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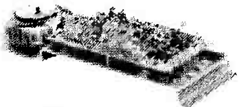

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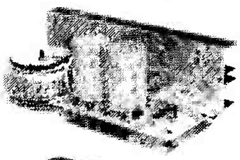

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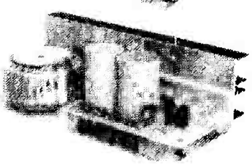

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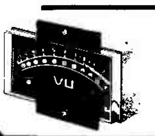

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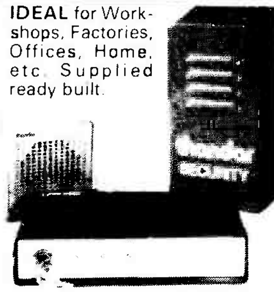

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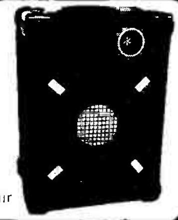

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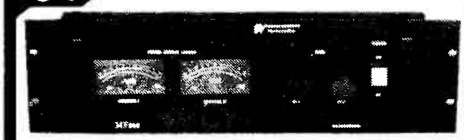

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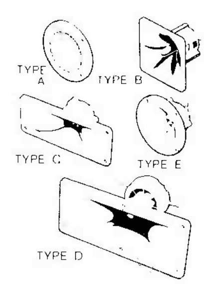

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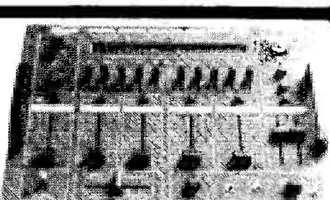

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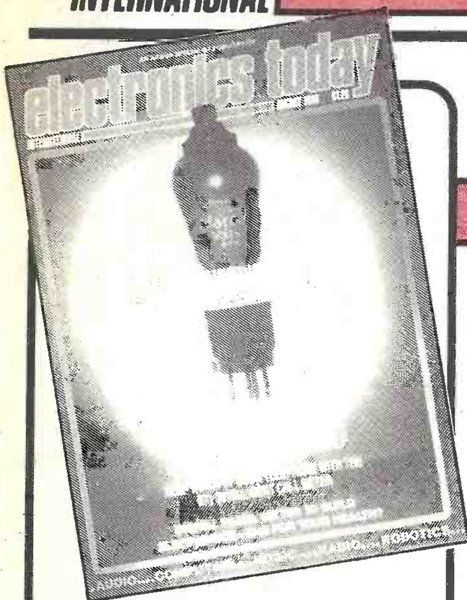

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DIGEST

World's First Gallium Arsenide Microprocessor

McDonnell Douglas have developed what is claimed to be the world's first gallium arsenide microprocessor chip.

It can process information as fast as conventional silicon microprocessors can but uses only one-tenth of the power.

The MD2901 is a four-bit device which has been designed as a direct substitute for existing four-bit silicon microprocessors. It occupies a one-eighth inch square chip, contains 1860 transistors and uses just 135 milliwatts of power. It will complement the company's existing range of static random access memories and gate array chips.

Gallium arsenide offers the promise of computers which not only use less power than their silicon equivalents but also operate at many times the speed. McDonnell Douglas say they are studying ways to improve the speed of the new chip and hope to reach a target of 100 million operations per second.

Although a number of gallium arsenide memory chips have been developed, the company say they do not know of anyone else who has successfully built and tested a microprocessor using the material. They are now working on the development of a 32-bit microprocessor using gallium arsenide.

McDonnell Douglas Ltd (European Operations), Albemarle House, 1 Albemarle Street, London W1X 3HF, tel 01-491 1492.

Pocket-Sized Digital Multimeter

The DM1000 digital multimeter from AB European Marketing is only a little larger than a credit card and is light enough to be carried around in a shirt pocket.

It features a 3½-digit, 10mm high display, measures AC and DC voltages, resistance and continuity (but not current), and comes with permanently-attached test leads in a plastic wallet. Its maximum dimensions are 108 x 54 x 8mm and it weighs less than 80 grams.

Function selection is by means of a rotary switch and the meter is fully autoranging on voltage and resistance measurements with maximum readings of 450V and 2M0. The most significant digit flashes to indicate over-range and indicators on the display remind the user which function has been selected and warn when the battery runs low. The continuity tester uses an audible warning device so that the operator can concentrate on the item under test and not have to look at the display, and there is also a diode checkfunction. Power is provided by two LR44 long-life button cells.

The DM1000 sells for £24.60 plus VAT complete with case, batteries and instructions. AB European Marketing, Forest Farm Industrial Estate, Whitchurch, Cardiff CF4 7YS, tel 0222-618 336.

32-Bit RISC Chip From Acorn

Acorn Computers, Manufacturers of the BBC microcomputer and the Master series, have introduced their much-heralded Reduced Instruction Set Computer chip.

Said to be considerably cheaper than any other single-chip RISC device, the new chip is complemented by a range of optional controller ICs and will be available towards the end of the year.

The VL86C010 ARM (Acorn RISC Machine) is fabricated in CMOS and has only 44 basic instructions. It has an average execution rate of four million instructions per second, a two-phase 8MHz clock and comes in an industry-standard ceramic leadless chip package. The associated family of controller chips currently includes devices for memory, video, sound and I/O operation and further ICs are under development.

The use of a small set of fundamental instructions, coupled with extensive use of internal registers to reduce the need for external fetch and carry operations, allows machines using RISC architecture to execute code very quickly and efficiently (see the article on RISC in last December's ETI). The ARM has 25 internal 32 bit registers which partially overlap, allowing fast interrupts to occur without the need for time consuming shifts to store. Acorn say the device handles high-level languages efficiently and that it is particularly suited to use in situations which require real-time response to external interrupts and high processing throughput.

The VL86C010 ARM is to be manufactured by VLSI Technology Incorporated in San Jose, California, under an agreement with Acorn. The first samples will be available in mid-summer at a price of $99 and full production should be reached during the third quarter of the year. VLSI are also planning to make an evaluation kit available and Acorn will be marketing a development system cum evaluation kit.

Acorn Computers Ltd, Cambridge Science Park, Newmarket Road, Cambridge, tel 0223-214 411 extension 409.

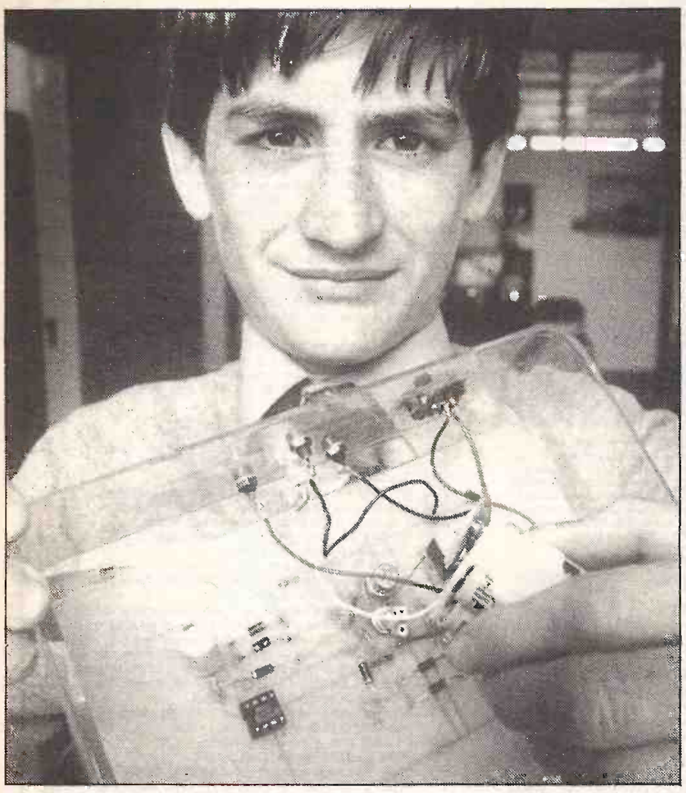
Dual-Purpose Portable Iron

A novel new tool from Camping Gaz International combines the functions of portable soldering iron and burner.

Called the Spotflam, it consists of a brass burner which screws onto a gas cartridge and a soldering bit which can be attached to the burner. The flame temperature is adjustable, giving up to 1800°C for burning and 400°C for soldering, and one gas cartridge will last for up to five hours.

The soldering attachment can be used for most commonly-encountered soldering operations while the burner is suitable for removing paint from small objects, releasing seized nuts and many more jobs. A patented device allows the burner to be used at any angle without flaring.

Recommended retail price of the Spotflam is £9.95 and replacement CV360 gas cartridges cost £1.70 each. Camping Gaz (GB) Ltd, 126-130 St. Leonards Road, Windsor, Berkshire, tel 95-55011.



Awards Off Course

Launched by component distributors, Cirkit, in 1985 and co-sponsored by Texas Instruments and trade journal Electronics Times, the Young Electronics Designer of the Year Award is intended to encourage young designers and promote the teaching of electronics in schools. Judging by the standard of entries in this its second year, the scheme seems none too successful.

The award presentation for 1986 took place recently at Westminster school and was introduced by Maggie Philbin, co-presenter of TV's Tomorrow's World and a somewhat less notable personality than last year's Duke of Edinburgh.

First prize in the junior category was awarded to Gareth Arthurs (above) for a circuit to switch bicycle lights between dynamo and battery according to the output from the dynamo, preventing the lights from being extinguished when the cycle is at rest. Runners up were a wheelchair control device and a thermometer for the blind.

In the intermediate category (15 to 18), the winner was Tim Price with a sound processor using a 16-bit MPU, 128K of RAM and 12-bit conversion ICs. The runner up, and only female finalist, was Rosemary Erskine with a digital anemometer. Third prize went to a stage lighting controller for the BBC micro.

The senior category was the most disappointing with many entries not even up to the standards of the intermediate category. The joint winners were Stephen Osborne and Howard Mitchell of Essex University with a netball scorer. Runners up were an 'electronic Lego' set and a rehabilitation aid to exercise the arms of stroke victims.

The netball scorer won on marketability, thanks to a team of judges who included Peter van Cuylenberg — TI's European head — and Jason Swift, electronics correspondent of the Financial Times.

The outright winners in the senior category received £500 in cash, a £450 a year sponsorship for the remainder of their course of study, a vacation job with TI and a reserved place in TI's graduate intake — in other words, they won a job, which is not be sneezed at these days.

It was noticeable, however, that the overall standard of this year's entries was poorer than that of a well-constructed ETI project in some respects and the scheme seems not to have mined the same vein of talent that was evident in last year's crop of entries. It may be that ETI readers could do better. Certainly, they are welcome to apply even if not at present in full-time education.

Entry forms for 1987 can be obtained by writing to:

Carla Sharyk, Young Electronics Designer Awards, Standard House, 16-22 Epworth St., London EC2A 4SH.

I Can See Clearly Now

Eleven scientists from the USA, Holland and Britain have been awarded three joint prizes totalling £115,000 for contributions to the growing field of opto-electronics. The awards were made in early June by the Rank Prize Fund at a ceremony at the Royal Institution in London.

The prizes were awarded for pioneering work in three major areas of opto-electronics: the invention of compact and video discs; the development of large screen television displays and the design of thermal imaging cameras.

Three Philips research scientists shared £45,000 for their invention of the laser disc — initially as a video medium but increasingly thought of as an audio and data medium. Dr. P. Kramer, Mr. G. Bouwhuis and Mr. K. Compaan invented the laser disc in the early seventies. In his acceptance speech Dr Kramer observed that his team had built on the work of many predecessors and also indicated that work was currently in progress on the use of crystalline and magneto-optical materials for erasable, re-usable discs.

A prize of £40,000 went to the four scientists who invented the liquid crystal light valve at Hughes Aircraft in California. The LCLV acts as a kind of optical transistor, accepting light from a low intensity source (like a CRT) and using it to modulate a bright source (for example, a xenon arc lamp) thus creating a high intensity version of a low intensity image.

The LCLV operates in real-time and is the device behind the giant screens used at pop concerts, sports meetings, for video conferencing and in NASA astronaut training.

A £30,000 prize was also awarded to four British researchers at the Royal Signals and Radar Establishment in Malvern and at the English Electric Valve Co. who between them developed a highly portable thermal imaging camera used in fire-fighting, rescue work and medical imaging.

The Rank prizes were established by Lord Rank just before he died in 1972. They are designed to promote research in the two fields which most interested him during his lifetime — nutrition (he was president of Rank Hovis McDougall) and opto-electronics (he founded the Rank Organisation film company).

● While on the subject of prizes (see the other ariticles on this page), the free PCB competition announced in our March issue has attracted a disappointing number of entries. If you recall, we asked readers to come up with designs for an original and interesting circuit using the PCB we gave away with our March issue. So far, we have not received any entries worthy of an outright win (shame on you all!) and — since the closing date for submissions was the 2nd May — we don't suppose we will. However, we've been working night and day to rescue something from the ruins, so watch this space next month for a PCB special. By the way, the PCB is still available from our PCB service at its commercial price.

Drawing Fruit

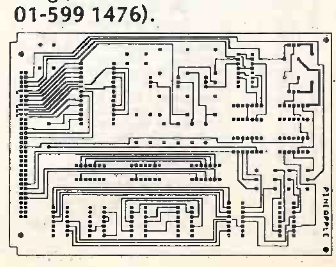
Pineapple Software, whose Diagram circuit drawing program for the BBC micro is to be reviewed soon, have announced two new products, also for the Beeb.

A utilities disc produced by one of the company's customers provides six additional features for the diagram package including the ability to specify a border, to identify the screens in large diagrams and to move diagrams either horizontally or vertically to make more space.

Pineapple also announced a PCB drawing program — supplied on a 16K EPROM and capable of handling double sided boards up to 8" x 5.6" in size. PCB (as the package is known) operates with any BBC B compatible computer with a disc drive, medium resolution monitor and Epson FX-type printer. Three standard track widths are available and the system operates on a standard 0.1" grid.

A sample of the program's output is shown in the illustration, this being the component side of a double sided board.

PCB retails for £85.00 plus VAT (p&p incl.) and Diagram Utilities for £10 plus VAT. Further details and programs may be obtained from Pineapple Software, 39 Brownlea Gardens, Seven Kings, Ilford Essex IG3 9NL (tel: 01-599 1476).



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4. 5 – surface mounting switches suitably insulated for mains voltage
5. 3 – electrical switches intermediate type, will also replace 1 or 2 way switches, white flush mounting
7. 4 – in flex line switches with neons
9. 2 – mains transformers with 6V 1A secondaries
10. 2 – mains transformers with 12V ½A secondaries
11. 1 – extension speaker cabinet for 6½" speaker
13. 12 – glass reed switches
17. 2 – ultra transmitters and 2 receivers with circuit
19. 2 – light dependent resistors
25. 4 – wafer switches – 6p 2 way, 4p 3 way, 2p 6 way, 2p 5 way, 1p 12 way small one hold fixing and good length ¼ spindle your choice
28. 1 – 6 digit counter mains voltage
30. 2 – Nicad battery chargers
31. 1 – key switch with key
33. 2 – aerosol cans of ICI Dry Lubricant
34. 96 – 1 metre lengths colour-coded connecting wire
39. 1 – long and medium wave tuner kit
41. 8 – rocker switch 10 amp mains SPST
45. 1 – 24 hour time switch mains operated (s.h.)
48. 2 – 6V operated reed switch relays
49. 10 – neon valves – make good night lights
50. 2 – 12V DC or 24V AC, 3 CO relays
51. 1 – 12V 2 CO miniature relay very sensitive
52. 1 – 12V 4 CO miniature relay
53. 2 – mains operated relays 3 × 8 amp changeover (s.h.)
54. 10 – rows of 32 gold plated IC sockets (total 320 sockets)
55. 1 – locking mechanism with 2 keys
56. 1 – miniature uniselector with circuit for electric jigsaw puzzle
60. 5 – ferrite rods 4" × 5/16" diameter aerials
61. 4 – ferrite slab aerials with L & M wave coils
63. 1 – Mullard thyristor trigger module
64. 10 – assorted knobs ¼ spindles
65. 5 – different thermostats, mainly bi-metal types
66. 1 – magnetic brake – stops rotation instantly
67. 1 – low pressure 3 level switch can be mouth operated
69. 2 – 25 watt pots 8 ohm
70. 2 – 25 watt pots 1000 ohm
71. 4 – wire wound pots – 18, 33, 50 and 100 ohm your choice
76. 1 – 1250 watt dimmer Ultra ref SE20
77. 1 – time reminder adjustable 1-60 mins clockwork
81. 2 – 30A panel mounting slyslok fuses
85. 1 – mains shaded pole motor ¾" stack – ¼ shaft
86. 1 – mains motor with gear box 1 rev per 24 hours
91. 2 – mains motors with gear box 16 rpm
96. 1 – thermostat for fridge
98. 1 – motorised stud switch (s.h.)
101. 1 – 2½ hours delay switch
103. 1 – mains power supply unit – 6V DC
104. 1 – mains power supply unit – 4½V DC
105. 1 – 5 pin flex plug and panel socket
107. 1 – 5" speaker size radio cabinet with handle
110. 10 – slider type volume controls
111. 2 – musical boxes (less keys)
112. 1 – heating pad 200 watts mains
113. 1 – FM front end with tuning condenser and data
114. 1 – 1W amplifier Mullard 1172
115. 1 – wall mounting thermostat 24V
116. 1 – teak effect extension 5" speaker cabinet
120. 2 – p.c. boards with 2 amp full wave and 17 other recs
121. 4 – push push switches for table lamps etc.
122. 10 – mtrs twin screened flex white p.v.c. outer
123. 100 – staples for thin flex
124. 25 – clear plastic lenses 1½ diameter
127. 4 – pilot bulb lamp metal clip on type
128. 10 – very fine drills for pcbs etc.
129. 4 – extra thin screw drivers for instruments
132. 2 – plastic boxes with windows, ideal for interrupted beam switch
134. 10 – model aircraft motor – require no on/off switch, just spin to start
136. 2 – car radio speakers 5" round 4 ohm made for Radiomobile
137. 1 – 6½" 4 ohm 10 watt speaker and 3" tweeter
142. 10 – 4 BA spanners 1 end open, other end closed
145. 2 – 4 reed relay kits 3V coil normally open or c/o if magnets added
148. 20 – pilot bulbs 6.5V.3A Philips
147. 1 – secret switch kit with data
149. 4 – socket covers (protect inquisitive little fingers) for twin 13A
152. 1 – air or gas shut off valve – clockwork operated
153. 1 – air or gas shut off valve – thermostat operated
154. 1 – 12V drip proof relay – ideal for car jobs
155. 3 – varicap push button tuners with knobs
158. 5 – 12 way connector blocks 2A 250V
159. 3 – 12 way connector blocks 25A 250V
162. 1 – 13A fused and switched spur for surface mounting or can be removed from box for flush mounting
163. 3 – 13A sockets good British make but brown
169. 4 – short wave air spaced trimmers 2-30f
171. 1 – shocking coil kit with data – have fun with this
172. 10 – 12V 6W bulbs Philips m.e.s.
178. 3 – oblong amber indicators with lilliputs 12V
180. 6 – round amber indicators with neons 240V
181. 100 – p.v.c. grommets ⅜ hole size
182. 1 – short wave tuning condenser 50 pf with ¼" spindle
184. 1 – three gang tuning condenser each section 500 pf with trimmers and good length ¼" spindle
188. 1 – plastic box sloping metal front, 16 × 95mm average depth 45mm
   2 – double pole 20 amp 250V flush mounting switch – white
191. 6 – B.C. lamp holder adaptors white
193. 6 – 5 amp 3 pin flush sockets brown
195. 5 – B.C. lampholders brown bakelite threaded entry
196. 1 – in flex simmerstat for electric blanket soldering iron etc.
197. 2 – thermostats, spindle setting – adjustable range for ovens etc.
199. 1 – mains operated solenoid with plunger 1" travel
200. 1 – 10 digit switch pad for telephones etc.
201. 8 – computer keyboard switches with knobs, pcb or vero mounting
206. 20 – mtres 80 ohm, standard type co-ax off white
211. 1 – electric clock mains driven, always right time – not cased
216. 1 – stereo pre-amp Mullard EP9001
232. 2 – 12V solenoids, small with plunger
236. 1 – mains transformer 9V 1 amp secondary C core construction
238. 1 – car door speaker (very flat) 6½" 15 ohm made for Radiomobile
241. 2 – speakers 6" × 4" 4 ohm 5 watt made for Radiomobile
243. 2 – speakers 6" × 4" 16 ohm 5 watt made for Radiomobile
244. 1 – mains motor with gear-box very small, toothed output 1 rpm
245. 4 – standard size pots, ¼ meg with dp switch
249. 1 – 13A switched socket on double plate with fused spur for water heater
266. 2 – mains transformers 9V ⅓A secondary split primary so ok also for 115V
267. 1 – mains transformers 15V 1A secondary p.c.b. mounting
289. 50 3.5V torch bulbs
290. 3 7" reel to reel tape spools
291. 1 ten turns 3 watt pot ¼ spindle 100 ohm
292. 5 two plate brown bakelite ceiling roses
293. 50 silicon diodes mixed unmarked
294. 50 Germanium transistors mixed and unmarked
295. 10 round pointer knobs ¼ spindle
296. 3 car cigar lighter socket plugs
297. 1 cover for 24hr time switch ref BD45
298. 2 15 amp round pin plugs brown bakelite
300. 1 mains solenoid with plunger compact type
301. 10 ceramic magnets Mullard 1" × 3/8 × 5/16
303. 1 12 pole 3 way ceramic wave change switch
304. 1 stereo amp 1 watt per channel
305. 1 tubular dynamic microphone with desk rest
306. 1 module, speaker & battery to make musical card
307. 5 thermal fuses 15 amp woods metal
308. 1 T.V. turret tuner (black & white T.V.)
309. 12 adaptable legended knobs ¼" spindle
310. 2 oven thermostats
311. 1 Clare Elliot sealed relay 12V
312. 1 pressure pad switch 24 × 18 (Trigger Mat)
313. 5 sub miniature micro switches
314. 1 12" 8 watt min fluorescent tube white
315. 1 6" 4 watt min fluorescent tube white
316. 1 round pin kettle plug with moulded on lead

MULLARD UNILEX AMPLIFIERS

We are probably the only firm in the country with these now in stock. Although only four watts per channel, these give superb reproduction. We now offer the 4 Mullard modules – i.e. Mains power unit (EP9002) Pre amp module (EP9001) and two amplifier modules (EP9000) all for **£6.00** plus £2 postage. For prices of modules bought seperately see TWO POUNDERS.

