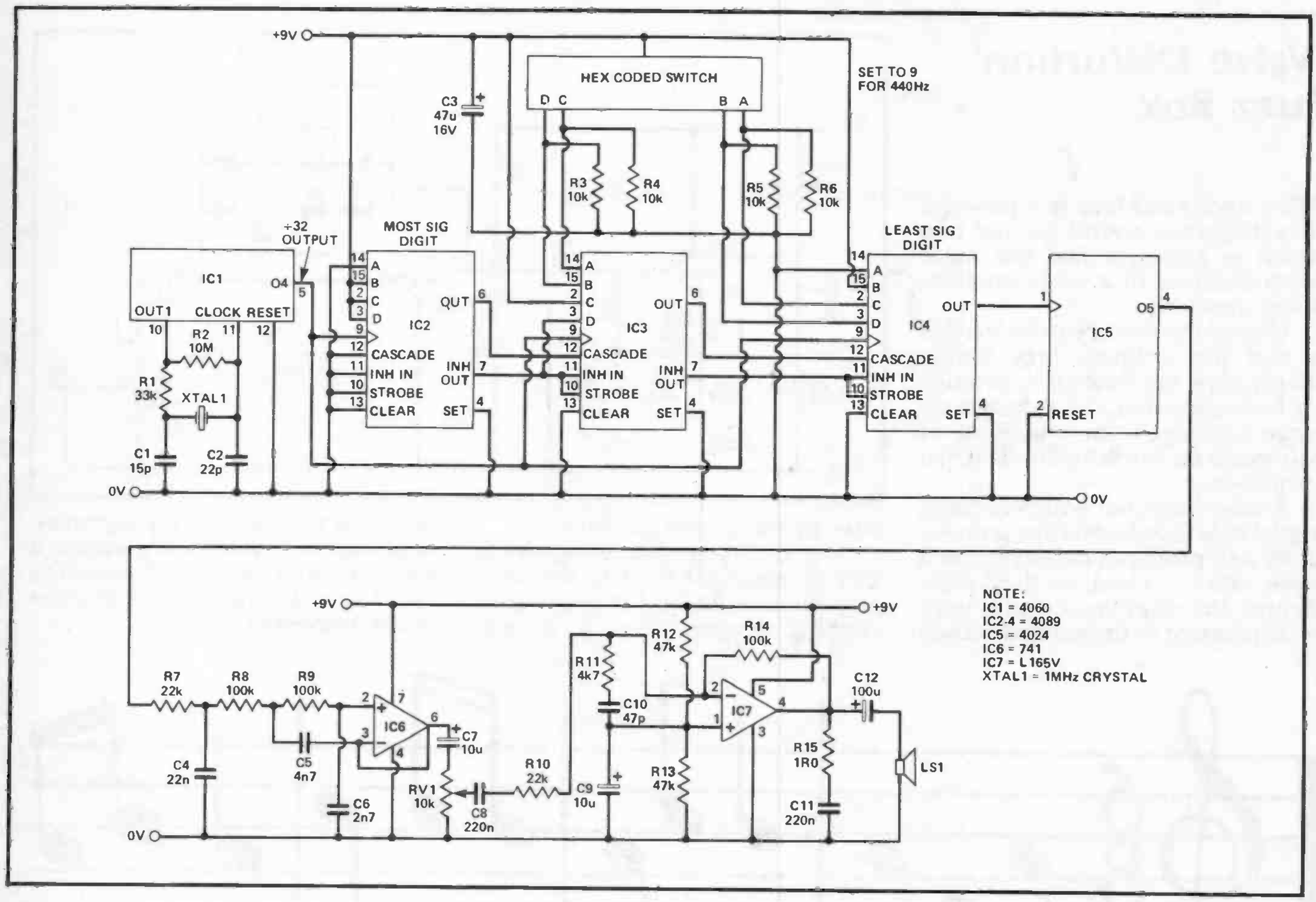
CONVERSION FROM DECIMAL TO BINARY FACTORS

Most musical instrument tuning is done using the A below middle C. Here is a design to produce this note very accurately, under crystal control.

Some instruments are more difficult to tune than others and it may sometimes be necessary for everyone else to tune a little off. This need may arise, for example, if you are using a piano, which cannot be retuned on the spot. If they all tune to the same standard, this causes no problem. This tuner has a switch to offset its standard a little high or low to match the requirement.

A 1MHz crystal is used as the frequency standard because this frequency is readily available. Unfortunately, there is no convenient whole number division ratio to produce the required frequency — 440 Hz.

The nearest frequency above is



488.28 Hz, provided by dividing 1MHz by 2^{11}. The required frequency is 0.90112 times this, which is not normally easy to provide. However, a binary rate multiplier is just the IC for the job. It multiplies an input frequency by a binary fraction.

"Binary fraction, What's that?" I hear you say. Well it's the same idea as a decimal fraction, except it uses powers of two instead of ten. The first digit after the binary point is half, the next a quarter, and so on. Thus, .1001 would be 9/16.

Binary rate multipliers (BRMs) can be cascaded to provide as many places after the binary point as you want, so long as you don't clock them so fast that the carry speed can't cope.

For this application we need ten bits to reach an accuracy of 1 part in 1024*.90112, which is a reasonable accuracy to aim for. This requries three 4-bit BRMs, but the last two bits are not very significant.

The only question now is how to convert a decimal fraction to a binary one. Easy peasy, if a bit tedious. Draw the point (the binary one, not a picture of the Milton Keynes cinema) then follow the flow chart until you have enough digits. The answer (to twelve places) is .111001101010

Inevitably, the output from the BRMs is not of an even frequency. There are missing pulses here and there. The BRMs are designed to provide as even an output as possible but jitter is inherent in the concept.

To give a clean output, the output frequency is divided down so that the jitter is also divided. Thus the total division by powers of 2 is shared before and after the BRMs to avoid clocking them too fast on the one hand and to provide a useable output on the other.

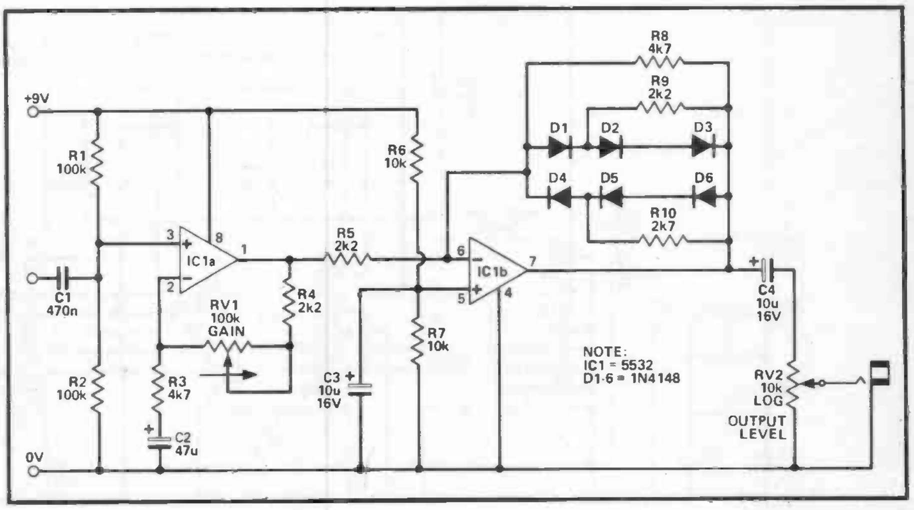
The result is a squarewave with slight timing jitter. This is filtered by an RC network (which also reduces the amplitude to below the clipping level of IC6) and then by an active second order filter.