CAR STARTER/CHARGER KIT

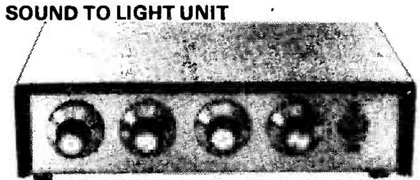
Flat Battery! Don't worry you will start your car in a few minutes with this unit – 250 watt transformer 20 amp rectifiers, case and all parts with data **£16.50** or without case **£15.00** post paid.

Ex-Electricity Board.
Guaranteed 12 months.

VENNER TIME SWITCH

Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only **£2.95** without case, metal case – **£2.95**, adaptor kit to convert this into a normal 24hr. time switch but with the added advantage of up to 12 on/offs per 24hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is **£2.30**.

SOUND TO LIGHT UNIT



Complete kit of parts of a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special price is **£14.95** in kit form.

12 volt MOTOR BY SMITHS

Made for use in cars, etc. these are very powerful and easily reversible. Size 3½" long by 3" dia. They have a good length of ¼" spindle –
1/10 hp **£3.45**
1/8 hp **£5.75**. 1/6 hp **£7.50**

25A ELECTRICAL PROGRAMMER

Learn in your sleep. Have radio playing and kettle boiling as you wake – switch on lights to ward off intruders – have a warm house to come home to. You can do all these and more. By a famous maker with 25 amp on/off switch. A beautiful unit at **£2.50**

THE AMSTRAD STEREO TUNER

This ready assembled unit is the ideal tuner for a music centre or an amplifier, it can also be quickly made into a personal stereo radio – easy to carry about and which will give you superb reception. Other uses are a "get you to sleep radio", you could even take it with you to use in the lounge when the rest of the family want to view programmes in which you are not interested. You can listen to some music instead.
Some of the features are: long wave band 115 – 170KHz, medium wave band 525 – 1650KHz, FM band 87 – 108 MHz, mono, stereo & AFC switchable, fully assembled and fully aligned. Full wiring up data showing you how to connect to amplifier or headphones and details of suitable FM aerial (note ferrite rod aerial is included for medium and long wave bands). All made up on very compact board.
Offered at a fraction of its cost only **£4.95**

GOODS ARE ON APPROVAL

these notes are often hastily written and technical information sheets are seldom available about the items we have to describe, also advertisements sometimes go to press without our having a chance to correct any mistakes, however, everything we sell is supplied on the understanding that if it is not suitable for your project you may return it within 7 days for credit. If there was a definite error of description in our copy then we will pay postage. If not, then you pay the postage. Note this offer applies to kits, but only if construction is **not started**.

FANS & BLOWERS

Woods extractors
5" **£5** + £1.25 post. 6" **£6** + £1.50 post
4" × 4" Muffin equipment cooling fan 115V **£2.00**
4" × 4" Muffin equipment cooling fan 230/240V **£5.95**
5" Plannair extractor **£5.50**
9" Extractor or blower 115V supplied with 230 to 115V adaptor **£9.50** + £2 post.
All above are ex computers but guaranteed 12 months.
10" × 3" Tangential Blower. New. Very quiet – supplied with 230 to 115V adaptor on use two in series to give long blow **£2.00** + £1.50 post or **£4.00** + £2.00 post for two.

IONISER KIT

Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder – a complete mains operated kit, case included.
£11.95 plus £2.00 post.

TELEPHONE BITS

Master socket (has surge arrestor – ringing condenser etc) and takes B.T. plug **£3.95**
Extension socket **£2.95**
Dual adaptors (2 from one socket) **£3.95**
Cord terminating with B.T. plug 3 metres **£2.95**
Kit for converting old entry terminal box to new B.T. master socket, complete with 4 core cable, cable clips and 2 BT extension sockets **£11.50**

MINI MONO AMP on p.c.b. size 4" × 2" (app.)

Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of **£1.15 each, or 13 for £12.00**

J & N BULL ELECTRICAL
128 PORTLAND ROAD, HOVE, BRIGHTON, SUSSEX BN3 5QL Dept ETI

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1 service charge. Monthly account orders accepted from schools and public companies. Access & B/Card orders accepted. Brighton 0273 734648. Bulk orders: write for quote.

OVER 400 GIFTS YOU CAN CHOOSE FROM

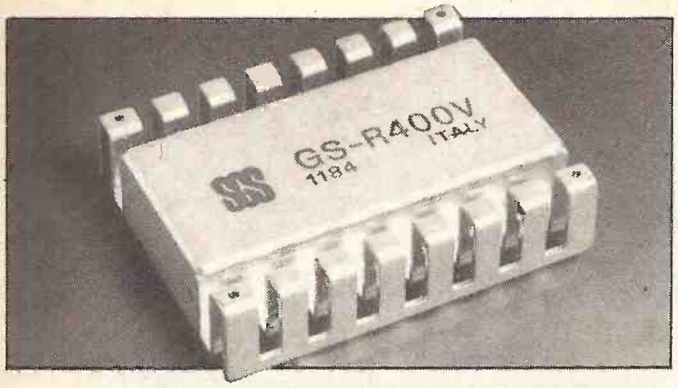
There is a total of over 400 packs in our Baker's dozen range and you become entitled to a free gift with each dozen pounds you spend on these packs. A classified list of these packs and our latest "News Letter" will be enclosed with your goods, and you will automatically receive our next news letters.

TWO POUNDERS*

2P2 – Wall mounting thermostat, high precision with mercury switch and thermometer
2P3 – Variable and reversible 8-12v psu for model control
2P4 – 24 volt psu with separate channels for stereo made for Mullard UNILEX
2P6 – 100W mains to 115V auto-transformer with voltage tappings
2P7 – Mini key, 16 button membrane keyboard, list price over £12
2P8 – Mains motor with gear box and variable speed selector. Series wound so suitable for further speed control
2P9 – Time and set switch. Boxed, glass fronted and with knobs. Controls up to 15 amps. Ideal to program electric heaters
2P10 – 12 volt 5 amp mains transformer – low volt winding on separate bobbin and easy to remove to convert to lower voltages for higher currents
2P11 – Power amp module Mullard Unilex EP9000 (note stereo pre-amp module Unilex 9001 is BD216
2P12 – Disk or Tape precision motor – has balanced rotor and is reversible 230v mains operated 1500 rpm
2P14 – Mug Stop kit – when thrown emits piercing squawk
2P15 – Interrupted Beam kit for burglar alarms, counters, etc.
2P17 – 2 rev pr minute mains driven motor with gear box, ideal to operate mirror ball
2P18 – Liquid/gas shut off valve mains solenoid operated
2P19 – Disco switch-motor drives 6 or more 10 amp change over micro switches supplied ready for mains operation
2P20 – 20 metres extension lead, 2 core – ideal most Black and Decker garden tools etc.
2P21 – 10 watt amplifier, Mullard module reference 1173
2P22 – Motor driven switch 20 secs on or off after push
2P24 – Clockwork operated 12 hour switch 15A 250V with clutch
2P26 – Counter resettable mains operated 3 digit
2P27 – Goodmans Speaker 6 inch round 8ohm 12 watt
2P28 – Drill Pump – always useful couples to any make portable drill
2P29 – 24 position Yaxley switch contacts rated 5A – ¼ spindle
2P31 – 4 metres 98 way interconnecting wire easy to strip
2P32 – Hot Wire amp meter – 4½ round surface mounting 0–10A – old but working and definitely a bit of history
2P34 – Solenoid Air Valve mains operated
2P35 – Battery charger kit comprising mains transformer, full wave rectifier and meter, suitable for charging 6v or 12v
2P38 – 200 R.P.M. Geared Mains Motor 1" stack quite powerful, definitely large enough to drive a rotating aerial or a tumbler for polishing stones etc.
2P42 – Tubular heater, 60 wetts per ft, unusued but slightly storage soiled, made by G.E.C. Perfect order (must be collected by appointment as 12ft long)
2P43 – Small type blower or extractor fan, motor inset so very compact, 230V
2P46 – Our famous drill control kit complete and with prepared case.
2P47 – Joy switch kit complete as previously sold.
2P48 – Telephone ringing unit reduces mains to 50 volts and changes frequency from 50 hz to 25 hz to give right ringing tone.
2P49 – Fire Alarm break glass switch in heavy cast case
2P51 – Stereo Headphone amplifier, with pre-amp
2P54 – 2½kw. blow heater section of coal or log effect fire, this is a sheet metal assembly which holds the elements, the motor with fan, and the lamp holders and bits which give the flickering flame effect. Collect or add £3 to cover p&p
2P55 - Mains motor. extra powerful has 1½" stack and good length of spindle
2P62 - 1 pair Goodmans 15 ohm speakers for Unilox
2P63 - 1 5Kv 20 mA mains transformer ex-equipment
2P64 - 1 five bladed fan 6½" with mains motor
2P65 - 2 resettable trips 4.5A mains
2P66 - 1 2Kw tangential heater 115v easily convertible for 230V
2P67 - 1 12v-0-12v 2 amp mains transformer
2P68 - 1 15v-0-15v 2 amp mains transformer
2P69 - 1 250v-0-250v 60 mA & 6.3v 5A mains transformer
2P70 - 1 E.M.I. tape motor two speed and reversible
2P71 - 1 PAPST 240v 5hz motor
2P72 - 1 115v Muffin fan 4" × 4" approx.
2P76 - 1 audax tweeter partner to 5P26 speaker
2P77 - 1 instrument box with key size 12" × 4½" wide 6" deep
2P82 - 9v-0-9v 2 amp mains transformer
2P83 - 25m .75 twin flat flex for mains appliances
2P84 - Modem board with press keys for telephone redialler
2P85 - 20v-0-20v ½A Mains transformer
2P88 - Sangamo 24 hr time switch 20 amp S.H.
2P89 - 120 min. time switch with knob.
2P90 - 90 min. time switch with edgewise engraved controller
2P91 - Panel meter size 2½" × 2" scaled power factor
2P92 - Bailey & Macky pressure switch 15 p.s.i.

£5 POUNDERS*

1. 12 volt submersible pump complete with a tap which when brought over the basin switches on the pump and when pushed back switches off, an ideal caravan unit.
2. Sound to light kit complete in case suitable for up to 750 watts.
3. Silent sentinel ultra sonic transmitter and receive kit, complete.
4. Dial indicator, measures accurately down to .01mm, "John Bull" or equally first-class make, a must for toolmaker or lathe worker.
5. 250 watt isolating transformer to make your service bench safe, has voltage adj. taps, also as it has a 115V tapping it can be used to safely operate American or other 115V equipment which is often only insulated to 115V. Please add £3 postage if you can't collect as this is a heavy item.
6. 12V alarm bell with heavy 6" gong, suitable for outside if protected from direct rainfall. Ex GPO but in perfect order and guaranteed.
7. Tape punch and matching tape reader, not new but believed in perfect working order if not so we would repair or replace within 12 months. Please add £2.50 postage.
8. Sensitive voltmeter relay, this consists of a 4½" dia moving coil meter with electronics (we will supply cct. dig.) over £120 each, they are new and still in maker's boxes.
9. Box of 25 fluorescent tubes 40 watt daylight or warm white ideal window pelmets, signs, etc. Please collect or add £2 postage.
10. Box of 25 18" fluorescent tubes assorted colours, please collect or add £2 postage.
11. 24 x 8 ft 85-120 watt warm white tubes. Ideal plant growing. Collect or send open cheque to cover carriage.
12. Equipment cooling fan – minin snail type mains operated.
13. Ping pong ball blower – or for any job that requires a powerful stream of air – ex computer. Collect or add £21 post.
14. Uniselector 360 degrees rotation, 5 poles, 50 ways, 50V coil.
15. Washing machine water pump, main motor driven so suitable for many applications.
16. Control panel case, conventional design with hinged front and finished metallic silver, easily arranged as lockable size approx. 15" x 10" x 5½", wall mounting.
17. Two kits: matchbox size surveillance transmitter and 2 FM receivers.



Self-Contained Switching Regulator

New from SGS is a series of Switch-mode voltage regulators which require no external components.

The GS-R400 series devices are available with outputs of 5.1V, 12V, 15V and 24V and there is also a variable output version offering between 5.1 and 40V. A special version of the 5.1V regulator includes a voltage-checking facility and produces an output signal when the voltage is correct. All models feature output current limiting at 4A and have a minimum voltage over-head of 3V.

The regulators use a switching frequency of 100kHz and efficiencies range from 75% for the 5V version to 90% for the 24V model. The ripple level is typically 0.25%. The metal package provides screening and also allows the regulators to be used without further heatsinking in many cases.

Further information is available from Unitel Ltd, Unitel House, Fishers Green Road, Sevenage, H rtfordshire SG1 2PT, tel 0438-314 393.

ETI PCB Service

With fingers firmly crossed (doesn't half make typing difficult) we are re-introducing the PCB Service as from this issue. A new pricing structure has been agreed and new PCB Service pages prepared (see pages 58 and 59). All orders placed from now on should use the new order form and prices; those given in previous advertisements no longer apply.

We are now in a position to run the service normally with the usual allowance of up to 28 days for orders to be fulfilled. Most customers who placed orders more than 28 days ago should by now have received either the board(s) ordered or a refund (last month's statement that ALL orders had been fulfilled was, unfortunately, incorrect: a small number of boards are still unavailable because of technical problems). Anyone who has waited 28 days and not heard from us should contact our Readers' Services department at Hemel Hempstead (tel 0442-41221).

Some boards previously advertised in the PCB Service have been temporarily withdrawn while problems with foils, etc, are sorted out. These boards will be returned to the service as soon as possible.

● *Oxfam receive a large quantity of electrical and electronic items for sale in their 750+ shops nationwide, but say they are often unable to use donated goods because of a shortage of qualified and experienced volunteers to carry out checks and simple repairs. If you would be prepared to give up some time to help in this way or would like to know more about other voluntary work with the charity, contact Faye Wark at Oxfam, Freepost, London N12 9BR tel 01-446 6888.*

● Unfortunately, ETI contributor Barry Porter was unable to take part in the British Heart Foundation's London to Brighton cycle ride because of illness (see News Digest last month). However, we gather that the ride itself was a great success, although it is not known at the time of going to press just how much money was raised for heart research. Barry is now well on the way to recovery (that is, if the state of his sense of humour is anything to go by) and we wish him better luck next year.

NEXT MONTH

AN ARGUS SPECIALIST PUBLICATION
electronics today INTERNATIONAL

WHEN WE SAY 'SEPTEMBER ETI!' FREEZE . . .

Low Cost Framestore

A little over a year ago, we produced a do-it-yourself design for a video framestore or framegrabber with some advanced features. Despite some very expensive hardware, a resolution of 640 x 512 pixels and the corresponding large amounts of RAM, the framestore was a very popular project. Now the designer has come up with a low-cost version offering 256 x 256 pixel resolution, storage of two complete images and the ability to perform a comprehensive range of logical operations on the images. And all at a price within almost everyone's reach.

Battery Power — The Charge Of The Light Brigade

Perhaps some of the most exciting developments in electronics involve new forms and uses of battery power. We provide a round-up from alkaline to zinc-carbon and from lithium to lead-acid, taking in solar cells along the way. Power to the people . . .

Plus:

Clean up your mains with our mains filter, find out whether transistors really sound different to valves, get close to your proximity detector and check out the circuit for a single-board controller which emulates a BBC micro.

THE SEPTEMBER ISSUE ETI — ON SALE 1st AUGUST

All the articles listed above are at an advanced stage of preparation, but circumstances beyond our control may prevent their publication.

DIARY

Radio Receivers And Associated Systems — July 1-4th
University College of North Wales, Bangor. For details see July '86 ETI or contact the IERE at the address below.

Voice Processing — July 2/3rd
Wembley Conference Centre, London. Conference. For details contact Online at the address below.

The History of Physics For the Physicist — July 2-4th
Oxford. Summer school which aims to bring together physicists, physics teachers and others to explore ways in which knowledge of the history of physics can be used in the development of the subject itself. Contact Dr. J.J. Roche, Linacre College, Oxford OX1 3JA.

Cable '86 — July 8-10th
Metropole Hotel, Brighton. Conference and exhibition. For details contact Online at the address below.

Satellite Communications Systems — July 20-25th
University of Surrey. Vacation school organised by the IEE. For details, contact them at the address below.

Fourth Official Acorn User Show — July 24-27th
Barbican Centre, London. Exhibition of software, services and peripherals for the BBC micro, the Electron and the new Master series machines. Tickets cost £3.00 for adults, £2.00 for children, £1.00 less if purchased in advance. Contact Editionscheme Ltd, HR House 447 High Road, Finchely, London N12 0AF, tel 01-349 4667.

Optical Fibre Telecommunications — August 31st-September 5th
University College of North Wales, Bangor. Vacation school organised by the IEE. For details contact them at the address below.

Electrical Measurements, DC to VHF — September 7-12th
Imperial College of Science and Technology, London. Vacation school organised by the IEE. For details contact them at the address below.

Radio Amateurs' Examination Course — September 8-10th
Paddington College, London. Twice-weekly evening class which prepares students for the City & Guilds Radio Amateurs' examination in May 1987. Course includes practical as well as theoretical skills and assumes no previous knowledge of electronics. Enrolment takes place between 1.00 to 4.00 pm and 6.00 to 8.00 pm on the dates shown at the college, 25 Paddington Green, London W2 1NB, tel 01-402 6221.

Commodore Horizons Show — September 13/14th
UMIST, Manchester. For details contact Database Exhibitions at the address below.

Software Engineering for Microprocessor Systems — September 21-26th
City University, London. Vacation school organised by the IEE. For details contact them at the address below.

Electron & BBC Micro User Show — September 26-28th
UMIST, Manchester. For details contact Database Exhibitions at the address below.

Electromagnetic Compatibility — September 30th-October 3rd
University of York. Conference with supporting exhibition devoted to electromagnetic compatibility (EMC) between systems at all levels from board components through to antenna systems. Topics covered will include measurements, suppression, safety, etc, and the first day's tutorials have been designed with the newcomer to EMC in mind. For details contact the IERE at the address below.

Addresses

Database Exhibitions, Europa House, 68 Chester Road, Hazel Grove, Stockport SK7 5NY, tel 061-456 8835.

Institution of Electrical Engineers, Savoy Place, London WC2 0BL, tel 01-240 1871.

Institution of Electronic and Radio Engineers, 99 Gower Street, London WC1E 6AZ, tel 01-388 3071.

Online Conference Ltd, Pinner Green House, Ash Hill Drive, Pinner, Middlesex HA5 2AE, tel 01-868 4466.