The signal at the volume control is quite a good sinewave and this is fed to a simple audio output stage using the L165V power op-amp, which should be familiar to ETI readers by now.

The binary bits can simply be hard wired to logic levels all through the circuit but if the switched offset facility is required a hexadecimal coded switch, or four individual switches, are required to program four of the bits. With the four bits chosen, each step on the switch will be approximately ½Hz. This should be close enough for the pickiest guitar player.

The power supply is not very critical but below about 7 or 8 volts the 1MHz oscillator might not start. Anything from about 7.5 to 15V will do, but it should be properly decoupled on the board.

'Valve Distortion' Fuzz Box

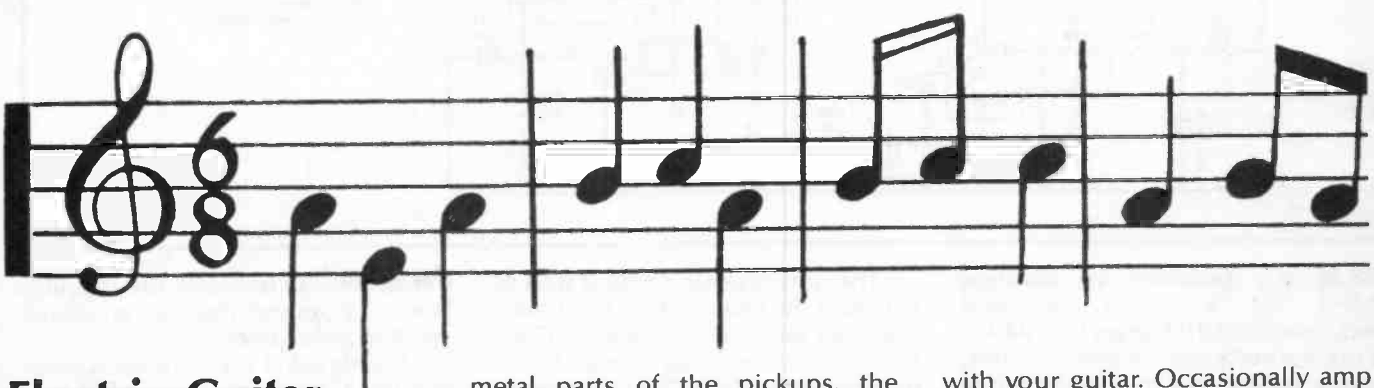


The traditional fuzz box provides a distinctive sound but not one which is remotely like the more musical sound of a valve amplifier being overdriven.

One of the main reasons for this is that the ordinary fuzz design simply clips the waveform, producing harmonics over a wide frequency range with significant amplitude of harmonics far from the fundamental frequency.

A valve amplifier which is being moderately overdriven clips progressively and produces harmonics of a lower order — closer to the fundamental. The resulting sound is both more pleasant to the ear and sought after by many rock guitarists.

The circuit here is designed to give an approximation to the valve amplifier sound by introducing its clipping progressively. It is also designed to give a slightly asymmetrical response which will generate a small amount of even harmonics. This too is an effect noted in valve guitar amplifiers.



Electric Guitar De-Fleaing

Most electric guitars have an annoying tendency to pick up hum and other noises, due mainly to the non-existent screening with which they are provided. A recent job of cutting the noise on a friend's Squire Telecaster proved educational.

Those who built the recent preamp project will realise how much hum twisted wire picks up. The guitar I was working on didn't even have properly twisted wire from the pickups to the controls — which is even worse. The first job was to replace this with proper co-ax.

At the same time I grounded the metal parts of the pickups, the controls, and the bridge. While the controls and pickups were out of the body, I fixed aluminium foil round the inside of the cutouts in such a way as to contact the grounded metalwork when it was re-assembled. Any flexible glue should do for the foil but do make sure that the foil is electrically continuous, not just held together with glue.

It wasn't easy to remove the output jack to fit co-ax, so I simply disconnected the wire at the control end, twisted it, and reconnected it. This wire is only a couple of inches long anyway so it will not pick up much interference.

It would be a good idea to fit a 60mA fuse (or lower, if you can find them) into both the signal and earth lines in the guitar lead if you try this with your guitar. Occasionally amp stacks have a habit of going live (when the beer you've been standing on the top of your backline finally spills all over it). The fuses prevent the strings and other guitar parts you come into contact with from following suit.

Tests showed the de-flead guitar to be much less noisy but there was still some hum. This proved to come from the lead which was a cheap spiral type.

It seems that the screening on some of these leads is little better than with twisted wire so a better quality lead was substituted. The only remaining noise came from a fluorescent light, when the guitar was directly underneath.

The verdict — not perfect, but a great improvement.

ETI

SAGE AUDIO MODULES

Les Sage has been making some very immodest claims about his new 100W amplifier modules. Ian Pitt connects a couple of them up to see if the claims are justified.

You may not have heard of Sage Audio but the man behind the company should be familiar to all regular readers of ETI. Les Sage was the author of the series Designing Transistor Stages which appeared in the November and December 1985 issues and in February 1986.

Since writing that series Les has set up in business and brought out his first two products, a pair of 100W amplifier modules called the Superamp and the SuperMOS. The Superamp is an all-bipolar design while the SuperMOS is similar but has a MOSFET output stage. Both are said to offer very high levels of performance combined with ease of use and high efficiency.

Les Sage claims the modules will out-perform any other amplifier modules on the market and says the SuperMOS is particularly good. He believes it offers at least a ten-fold improvement over its competitors.

The internal circuit of the modules has not been disclosed but the data sheet includes a block diagram and the operating principles are described in general terms. The most notable features are a Class A output stage and the use of very low levels of feedback derived from nested loops. The output stage is fully-complementary and uses four bipolar or MOSFET transistors with very high transition frequencies. This arrangement is said to contribute greatly to the performance, combining high current capability, very high slew rate and an efficiency of around 70%, far higher than is normal for Class A amplifiers.

According to Sage's product literature, the modules have been designed so that high-quality audio systems can be constructed as simply as possible. To this end they contain all the circuitry of an audio power amplifier and the only additional items required are a dual-rail supply, a case and a signal feed from a suitable preamplifier.

Internal overload and short-circuit protection is provided and the heatsinking fins can comfortably dissipate the heat developed during domestic operation. Additional heatsinking may be required when the modules are to be used for sustained periods at high powers, as might be the case in a club or a disco.