ETI

74 SERIES

7400	30p
7401	30p
7402	30p
7403	30p
7404	36p
7405	30p
7406	40p
7407	40p
7408	30p
7409	30p
7410	30p
7411	30p
7412	30p
7413	50p
7414	70p
7416	36p
7417	40p
7420	30p
7421	60p
7422	36p
7423	36p
7425	40p
7426	40p
7427	40p
7428	43p
7430	30p
7432	36p
7433	30p
7437	30p
7438	40p
7439	40p
7440	40p
7441	90p
7442A	70p
7443A	100p
7444	110p
7445	100p
7446A	100p
7447A	100p
7448	120p
7450	38p
7451	35p
7453	38p
7454	38p
7460	55p
7470	50p
7472	55p
7473	55p
7474	50p
7475	60p
7476	45p
7480	65p
7481	180p
7483A	105p
7484A	125p
7485	110p
7486	42p
7489	210p
7490A	55p
7491	70p
7492A	70p
7493A	55p
7494	110p
7495A	60p
7496	80p
7497	210p
74100	190p
74107	50p
74109	75p
74110	75p
74111	55p
74116	170p
74118	110p
74119	170p
74120	100p
74121	55p
74122	70p
74123	80p
74125	65p
74126	55p
74128	55p
74132	75p
74136	70p
74141	90p
74142	250p
74143	270p
74144	270p
74145	110p
74147	170p
74148	140p
74150	175p
74151A	70p
74153	80p
74154	140p
74155	80p
74156	100p
74157	80p
74159	175p
74160	110p
74161	80p
74162	110p
74163	110p
74164	120p
74165	110p
74166	140p
74167	400p
74170	200p
74172	420p
74173	140p
74174	110p
74175	105p
74176	100p
74178	150p
74179	150p
74180	100p
74181	340p
74182	140p
74184	180p
74185A	180p
74190	130p
74191	130p
74192	110p
74193	115p
74194	110p
74195	80p
74196	130p
74197	110p
74198	220p
74199	220p
74221	110p
74251	100p
74259	150p
74265	380p
74273	200p
74276	140p
74278	170p
74279	90p
74283	105p
74285	320p
74290	90p
74293	90p
74298	180p
74351	200p
74365A	80p
74366A	80p
7436A	80p
74367A	80p
74368A	70p
74376	160p
74390	110p
74393	112p
74490	140p

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74LS01	24p
74LS02	24p
74LS03	24p
74LS04	24p
74LS05	24p
74LS08	24p
74LS09	24p
74LS10	24p
74LS11	24p
74LS12	24p
74LS13	34p
74LS14	50p
74LS15	24p
74LS20	24p
74LS21	24p
74LS22	24p
74LS24	50p
74LS26	24p
74LS27	24p
74LS28	24p
74LS30	24p
74LS32	24p
74LS33	24p
74LS37	24p
74LS38	24p
74LS40	24p
74LS42	50p
74LS43	150p
74LS47	80p
74LS48	90p
74LS49	100p
74LS51	24p
74LS54	24p
74LS55	24p
74LS73A	30p
74LS74A	35p
74LS75	45p
74LS76A	36p
74LS83A	70p
74LS85	75p
74LS86	35p
74LS90	48p
74LS91	90p
74LS92	55p
74LS93	54p
74LS95B	75p
74LS96	90p
74LS107	40p
74LS109	40p
74LS112	45p
74LS113	45p
74LS114	45p
74LS122	70p
74LS123	80p
74LS124/	629/140p
74LS125	50p
74LS126	50p
74LS132	65p
74LS133	50p
74LS136	45p
74LS138	55p
74LS139	55p
74LS145	95p
74LS147	175p
74LS148	140p
74LS151	65p
74LS152	200p
74LS153	65p
74LS154	160p
74LS155	65p
74LS156	65p
74LS157	50p
74LS158	65p
74LS160A	75p
74LS161A	75p
74LS162A	75p
74LS163A	75p
74LS164	75p
74LS165A	110p
74LS166A	150p
74LS168	130p
74LS169	100p
74LS170	140p
74LS173A	100p
74LS174	70p
74LS175	75p
74LS181	200p
74LS183	190p
74LS190	75p
74LS191	75p
74LS192	80p
74LS193	80p
74LS194A	75p
74LS195A	75p
74LS196	80p
74LS197	80p
74LS221	80p
74LS240	80p
74LS241	80p
74LS242	90p
74LS243	90p
74LS244	90p
74LS245	110p
74LS247	110p
74LS248	110p
74LS249	110p
74LS251	75p
74LS253	75p
74LS256	90p
74LS257A	70p
74LS258A	70p
74LS259	120p
74LS260	75p
74LS261	120p
74LS266	60p
74LS273	125p
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74LS283	80p
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74LS292	900p
74LS293	80p
74LS295	140p
74LS297	£9
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74LS299	220p
74LS321	370p
74LS323	300p
74LS324	320p
74LS348	200p
74LS352	120p
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74LS356	210p
74LS363	180p
74LS364	180p
74LS365	50p
74LS366	50p
74LS367	50p
74LS368A	50p
74LS373	90p
74LS374	90p
74LS375	75p
74LS377	130p
74LS378	95p
74LS379	130p
74LS381	450p
74LS385	325p
74LS390	60p
74LS393	100p
74LS395A	100p
74LS399	140p
74LS445	180p
74LS465	120p
74LS467	120p
74LS490	150p
74LS540	100p
74LS541	100p
74LS608	700p
74LS610	1900p
74LS612	1900p
74LS624	350p
74LS626	225p
74LS628	225p
74LS629	125p
74LS640	200p
74LS640-1	
	300p
74LS641	150p
74LS642-1	
	300p
74LS643	250p
74LS643-1	
74LS644	350p
74LS645	200p
74LS645-1	
	400p
74LS668	90p
74LS669	90p
74LS670	170p
74LS682	250p
74LS684	350p
74LS687	350p
74LS688	350p
74LS783	£21

74S SERIES

74S00	50p
74S02	50p
74S04	50p
74S05	50p
74S08	50p
74S10	50p
74S11	75p
74S20	50p
74S22	50p
74S30	50p
74S32	60p
74S37	60p
74S38	60p
74S40	50p
74S51	45p
74S64	45p
74S74	70p
74S85	300p
74S86	100p
74S112	150p
74S113	120p
74S114	120p
74S124	300p
74S132	100p
74S133	60p
74S138	180p
74S138	180p
74S139	180p
74S140	100p
74S151	150p
74S153	150p
74S157	200p
74S158	200p
74S163	300p
74S169	550p
74S174	300p
74S175	320p
74S188	180p
74S189	180p
74S194	300p
74S195	300p
74S196	350p
74S200	450p
74S201	320p
74S225	520p
74S240	400p
74S241	400p
74S244	500p
74S251	250p
74S257	250p
74S258	250p
74S260	100p
74S261	300p
74S283	270p
74S287	200p
74S288	200p
74S289	225p
74S299	550p
74S373	400p
74S374	400p
74S387	225p

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4001	24p
4002	25p
4006	70p
4007	25p
4008	60p
4009	45p
4010	60p
4011	24p
4012	25p
4013	36p
4014	60p
4015	70p
4016	36p
4017	55p
4018	60p
4019	60p
4020	80p
4021	60p
4022	70p
4023	30p
4024	48p
4025	24p
4026	90p
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4030	35p
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4048	55p
4049	36p
4050	35p
4051	65p
4052	60p
4053	60p
4504	80p
4055	80p
4056	85p
4059	400p
4060	70p
4063	85p
4066	40p
4067	230p
4068	25p
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4070	24p
4071	24p
4072	24p
4073	24p
4075	24p
4076	65p
4077	25p
4078	25p
4081	24p
4082	25p
4085	60p
4086	75p
4089	120p
4093	35p
4094	90p
4095	90p
4096	90p
4097	270p
4098	75p
4099	90p
4501	36p
4502	55p
4503	36p
4504	95p
4505	360p
4506	90p
4507/4030	
	35p
4508	120p
4510	55p
4511	55p
4512	55p
4513	150p
4514	110p
4515	110p
4516	55p
4517	220p
4518	48p
4519	32p
4520	60p
4521	115p
4522	80p
4526	70p
4527	80p
4528	65p
4529	100p
4531	75p
4532	65p
4534	380p
4536	250p
4538	75p
4539	75p
4541	90p
4543	70p
4551	100p
4553	240p
4555	36p
4556	50p
4557	240p
4560	140p
4566	140p
4568	240p
4569	170p
4572	45p
4583	90p
4584	48p
4585	60p
4724	150p
14411	750p
14412	750p
14416	300p
14419	260p
14490	420p
14495	450p
14500	650p
14599	200p
22100	350p
22101	700p
22102	700p
40014/4584	
40106	
	48p
40085	120p
40097	36p
40098	40p
40100	150p
40101	125p
40102	130p
40103	200p
40104	120p
40105	150p
40106	48p
40107	55p
40108	320p
40109	20p
40110	225p
40114	225p
40147	280p
40163	100p
40173/4067	
	120p
40174	100p
40175	100p
40192	100p
40244	150p
40245	150p
40257	180p
40373	180p
40374	180p
80C95	75p
80C97	75p
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ADC0808	1190p	LM394CH	400p	TBA800	80p
AM7910DC	£25	LM709	35p	TBA810	90p
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AY-1-5050	100p	LM711	100p	TBA820M	75p
AY-3-1350	450p	LM723	80p	TBA920	200p
AY-3-8910	450p	LM725CN	400p	TBA950	225p
AY-3-8912	500p	LM733	65p	TC9109	500p
CA3019A	100p	LM741	22p	TCA940	175p
CA3028A	110p	LM747	70p	TDA1010	225p
CA3046	70p	LM748	30p	TDA1022	400p
CA3059	325p	LM1011	480p	TDA1024	110p
CA3080	50p	LM1014	150p	TDA1170S	300p
CA3080E	70p	LM1801	300p	TDA2002	325p
CA3086	60p	LM1830	250p	TDA2003	190p
CA3089E	210p	LM1871	300p	TDA2004	240p
CA3090AQ	375p	LM1872	300p	TDA2006	320p
CA3130E	90p	LM1886	550p	TDA2020	320p
CA3130T	130p	LM1889	450p	TDA2030	250p
CA3140E	45p	LM2917	300p	TDA2593	500p
CA3140T	100p	LM3302	90p	TDA3810	750p
CA3160E	90p	LM3900	80p	TDA7000	350p
CA3161E	200p	LM3909	100p	TEA1002	700p
CA3162E	600p	LM3911	180p	TL061CP	40p
CA3189E	270p	LM3914	350p	TL062	60p
CA3240E	150p	LM3915	340p	TL064	90p
CA3280G	270p	LM3916	340p	TL071	40p
D7002	£6	LM13600	150p	TL072	70p
DAC1408-8	300p	M51513L	230p	TL074	110p
DAC0800	300p	M51516L	450p	TL081	35p
DAC0808	300p	MB3712	200p	TL082	55p
DG308	300p	MC1310P	150p	TL083	75p
HA1366	190p	MC1413	75p	TL084	100p
ICL7106	675p	MC1458	45p	TL094	200p
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ICL7650	400p	MC1496	70p	UA759	330p
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ICL8038	400p	MC3401	70p	UAA170	170p
ICM7216B	£22	MC3403	65p	UCN4801A	550p
ICM7217	750p	MF10CN	400p	ULN2003A	75p
ICM7555	80p	MK50240	900p	ULN2004A	75p
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LC7120	300p	ML920	500p	ULN2802	190p
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LF347	120p	NE531	120p	UPC575	275p
LF351	60p	NE544	190p	UPC592H	200p
LF353	90p	NE555	22p	UPC1156H	300p
LF355	90p	NE556	60p	UPC1185H	500p
LF356N	110p	NE564	400p	XR210	400p
LF357	100p	NE565	120p	XR2206	400p
LM10C	450p	NE566	150p	XR2207	375p
LM301A	30p	NE567	125p	XR2211	575p
LM307	45p	NE570	400p	XR2216	675p
LM308CN	75p	NE571	300p	XR2240	120p
LM310	225p	NE592	90p	ZN409	190p
LM311	80p	NE5532P	150p	ZN414	80p
LM318	150p	NE5533P	180p	ZN419P	175p
LM319	180p	NE55334P	120p	ZN423E	130p
LM324	45p	NE5534AP	150p	ZN424E	130p
LM334Z	115p	OP-07EP	500p	ZN425E8	350p
LM335Z	130p	PLL02A	500p	ZN426E	300p
LM336	180p	RC4136	55p	ZN427E	600p
LM339	40p	RC4151	200p	ZN428E	450p
LM348	60p	RC4558	55p	ZN429E8	225p
LM358P	50p	S566B	220p	ZN447E	£9.50p
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		TA7310	150p		

VOLTAGE REGULATORS

FIXED PLASTIC

		+ve		+ve	
1A					
5V		7805	45p	7905	50p
6V		7806	50p	7906	50p
18V		7808	50p	7908	50p
12V		7812	45p	7912	50p
15V		7815	50p	7915	50p
18V		7818	50p	7918	50p
24V		7824	50p	7924	50p
5V	100mA	78L05	30p	79L05	45p
8V	100mA	78L08	30p		
12V	100mA	78L12	30p	79L12	50p
15V	100mA	78L15	30p	79L15	50p

OTHER REGULATORS

Fixed Regulators		
LM309K	1A 5V	140p
LM323K	3A 5V	250p
78H05KC	5A 5V	575p
78H12	5A 12V	750p
Variable Regulators		
LM305AH		250p
LM317T	TO-220	150p
LM317K	TO3	240p
LM337T	3A+VAR	225p
LM350T	5A+VAR	400p
LM396K	10A+VAR	£15
LM723N		50p
78HGKC	5A+VAR	650
79HGKC	5A+VAR	675p
78GUIC	1A+VAR	225p
79GUIC	1A+VAR	250p
Switching Regulators		
ICL7660		250p
SG3524		300p
TL494		300p
TL497		300p
78S40		250p

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CPU

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2650A	1050p
6502	400p
6502A	450p
65C02A	£15
6800	250p
6802	300p
6809	650p
6809E	£8
68B09	£10
68B09E	£12
68000-LB	£36
8035	350p
8039	420p
80C39	700p
8080A	420p
8085A	300p
80C85A	900p
8086	£22
8088	1750p
8741	£12
8748	£16
TMS9980	£14.50
TMS9995	£12
Z80	250p
Z80A	290p
Z80B	550p
Z80CMOS	750p
(CMOS Z80)	

8279	£11
8282	300p
8284	480p
8287	380p
8288D	950p
8755A	£16
TMS9901	£14
TMS9901	500p
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TMS9911	£18
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Z80PIO	240p
Z80APIO	250p
Z80BPIO	500p
Z80CTC	250p
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Z80DART	650p
Z80ADART	700p
TMS4500	£14
TMS9901	600p
TMS9902	500p
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Z80ADMA	750p
Z80ASIO-0/1/2	
/9	700p
Z80BP10	500p
Z80BCTC	500p
Z80DART	900p
Electrically programmable and erasable PROMS	
2816-30	£15
9306	450p

SUPPORT DEVICES

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3242	800p
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6522A	550p
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8156	380p
8205	225p
8212	200p
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8224	300p
8226	425p
8228	550p
8243	260p
8250	950p
8251A	325p
8253C-5	350p
8255AC-5	
	320p
8256	£18
8257C-5	400p
8259C-5	400p
8275	£29

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2532	450p
2532-30	550p
2564	£11
2708	400p
2716+5v	350p
2716-35	550p
2732	450p
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2732A-35	£7
2764-25	200p
27C64-25	£10
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CRT5037	£12
CRT6545	£9
EF9364	£8
EF9365	£25
EF9366	£25
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MC6845SP	
	650p
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TMS9918	£15
TMS9928	£10
TMS9929	£10

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AD561J	£20

AD7581	£15
ADC0808	1190p
AM25S10	350p
AM25LS2521	
	350p
AM25LS2538	
	350p
AM26LS31	
	120p
AM26LS32	
	120p
D7002	£6
DAC80-CB1-V	
	£28
DM8131	600p
DP8304	350p
DS3691	350p
DS8830	140p
DS8831	150p
DS8832	150p
DS8833	225p
DS8835	280p
DS8836	150p
DS8838	225p
MC1488	60p
MC1489	60p
MC3446	250p
MC3459	450p
MC3470	475p
MC3480	850p
MC3418L	990p
MC3486	250p
MC3487	250p
MC4024	550p
MC4044	550p
MC14411	950p
MC14412	750p
ULN2003	75p
ULN2004A	
	75p
ULN2068	290p
ULN2802	190p
ULN2803	180p
ULN2804	190p
75107	90p
75108	90p
75109	120p
75110	90p
75112	160p
75113	120p
75114	140p
75115	140p
75121	140p
75122	140p
75150P	120p
75154	120p
75159	220p
75160	500p
75161	350p
75162	400p
75172	300p
75182	90p
75188	60p
75189	60p
75365	150p
75450	50p
75451	50p
75452	50p
75453	70p
75454	70p
75480	150p
75491	65p
75492	65p
8T26	120p
8T28	120p
8T95	120p
8T96	120p
8T97	120p
8T98	120p

81LS95	140p
81LS96	140p
81LS97	140p
81LS98	140p
88LS120	300p
9602	300p
9636A	160p
9637AP	160p
9638	190p
ZN425E8	350p
ZN426E8	350p
ZN427E	600p
ZN428E8	450p
ZN429E	210p
ZN447E	900p

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2102	250p
2107B	500p
2111A-35	400p
2114-3L	250p
2147	400p
4116-15	200p
4416-15	300p
4532-20	250p
4816AP-3	300p
5101	370p
5514	450p
5516	550p
6116P-3	350p
6116LP-3	400p
6264-15	700p
6264LP-15	340p
6810	260p
74S189	225p
74S201	350p
74S289	225p
93415	600p
93L422	950p
93425	600p

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28L22	400p
24S10	250p
18S030	200p
18SA030	200p
74S188	180p
74S287	225p
74S288	180p
74S387	225p
82S23	150p
82S123	150p

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6843	£8
8271	£48
8272	£12
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ACCESS

READ/WRITE

Dear ETI,

A colleague has recently shown me a copy of your June issue, with R.A. Penfold's MIDI to CV converter project in it. Potential constructors be warned! His design contains serious deficiencies and will not work with all MIDI equipment.

1) Its inability to receive on channel 1 is a limitation because this is the most commonly used channel. For example, a synthesiser with built-in sequencer may transmit keyboard 'note on/off' events on channel 1 (code 0) and sequencer events on channel 2 (code 1), without any ability to change these channel numbers. In a case like this the only way to receive keyboard data is to put the converter in OMNI mode, which will mean that it has no choice but to receive sequencer data as well whether you want it to or not.

2) The gate output is simply toggled, rather than being turned on by 'note on' codes and turned off by 'note off' codes. This means that it will only work properly if the incoming codes follow a strictly alternating on/off sequence. They often won't. If the player hits a key before releasing the previous one, a second 'note on' will be produced for that key before the 'note off' for the previous one occurs. This 'note on' would be interpreted as a 'note off', and if the 'note off' for the first key pressed were then produced it would be interpreted as a 'note on'.

3) Some equipment does not re-issue the status byte (9n for 'note on' or 8n for 'note off') if it is the same as the status byte for the previous event. This technique is being increasingly used, too. Its advantage is speed — even though at 31.25kHz the MIDI baud rate is high compared with RS232, it is only barely adequate for the kind of timing accuracy required of it. The circuit described would ignore successive event data without preceding status bytes.

4) There are two ways MIDI transmits 'note off' codes — either by a 'note off' command, or by a 'note on' with a key velocity of zero. Since, however, the design does not even decode the incoming status codes at all, I suppose the fact that it does not take this into account is only a minor quibble!

5) The design assumes that the only status bytes received will be 'note on' and 'note off' codes. This is a very dangerous assumption. MIDI handles considerably more than just this information, and some means of detecting and ignoring other status codes should have been provided.

6) The MIDI THRU socket is simply connected in parallel with the MIDI IN. This is dodgy — and certainly not correct. The 5mA current loop contains a total of three 200R series resistors — two in the transmitter and one in the receiver. If more than one receiver is connected to a single transmitter, the loop current is shared between a number of receivers and is therefore reduced in each receiver, which could cause data errors. Done properly, the MIDI THRU should be driven by a buffer connected to the optoisolator output. The MIDI THRU also has no ground connection to pin 2, which means that the MIDI THRU lead will be unscreened.

MIDI is a horrible cross between a de jure and a de facto standard, for example the specifications published by Yamaha and SCI differ. Before releasing any MIDI design it should be tested with as wide a variety of commercial equipment from as many manufacturers as possible before accepting it. In this case I suspect that neither Penfold nor yourselves can have done so.

Yours sincerely,
Alan Robinson,
London N11.

We have contacted R.A. Penfold about this letter. He accepts most of the criticisms made, but points out that none of these apparent deficiencies are likely to cause problems if the converter is used as intended.

As was pointed out in the original article, the circuit was designed to enable MIDI-equipped instruments or computers to control older monophonic synthesisers fitted with GATE/CV inputs. Only 'note on' and 'note off' information will be of relevance to a monophonic machine and such information should be purely sequential - if two notes are pressed at once it can only be because of sloppy playing! The inability to receive on channel one may prove a limitation in some cases, but on most MIDI equipment the channel functions can be defined as required. The points regarding the THRU socket and the re-issuing of status bytes are taken, but neither of these has caused any problems in use. More sophisticated decoding could be added if required, but the original aim was to provide only what was absolutely necessary in order to keep costs to a minimum. The prototype converter has been used for some time now to enable a polyphonic SCI synthesiser to control an older, monophonic SCI synth, and it has also been used with a Yamaha DX7 as the controlling synthesiser. In neither case have any problems arisen.

An Auntie Matter

Dear Sir,

Thank you for your reply to my letter about temperature compensating resistors (Auntie Static, ETI June '86). The principles you explained have proved very useful to me. Now all I've got to do is find someone who supplies copper wire wound resistors with a temperature coefficient of 3900 PPM!

Yours sincerely,
A.J. Dolan,
Ilford,
Essex.

Driven to Write . . .

Dear Sir,

Two months ago, I sent a cheque for just under £100 to Watford Electroncis for a Mitsubishi Disk drive. I was informed by the bank that the cheque was cashed after about two weeks.

Five weeks after having sent my cheque I rang Watford to ask where the disk drive was, and was told by a very grumpy member of staff that "Mitsubishi put their prices up, so all the cheques are being refunded".