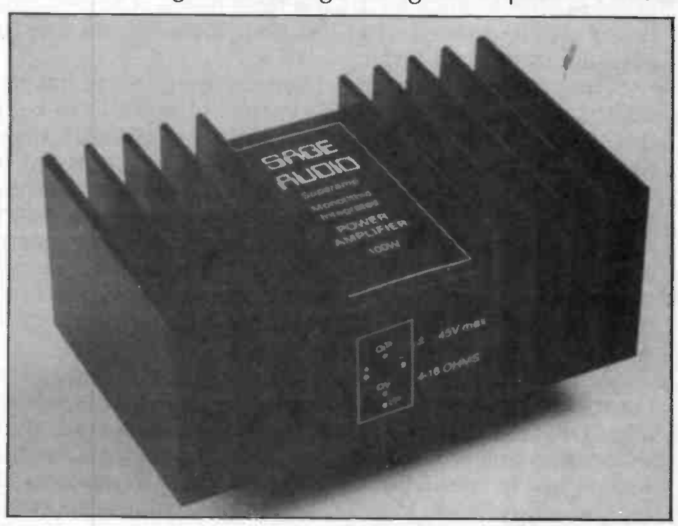
Gathering No MOSFETs

Both modules have already been launched onto the market but the SuperMOS has been suspended temporarily. Les Sage told us he is having difficulty obtaining MOSFET output transistors which are up to standard and consistent from sample to sample. For this reason the modules reviewed here are the bipolar version, the Superamp.

The modules consist of a black-anodised aluminium heatsink with a central well containing the circuitry. Black encapsulating resin covers the well, hiding the Superamp's circuitry from prying eyes, and a piece of paper stuck over the resin carries information on the pin connections, maximum voltage ratings, etc. The lead-outs protrude from the back of the module and the positive supply lead is coloured red to reduce the risk of confusion. Four nuts and bolts are provided to secure the module in place.

A considerable amount of information is provided, including a suggested layout, advice on wiring and earthing, some simple circuits to test various aspects of the amplifier's performance and a list of specifications. A suitable power supply circuit is given and the accompanying text suggests sources for some of the components and even lists the supplier's order codes. There is a paper template to help you drill the right pattern of holes for the module's lead-outs.

The recommended power supply circuit is a simple dual-rail unregulated design using two capacitors and a bridge rectifier for each channel. Sage claims the modules have a differential input stage with balanced impedances and says this gives a very high power supply ripple-rejection ratio. However, the best results will only be obtained when the modules are fed from a source impedance which balances out the internal feedback loop impedance, in this case a figure somewhere below 1k0. Sage recommends using a preamplifier with an output impedance of 600R, and suggests that the power supply should be stabilised if significantly higher source impedances are to be used.



Transforming The Sound

Certain decisions have to be made before ancillary components can be purchased. The main one concerns the choice of mains transformer. Since this is likely to be the largest item in the amplifier it will also play a part in determining the size of case needed.

If the full output power of the modules is not needed, a low voltage, low VA rating transformer can be used instead of the specified type. The notes supplied with the modules list suitable DC supply voltages and the AC transformer output voltages which will provide them, taking into account such factors as regulation.

On the other hand, if you want both full output power and the highest possible quality, Sage recommends you buy a transformer which is considerably larger than would be needed to supply a module operating at full output. There is a strong feeling among certain groups of audio designers that sound quality can be improved by the use of over-size mains transformers, and regular readers may recall Graham Nalty's comments on the subject in his Upgradeable Amplifier series (ETI June, July, August, September and November 1986). Since the Sage modules are designed for use in very demanding applications, it seemed a good idea to put this proposition to the test.

Accordingly, it was decided that two different sizes of transformer would be used. The minimum VA rating needed to drive the modules to full output is 225VA so toroidal transformers of this size were used for the bulk of the review.

For the larger size the choice was limited by the range of voltages provided on commercial toroids. Transformers of up to 1000VA are readily available but sizes above 600VA rarely offer voltages as low as the 25-0-25 required by the Sage modules. Because of this, the transformer eventually chosen for the second part of the test was a standard 500VA toroid.

The choice of case also needs to be thought about carefully. The layout given in the instructions is very specific and the accompanying notes suggest there is good reason to stick to it. One false move, it seems, and those much-vaunted ultra-low distortion figures will be severely compromised.

The problem is that the recommended layout has the reservoir capacitors mounted vertically in order to keep the supply leads as short as possible. Any other arrangement seems to fall foul of one or other requirement of the layout, such as not placing the capacitors anywhere near the input wiring. This imposes something of a height restriction on the chosen case and rules out many modern slimline designs sold for audio use. It seems a pity since the other components and the modules themselves will all fit comfortably into any one of a number of attractive cases.

Being a sucker for good-looking gear, I decided to compromise slightly and mount the capacitors horizontally. This allowed me to fit both modules and their associated power supplies in a 2U high 19in racking case with space to spare. Were it not necessary to make room for the large 500VA toroids, an even smaller case could have been used.

Loudspeaker Choice

The notes supplied with the modules include a loudspeaker crossover and driver circuit which is recommended for use during testing. Presumably it shows the arrangement used during initial testing and on which the published specification is based. The diagram specifies Peerless drive units, and although not stated it appears to be the circuit of the Peerless 825/2R kit loudspeaker available from Wilmslow Audio.

I am not familiar with the 825/2R but I do have a pair of Peerless CD825/2Rs, a very similar design which uses a 100W paper-coned bass driver instead of the 90W polypropylene-coned unit on the 825/2R. A review of the CD825/2Rs appeared in the June 1984 issue of ETI. All listening tests on the Sage amplifiers were made using these loudspeakers.

Rather than get caught up in convoluted arguments regarding the suitability of this or that preamplifier, I auditioned the modules using a direct feed from a Philips CD104 compact disc player via a pair of 10k volume control potentiometers. For comparison I used the power amplifier stages of a NAD 3130 and my own home-grown 30W Class B power amplifiers.

Listening first of all to a selection of rock albums, the most noticeable difference between the Sage modules and the other amps was the quality and stability of the stereo image. The digitally-mastered album *Brothers In Arms* by Dire Straits showed this up particularly well. Vocal solos were firmly positioned in relation to the backing tracks and the sound effects on *Across The River* detached themselves from the music and became a living backdrop.

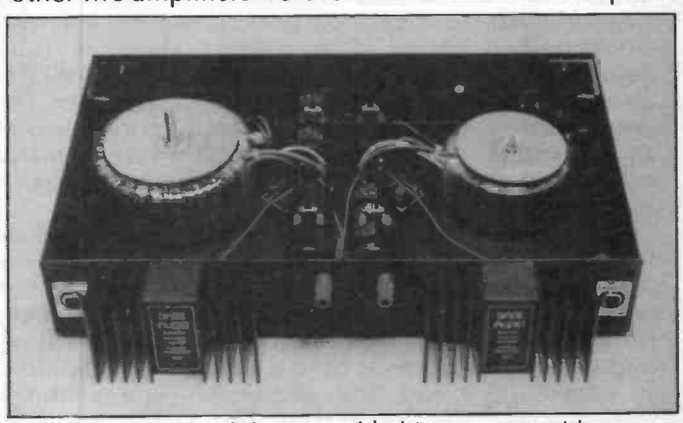
The difference was even more noticeable on *Don't Worry*, a track I had hardly noticed on previous playings. The descending chime passages took on a life of their own and seemed to hang in the air long after they had sounded.