I understand that today's

AUNTIE STATIC'S PROBLEM CORNER

Dear Auntie,

I keep coming across the expression 'common mode' But I'm not sure I know what it means. Will you please explain?

D. Garfield
Surbiton,
Surrey.

The term 'common mode' is most easily explained by reference to a particular circuit (Fig.1). This represents an amplifier with a gain of two which amplifies the difference in voltage between $v_{in}(+)$ and $v_{in}(-)$. The output of the amplifier will be $2(v_{in}(+) - v_{in}(-))$, so any change in the voltage difference between the two input terminals will be amplified, whereas any input which causes both to rise or fall by the same voltage will not change the output, since the difference in input voltages will remain constant.

A change in the voltage of one input terminal with respect to the other is known as a 'differential mode' input; an equal change in both input terminals is a 'common mode' signal. any arbitrary input can be thought of as a combination of common mode and differential mode signals. For example, if $v_{in}(+)$ rises by 3V and $v_{in}(-)$ by 5V, this is a differential mode input of - 2V about a mean change of 4V (from (3V+ 5V/2). This average is the common mode. In a perfect circuit, the differential mode component would be amplified by a factor of 2, the common mode component would be ignored, and the result would be a change in output voltage of -4V.

In a practical differential amplifier, there will always be a certain amount of amplication of common mode signals. With the circuit of Fig.1, the most significant cause of this would be resistor tolerances - the ratios R2/R1 and R4/R3 must be exactly equal for proper operation. Often, it is a matter of concern that common mode signal amplification should be kept to an absolute minimum.

Induced noise voltages on balanced lines appear as substantially common mode inputs at the amplfier. A circuit with very small common mode gain, or,

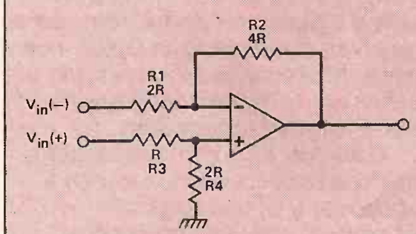


Fig. 1 A differential amplifier.

to put it another way, good common mode rejection, will greatly attenuate noise voltages. This is one good reason why balanced lines are often used in preference to single-ended ones for low-level signals. In instrumentation circuits, transducers are often incorporated in a bridge arrangement; common mode signals can arise from drifts in supply voltage, temperature change in transducer characteristics, and so on. It is essential that these spurious outputs are rejected by the measuring apparatus.

Common mode rejection ratio (CMRR) is often used as a figure of merit in the specifications of instrumentation amplifiers. The CMRR is simply the ratio of the differential mode gain to the common mode gain (A_{dm}/A_{cm}), often seen expressed in dB as $20 \log_{10}(A_{dm}/A_{cm})$. A well designed differential amplifier will have a common mode rejection of around 10^4 to 10^5 (80dB to 100dB).

In a slightly different context, you may see common mode and differential mode inputs mentioned in op-amp and comparator data sheets. In this case, the figures given usually refer to electrical limits on the IC's operation. For instance, the LF400C op-amp has an absolute maximum differential input voltage range of ±40V. This is the maximum voltage that can appear between the input terminals without causing damage to the IC. (There is also the additional constraint that neither input must go below the negative supply voltage).

The input common mode voltage range is given as ± 11V minimum for a supply voltage of ± 15V. This means that the LF400C will function according to its specifications with a common mode voltage on the inputs anywhere within this range. In normal operation, unless the op-amp is being used in comparator or switching applications, both inputs can be considered to be at the same voltage for practical purposes, and the common mode voltage will be equal to this.

Auntie.

---

business policies mean selling the goods before you actually own them (Sinclair was the pioneer of that), but it appears that some of the older companies are starting to follow this trend as well, protecting themselves but not the customers with "prices subject to change without notice". I understand all this, but why didn't they have the decency to at least write or ring to tell me what was happening.

Now, two months after sending my cheque off, I still haven't seen a single sign of my money, or an apology. I rang up Watford to talk to the complaints department, and ran out of money on the phone trying to find out what had happened to my money. The staff at the other end helped me to waste a phone call, and refused to phone back because they said they have no outgoing lines!

The purpose of this letter is to warn anyone out there who is thinking of trading with Watford Electronics that here at least is one person who will never even think of buying from Watford again.

Yours faithfully,
A.F. Stratton,
Zeals,
Warminster,
Wiltshire.

We have received several complaints from readers regarding the disc drive special offer we ran in conjunction with Watford Electronics in our January and March 1986 issues.

We have followed up individual complaints with Watford and as far as we know all those who placed orders should by now have received either a disc drive or a refund. If anyone is still having problems, we suggest they get in touch with us immediately. We have also had some complaints from people who received their disc drives but found the free utility disc was missing. In this situation we suggest you write directly to Watford. — Ed.

Beyond the DES

Dear Sir,

For some time before your magazine wrote the first article on data encryption (September 1985) I had been working on the design of an 'Electronic One-time Pad' IC. At the moment I am about to assemble the circuit board which contains around 40 standard logic ICs, which will do the job of the final chip.

The final system will plug into

any eight or 16-bit computer and will work like a standard memory device. An eight - byte key is entered into eight locations and the data to be encrypted is written into another eight. The encrypted data is read out immediately after the final write operation. To decrypt, the encrypted data is written into the system and the decrypted data is read out. The system will contain two ICs: the data encryption chip and an EPROM programmed to drive the encryption chip in the most suitable way for the computer it is used with. The key is changed automatically between each encryption operation and can be read out at any time, but knowing the current key would not help anyone to break the system.

My system has similarities to the DES, but the security of the DES system has been brought into question, as anyone who saw the 'Horizon' TV program on the subject will know. The NSA have deliberately weakened it to allow them to intercept messages. My system has not been interfered with in this way.

I am hoping to find a company who will help me to develop my circuit into a single IC and provide some financial assistance. Will you please print my complete address so that anybody who is seriously interested can contact me?

Yours sincerely,
P.R. Moyes,
62, Lingway Gardens,
Leicester,
Leicestershire
LE3 0LU.

Sale Of Effects?

Dear ETI,

At a recent jumble sale I bought an LED light effect unit called a Starburst and a ham radio receiver, an Eddystone 990R. There were, however, no instructions or other written information with either of my bargain buys.

Can you or any of your public-spirited readers help out with a photocopy of the original 'Starburst' article from Hobby Electronics, September 1979, and any information whatsoever on the Eddystone unit, especially operating manuals, circuit diagrams, addresses of crystal suppliers, etc. Do Eddystone still exist and if so do you have an address for them?

I will pay for any photocopying and postage etc and I will also pay a modest sum for any Eddystone material supplied.

Yours sincerely,
Alistair Bell,
Handsworth,
Birmingham.

Although our sister magazine Hobby Electronics has long since ceased publication, photocopies of articles are still available through the ETI Photocopy Service. There is a standard charge of £1.50 and your cheque or postal order should be made payable to ASP Ltd. Send your order to the address given on the contents page. We don't have any information on the 990R but we do have an address for the company: Eddystone Radio Ltd, Eddystone Works, Alvechurch Road, Birmingham B31 3PP, tel 021-475 2231. — Ed.

ETI

MICRO-COMPUTER AIDED CIRCUIT DESIGN

Julian Burt continues his investigation of circuit design and analysis techniques for use on microcomputers with a look at active components, DC analysis and program overlay techniques.

Last month we restricted ourselves to passive two port networks. Active components, however, can be represented by equivalent circuits containing passive components and voltage and current sources. To explain how to handle networks with active components, we'll use the example circuit of Fig. 1 — a simple low pass filter with a cut-off frequency of about 1.5 kHz.

Suppose we wish to find the response of the circuit at 1 kHz. The two rules for formulating a nodal admittance matrix specify that Y_{nn} should be equal to the sum of all admittances connected to node n and Y_{nm} should be equal to minus the sum of all the admittances connecting node n to node m. That being the case we can assume the matrix we're after to be composed of two separate matrices added together. One will represent the admittances due to passive components and one will represent the admittances due to active circuitry. Notionally, we remove the op-amp from the circuit, use $2\pi fC$ to calculate the admittance of capacitor C1 and 1/R to calculate the admittances of the resistors and come up with the passive admittance matrix:

node	1	2	3	4	5
1	10^{-3}	0	0	0	-10^{-3}
2	0	$10^{-3}-6.10^{-4}j$	0	0	$-10^{-3}+6.10^{-4}j$
3	0	0	10^{-4}	-10^{-4}	0
4	0	0	-10^{-4}	10^{-4}	0
5	-10^{-3}	$-10^{-3}+6.10^{-4}j$	0	0	$2.10^{-3}-6.10^{-4}j$

Next, we must consider the op-amp by itself. A simple equivalent circuit for the op-amp is shown in Fig. 2. On the asssumption that the op-amp displays no frequency dependent characteristics, the input and output impedances can be expressed as purely resistive. Input voltage is the voltage difference across the inverting and non-inverting inputs to the op-amp and is multiplied by gain, A_0, to provide the output voltage.

The op-amp equivalent circuit has four nodes and we require four equations to produce its admittance matrix. Formulation is complicated by the need to account for the dependent voltage source in the output half of the equivalent circuit. To get round the problem, we will formulate the circuit description equations 'by hand'. On the input side:

$I_1=Y_{in}(V_1-V_2)$ and

$I_2=Y_{in}(V_2-V_1)$.

The output equations can be obtained by applying the principles of superposition and proportionality touched on last month:

$I_3=Y_{out}(V_3-A_0(V_1-V_2)-V_4)$ and

$I_4=Y_{out}(V_4+A_0(V_1-V_2)-V_3)$.

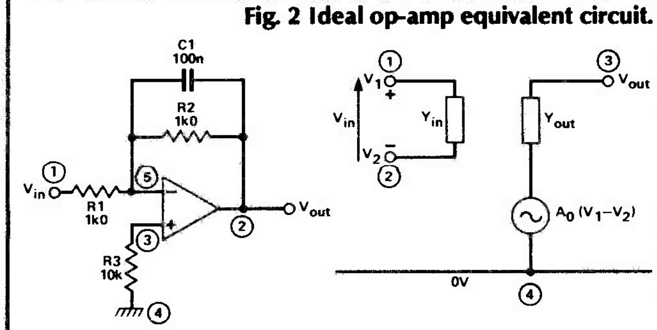
These can be rewritten in matrix form to obtain the general op-amp admittance matrix:

Y_{in}	$-Y_{in}$	0	0
$-Y_{in}$	Y_{in}	0	0
$-A_o Y_{out}$	$A_o Y_{out}$	Y_{out}	$-Y_{out}$
$A_o Y_{out}$	$-A_o Y_{out}$	$-Y_{out}$	Y_{out}

Typical input and output admittance values for a 741 op-amp are in the order of $Y_{in}=10^{-6}$ and $Y_{out}=10^{-2}$ Siemens. Assume a gain of $2x10^5$ and the matrix looks like this:

10^{-6}	-10^{-6}	0	0
-10^{-6}	10^{-6}	0	0
-2.10^{-3}	2.10^{-3}	10^{-2}	-10^{-2}
2.10^{-3}	-2.10^{-3}	-10^{-2}	10^{-2}

Fig. 2 Ideal op-amp equivalent circuit.



The complete matrix for the circuit of Fig. 1 is formed by re-arranging the above matrix into a 5x5 matrix with rows and columns corresponding to the nodal matrix for the passive part of the circuit and then adding the active and passive matrices.

The re-arranged matrix looks like this:

$$\begin{Vmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 10^{-2} & 2.10^{-3} & -10^{-2} & -2.10^{-3} \\ 0 & 0 & 10^{-6} & 0 & -10^{-6} \\ 0 & -10^{-2} & -2.10^{-3} & 10^{-2} & 2.10^{-3} \\ 0 & 0 & -10^{-6} & 0 & 10^{-6} \end{Vmatrix}$$

And the combined and final matrix like is produced by adding the elements of each matrix in their proper positions. The result can then be simplified using the techniques discussed in the first part of this series.

Model Techniques

Equivalent circuits for active components are really models of component behaviour. The models presuppose a particular circuit configuration and are limited to small signal changes around a given operating point. The models familiar from text-books are often extraordinarily complex. Approximations and acceptable short-cuts are commonplace. But the remarkable growth of computing power in recent years means that complexity need no longer be a barrier to accuracy.

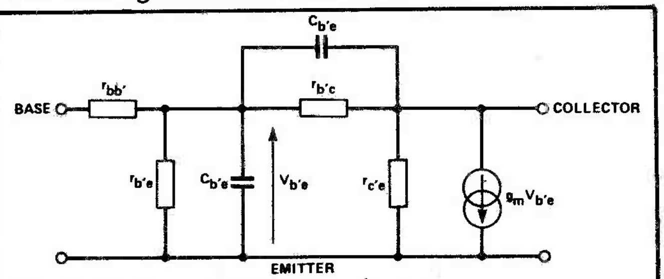


Fig. 3 Hybrid π model with capacitance.

Take the models for a bipolar transistor in common emitter mode, for example. Two familiar models are the hybrid-π model (Fig. 3) and the hybrid parameter model (Fig. 4). The hybrid-π model is popular in America, while hybrid (or h) parameters seem to be increasingly used elsewhere. Of course, the two systems are convertible (as they both are with the third popular model, the T-network) and conversion formulae can be found in any basic textbook. Once having found or calculated the h-parameters (h_{be} or base circuit resistance; h_{re} or reverse voltage transfer ratio; h_{fe} or forward current gain; and h_{oe} or output admittance), we can formulate a nodal admittance matrix for a bipolar transistor in common emitter mode by means of these equations:

$Y_{ie}=1/h_{ie}$ $Y_{re}=-h_{re}/h_{ie}$ $Y_{fe}=h_{fe}/h_{ie}$ and
$Y_{oe}=(h_{ie}h_{oe}-h_{re}h_{fe})/h_{ie}$

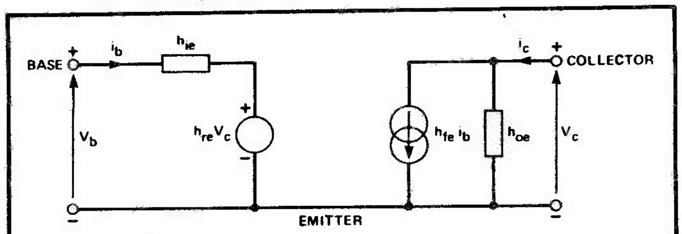


Fig. 4 Hybrid parameter model.

The matrix looks like this:

$$\begin{Vmatrix} Y_{ie} & Y_{re} & -Y_{ie}-Y_{re} \\ Y_{fe} & Y_{oe} & -Y_{fe}+Y_{oe} \\ -Y_{ie}-Y_{fe} & -Y_{re}-Y_{oe} & Y_{ie}+Y_{re}+Y_{fe}=Y_{oe} \end{Vmatrix}$$

As with any models, equivalent circuits can be indefinitely improved upon. The op-amp model we used earlier includes no frequency resonsive elements. A quick look at the frequency repsonse of a 741 (Fig. 5) should confirm that it will only be acceptable from DC to about 200Hz. To account for the fall-off in frequency response beyond 200Hz, we could improve the model by adding a simple RC low pass filter to the ideal op-amp (Fig. 6). Matrix reduction can ensure that extra nodes introduced by adding such 'compensatory' components can always be eliminated before active and passive matrices are combined.

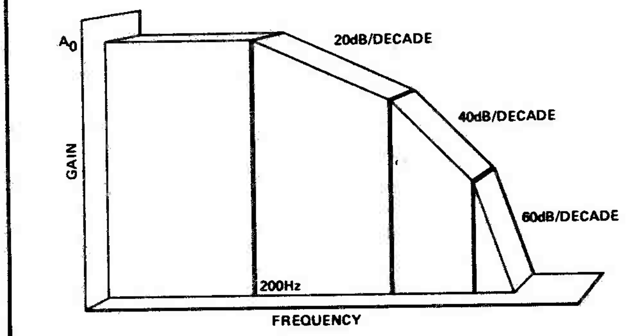


Fig. 5 Op-amp frequency response.

Op-amps and bipolar transistors are probably the most popular active components in linear circuit analysis, but models are available for most components. A selection of the more useful models is shown in Table 1. We now have the tools to analyse any two port network. It will be useful to examine some of the ways in which the resulting long programs can be implemented on small micros (referring throughout to the BBC and Acorn Electron computers).

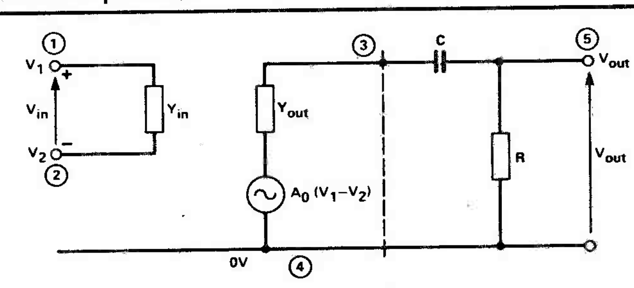


Fig. 6 Op-amp equivalent circuit with frequency compensation.

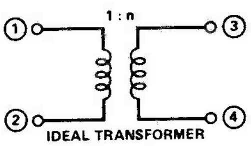
Program Overlay

A good analysis program will have three main data entry properties:

1) choice of input sources (for example, file or keyboard);
2) capability of obtaining all the results of analysis from one set of data and one run of the program;
3) ability to edit data.

The inclusion of these facilities, and the requirements of user friendliness and comprehensiveness mean that the program is likely to be very long. The BBC B micro has a maximum of 28.1K user RAM which is cut down to 25.3K if the disc filing system is used. The Acorn Electron is in a worse position. This means that if a cassette filing system is used we must limit ourselves to a very basic program. If a disc system is used, however, the problem can be greatly reduced by means of program overlay.

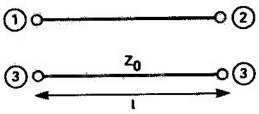
Partial overlay is one method used on mainframe computers. It can be adapted for use on most disc systems which allow loading addresses to be altered. BBC BASIC has four resident pseudo variables which give information about the memory. PAGE returns the start address of user programs, TOP the address of the first free byte above a user program, LOMEM the start of the BASIC area used to store dynamic variables and HIMEM the address of the first byte of screen memory.



IDEAL TRANSFORMER

$$\begin{Vmatrix} n^2Y & -n^2Y & -nY & nY \\ -n^2Y & n^2Y & nY & -nY \\ -nY & nY & Y & -Y \\ nY & -nY & -Y & Y \end{Vmatrix}$$

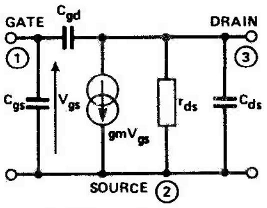
$Y = 1.5 \times 10^4$



TRANSMISSION LINE

$h = 2\pi/\lambda$

$$\begin{Vmatrix} \frac{1}{jZ_0 \sin hl} + \frac{j\tan(hl/2)}{Z_0} & \frac{-1}{jZ_0 \sin hl} & \frac{-j\tan(hl/2)}{Z_0} \\ \frac{-1}{jZ_0 \sin hl} & \frac{1}{jZ_0 \sin hl} + \frac{j\tan(hl/2)}{Z_0} & \frac{-j\tan(hl/2)}{Z_0} \\ \frac{-j\tan(hl/2)}{Z_0} & \frac{-j\tan(hl/2)}{Z_0} & \frac{Zj\tan(hl/2)}{Z_0} \end{Vmatrix}$$



FIELD EFFECT TRANSISTOR

$$\begin{Vmatrix} Y(C_{gs} + C_{dg}) & -Y(C_{gs}) & -Y(C_{gd}) \\ -Y(C_{ds}) + gm & Y(C_{gs} + r_{ds} + C_{ds}) - gm & -Y(r_{ds} + C_{ds}) \\ -Y(C_{dg}) + gm & -Y(C_{ds} + r_{ds}) + gm & Y(C_{dg} + r_{ds} + C_{ds}) \end{Vmatrix}$$

$Y(C_{gs} + C_{dg})$ IS THE ADMITTANCE OF C_{gs} PLUS THE ADMITTANCE OF C_{dg} ETC.

Table 1 Some equivalent circuits and their nodal admittance matrices

These variables can be altered to allow storage of more than one program. A complete program can be broken up into a main program containing all the commonly used subroutines and procedures and the program logic and several sub-programs which perform specific tasks and make use of the main program's subroutines and procedures. The subprograms can only be held in memory one at a time, so they are not allowed to call or direct program flow to other subprograms.

A circuit analysis program may contain subprograms to interpret circuit data, set up active component model matrices, complete nodal admittance matrix formulation, reduce matrices and present the results of analysis. The actual process of overlaying is relatively simple.

On the Acorn machines, the start of BASIC lines is signified by a carriage return byte plus a two-byte line number. The end of a BASIC program is signified by a line-number high byte of over 127. Since TOP carries the address of the next free byte after the end of the program, an extra section of program has to be loaded at address TOP-2. This can be done by means of the command *LOAD"name"/hexaddress/. Normally, LOMEM and TOP are equal but if they are allowed to remain equal the extra section of program will be overwritten by dynamic variables. LOMEM must be reset to TOP plus the length (in bytes) of the largest subprogram to be used. This length can be found by loading the subprogram by itself into memory as normal and then returning the value TOP-PAGE. Resetting LOMEM will then also prevent main program variables being lost when a subprogram is loaded. This resetting should be done at the very beginning of the main program. (More information about this technique, if required, can be found in the article 'Disc Overlays' by Patrick Quick, ACORN USER, November 1983).

Using Data Files

The advantage of partial overlay is that only one area of memory is required. But it takes time to load each subprogram from disc and one subprogram cannot call on the services of another.

Another method of overlay avoids these problems. It is suitable for all disc based systems and makes use of data files. The complete program is written as a number of independent programs which would be used in a specific order. The first program would be an editor, allowing data on the circuit to be entered and edited and then stored in a data file. Next, an interpreter would be loaded and this would reload the data file and create the circuit description matrices for the passive and active parts of the circuit. The matrices would then be saved to a data file and the next program loaded. In the case of AC analysis, this would contain all the procedures for forming the complete nodal admittance matrix from the matrix information in the data file. It would also reduce the matrix and calculate the results for a range of frequencies. The results would be written to a data file and then the final output program would be loaded to display the results or print them out.

The advantage of this system is that the data file will, at the end of the program, contain all the important information of the circuit and so can be used again. If the data file is created in the proper manner, it can also be used with a word processor to contribute to the documentation. Another advantage is that it becomes a relatively simple matter to add extra programs to the suite to further analyse the data.

The Acorn computers have 26 reserved variables, A% to Z%, which are not changed when a new program is loaded. These can be set to different values so that each analysis subprogram can select what program to load next by examining the contents of these variables. This method can be implemented on other computers by POKEing values into a block of memory not affected by program loading. Then by PEEKing at these bytes the required action can be determined.

Some micros allow direct screen access, so data on the circuit can be stored in byte form in this area allowing larger circuits to be analysed. Obviously, the program should not then use the screen for text as this will cause information to be lost.

DC Operating Point Analysis

An area of analysis we have so far overlooked is DC operating point analysis. We can employ the nodal admittance matrix technique again here, if we assume that any capacitors represent open-circuits to DC and any inductors represent resistors of between around 10 and 100 ohms depending on the value of the inductor and its physical characteristics. Replacing capacitors and inductors by open circuits and resistors can be done by the program, especially if it is acceptable to assume equivalent resistances.

Now the matrix can be formed in the usual way. If the method for creating two reactive matrices for AC analysis is used, the formation of the DC matrix is a matter of replacing any non-zero element in the inductive matrix with the conductance figure for the appropriate equivalent resistor and then adding the modified inductive matrix to the resistive one.

To find the voltages at each node we need to solve the set of linear equations represented by the single nodal admittance matrix equation. This equation consists of a current vector containing the currents meeting at each node, the nodal admittance matrix itself and a vector containing the unknown nodal voltages. Kirchoff's Current Law demonstrates that the internal nodal currents sum to zero while signal input and output currents are undefined. For DC conditions, however, we can ignore signal input and output nodes which will be effectively disconnected. On the other hand, we can't ignore the power supply as we would with an AC analysis. This is connected to an external current source producing an unknown nodal current.

Norton's Theorem allows us to convert a voltage source into a current source, which is a necessary first step towards finding the unknown nodal current. The theorem says, in essence, that the Thevenin equivalent of a linear circuit — voltage source plus impedance in series — is effectively the same as a current source shunted by an equal value impedance (see Fig. 7). We can incorporate the current source into the circuit description equations by introducing an extra node.

If the power supply is connected to node 'k' at one end of the notional shunt impedance and extra node — at the other end of the shunt impedance — is called 'j' (and if we assume the impedance to be purely resistive), then both Y_{jk} and Y_{kj} will be equal to $-1/R$ while the new value of Y_{kk} will be the old value plus $1/R$ (where R is the value of the shunt resistance). This change is easy to implement in BASIC if arrays have been used and the node numbering has started from 1. We simply give the extra node the number zero. We don't have to redefine the nodal admittance matrix and the nodal equations for a circuit with a single-rail power supply of V_{cc} volts become:

$$\begin{Vmatrix} V_{cc}/R \\ 0 \\ 0 \\ \cdot \\ \cdot \\ 0 \end{Vmatrix} = \begin{Vmatrix} Y_{00} \cdots\cdots Y_{n0} \\ \cdots\cdots\cdots \\ \cdots\cdots\cdots \\ \cdots\cdots\cdots \\ \cdots\cdots\cdots \\ Y_{0n} \cdots\cdots Y_{nn} \end{Vmatrix} \begin{Vmatrix} V_0 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ V_n \end{Vmatrix}$$

where n is the number of nodes and all currents apart from V_{cc}/R are zero.

The method we use to solve such systems is known as Gauss-Jordan elimination. The method is very efficient requiring, for example, only 441 multiplications to solve a nine-node circuit, as compared to up to 3.10^6 if determinants are used. In essence, the technique uses repeated multiplication and addition or subtraction to eliminate all but one variable from each equation. In matrix terms, we can say that if a system of equations has a unique solution, row reduction can be employed to reveal the solution by the systematic elimination of coefficients to produce the identity matrix.

$$\begin{Vmatrix} Y_{11} & Y_{12} \cdots\cdots Y_{1n} \\ Y_{21} & Y_{22} \cdots\cdots Y_{2n} \\ \cdot & \cdots\cdots\cdots \\ \cdot & \cdots\cdots\cdots \\ Y_{n1} & Y_{n2} \cdots\cdots Y_{nn} \end{Vmatrix} \begin{Vmatrix} V_1 \\ \cdot \\ \cdot \\ \cdot \\ V_n \end{Vmatrix} = \begin{Vmatrix} I_1 \\ \cdot \\ \cdot \\ \cdot \\ I_n \end{Vmatrix}$$

can always be reduced to:

$$\begin{Vmatrix} 1 & 0 & \cdots\cdots & 0 \\ 0 & 1 & \cdots\cdots & 0 \\ \cdot & \cdot & \cdots\cdots & \cdot \\ \cdot & \cdot & \cdots\cdots & \cdot \\ 0 & 0 & \cdots\cdots & 1 \end{Vmatrix} \begin{Vmatrix} V_1 \\ V_2 \\ \cdot \\ \cdot \\ V_n \end{Vmatrix} = \begin{Vmatrix} J_1 \\ J_2 \\ \cdot \\ \cdot \\ J_n \end{Vmatrix}$$

where J_k is produced by the arithmetic operations involved in the elimination of every coefficient from the k^{th} equation. In the particular case of the DC operating point matrix above, J_k will be a function of V_{cc}/R and the relevant admittances.

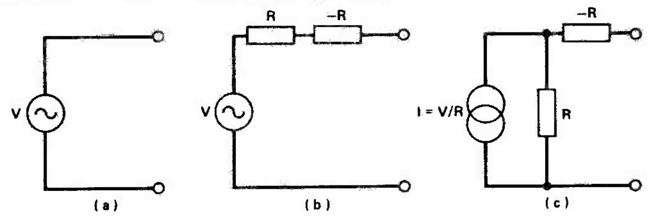


Fig. 7 Turning a simple voltage source into a current source by means of Norton's Theorem.

Listings 1 and 2 are both routines for performing Gauss-Jordan elimination. The second listing represents an improvement on the basic procedure of Listing 1, and will reorder the matrix rows and eliminate unnecesary computations (such as multiplication of zero elements) in order to make the process more efficient. The reordering makes sure that the largest coefficients are always on or below the main diagonal point of any column.

```
1000  DEF PROCeliminate
1005  :
1010  FOR I%=1 TO N
1020  FOR J%=1 TO N
1030  IF J%=I% THEN GOTO 1090
1040  C=Y(J%,I%)/Y(I%,I%)
1050  FOR K%=1 TO N
1060  Y(J%,K%)=Y(J%,K%)-C*Y(I%,K%)
1070  NEXTK%
1080  I(J%)=I(J%)-C*I(I%)
1090  NEXTJ%
1100  NEXTI%
1105  :
1110  FOR I%=1 TO N
1120  V(I%)=I(I%)/Y(I%,I%)
1130  NEXTI%
1135  :
1140  ENDPROC
```

Listing 1 Basic Gauss-Jordan elimination.

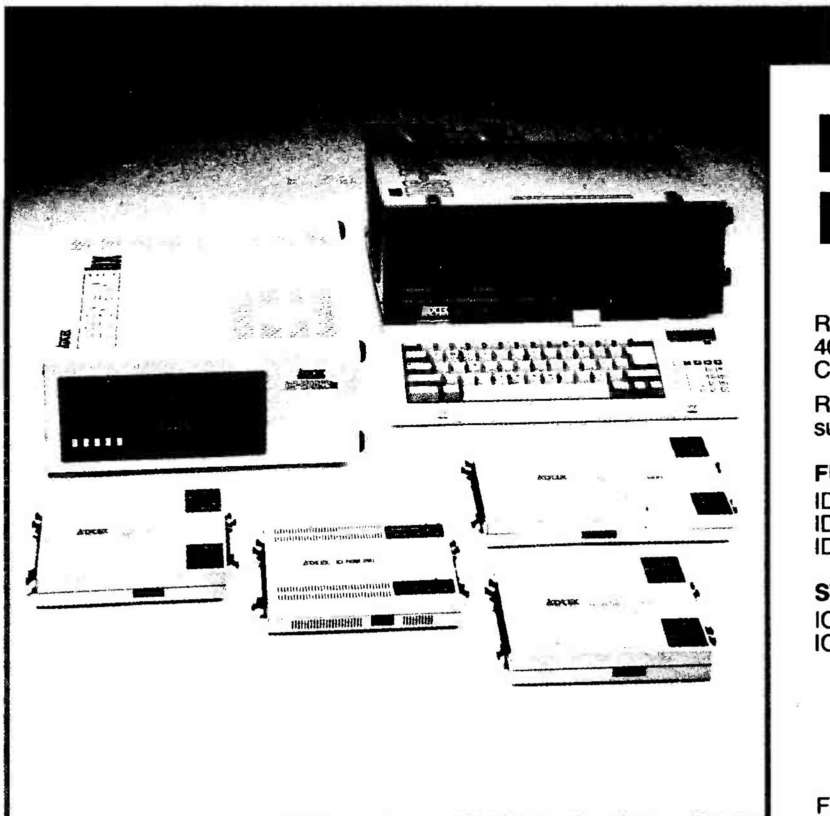
As with last month, the routines are written in BBC BASIC, but can be adapted for general use by converting them into subroutines rather than procedures.

```
1200  DEF PROCquick_eliminate
1205  :
1210  FOR I%=1 TO N
1220  MAX=-1
1230  FOR K%=I% TO N
1240  IF ABS(Y(K%,I%))>MAX MAX=ABS(Y(K%,I%))
:ROW%=K%
1250  NEXTK%
1270  FOR K%=I% TO N
1280  TRANS=Y(I%,K%)
1290  Y(I%,K%)=Y(ROW%,K%)
1300  Y(ROW%,K%)=TRANS
1310  NEXT K%
1320  TRANS=I(I%)
1330  I(I%)=I(ROW%)
1340  I(ROW%)=TRANS
1345  :
1360  FOR J%=1 TO N
1370  IF J%=I% THEN GOTO 1430
1380  C=Y(J%,I%)/Y(I%,I%)
1390  FOR K%=I%+1 TO N
1395  IF K%=4 THEN GOTO1410
1400  Y(J%,K%)=Y(J%,K%)-C*Y(I%,K%)
1410  NEXT K%
1420  I(J%)=I(J%)-C*I(I%)
1430  NEXT J%
1450  NEXT I%
1455  :
1470  FOR I%=1 TO N
1480  V(I%)=I(I%)/Y(I%,I%)
1490  NEXT I%
1495  :
1510  ENDPROC
```

Listing 2 Improved Gauss-Jordan elimination.

Next month we'll be looking at non-linear analysis and transfer functions. We'll also touch on time domain analysis and useful routines for Fourier analysis and quick line printer plotting.

ETI



DANGER — ELECTRONICS AT WORK

Anna Paczuska finds that appearances are deceptive and that electronics can be bad for your health.

Even the smallest speck of dust can flaw a wafer and make it unusable if it sticks to it during manufacture. For that reason the dust level in semiconductor factories is kept about 100 times lower than in a modern hospital. Workers wear special clothing, headgear and gloves not to contaminate the product in any way. Air conditioning constantly filters the air supply.

The dust-free surfaces, the smartly attired workers, and the air control give an impression of cleanliness. This, in turn, has led to the illusion that work in the semiconductor industry is safe. It isn't. A growing body of evidence shows that in spite of low accident rates, the level of work-related illness for the industry is exceptionally high.

A US government survey found that industrial illness was three times as common in semiconductor manufacturing as among workers in general manufacturing. . . .

Illness is not the only danger. Elfreda was 18 when she left her rural home in the Philippines and went to work at Dynetics, a semiconductor assembly plant in Manila. She worked in the tin-dip and plastic moulding sections.

After three years she developed chronic anaemia, skin problems and swollen lymph glands. She was found to be suffering from cancer of the lymph system. Elfreda died when she was 22. Her case, though dramatic, is not atypical.

Endemic Illnesses

In 1980, a US government survey found that industrial illness was three times as common in semiconductor manufacturing as among workers in general manufacturing. Chemically caused illnesses, known as systemic poisoning, are twice as high for the semiconductor workers clustered round Silicon Valley as for other industrial workers in California.

In Asia, labour organizations, community health groups and concerned doctors have gathered evidence of a range of industrial diseases and injuries associated with the electronics industry. A 1978 survey of 600 workers at Control Data in Korea, for example, found that almost two thirds of them had ulcers, probably related to work stress. Nearly half the workers who did soldering had skin diseases. Swedish research shows that soldering is associated with four times the average incidence of skin cancer.

In the Philippines there is an abnormally high rate of tuberculosis and pneumonia among electronics workers. In some factories women are forbidden to wear their own clothes underneath their uniforms in case that brings dust into the plant. So women used to a humid tropical climate are obliged to wear thin uniforms in cold, air-conditioned rooms. To compound injustice, they lose their jobs if they get pneumonia or tuberculosis.

In Britain the few statistics available show the same disturbing trend towards ill health. For example, researchers at Birmingham University recently reported that workers employed by Lucas Industries in the West Midlands suffer a higher than expected cancer rate.

Dangers to health have multiplied in the electronics industry since the transistor was developed in 1948. The increased risks, however, were not immediately obvious, partly because rapid innovation meant there was hardly time to investigate one process before it was replaced by another. The main reason for the delay in awareness,

however, was and is that effects are often long term. It can take between two and 50 years after exposure to a cancer causing substance before a cancer appears. Daily use of a microscope can cause permanent eye damage but may take five years to do so.

Delay in visible symptoms is compounded by high labour turnover. By the time workers are suffering the ill effects of production processes they have often left the workplace. In Malaysia worker turnover is 6% per month. Even in Britain workers over 35 may be encouraged to leave to be replaced by school leavers (see p.7, ETI, April 1986, for this).

When older workers are constantly replaced by young workers in this way, awareness of hazards does not carry over. Each intake learns by experience — by which time it may be too late.

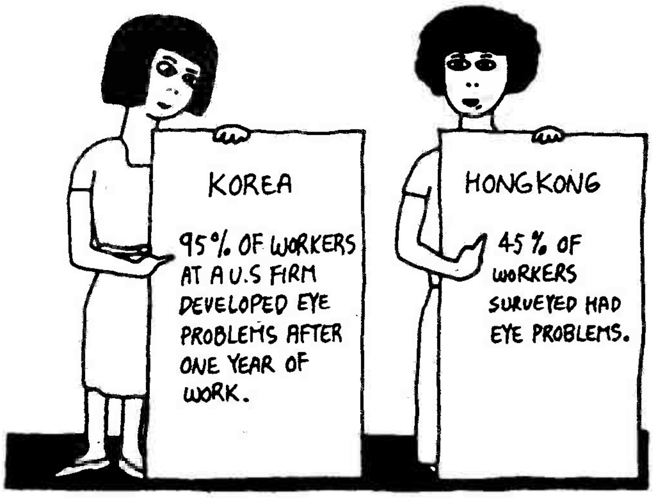
The electronics industry is not just dangerous for production workers. It can be lethal for anyone living nearby. According to one 1984 estimate, 80% of chemical storage tanks in Silicon Valley were leaking. At the Fairchild plant in South San Jose in 1981 an estimated 58,000 gallons of solvents and chemicals leaked through the soil and into the community water supply. Poisonous chemicals were found in the drinking water. Birth abnormalities in the area soared to twenty times the normal rate.

Chemicals

Many of the hazards affecting electronic workers are caused by chemicals. They are the raw material of the electronics industry and the growth of the electronics industry has been accompanied by their proliferation.

A thousand new synthetic chemicals are launched on to the world market every year, and the annual rate of production of chemicals doubles every ten years. Most of the chemicals used in industry did not even exist 40 years ago — and there are a lot of them. Hewlett Packard alone keeps records on 3,000 different chemicals at its California headquarters.

Huge sums of money are involved. In 1980, the world turnover of chemicals was valued at $550 billion. Three-quarters of production was controlled by a handful of multinationals based in Europe, Japan and the US whose average annual profit rate in 1979 was 25%. With cut throat competition and high stakes, it is inevitable that companies give precedence to productivity and competitiveness. As a result products are not tested adequately and serious threats to workers' long term health are ignored.



Health is threatened at every stage of semiconductor wafer prouction — by the dopants and gases used in crystal growing and deposition, by the acids and solvents used in wafer preparation, and by metals and oxides used in implantation and metallization. Semiconductor assembly and PCB fabrication carry further risks from curing agents, epoxy resins and dyes.

Dopants can be particularly insidious. Doping is, of course, the introduction of controlled amounts of impurities into solid crystalline substrates and is the key process in the fabrication of microelectronic circuits. In the standard diffusion process, dopant vapour is used at temperatures between 900–1000°C. Ion implantation is a newer and increasingly propular process in which dopants are introduced to the silicon substrate in a vacuum at room temperature. The risk of exposure to dopants is substantial with either process and all dopants are extremely hazardous. They include hydrides, oxides and halides of elements such as arsenic, phosphorus, antimony, cadmium, aluminium and zinc.

Many of these chemicals are well known to be dangerous. Phosphorus was banned for use in match and firework production over 50 years ago because it was known to cause the chronic bone condition 'phossy-jaw'. Phosphorus compounds used in semiconductor production are known to damage liver and lungs as well as cause severe irritation to the eyes, throat and skin.

In 1983, nearly 200 women at a Japanese electrical factory in Hong Kong were taken to hospital suffering from exposure to phosgene and ozone. At first the women thought they had flu because they felt dizzy, nauseous and had headaches. One woman went into a coma for over four days. At least three pregnant women lost their babies. Some suffered permanent lung damage.

Hewlett Packard alone keeps records on 3,000 different chemicals at its California headquarters....

Arsenic compounds, too, are notoriously dangerous and can damage the nervous system and cause leukaemia. In 1982, a 23-year-old US university lab technician was found dead near equipment in which he was replacing a cylinder of arsine (arsenic hydride). His death was the result of massive exposure. The ion implanter he was using is common equipment in the semiconductor industry.

Burns

Poisoning is one chemical hazard, but burns are another. Chemical burns to the skin of the face and hands are often cuased by hydrofluoric acid, the most notorious burn-producing chemical in the semiconductor industry.

As with other chemicals the seriousness of the burn depends on the strength of the acid and how long it stays in contact with the skin. But workers often find out they have been burned only after they take their gloves off and see moisture on their fingers. There may be no pain, or it may be delayed. The symptoms may not appear until they have left work and gone home.

Cancer

No more than 2% of the chemicals available on the world market have been tested properly to see whether they cause cancer. In some cases companies eager to make sales have falsified or covered up test data. Little or no research has been done on the effects of exposure to combinations of chemicals. Yet the American Government Survey estimates that between one and two fifths of all cancer in the US is due to exposure to chemicals or radiation at work.

For workers in assembly and testing plants in Asia there are other hazards. Multinationals moved the labour intensive sectors of electronics production to where labour was cheap. Chemicals and parts are imported, and health risks come with the cost saving.

Thousands of Asian electronics worker have poor eyesight. Tedious detailed work using microscopes and VDUs causes extensive and permanent eye damage.

A study in South Korea showed that 95% of workers surveyed in various electronics factories developed eye problems after only a year of work. Their problems included chronic conjunctivitis, short sight and astigmatism. In the Philippines one recent estimate showed that half of the electronics workforce had poor eyesight. Yet factories will only accept new workers if they have perfect eyesight.

The electronics industry is not just dangerous for production workers. It can be lethal for anyone living nearby . . . .

Noise and stress also cause health problems. Cases of what has been called 'mass hysteria' have occurred in Singapore, Malaysia and the US. Workers using microscopes complain they have seen ghosts or evil spirits. One or more start screaming and the whole workforce goes into uproar. One researcher has suggested that evidence points to these outbreaks being related to the lack of union organization or of any ways of making complaints.

Unions

The electronics industry is relatively new and in most countries few of its workers are unionized. Indeed, firms and governments often actively oppose unionization.