Moving on to classical music only confirmed the first impression. Solo instruments were spaced well away from the orchestra and there seemed to be much more room between different groups of instruments. By comparison, the other amplifiers produced nice, well behaved sounds which remain rooted in the speaker boxes and were content to be heard and not seen.

Doubling Up

I assume the difference lay in the use of separate power supplies for the two channels on the Sage amplifier, a feature not shared by the other two amps. Temporarily I connected up the 500VA toroidal transformer in place of the separate 225VA toroids and doubled-up the reservoir capacitors. The Sage modules didn't quite admit defeat in the face of this emasculation but they did start to behave a lot more like the other two amps.

The differences between the Sage modules and the other two amplifiers were less marked in other respects.



The Superamp modules assembled into a case with power supplies. Note the two different sizes of toroidal transformer referred to in the review.

I liked the tightness and bass extension they provided and fancied I could hear a little more detail at lower frequencies than with either of the other amps. The NAD by comparison seemed almost to emphasise the lower register with some coincident muddling of the sound.

The mid-range seemed very slightly veiled but that might have been because the treble was particularly clear. Higher pitched voices and instruments seemed to start up with a little more assurance than on either of the other amps but I could not hear any ringing or other indication of poorly controlled treble.

A Definite Possibility

Having got the 500VA toroid into circulation it seemed a good idea to press on with the transformer comparison. I reconnected one of the channels to its 225VA toroid, separated out the capacitors again and left the second channel running from the 500VA toroid. With the two loudspeakers side by side I soldered a couple of mixing resistors across the volume pots to give a mono signal and then faded up and down rapidly between the two channels.

Power output	**50-150W RMS depending on supply voltage, load impedance, etc.**
Load impedance	**4-16R**
Supply voltage	**±30V to ±45V**
Input sensitivity (for 100W into 8R)	**0.775V RMS**
Distortion (THD)	**0.0009%**
Frequency response	**5Hz-125kHz**
Signal-to-noise ratio (CCIR/ARM)	**120dB**
Slew rate	**125V/us**
Transient output current	**45A peak-to-peak**
Damping factor (typical at 100Hz)	**800**

Table 1 Manufacturers' specification for the Superamp module.

And? Well yes, there was a difference, but I'm not sure what it was or which of the two sounds I preferred. With a little bit of imagination I could convince myself that the channel with the 500VA toroid sounded better at low frequencies, a little more open, perhaps, a little less mud and confusion. Then I'd play another disc and everything would change.

Perhaps a transformer rating of twice the minimum wasn't enough. Maybe I should have stuck out for a 1000VA model and hung the expense. Then again, it's possible that any differences were being masked by the use of a mono signal and that a full stereo audition would reveal them more clearly. Personally I doubt it, but it would be interesting to be proved wrong on this point.

In Conclusion

The Sage bipolar Superamp modules are clearly worthy of consideration by anyone building a high power, high-quality audio system. In spite of the stern warnings in the instructions the modules seem reasonably tolerant on the layout front and this coupled with their simple power supply requirements must make them a good choice where ease of construction is a major consideration.

I'm not keen on the sort of lash-ups which are all too often found on stage and disco equipment, but if any module is going to survive and sound good in that sort of application I suspect these will. They should also be of interest in domestic audio systems since they offer good quality sound at a not unreasonable price. The set-up used here cost around £170 in total and I suspect you would have to pay a lot more for anything substantially better.

The Superamp bipolar power amplifier module is available from Sage Audio, Construction House, Whitley Street, Bingley, West Yorkshire BD16 4JH, Tel (0274) 568 647. They cost £47.50 each inclusive of VAT and postage. The MOSFET-output SuperMOS modules are currently unavailable but should be on sale again soon. Contact Sage Audio directly for details. **ETI**

KEYNOTES

During the last five years digital technology has ravaged the world of music synthesis and audio in general. Polyphonic capability, velocity and/or pressure sensitive keyboards, battery-backed patch and sequence storage, multistage envelope generation and MIDI are now accepted norms, while still more impressive features such as additive synthesis and 16 bit quality are unlikely to raise many eyebrows. All this at prices that made traditional analogue synthesis wish in vain that the micro would go away and die quietly.

Gone forever is that golden era when you could impress your friends with a simple monophonic synth housed in a biscuit tin.

The Micro

In its earliest days the microprocessor offered the promise of reduced cost, increased performance and reduced design time. Synth manufacturers of American and Japanese origin (Australian too, I should add) were quick to adopt this new technology. Those that did not died overnight. EMS and ARP (once famous names) are no longer with us.

The classical Von Neumann architecture (bus-orientation) of microprocessors imposes serious limitations on their ability to directly process or generate waveforms in real time, even at audio frequencies, since most machine cycles are wasted on calculations of address values and transfer of data.

NED's Synclavier and the Fairlight circumvented the proverbial Von Neumann bottleneck by entirely different design philosophies. NED used a wider bottle. Fairlight used more of them. However, both machines were of necessity hardware-intensive and you were getting what you paid for.

The current Fairlight employs a 6809 and 68000 in each of its sixteen voice channels. The Synclavier, on the other hand, is based on bipolar bit-slice technology (probably AMD's 4 bit 2901s but don't quote me on that) with 25ns static RAM memory. Easier said than done, as witnessed by the fact that NED commenced work on the project in 1973.

With the dawn of the '80s the pace quickened as Japanese firms unfettered themselves from what was at one time a deserved reputation for poor quality. Even Moog was having to run to stand still in spite of the demise of arch-rival ARP.

However, more surprises were to come and few people knew of the activities proceeding in the development laboratories of Yamaha.

DX7

These few were affiliated to Stanford University and included Dr John Chowning who had almost accidentally pioneered the application of FM to audio signals back in 1967. There was nothing new about FM itself. The theoretical and mathematical aspects had all been laid down before the advent of the triode valve. Furthermore, the modulation of one VCO by another in analogue synthesis had already been investigated and found to produce interesting results.

Chowning nevertheless had the foresight to realise the FM synthesis technique constituted an exceptionally efficient means for digitally generating complex yet controllable audio spectra and consequently registered a patent under the auspices of Stanford University. Stanford contacted a number of major US manufacturers (such as Hammond and Lowrey) none of whom understood what all the fuss was about. A licensing agreement was finally signed with Japanese Yamaha.

The DX7 bombshell finally dropped in 1983 and caused devastation in the wake of its sales (about 200,000 to date).

Here was a machine that offered sixteen-voice polyphony, multistage envelopes, an implementation of the then new MIDI standard, a velocity and after-touch sensitive keyboard, 32 patch memories, provision for external ROM/RAM cartridges, plus all the usual performance controls.

Each voice sported no less than 145 controllable parameters and comprised six stages of FM modulation (dubbed 'operators') which could be configured in any of 32 different series/parallel combinations. The price tag was a miraculous £1,600 and the miracle was implemented entirely digitally (albeit only eight bit, but that was eight more than might have been expected at the time).

The protracted development of the DX7 had been undertaken in absolute secrecy and the competition and market alike were taken by genuine surprise.

LSI

Yamaha had been able to reduce the size and complexity (and cost) of their original lab prototypes only by the design of custom LSI devices.

To digress for a moment, custom chips (usually called ASIC — 'application-specific' IC) fall into two categories: semicustom and full custom. In semicustom, a chip pattern is built in modular fashion from a library of smaller standard patterns (macrocells or megacells, depending on size) each representing ready-made logic functions such as shift registers, latches or RAM.

Development cost for a semicustom is commonly under £40,000 — surprisingly low considering the level of technology involved.

However, production costs make semicustom LSI expensive and the only solution is to reduce the required silicon area by going the whole hog with full custom — laying out a chip transistor by transistor — typically tens of thousands of them, often more. Needless to say, this is exorbitantly expensive.

Yamaha had to adopt the full custom approach to keep the retail price of the DX7 low enough to make it a winner. Yamaha is no longer the only synth manufacturer to have developed its own LSI but they were certainly the first. Their marketing department knew what it was doing (an unusual phenomenon in the music busness) and the gamble paid off as the machine soared into the commercial sky, followed by the DX1, DX5, DX9, DX21, DX27, DX100, TX7, TX216 and TX816, all based on proprietary chips.

Moog and other firms that had been letting the grass grow retired from the race before it was too late, moving into other areas such as MIDI software and sound sampling (the latter becoming a temporary haven for Western manufacturers).

Synthesiser circuitry slowly disappeared from electronics magazines as designers and readers realised that competition on the same price/performance level as the industrialists was no longer viable or worth the effort.

I paint a gloomy picture, but it is necessary to be realistic. Although it is possible to put together a synth that is in some aspects superior to commercialy available equipment, this is a challenging task and is exceedingly unlikely to work out cheaper. Having said that, a wealth of interesting opportunities to break new ground exist for anyone prepared to accept these terms.

Books

Some new ground worth breaking will be covered in this magazine over forthcoming months but in the unlikely event of uncontrollable enthusiasm you could certainly do worse than to visit the local university or polytechnic library in search of the Computer Music Journal and Journal of the Audio Engineering Society.

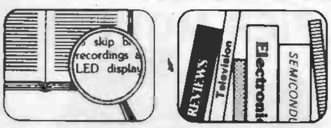
Not all libraries have these, but you will almost certainly be able to find *Signal Processing Aspects of Computer Music: A Survey* by J.A. Moorer (IEEE Proceedings, Vol. 65, No. 8, August 1977). This concise and well-referenced overview neatly illustrates the width of the gulf that exists between the know-it-alls and the real know-it-mores.

Are there any good books on music synthesis? Yes, but only one. Hal Chamberlin's *Musical Applications of Microprocessors* (Hayden, NJ) is now in its 700 page second edition. Chamberlin's book covers many more general issues than its title implies, including signal analysis techniques and analogue synthesis.

Particularly clear and readable accounts are given of difficult issues such as digital filtering and the fast Fourier transform. The only major gripes are the lack of adequate referencing for further reading and perhaps the very-American price. Even the softback leaves scant change from £20 but take heart that there are simply no comparable books available to choose from.

Bruno Hewitt

BOOKS



Sinclair and the 'Sunrise' Technology. Ian Adamson and Richard Kennedy (Penguin Books) £3.95

This Penguin paperback takes a long hard look at the Sinclair myth. It is basically a biography covering Sinclair's achievements from his early efforts in the world of audio kits up to the recent Amstrad buyout and the formation of Anamartic to produce the waferscale memory.

However, unlike most biographies (and certainly most about Sir Clive) this one is far from reverent.

Adamson and Kennedy aim to show that Sinclair, far from being the avuncular figure and darling of Thatcher's hopes for the future of British industry, is actually the epitomy of the British failings.

Documented like this, Sinclair's repeated flounderings despite the obvious success of (most of) his products shows him to be nothing short of a poor and narrow minded businessman.

To put forward such a controversial re-assessment of the man who could do no wrong as far as the press were (and still are?) concerned, you have to have your facts right. Unfortunately this work is plagued by many minor (and some less than minor) errors. The launch of the QL is portrayed as a total con with nothing working at the launch and no-one allowed near the 'mock-ups' displayed.

That must have been a different launch to the one I attended. I will grant that the QL when launched was not in production and still largely unfinished, but there were certainly working machines available for (rather limited and undirected) tinkering.

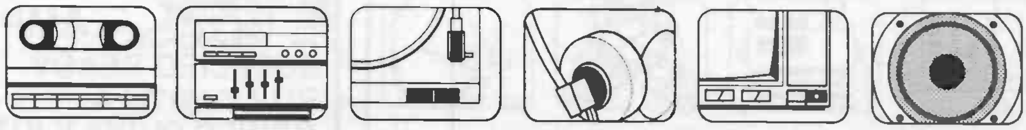
Worse than the odd inaccuracy is that this book suffers from tedium. It is difficult to present a detailed story of anyone's life in a truly interesting manner. After a few chapters all we are hearing is the same story, the same tales of commercial disaster and the same home-grown philosophies.

Nevertheless, this book makes a refreshing change. The angelic image of Sinclair in the press is not a true one. Like all people he has made many mistakes. Many of these mistakes, if we are to believe this book, are down to business incompetence and obsessions with the irrelevant.

It is good to feel a breath of fresh air but also a little sad to see the idol come crashing down.

Malcolm Brown

PLAYBACK



Recently I had the chance to play with a review copy of Sony's top of the range recording Walkman — with Dolby C and a crystal locked capstan. The advance of this interesting beastie over early models led me to reflect on the development of the ubiquitous personal stereo.

The Original

The first personal stereo to hit the market was the original and now legendary Sony Walkman about six years ago. This was a smart all-metal cased unit 140x-85x30mm. It looked well made to me and, although large by modern standards, it seemed tiny at the time.

It had two headphone outlets and a press to talk internal microphone, presumably to allow the two people to converse while wearing the headphones. A silly habit at the best of times.

It boasted separate left and right channel volume controls and a treble cut switch labelled 'metal'. The sound was pretty good but the treble cut was not enough to avoid a sensation of cheesewire between the ears when playing a Dolby encoded metal tape.

This old faithful has been thrashed continuously and it's still working perfectly with just one change of drive belt.

And The Next

Its successor, a Sanyo M-G18D, proved lighter, more beautiful, and less durable. It's a whole heap smaller, 110x80x-30mm, with Dolby B, separate left and right volume controls, and continuously variable treble cut. Judicious use of the tone control rendered Dolby C recordings listenable. This tiny miracle also had an internal mono loudspeaker and auto-reverse.

One other thing Sanyo got right — the player comes equipped with a clip to hang it over the waistband of the jeans. All the others I have seen offer the choice of wearing a belt (which I don't) or swinging the player around on a shoulder strap.

After about two years of heavy use the Sanyo declined to remain at the speed normally associated with cassette players. I took the machine to bits to try to find the reason for the speed variation. A few electrical measurements pinpointed the fault to the motor but given the size of it a repair looked chancy. It still works, but after a brief period the speed variation tends to bring on seasickness.

Sony DC6

It was about this time I got a chance to play with the do-everything recording Walkman, the Sony DC6. The words *Quartz Locked Capstan* attracted my eye, after my problems with the Sanyo variable speed motor.

In fact, this particular Walkman has an intentionally variable speed function whereby the tape speed can be adjusted about 10% either side of nominal or run at the right speed when you tell it.