US electronics firms offer training and advice in anti-union tactics to managers of multinationals operating in Asia. The US government has set up an Asian American Free Labour Institute (AAFLI) which is linked to government controlled and company unions. The vast majority of their funding (94% by one report) comes from the US Agency for International Development (USAID). According to the authors of a recently published handbook called *Health Hazards In Electronics*, the aim of the AAFLI is to 'help prevent or undermine any organized labour activities which may threaten free enterprise of US business interests'.

The handbook lists the tactics which multinational employers use to discourage unionization. These include rotating shifts to prevent workers' groups from forming, hiring and firing to weed out 'trouble-makers', the encouragement of individualism against cooperation and the setting up of toothless committees which give workers the illusion of participation.

Intensive competition in the electronics industry means employers are wholly concerned with production figures. Health issues are attended to only when workers raise them, and workers are not encouraged to raise them. Published in Hong Kong, *Health Hazards In Electronics* recommends that employees set up their own health committees to monitor hazards. This is more than most people in the West are prepared to do even when they are aware of the dangers inherent in the electronics industry.

Since most electronics factories are not unionized, there is often no-one to take up issues on the workers' behalf. One organization involved in a wider hazards campaign is the General, Municipal, Boilermakers and Allied Trades Union (GMBATU), currently attempting to get Repetitive Strain Injury (RSI) recognised as a legitimate industrial disease.

Such injury is common to a number of industries where repetitive and awkward movements are required from workers. Although not as dramatic as burns or poisoning, RSI is a major hazard for many manual workers in electronics manufacturing.

Electronics assembly work can be particularly risky, although RSI can affect typists, packers and bricklayers as well. One case recorded by the GMBATU involved an assembly-line worker in a Scottish electronics factory whose repeated gripping and wrist movements resulted in Carpal Tunnel Syndrome — loss of movement and feeling in the hand caused by swelling in the channel in the wrist through which nerves and tendons pass from arm to hand. An operation on both wrists relieved some of the pain but the disability persists and the woman is still unable to work.

Her case was taken up by the GMBATU and she was awarded £1,500 by the Appeal Court in Scotland to cover pain and injury and a further £2,100 for loss of earnings. She may never work again, but she may have helped to get the problem of hazards in the electronic industry recognised.

'Occupational Medicine: State Of The Art Reviews', vol. 1, no. 1, *The Microelectronics Industry*, ed. Joseph LaDou. (Available from Hanley and Belfus, 210 South 13th Street, Philadelphia, Pennsylvania 19107, USA).

'Health Hazards In Electronics: A Handbook,' Thomas H. Gassert. (Asia Monitor Resource Centre, 444 Nathan Road, 8/B Kowloon, Hong Kong).

Illustrations from 'Health Hazards In Electronics'.

CANCER CHEMICALS IN ELECTRONICS MANUFACTURING

This is a partial (not complete) list of chemicals used or occurring in electronics manufacturing which, according to medical experts, are known or suspected to cause cancer in humans or animals. For more information on each chemical, see the Chemical List (p. 271) and the sources listed on the next page. Most of these substances should be labelled "CANCER SUSPECT AGENT".

	Humans	Animals
acrylonitrile	yes	yes
antimony	S	S
aromatic amines (dyes)	yes	yes
arsenic (and compounds)	yes	S
arsine	yes	S
asbestos	yes	yes
benzene	yes	S
benzidine	yes	yes
benzyl chloride	S	yes
beryllium (and compounds)	S	yes
bis(chloromethyl)ether	yes	yes
boric acid	S	S
cadmium (and compounds)	yes	yes
carbon tetrachloride	S	yes
chlorinated diphenyls	S	S
chlorinated hydrocarbons	S	S
chloroform	S	yes
chlorotoluene	S	yes
chromates	yes	yes
chromic acid	yes	yes
chromium (and compounds)	yes	yes
cobalt	S	yes
dichlorobenzene	S	S
3,3'-dichlorobenzidine (and salts)	S	yes
a,a-dichloromethyl ether	S	S
diepoxy butane	S	yes
diethyl amine	S	yes
diglycidyl ether	S	S
diglycidyl ether of bisphenol A	S	yes
1,4-dioxane	S	yes
diphenyls	S	S
epichlorohydrin	S	yes
ethyl acrylate	S	S
ethyl alcohol*	S	yes
ethylene dibromide	S	yes
ethylene dichloride	S	yes
ethylene imine	S	yes
ethylene oxide	S	S
fiberglass (crystalline)	S	S

	Humans	Animals
formaldehyde	S	yes
gold		S**
isopropyl alcohol***	S	S
lead (and compounds)	S	yes
maleic anhydride	S	S
manganese	S	S
methyl methacrylate	S	S
moca	S	yes
molybdenum trioxide	S	yes
nickel (and compounds)	yes	yes
perchloroethylene	S	S
phenol	S	S
platinum		S**
polychlorinated biphenyls	S	yes
polymers (plastics):		
polyethylene	S	yes
polystyrene	S	yes
polytetrafluoroethylene	S	yes
polyurethane	S	yes
polyvinyl chloride (dust)	S	S
propyl alcohol	S	yes
radiation*:		
microwaves	S	S
radioisotopes	yes	yes
ultraviolet light	yes	yes
x-rays	yes	yes
selenium (and compounds)	S	S
silica, quartz (crystalline)		S**
silver		S**
styrene	S	S
styrene oxide	S	S
tetrafluoroethylene	S	S
titanium dioxide	S	S
1,1,1-trichloroethane	S	S
trichloroethylene	S	yes
triethylene glycol diglycidyl ether	S	yes
vinyl chloride	yes	yes
vinyl cyclohexene dioxide	S	yes
zinc chloride	S	S

yes = sufficient proof of causing cancer
S = SUSPECTED of causing cancer (Note: SUSPECTED means either that there is some evidence but not enough yet for conclusive proof, or that since there is some evidence of cancer in animals we must suspect there is also a cancer risk for humans.)
* probably due to contaminants which may act as co-carcinogens
** by implant only
*** manufacture of isopropyl alcohol is a definite cancer risk for humans

FIBRE OPTICS AND LASERS

Roger Bond completes this series of articles with an examination of the ways in which fibre optics and lasers are used.

Lasers have found applications in areas as diverse as surgery, communications and entertainment. In many cases, the power and precision of the laser give considerable improvements over alternative techniques, whilst in others the benefits are mainly economic. The following examples are by no means exhaustive, but they will give an indication of the present applications and future potential of laser technology.

Communications

Until recently, the electronic signals required for telephony, television, data and other services were carried either as radiated electromagnetic waves through the air or through cables. Then, in the early 1970s, a great deal of effort was put into developing low-loss optical fibres which could be used in place of copper wires for communications purposes.

The advantages offered by optical fibres are considerable. Optical signals are immune from electrical interference and the fibres do not rust as copper does. This latter feature is extremely useful since underground cables often get wringing wet in a storm. There is also the advantage of wide bandwidth.

Cable type	Application	Repeater Spacing	Bandwidth (Channels)	
0.63 mm	PCM	2000 yds		(24 or 30)
0.63 mm	audio	—	4 kHz	(1)
Coaxial 1.2/4.4mm*	FDM	4 km	4 MHz	(900)
Coaxial 1.2/4.4mm*	FDM	2 km	12 MHz	(2700)
Coaxial 2.6/9.5mm*	FDM	9.7km	4 MHz	(900)
Coaxial 2.6/9.5mm*	FDM	4.5km	12 MHz	(2700)

PCM = pulse code modulation
FDM = freuqency division multiplex
* figures are diameters of inner and outer conductors respectively.

Table 1 The types of cable used on the existing inland network.

Optical fibre is also cheap compared to copper wire, the price of which depends on world copper prices. Since optical fibre is light in weight compared to copper wire, it is easier to pull through ducts and transport from factory to site. It is also thinner and therefore occupies less duct space. In cities where there are so many underground services — gas, electricity, drains, transport, etc — any saving in space is welcome.

The use of optical fibres in communications can be divided into two broad categories, inland systems and intercontinental (submarine cable) systems.

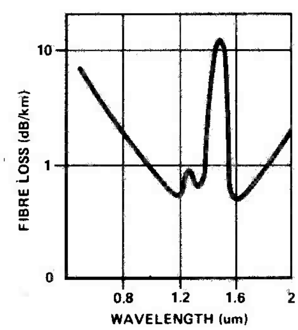


Fig. 1 The response of a typical optical fibre.

Inland Systems

Table 1 shows the make up of the inland network in this country, the volumes of traffic carried and the types of carrier. Table 2 shows the probable structure of the digital network in the future. Although the higher bit rates are carried by monomode fibre operating at 140 Mbit/s, the multimode fibre is useful for the lower bit rates since the fibre is generally easier to use and join.

A field trial of the first optical fibre system in the UK took place between Stevenage and Hitchin from 1977 to 1980. The cable consisted of four copper wires to carry direct current to the regenerators and three fibres for communications. A central steel member was used to give the cable strength and the whole cable was no more than 7mm in diameter. From Hitchin to Stevenage is a distance of 9km and there were two intermediate repeaters spaced at 3km. The system carried 140Mbit/s.

Intercontinental Systems

Before installing long lengths of optical fibre to span the oceans, it is as well to examine the frequency response of a fibre with a view to determining at which

Fibre types	Bit rate (Mbit/s)	Regenerator Spacing (km)	Wavelength (um)	No. of Speech channels
Multimode	2	10	0.85-0.95	30
Multimode	8	10	0.85-0.95	120
Monomode	34	30	1.3, 1.5	480
Monomode	140	30	1.3, 1.5	1920

Table 2 The types of fibre optic link likely to be used for inland traffic in the future.

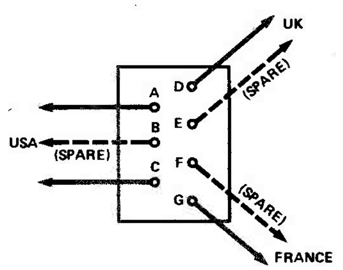
frequencies the loss is minimum. It is normal to speak in terms of wavelength rather than frequency when dealing with optical fibre since at these high frequencies the wavelength is small enough to be associated with the fibre dimensions.

Figure 1 shows the response of optical fibre to different wavelengths and it can be seen that the lowest losses are achieved at 1.3um and 1.55um. By operating monomode at 1.3um, the resulting loss is so low that regenerators will only be required at intervals of 30km or more. Compare this with the performance of coaxial cable where, as Tables 1 and 2 show, even the larger diameter type requires repeaters every 4.5km.

The world's first international optical fibre system is presently being installed. Called UK-Belgium 5, it will run between the UK and Belgium and cost £7.25 million. Over the 122km distance there will be three intermediate repeaters at a spacing of 30km. It will operate at 1.3um monomode and each fibre pair will carry 280Mbit/s. Therefore the total of three fibre pairs will offer about 12,000 circuits.

Another cable that is currently planned for 1988 is the TransAtlantic No. 8 (TAT8) costing about £250

Fig. 2 The branching arrangement on the TAT8 cable showing the provision of spare fibre optic links.



million. It will be 6600km long and run from the USA to the UK and France. Existing submarine cables land in one country before proceeding to another, but TAT8 will have a branching unit off the European continental shelf. Three fibre pairs will run from the USA to the branching unit. From the branching unit, two pairs will go to the UK and two to France. In normal operation A would be connected to D and C to G. The others will be spare (B, E,F).

In case of failure of one of the American cables, B would be a replacement or in case of the Eurpean ends, E or F could be used. The UK and France could also be connected via E and F if necessary, and the total capacity of TAT8 wil be about 8,000 circuits.

Medical Applications

Communications aside, one of the most important fields in which lasers and fibre optics have been used is medicine. The hair-like strands of a fibre system can be inserted into the stomach or lungs of a patient without too much discomfort and allow more detailed internal examination than was previously possible. Light can be carried on fibres to illuminate the area to be examined while other fibres carry back an image which can be projected onto a screen.

Lasers are used in eye surgery to 'spot weld' peeling retinas. Referring to Fig. 3, if the retina tears, the vitreous humour gets behind it and the pressure starts peeling more of it off. This finally results in blindness.

To spot weld the retina back, the light must pass through the front part of the eye without being absorbed. Formerly a xenon arc lamp was used, and

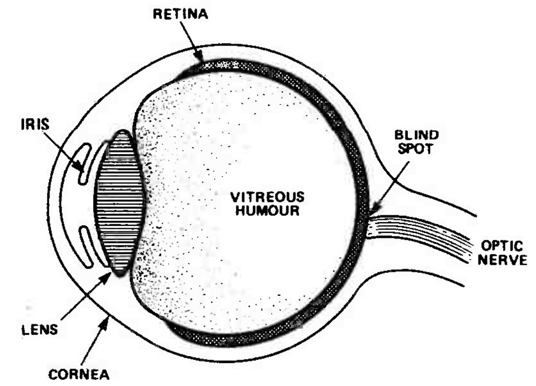


Fig. 3 A cross-section through the human eye.

because the eye had to be exposed to the light for a long time, anaesthetic was required and the eye had to be clamped. With lasers, 1 joule of energy for only 300uS is all that is required. This means that anaesthetic and clamping are not required.

Naturally, this type of repair results in a blind area of retina and a compromise must be reached between keeping the blind area to a minimum and producing a large enough weld to hold the retina in place. The scar left by xenon arc lamp welding is around 800um long, whereas that produced by a laser is only 50um or so.

Industrial Applications

Lasers are used in a wide range of welding, cutting and drilling operations in industry. The precise control of position and energy which lasers offer makes them ideal for delicate welding processes in the microelectronics industry, allowing only a very small area to be raised in temperature. The same advantages also make

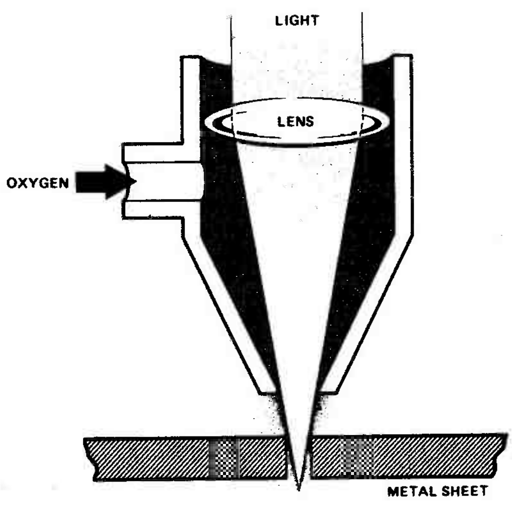
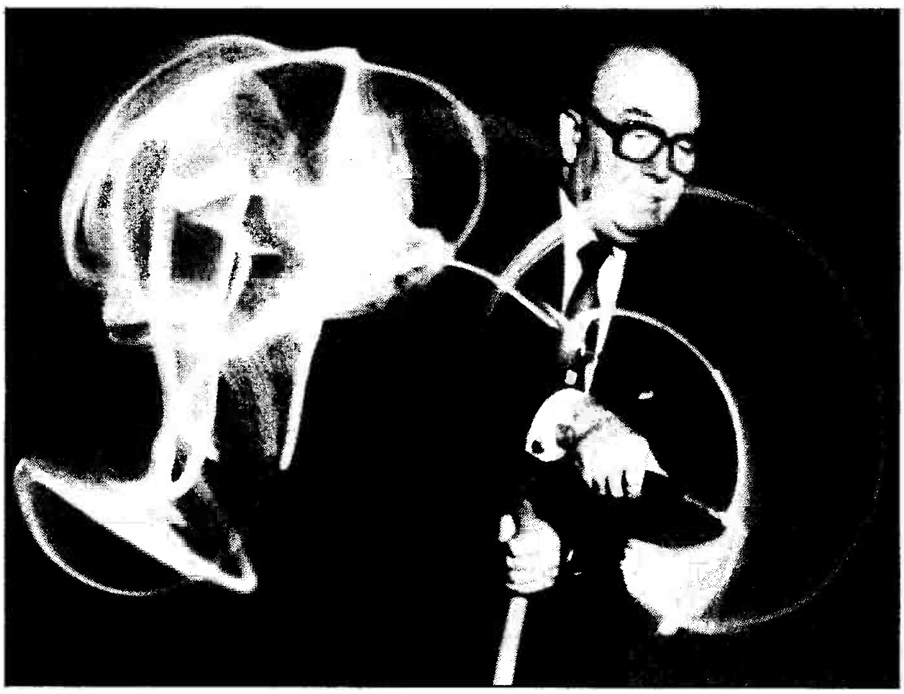


Fig. 4 Using a laser to cut metal.

lasers an attractive proposition for critical metal cutting operations in the aircraft industry and elsewhere. The hot swarf produced during cutting can be burnt away using oxygen (Fig. 4).

Metal drill bits can be used to produce holes as small as 250um diameter, but smaller drill bits would not be able to take the stress. Lasers can focus down to

Laser light travelling through a fibre bundle, as demonstrated by former STC Chairman and Chief Executive Sir Kenneth Corfield.



10um, allowing holes of this size to be made quite easily. The watch industry in particular uses neodymium lasers for drilling holes in ruby jewels.

Optical fibres are also widely used in industry. Signals transmitted along optical fibres are not generally affected by external electromagnetic fields, so they're immune to electromagnetic interference. This make optical fibres very useful for control and other applications in electrically noisy environments.

There is one respect in which light transmitted along optical fibres will be affected by external fields, and that is in terms of polarisation. The plane of polarisation of a light beam will be twisted in the presence of a strong magnetic field (the Faraday Effect), the degree of twisting being proportional to the length of the light path through the field and the strength of the field. Most sensors used with optical fibres will not detect changes in polarisation and are therefore immune to such effects, but there applications in which is desirable to know the strength of an incident field, and sensors which register changes in polarisation can be used to detemine this. An example is the use of optical fibre wrapped around a high voltage bus-bar to measure current. Using this technique, it is possible to avoid the risks associated with using metal cables.

At Home And Beyond

Fibre optics first came to the attention of the general public in the form of small plastic vases in which mushroom bundles of fibres were illuminated with coloured light. These simple domestic ornaments have long since fallen from favour, but laser and fibre optic technologies have continued to find applications in the home and in the field of entertainment. Among the most notable recent developments has been the compact disc system, which users a laser to read a series of minute pits on the surface of the disc. Other examples include the use of laser holograms in discotheques and some have suggested the use of laser holography as the basis of a three-dimensional television system in the future.

In the office, too, lasers have provided new solutions to old problems. The accuracy they offer is used to good effect in laser printers. These use a laser to control a toning process not unlike that used in photocopiers, offering the high print quality associated with golf-ball and daisywheel systems coupled with the speed and versatility of dot-matrix and thermal print systems. As we reported in a recent News Digest article, the versatility of the system is such that it can cope with the large print and special type faces used by partially sighted people as well as more common print styles.

In yet wider fields, lasers can be used to check for the presence of various substances in the atmosphere. There is widespread concern that the accumulation of freon from aerosol cans will eventually deplete the ozone layer and allow harmful ultra-violet radiation through. By shining a laser of the appropriate wavelength through the atmosphere and measuring the absorption, the extent of the damage can be assessed.

ETI

HARDWARE DESIGN CONCEPTS

Mike Barwise begins a series of short articles on the considerations and concepts underlying the design of intelligent peripherals with some ruminations on the nature of the printer buffer.

The aim of this series is to suggest to the reader a mode of thought necessary for successful systems design, and in passing to introduce some of the less familiar standard mechanisms of digital logic control and data handling.

I must stress that I am presenting a personal viewpoint throughout. There are almost limitless ways of implementing practically any medium complexity logic problem, and almost all of them have been used by someone already. The more you learn, the more you realise how difficult it is to be really innovative.

Except in Silicon Valley (where innovation per se seems more important than utility these days), it is usually much better for the end user to have a simple, obvious, reliable solution to their problem than a whiz-kid gadget which is impossible to debug when inevitably it crashes.

There are almost limitless ways of implementing any medium complexity logic problem, and almost all of them have been used by someone already....

The first peripheral I want to discuss is the printer buffer. Incidentally, there are dozens of other uses for these buffers. The main variation between implementations will be in their port design and speed capabilities.

Basic Principles

Buffers generally work on the principle of a store of data bytes which can be read out sequentially in the same order they were written in. This mechanism is called a FIFO (First In First Out) memory.

There are many different types of FIFO, implemented in both hardware and software. Hardware FIFOs vary in size between 16 bytes and several Megabytes, and in speed between about 30ns and 2ms per read or write operation (30MHz to 500kHz operation).

They are also sub-divided by protocol. The main variants are SYNCHRONOUS, where reading and writing are performed under the control of a common clock and the data bus may be shared; SEMI-SYNCHRONOUS, where read and write requests may be made at any time, but are internally arbitrated and synchronized within the FIFO to a common clock , and ASYNCHRONOUS, where data may be freely written to and read from the FIFO at different rates or even at random intervals without conflict, so long as the FIFO is never empty or full. This last asynchronous FIFO is inevitably a dual port device.