The facilities on this recorder include Dolby C and an LED peak reading record level meter. In addition to the stereo microphone input and the headphone output, it has line input and output sockets. The record and replay level controls have no separate adjustment for left and right channels.

This (fairly substantial) object seems to be intended to double as a component in a larger stereo system, so I tested it accordingly. It did stand up well. I carried out my tests using TDK SA tape and Dolby C. If there are any errors in the frequency response then Dolby C accentuates them greatly.

The results from the left and right channels were very similar. I measured the frequency response at two different levels, with the –5dB LED just on, and then with the –10dB LED just off. This corresonds to about –3dB and –12dB respectively. In both cases the response was ruler flat up to 15kHz, and about –3dB by 16kHz. After this the roll off is like the side of a cliff. Without getting too tied up with measurements, this is quite impressive. The important question is whether the sound is as good as the measurements.

A recording made with a microphone was indistinguishable on playback from the original on the headphone monitoring. The perceived noise level was low and the main limitation on quality was the microphone itself. Recordings of music made on my Nakamichi recorder in Dolby C also sounded good, but there was a detectable flaw.

On some rapid changes of sound level there was a slight hesitation, as if the replay Dolby system was responding at a slightly different rate from the one which made the recording.

Dolby C

The Dolby C system compresses certain frequency ranges very heavily on record and expands them again on replay. If there is any error in the tracking of the replay system with the record system then the very high degree of compression will make this more obvious than with Dolby B. Taking an extreme example, if you play a Dolby B recording with Dolby C switched on, the result is almost unlistenable.

Bearing all this in mind, it is not surprising that mismatches between different machines are evident. What is more surprising is that any Dolby C machine without adjustments to compensate for differences between tapes of nominally the same grade should work well. Some of them do though, as witness the Sony DC6.

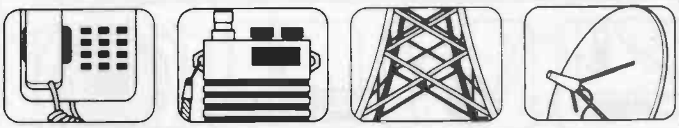
To cut a long tale short, I found the effect of the Dolby C mismatch much less irritating than the pit-of-adders tape hiss which is the alternative. On the strength of the tests on the DC6, I bought its smaller brother (the DC2) which does not record. It's about a millimetre smaller in all dimensions than the Sanyo machine and makes most other walkmen sound like tin boxes. It is too soon to comment on its reliability but it has survived a crash which snapped my ski pole. The speed remains absolutely constant as I lurch unevenly around the ski slopes and the headphones are comfortable. Even under a ski hat.

Of all the walkmen I have looked at (including many others in various hi-fi shops) this one seems the clear winner in the choice between size, price, and performance.

The DC6 costs about £250, the DC2 about £150.

Andy Armstrong

OPEN CHANNEL



I have reported in the past regarding my concern for the work involved in gaining requisite approvals to market products in Britain. At the time I was concerned that too many approvals bodies existed.

My suggestion was simple: combine all approvals bodies into one so that manufacturers had only one office to deal with.

However, if streamlining means a lowering of standards then this is not the way forward. Any easing of approvals procedures must not allow the equipment to be of inferior quality.

A recent report suggesting simplification of approvals procedures for telecommunications equipment went decidely close to doing just this by recommending that transmission and signalling performances need not be tested. Instead, one presumes, market forces will decide whether the equipment sells — users will not buy the product if it doesn't work sufficiently well!

This is a dangerous and slippery path to take. Unfortunately, there will always be a market for cheap products, even if they don't work as well as they should. Take a look in any 'backstreet' electronics equipment shop window and you'll see many unapproved telephones which sell for much less than approved counterparts. True, some of them may be perfectly adequate as far as the user is concerned (in that they are cheap) but are they up to the mark regarding telecoms quality? At present if the product is unapproved, we can only assume it is not.

If the suggestions of the report are followed, it may be difficult to ensure that even approved equipment is of a high enough quality to maintain good telecommunications services.

Streamline approvals by all means. But don't interfere with quality!

Second Generation Cells

Narrowband time division multiple access is probably to be the standard for the second generation of cellular telephones, planned for the early 1990s. This standard was agreed by all but France and Germany in late February and work has already been commenced to define the system in detail.

Agreement has been reached more by necessity than by mutual consent. All involved parties have realised the importance of the tight timescale and scheduling which must be met if the system is to start early enough.

The overriding concern has been that existing systems will be totally overloaded by about 1991 at current rates of expansion. Overloading will occur even before that in dense urban areas. Development work must start now.

Need For Speed

Hopefully, the Department of Trade and Industry will take note of the need for speed as it has yet to decide on the British operator. A lot of design, development, manufacturing and marketing jobs depend on an early decision.

To delay will almost certainly mean that operators from other countries could steal some, if not all, of the British potential.

If a DTI decision comes rapidly, on the other hand, British operators could perhaps steal some of the other European countries' potentials. The second generation cellular system is to be a pan-European system (nick-named PEDS 92 — pan-European digital system 1992) which means users will be able to roam — use an individual cellular telephone anywhere in Europe.

Because of this manufacturers and operators will theoretically *also* be able to 'roam' with their products — selling equipment and services throughout Europe. However, this will only be so for those with products and services to sell.

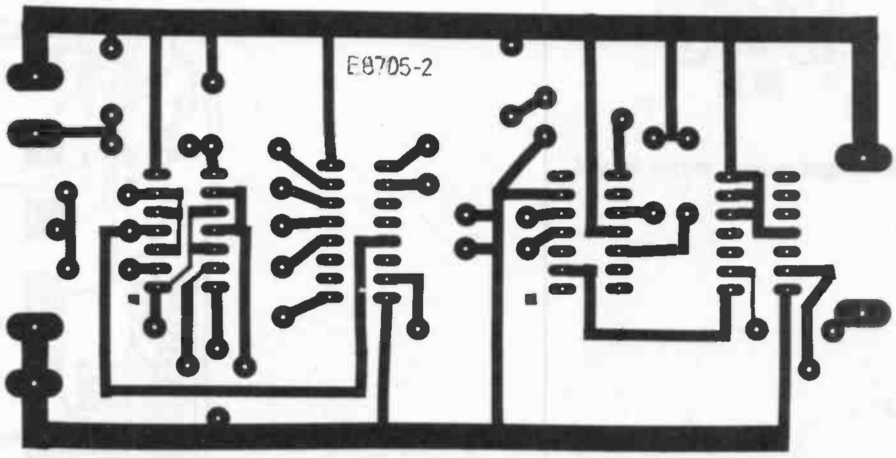
Incidentally, any reader who currently has a first generation cellular telephone and feels a little put out by all this talk of a new system within just a few years — take heart. The development of second generation services will not kill existing services. Far from it!

First generation services will continue to operate until well into the next century. All the second generation system will do is ease the pressure on the current deadlines for the overloading of the existing services.