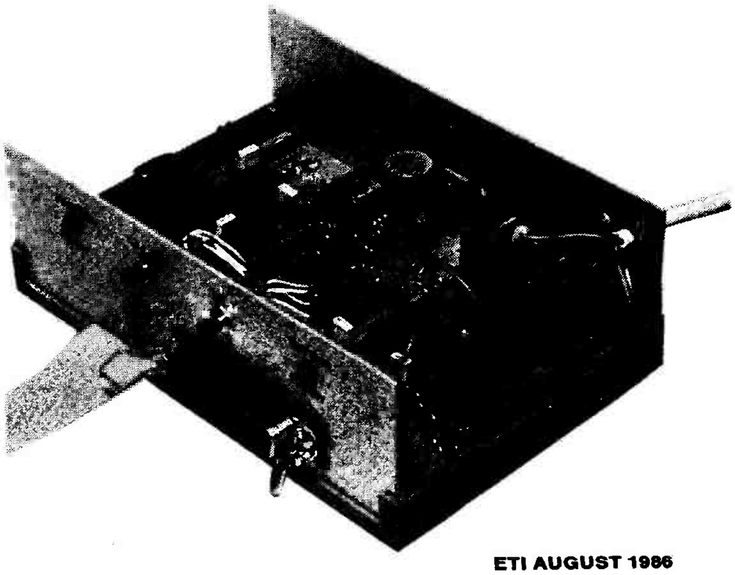
Different buffer applications will require different modes of FIFO operation, so it is important to be able to analyse the job in hand and choose the best type of FIFO for it. Large hardware FIFOs get very expensive, even at quite low speeds. Software solutions are usually used for data rates lower than 500 Kbytes per second, particularly when buffer sizes greater than 256 bytes are needed — so, let's talk software.

The Printer Buffer

What do we demand of a printer buffer? The primary aim is to release the host micro from the task of driving the print stream sooner than is possible at the real printing speed of the mechanical hardware. We are more interested in keeping the micro transfer (write) speed as high as possible than in keeping the already very slow printer working at maximum speed.

Most practical solutions turn out to be small standalone microsystems, consisting of a CPU, program ROM, RAM for scratchpad and buffer storage, and suitable input and output ports for the host micro/word processor and printer. Logic could be used instead of a

The ETI printer buffer from July, 1985.



micro, in view of the relative simplicity of most of the control programs, but the design effort is probably not merited at the low speeds demanded of a printer buffer.

Most printers can work at a maximum of about 150 characters per second, and host transfer rates greater than eight to ten times this are unlikely to be required except under the most arduous of conditions, when you are not well advised to use a home micro anyway.

The immediately obvious answer is to load a very large buffer from the host in a single high speed burst transfer, and then release the host and let the buffer take over the task of supplying data and control signals to the printer hardware until it is completely empty again.

This type of alternate load/unload buffer consists of an array starting from a fixed base, into which the buffer's micro loads characters presented by the host until either the array is full or the file transfer is complete. A chosen signal — a control code, for example — is used to indicate end of file.

The buffer's micro then resets the array and sends the characers one-by-one to the printer. Either the terminal count reached by the loading operation or the control character (appended to the file during the store mode), is used during output to indicate when all valid characters have been sent. This is the principle used by BASIC for its DATA statements.

Such an implementation is fine for word processing if your buffer is guaranteed to be larger than your maximum document size, but if you are spooling intermittent output from a program (for example, the results of calculations) you will have problems as soon as the buffer is full. The host must then be flagged to stop sending, and is held up until the buffer has been completely emptied again. So, there is practically no buffering action unless output from the host is continuous, and the total data volume is less than the buffer size.

A solution to this hang-up is to use a small buffer and let the buffer's micro interrupt the host *when it is empty*, allowing the host to proceed with other tasks in the interim and placing on the buffer the requirement to request data. This needs more than the ideal minimum of buffer support code to reside in the host, and also raises problems of scheduling to avoid data losses, even supposing the host can find something useful to do while waiting for buffer access.

We are more interested in keeping the micro transfer speed as high as possible than in keeping the already very slow printer working at maximum speed....

An alternative design, which is much better, although it needs a little more thought in implementation, is a buffer which can alternate according to demand between read and write operations on a byte-to-byte basis, keeping track of free space and using it as needed. The absolute size of the buffer RAM then has less effect on performance, and you can happily keep sending data to the buffer all day long without hanging the host micro up more than very occasionally.

Next month, we'll move on to a consideration of just such a buffer — the software semi-synchronous FIFO.

ETI

VALVE PREAMPLIFIER

Jeff Macaulay sets out to prove that thermionic emission isn't simply a load of hot air.

Despite twenty - odd years of solid state audio development there are still many audio enthusiasts who swear that valve equipment is better. At first sight these beliefs may seem a little eccentric; after all, modern semiconductor equipment boasts specifications which, at least on paper, far exceed those obtained with valves. In addition, valves require high voltages and a separate supply for the heaters. Another problem is that the parts can be difficult to obtain nowadays.

On the plus side, valves are approximately ten times more linear than transistors and are simple to design around. Furthermore the large signal swings available make it far easier to obtain high overload margins and low distortion at the same time without overall negative feedback. These features make the valve ideally suited to preamplifier designs.

The design to be described here is a stereo preamplifier which has an RIAA-equalised input for disc and un-equalised or 'flat' inputs for tuner, tape, compact disc, etc. Three double-triode valves are used giving a total of six active devices, three in each channel.

Figure 1 shows the complete circuit diagram of one channel of the preamp. One of the double triodes, V1 is used to provide RIAA equalisation. The pickup cartridge is fed directly into the grid of the lower triode which is held at ground potential by R3. This component also defines the input impedance to the required value of 47k.

The triode acts as an input voltage to anode current converter, a transconductance amplifier. The anode is held at a constant DC level of about 100V by the cathode of the second triode, V1a, which acts as a capacitance multiplier for C1. R1 and R2 provide grid bias whilst C1 decouples the grid to ground at AC.

As the second triode is in series with the first it follows that the anode current flows through both valves. One of the advantages of the cascode configuration is that the output impedance is extremely high, several tens of megohms in fact. As this is so, it follows that the output voltage generated across the load network is directly proportional to the impedance of the network.

In this case the anode load is the network consisting of R4, R5, C2 and C3. At low frequencies, below 50Hz, R5 defines the gain at about 50. Above 50Hz the response rolls off at 6dB per octave until a plateau is reached at about 500Hz. This is due to the shunting effect of the series combination of C3 and R4. From 500Hz the response is flat until 2160Hz where it is 3dB down due to the impedance of C2. This component ensures that the response continues to fall at 6dB per octave indefinitely, thus producing the standard EQ.

As was mentioned earlier, the output impedance at the anode is very high so the impedance 'seen' by the following stage is equal to the impedance of the network at any given frequency. This never exceeds 33k, so feeding it to a second stage with an input impedance of 1M0 won't upset the equalisation.

Having discussed the EQ stage we can now turn our attention to the second stage of the preamp based around V2. One of the main disadvantages of valves when compared to their solid-state counterparts is their high output impedance. In order to match the preamp to ancillary equipment a reasonably low impedance drive is required.

The obvious answer is to use a matching transformer but these are expensive and also, unless very carefully designed, are prone to treble loss as well. The solution

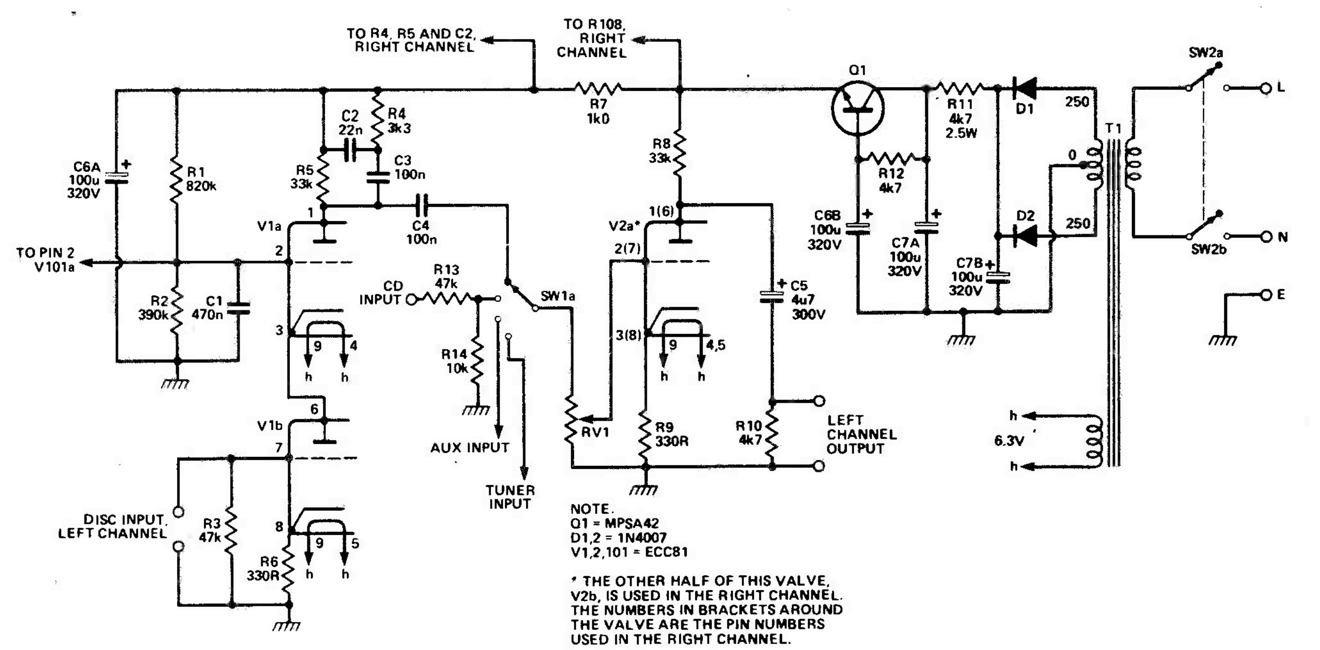


Fig.1 Circuit diagram of one channel of the valve preamplifier.

used here is to 'dump' some of our available gain to provide a lowish output impedance.

Refering again to Fig. 1, V2 is half a double triode, the other half being used for the other channel. The valve is used in standard common cathode mode. Input signals are fed into the grid which is biased to ground by RV1. The value of this component defines the input impedance of this stage. R9 provides cathode bias and a little negative feedback. The output appears across R8.

The gain of the stage is about 40 which is more than is required, so to provide a lower output impedance the signal is fed via C5 to R10. As the valve is capable of providing 10V RMS a 40dB overload ratio is obtained from disc.

R13 and R14 form an attenuator for high level inputs and the values are chosen with CD players in mind. The other input is designed for use with tuners and the sensitivity here is 50mV for 500mV output.

The Power Supply

The main problem associated with HT power supplies for circuits such as this one is the reduction of supply ripple.

With solid state audio equipment one can rely on overall feedback to reduce ripple voltages at the output. This is not the case here, so the key to getting a good sound is the quality of the power supply.

It is often said that amplifiers simply act like a kind of magnifying glass enlarging an already present signal. Nothing could be further from the truth! An amplifier, any amplifier, manufactures an enlarged copy of the signal presented at its input. It does this by modulating an external power source, the power supply. No matter how good the signal path may be, if the power supply misbehaves you will have a bad-sounding piece of equipment.

In the present case the valves are operated in class A. That is to say that current consumption doesn't alter with varying input levels. To provide proper operation a low impedance output supply is required. In particular the impedance seen by the circuit between HT and ground must be as small as possible. To this end, the HT winding on T1 is centre-tapped and is full-wave rectified by D1 and D2. If I were a valve freak, which I'm not, I might use an EZ80 here. The IN4007's do the

BUYLINES

Complete kits for this project (less case) will be available from Bewbush Audio, 47b Elmer road, Middleton-on-sea, Near Bognor Regis, Sussex PO22 6DZ. The price is £49.99 inclusive of VAT and postage. Those who prefer to find their own components should be able to obtain most of the parts without difficulty, but the mains transformer poses a problem. RS Components stock a transformer which supplies the correct voltages (order code 196-072) but it is rated to supply much higher currents than are needed in this project and in consequence is quite expensive. RS will only supply to trade and professional customers, but most local radio and electrical dealers will obtain RS parts for you or you can order by post through Crewe-Allan & Company of 51 Scrutton Street, London EC2 or Trilogic, 29 Holm Lane, Bradford BD4 0QA. The alternative is to wind your own transformers. The only other components which may not be too widely available are the valves, and these can be obtained from Cricklewood (see advertisement in this issue) or Marco Trading, The Maltings, High Street, Wem, Shropshire SY4-5EN, tel 0930 - 32763.

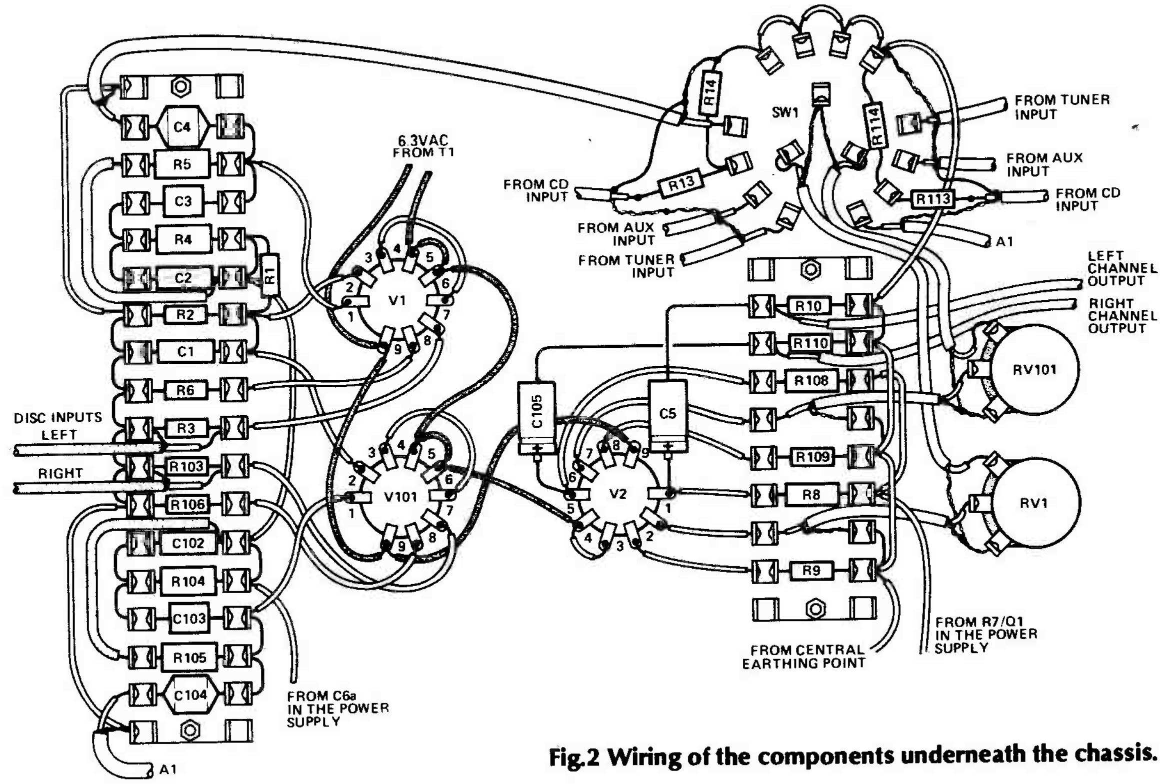


Fig.2 Wiring of the components underneath the chassis.

same job at a fraction of the cost.

Primary smoothing of the raw DC is done with C7B. R11 and C7A smooth the ripple down to a few millivolts. Final smoothing is achieved with a gyrator circuit comprising R12, Q1, and C6B. R12 and C6B provide a very smooth DC voltage to the base of Q1. The latter component acts as an emitter follower providing a very low output impedance supply for V2.

R7 and C6A provide further smoothing and hefty decoupling for the input stage. Ripple voltages here are miniscule, of the order of a few microvolts.

Construction

Before assembling any part of the preamplifier you will have to decide what sort of case it is be built in and how the valves are to be mounted. The traditional approach, of course, is to use a case with a chassis in it and to mount the valveholders through the chassis. If this is your preferred method, use Figs. 2 and 3 as a guide and cut the holes for the valveholders with a ¾" metal punch.

An alternative approach is to bolt the tagstrips and other components through the floor of a case in the usual way and to mount the valveholders on stand-

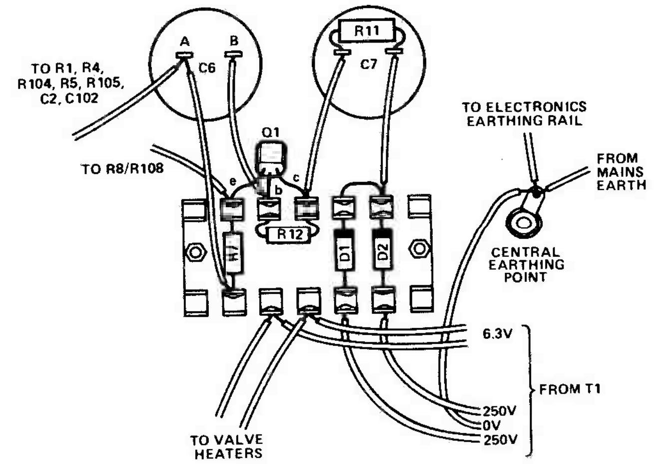


Fig.3 Wiring of the power supply.

off pillars. If you do this, make sure the pillars are long enough to prevent the valveholder pins touching the case metalwork and use either nylon pillars and/or sleeved connections so that there is no risk of a pin shorting to the pillar. Bear in mind that the layouts in Figs. 2 and 3 show the underside of the valveholders and that the connections will run in reverse order if you are wiring them from above.

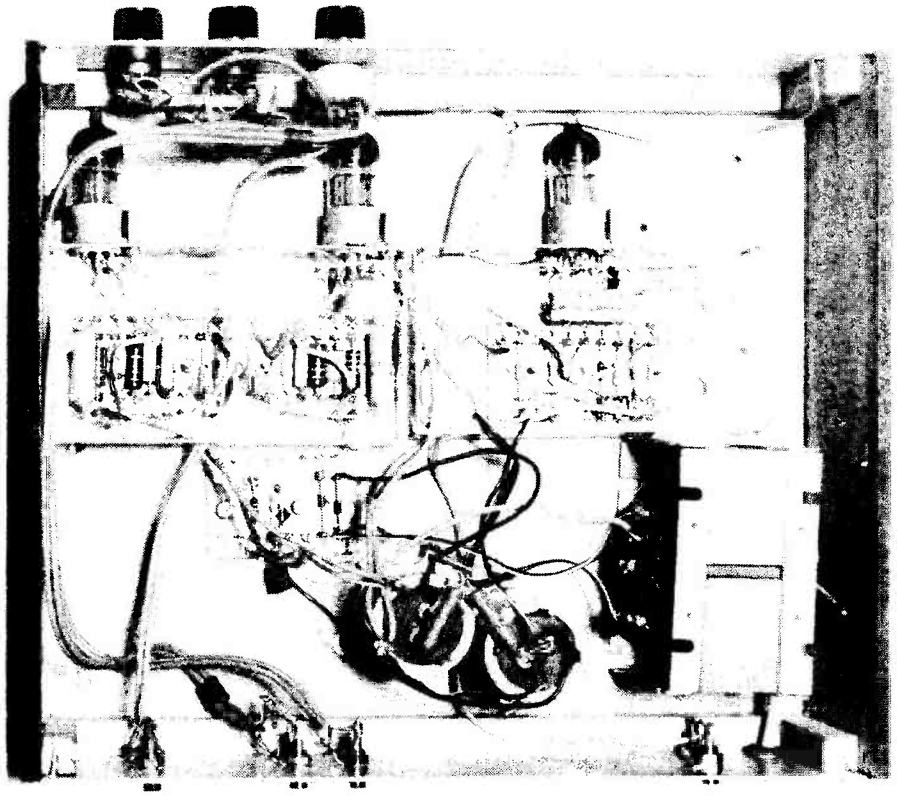
As a final suggestion, a small metal box could be used as a chassis within a larger case. An example of this can be seen in the photograph. The boxes are of the type designed to carry conduit and wiring behidn wall switches, etc, and have pre-punched metal holes which are, conveniently, ¾" in diameter. They may not be particularly attractive but they work as well as any other mounting method.

When your chosen case or chassis is ready, begin assembly by installing the valveholders and the tag-strips. The tagstrips have to be held above the chassis to avoid shorting the contacts, and this is best done either with small spacers, or, if these are not to hand, with a couple of nuts between the tagstrip and the chassis. Both the valve holders and the tagstrips should be secured by means of 6BA screws and nuts.

Wiring up a circuit on tagstrip is no more difficult than wiring up a PCB. Start by assembling the components onto the tagstrip, and then solder them. Remember to solder both ends of each component and visually check as you go that there are no dry joints. When all the components are in place, wire the links.

The easiest way to wire the interconnections is as follows. First wire the heaters as shown in Fig. 2. Next wire the links between the valveholder pins. Lastly connect flying leads, about 4" long to the remaining pins and connect the other ends to their appropriate terminations on the tagstrip. Valve equipment is very forgiving about wiring errors, and it is almost impossible to damage the valves by incorrect connection. Nevertheless, if the illustrations and these instructions are followed there should be no errors anyway.

Figure 3 shows the layout and interwiring of the power supply. A seven-way piece of tagstrip is used to mount most of the components.



An internal view of the development prototype. We suggest you don't follow this layout too closely....