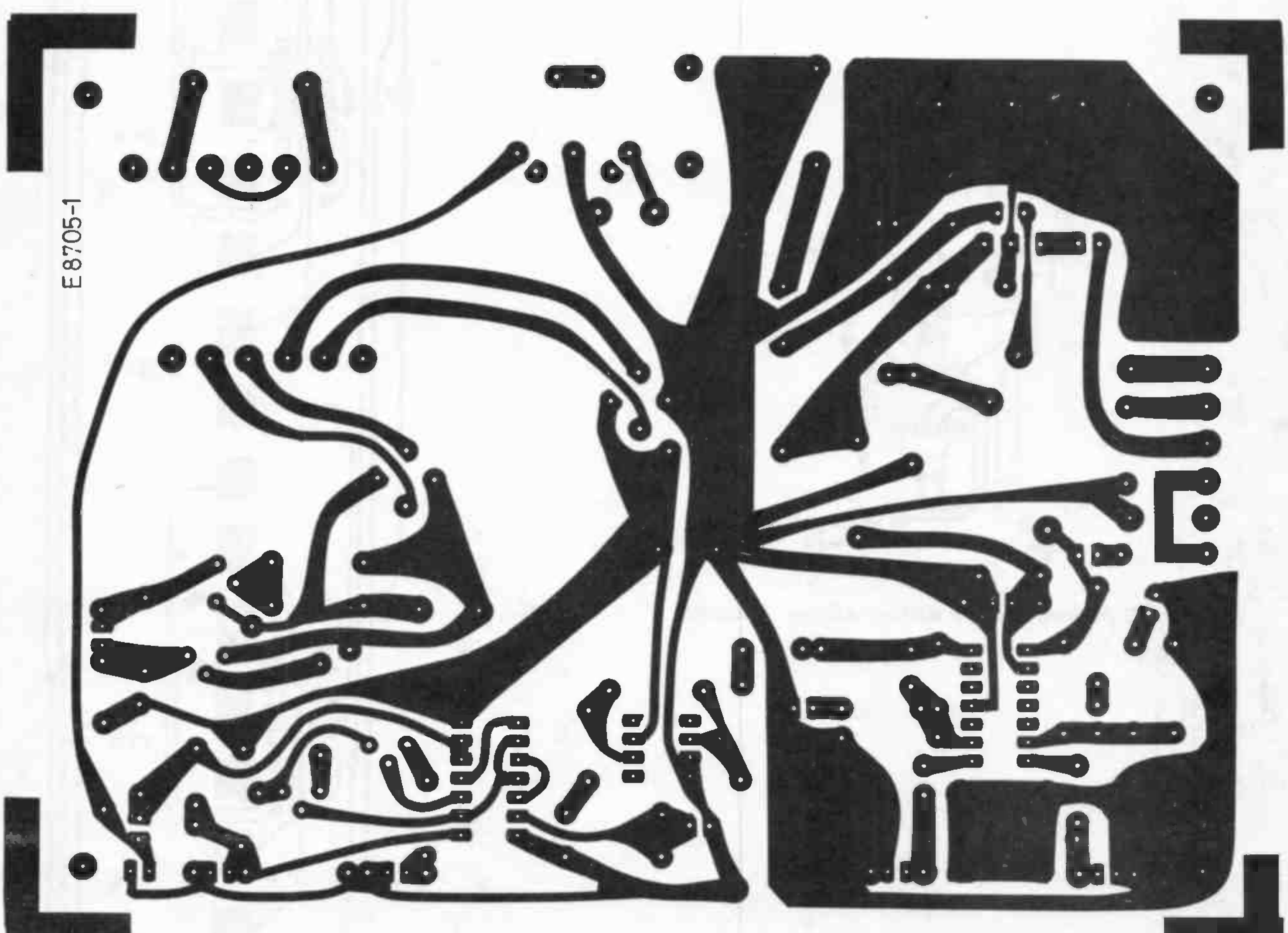
Second generation cellular telephones will also (I predict) be far more expensive than present cellular telephones. So, if you're considering a cellphone at present but are put off by talk of a new system, don't be. Go ahead and get your phone!

Keith Brindley

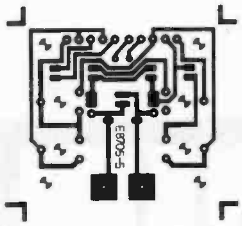
PCB FOIL PATTERNS



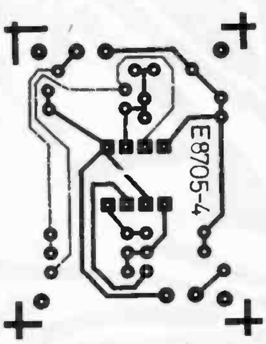
The Telfax 1kHz cue tone generator board.



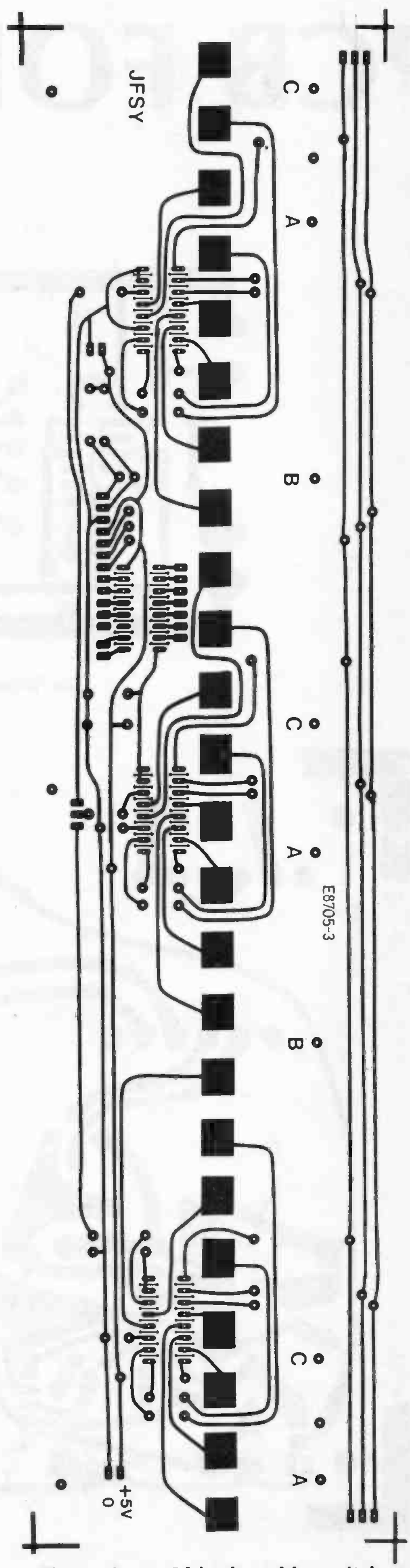
The main Telfax board foil pattern.



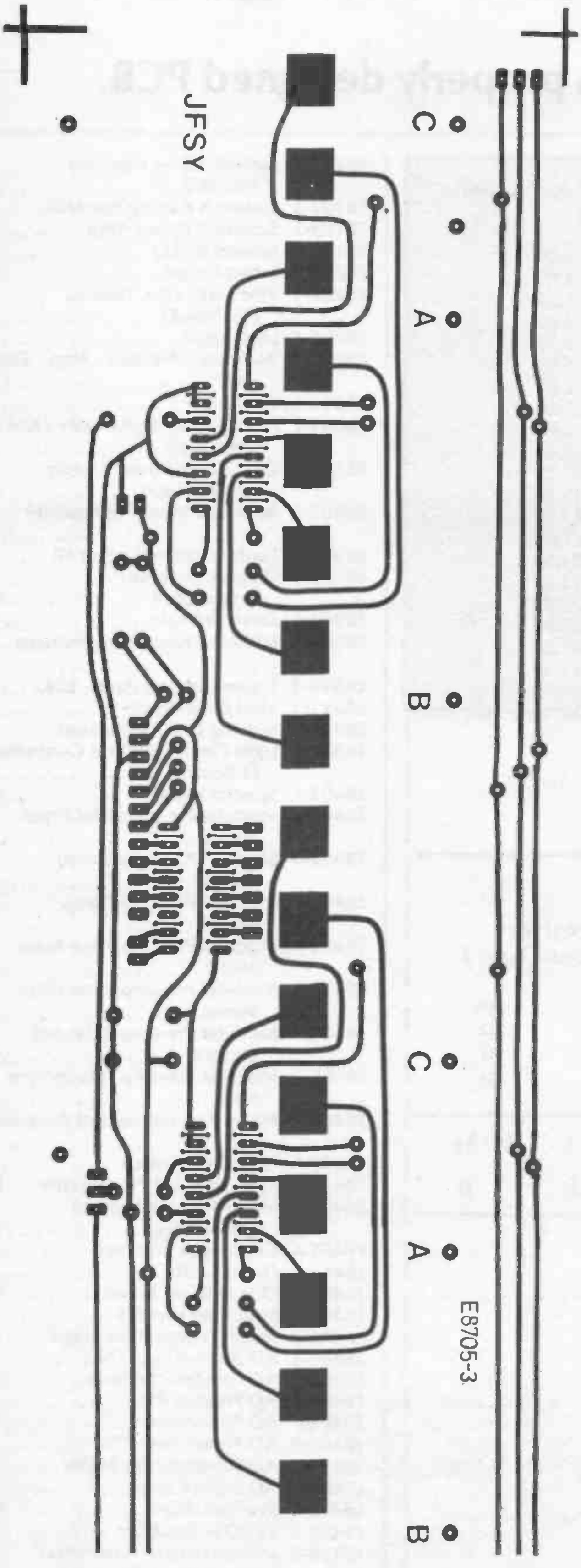
The budget power meter board.

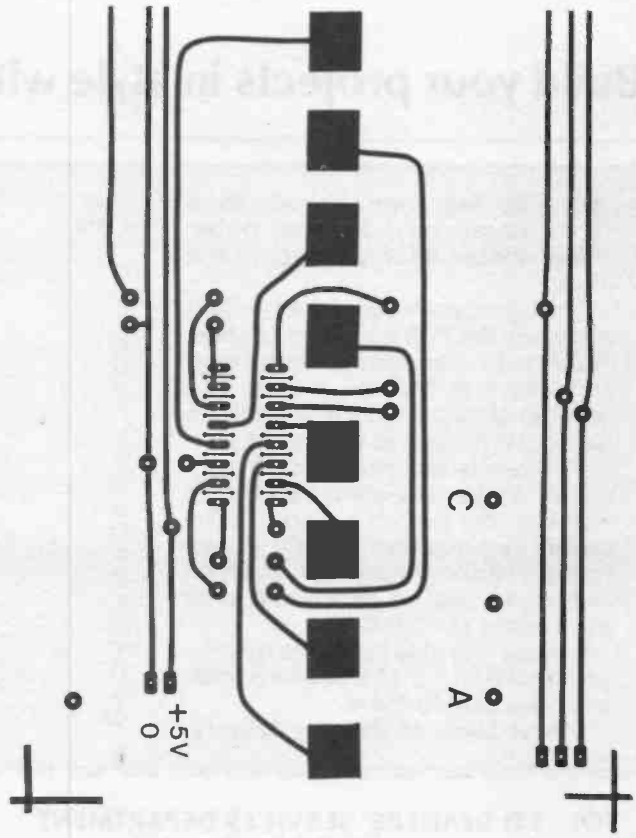


The foil pattern for the Batlite voltage indicator.



The entire MIDI keyboard keyswitch PCB approx 75% full size.





Sections of the MIDI keyboard keyswitch PCB full size.

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Audio Analyser (October 1986)
The PCB foil for this project was printed incorrectly. Referring to the overlay diagram (Fig. 3), a short vertical length of track should be inserted between the elbow to the right of R35(4) lower connection and the elbow to the right of R33(4) right hand connection so as to connect pin 11 of IC9(3,4) to 0V. A similar length of track connecting the elbows to the right of Ra(6) should be removed so that pin 3 of IC8(5,6) is *not* connected to pin 4. In the parts list C2 should be 100n and ICI should read LM3915N.

Digital Audio Selector (November/December 1986 and January 1987)
In Fig. 5 (December 1986) the resistors shown as R14 and R114 should be R19 and R119. This error is continued in the discussion of gain setting in the January 1987 issue.

The DG507A IC used in the prototype came from Farnell Electronic Components of Leeds, Tel: (0532) 636 311. Farnell normally deals only with trade customers but private ordes are sometimes handled at the company's discretion. Trilogic of 29 Holm Lane, Bradford BD4 0QA, Tel: (0274) 684 289 will obtain any Farnell component to order on payment of a 25% handling charge. The Farnell order code is simply the full device number — DG507ACJ.

Biofeedback Monitor (December 1986)
The capacitor C4 is shown the wrong way around in the component overlay diagram (Fig. 4).

The Intelligent Call Meter (December 1986)
The hex dump listing of the ROM for this project (Table 3) was badly printed. The byte at location BF should read 7F.

The Better Flanger (January 1 1987)
In the circuit diagram (Fig. 2) D1 is not labelled. This is connected to Q1. In the component overlay (Fig. 5) several components are missing. A link should connect the two pads to the left of C1. Q1 is situated next to D1 and connection point P4 is situated between R16 and R33. In addition, the positions of R16 and C11 should be swapped.

Aerial Without Holes (In-Car Tech Tips, January 1987)
Using enamelled wire of only 0.5mm diameter for the bifilar coils could cause over-heating problems and even a fire risk with some cars. A much thicker wire (1.5mm should be sufficient) should be used.

Credit Card Casino (March 1987)
The circuit diagram (Fig. 1) incorrectly showed a connection between C2 (negative lead) and the positive rail. The PCB foil is correct.

Capacitometer (March 1987)
The circuit diagram (Fig. 1) should show pin 1 of IC1 connected to 0V. The zener diode (ZD1) should be connected between the junction of R10/R11 and 0V. The PCB foil is correct.

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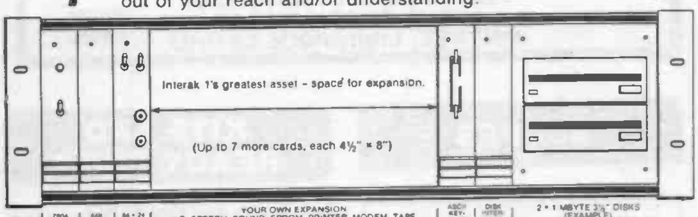

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