C6 and C7 are connected to earth through their cans which are not isolated. Q1 and R12 are mounted on the tagstrip as are D1 and D2. Note the orientation of these components. The central earthing point is a solder tag attached to the chassis by a 4BA screw and nut. For safety reasons a shakeproof washer should be used over the tag to ensure that this cannot loosen with time. For the same reason a plated screw should be used here as the brass variety tend to oxidise.

Having assembled the preamplifier you should find it operates first time. If not, an error has been made in the wiring up and this should be found and rectified.

If an error is found switch the equipment off and wait for at least fifteen minutes for the HT circuit to discharge. The HT lines have a low output impedance and are capable of delivering a nasty shock. Never attempt to service the unit with the mains connected.

Because of the high voltages used the equipment must be earthed. As often as not the power amplifier will already be earthed and in this case the preamplifier will be automatically earthed when connected to the rest of the system. In this eventuality earthing the preamp as well will probably cause a 'hum loop' with consequent reproduction problems. The answer here is not to earth the preamp! **ETI**

PARTS LIST

RESISTORS (¼W, 5% unless stated)	
R1	820k
R2	390k
R3, 13, 103, 113	47k
R4, 104	3k3
R5, 8, 105, 108	33k 1W0
R6, 9, 106, 109	330R
R7, 107	1k0
R10, 12, 111	4k7
R11	4k7 2W5 wirewound
R14, 114	10k
RV1, 101	1M0 single-gang potentiometer
CAPACITORS	
C1	470n 250V polyester
C2, 102	22n 250V polyester
C3, 4, 103, 104	100n 250V polyester
C5, 105	4u7 300V electrolytic
C6, 7	100+ 100u 320V electrolytic
SEMICONDUCTORS	
Q1	MPSA42
D1, 2	IN4007
VALVES	
V1, 2, 101	ECC81
MISCELLANEOUS	
SW1	3-pole, 4-way rotary switch
SW2	DPDT mains toggle switch
T1	250-0-250V + 6.3V/2A mains transformer

Chassis; B9A chassis-mounting valve-holders, 3 off; double-row miniature tag strip, 1 off 18-way, 1 off 10-way and one off 7-way; capacitor clips for C6 and C7; Knobs, case and input/output sockets as required; nuts, bolts, solder tags, spacers, etc.

Right channel component numbers are left channel numbers plus 100. Note that some components are common to both channels and only one of each is required (eg., R1, R11, C6, etc.).

INTELLIGENT CALL METER

The trouble with most telephone call meters is that you have to tell them so much - whether it's a local call or not, what time it is, etc. Of course, says Chris Ranklin, a really intelligent call meter would work all that out for itself....

The intelligent call meter is a fully-automatic device which provides a continuous display of the cost of a telephone call as it progresses. It can handle both UK and international calls, has a memory which stores details of the last 135 calls made, and features a battery back-up to protect the stored data in the event of a power failure. It couples into a standard British Telecom telephone line using an opto-isolator for safety and when not in use provides a 24-hour clock display.

The meter is connected in parallel with the telephone line it is monitoring, either by hard-wiring or by means of a dual adaptor which plugs into a standard BT socket. When the receiver is lifted and a number dialled, the call meter analyses the tones and voltages appearing on the line to determine whether the call is to a local, A, B, or B1 number. It also uses data from an on-board clock and calendar to select the appropriate charge rate. The four-digit display then shows the cost as the call proceeds up to a total of £99.99 (which is unlikely to be exceeded on one call!).

International calls are analysed in much the same way but there is the problem that many different dialling tones are used around the world. To overcome this, a button is provided which can be used to start the meter as soon as a call is connected. The meter will then assume international call charges and use the clock and calendar data to calculate and display the appropriate rate.

When a call is completed, the meter will store the final cost and

WARNING!

This circuit does not have BT approval and should therefore not be connected to a BT telephone line. It can, of course, be used with private exchanges or as the basis of a submission to BT for approval.

the number dialled in its memory. Up to 135 calls can be stored in this way, the earlier entries being dropped in favour of the newer ones when the memory is full. By pressing a button, the meter can be made to display the cumulative cost of all the calls it has details of in its memory, up to a total of £999.9. The charge rate information which the meter uses is itself held in RAM and can be changed readily when BT change their prices.

The Circuit

The call meter is designed around a Z80 microprocessor. A 2716 EPROM stores the operating software and a 6116 RAM holds the variables (call charge data, etc.) and stores details of calls made. The 6116 has a battery back-up which is trickle-charged from the supply during normal operation. This circuitry is contained on one board along with the four-digit liquid crystal display and the display drivers. The layout has been arranged so that the display can be mounted

On	0.4 secs	Tones are 1 volt 400 or 450 Hz Modulated by 17, 25, or 50 Hz
Off	0.2 secs	
On	0.4 secs	
Off	2.9 secs	
Repeat		
On	0.35 secs ←	Tones 400 or 450 Hz
→ Off	0.22	
On	0.40 secs	
Off	0.20 secs	
On	0.40 secs	Any start Position ←
Off	2.0 secs	
Repeat		

Table 1 Dialling tones and times used on the public telephone network.

Line voltage	-50 volts with respect to earth
Dialling tone	400 Hz or 450 Hz continuous
Bandwidth	300 Hz to 3400 Hz
Ringing-in	63 volts to 100 volts 17 Hz or 25 hz
Busy line	400 Hz 1 volt, 750ms on 750ms off
Number unobtainable	400 Hz 1 volt continuous
Pay tone	400 Hz 1 volt, 125ms on 125ms off

Table 2 Telephone line signal conditions and voltage levels.

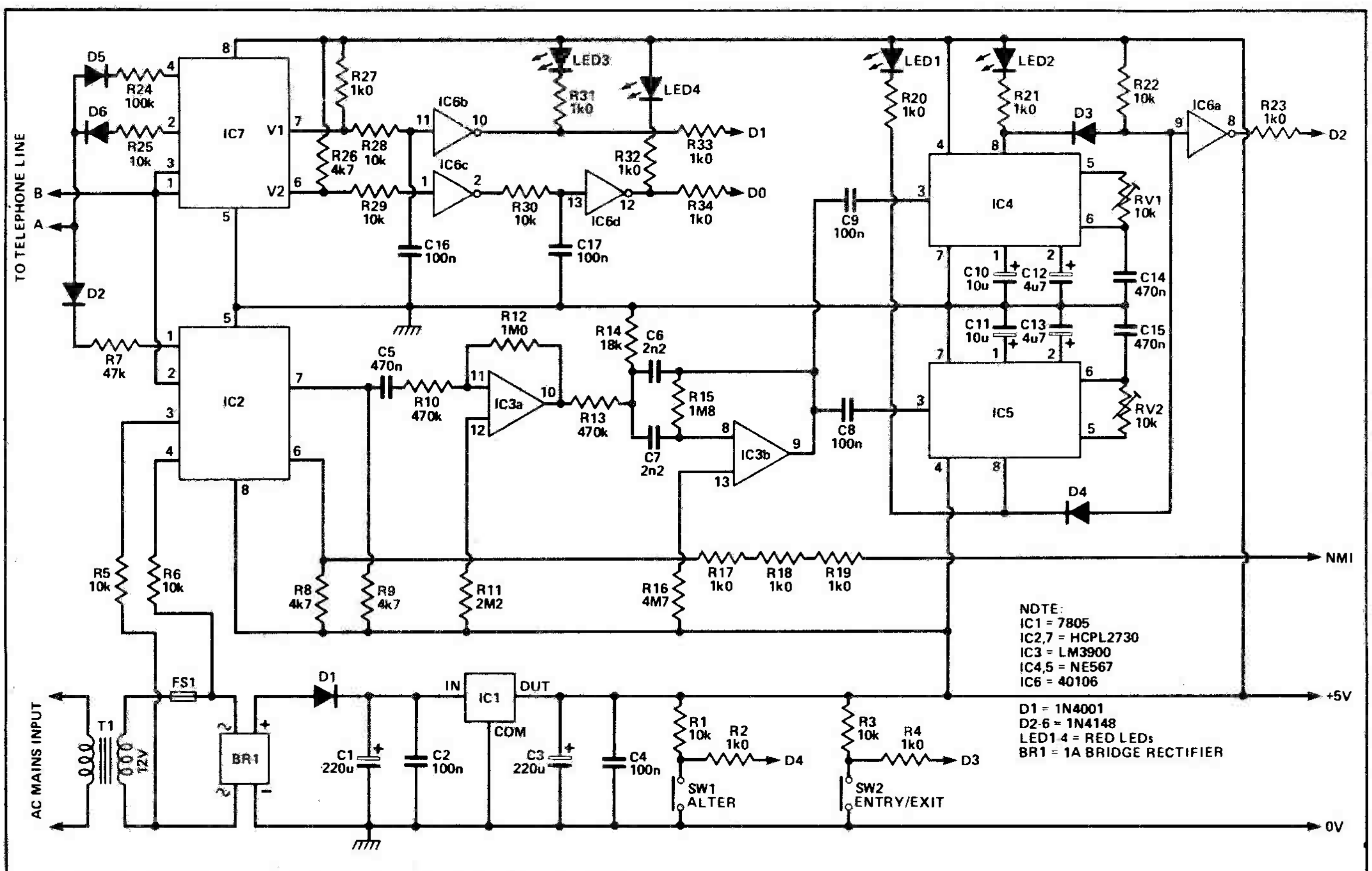


Fig. 1 Circuit diagram of the call meter interface board.

HOW IT WORKS - INTERFACE BOARD

Diode D5 and resistor R24 limit the current through IC7 to about 0.5mA. The V2 output of IC7 is buffered by IC6c and d, noise and interference being removed by resistor R30 and capacitor C17. This is connected to the data 0 input on the port.

Diode D6 and resistor R25 pass any positive voltage appearing on the line. This occurs during ringing in and when a local call is conected. The V1 output is buffered by IC6b and connected to the data 1 line. R28 and C16 remove any interference.

Diode D2 and resistor R7 rectify and limit the current through IC2 to approx 1mA. The V1 output is connected to IC3a which is an LM3900 amplifier with a gain of two. The signal then goes to IC3b which is connected as a 400 Hz bandpass filter. This is fed via C8 and C9 to LM576 phase-locked-loops, ICs 4 and 5. The lock range is set by RV1 and RV2 for 400 and 450 Hz. The output from these 567s is fed into the diode gate formed by R22, D3, D4 and buffer IC6a and then to the data 2 input on the port.

When the phone is down on the hook D0 is at 0 volts; if the phone is lifted D0 goes to 5 volts. The telephone handset pulses the line for 33ms with 66ms between each pulse during a dialling operation. There is a minimum delay of 400ms between each number dialled and this is called the interdigit pause (see Table 3). This figure, in 1/50ths of a second, is stored at memory location 0280 as 1B (hex).

On pulse	33ms
Off pulse	66ms
Interdigit pause	400ms min
Clear forward	700ms min
Seizure	50ms min

Table 3 Telephone handset pulses.

If the phone is replaced for 700ms the line is cleared and you get a dialling tone. This figure in 1/50ths of a second is stored at memory location 026B and 036D as 23 (hex). When local calls are connected a positive voltage appears on the line. This is called local reverse battery and D1 goes to 5 volts. This doesn't happen on calls to the operator so the machine will not charge for them.

For long distance calls, the 567 phase-locked-loop detects the ringing tone which has a minimum length of 400ms. The 567 will not respond immediately due to turn on delay, so a minimum figure of 280ms is stored at memory location 0383. Any interference or noise of shorter duration than this will not be regarded as a ringing tone and will be ignored. The maximum no ring time is 2 seconds + 0.22 seconds + turn on delay: a figure of 2.4 secs is used. See Table 1 for dialling tones and time lengths. A greater time than 2.4 seconds means either the phone is down or the call is through. If D0 is high and the ringing has stopped the call has been answered. If D0 is low the phone is down.

When the phone is ringing-in, D0 goes to 5 volts and D1 goes to 5 volts (see Fig.2 for ringing-in waveform and trip point). The software between 0253 and 0263 recognises this as ringing-in and ignores it.

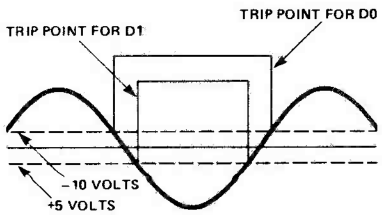


Fig. 2 Ringing-in waveform and trip points.

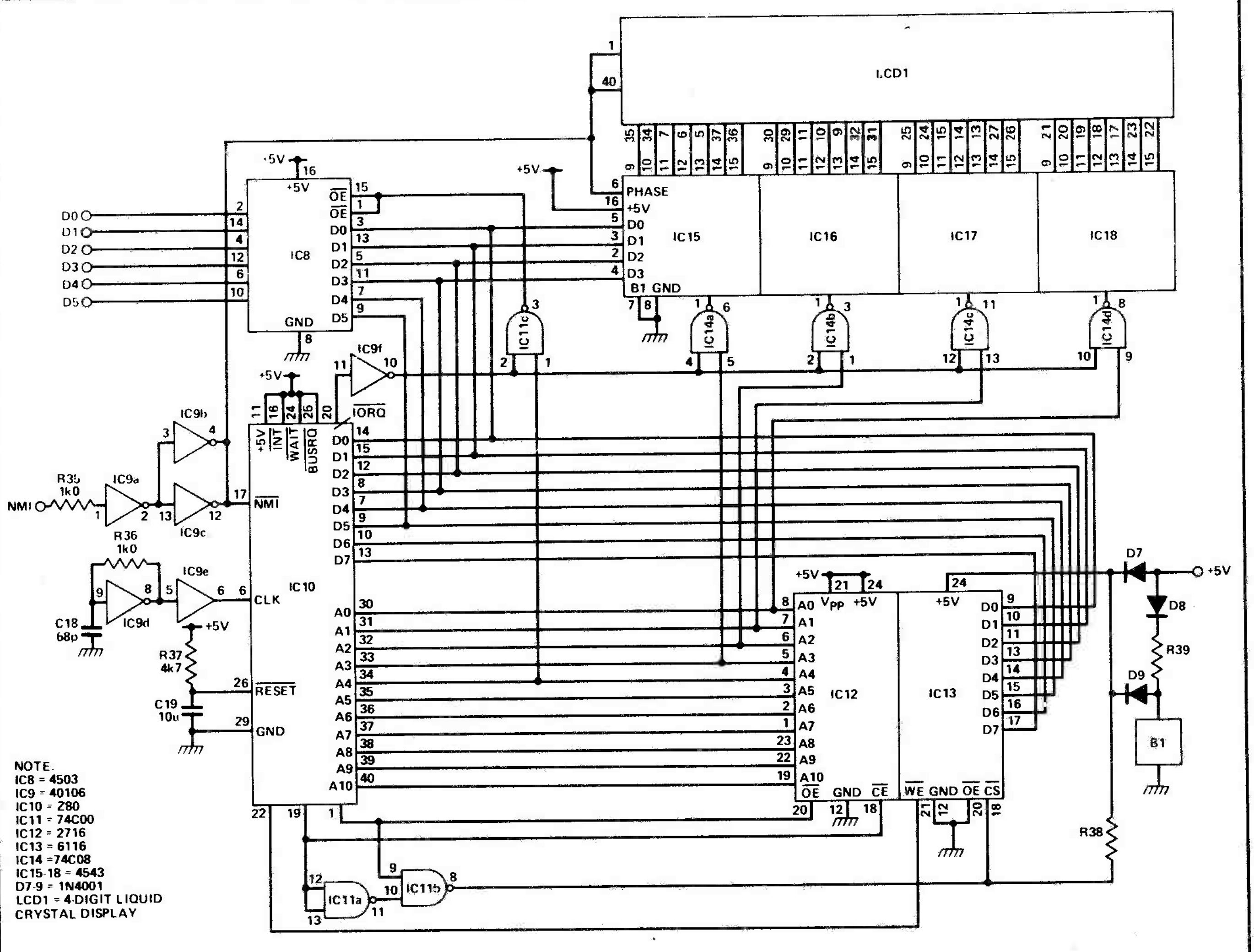


Fig. 3 Circuit diagram of the main board of the call meter.

HOW IT WORKS - MAIN BOARD

On power up C19 and R37 reset the Z80 to memory location 0000. IC9d is connected as a 2.6 MHz low power oscillator, and IC9e buffers this to the Z80 clock. The actual clock frequency is not critical as all timings are taken from the 50Hz mains. IC2 on the interface board detects the 50Hz sine wave on the transformer secondary and converts it to a square wave. This is fed to IC9a, then to IC9b and c which are connected in parallel for extra drive. The square wave is fed to the NMI of the Z80 as an interrupt every 1/50th of a second. This is also fed to the LCD backplane and phase of the driver chips (ICs 15 to 18) for update and display purposes.

The memory is kept as simple as possible as can be seen from the circuit diagram. The 2716 ROM IC12 is enabled by A11 (low) plus Mreq (low) in the range 000 to 7FF plus. This chip holds the software program.

PIN		18	20	21		
		Mreq	A11	Vcc		
2716		L	L	H	Dout	Read
		L	H	H	High Z	Off
		H	X	H	High Z	Off
	InvA11+	Mreq	Gnd	Wr		
6116		L	L	H	Dout	Read
		L	L	L	Din	Write
		H	X	X	High Z	Off

Table 4 Details of the memory addressing.

The 6116 RAM IC13 is enabled by A11 (high) plus Mreq (low). This is done by IC11a and b for the range 800 to FFF. During normal use power is fed via diode D7 to IC13 pin 24. Diode D8 and resistor R39 trickle charge the battery. During power down, battery B1 provides power via diode D9 with diode D7 blocking power to the rest of the circuit.

The input port consists of a 4503 tri-state hex buffer (IC8) which is enabled by IORQ plus A4 (IC11c).

directly onto the board and viewed through a cut-out in the case.

A second board mounts below the first one in the case and carries the remainder of the circuitry (with the exception of the mains transformer, etc). Two HCPL2730 opto-isolators are used, these devices having specifications which meet BT requirements (BT spec. D5002). One of the opto-isolators connects to the telephone line while the other derives a 50Hz signal from the mains via the transformer secondary. Although a 2.6MHz oscillator is contained on the main board, all timings are taken from this signal which provides a regular 1/50th of a second interrupt to the microprocessor. All delays and timed intervals are set-up in the software as multiples of 1/50th of a second and the internal clock and 7-day calendar are also generated in software directly from this signal.

Also contained on the opto-isolator board are a regulated power supply and two phase-locked-loops. The PSU uses a standard 5V IC regulator and supplies both boards. The two phase-locked-loops take the output from the telephone line via one of the opto-isolators and detect the 400Hz and 450Hz ringing tones which indicate long-distance calls.

In use, the output from the opto-isolator goes high when the receiver is lifted. There is then a short delay to allow for the response time of the phase-locked-loops and to ensure that any short duration noise or interference on the line is ignored. At the end of this period the software interrogates the data lines to determine whether the call being made is to a local or a long distance number. The output from the phase-locked-loops goes high to indicate long distance calls while the output of the opto-isolator goes high when a positive voltage appears across the telephone line. This occurs only on local calls. This voltage will not be present during calls to the operator so the meter will not charge for them.

The meter will not count-up charge while the line is ringing. As soon as the ringing stops, the software institutes a short delay before checking the line again. If the ringing has then resumed, the pause was probably just the normal gap between successive ringing tones. If the ringing is still absent at the end of the delay, the phone has either been put back on the hook or the receiver at the other end has been lifted and the call is through. The output from the opto-isolator will have returned to 0V if the receiver has been replaced, so if this line is still high it indicates that the call is through. The meter will then check the time at which the call is established, determine a charge-rate and begin counting-up the cost of the call.

When a call is received, both the opto-isolator and the phase-locked-loop outputs will be high during the ringing period. The software will recognise this as an incoming call and will not display a charge. When the 'phone is not in use at all, the system will revert to displaying 24-hour time.

To be continued. **ETI**

DIGITAL PANEL METER

Paul Chappell gets the measure of a meter...

Our panel meter offer in the April issue was so popular that all the available stocks sold out within a few weeks, leaving many readers disappointed. As we can't get hold of any more, we thought the next best thing would be a project to build your own. The specification for this meter is similar to the one in the offer: 3½ digit LED display with a full-scale reading of 199.9mV. In this meter, however, the display and control boards are separate so that you can mount them separately if required with a length of ribbon cable in between.

Dual Slope Conversion

The project is based on the ICL7107 panel meter IC, which is essentially a dual slope A-to-D converter with internal decoding and driving circuits for 7-segment LED displays. Dual slope is a relatively slow method of A-to-D conversion; it can take up to 6,000 counts, or 24,000 clock cycles (the clock is internally divided by four to give the count rate) for the 7107 to perform a conversion, as opposed to only about 12 cycles for a successive approximation converter of similar resolution.

The advantage of the technique is that it can produce very accurate results with relatively simple and trouble free circuitry. For a voltage meter, it fits the bill nicely: two or three conversions a second is all that is required, and the 3½ digit (approximately 11-bit) accuracy is all important.

Figure 1 illustrates the general principle of dual slope conversion. At the beginning of the conversion, SW1, which represents an analogue switch, is set to position 1 for a fixed number of clock cycles. The circuit around the op-amp is an integrator, so C1 will charge up at a rate proportional to the input voltage. At the end of the charge period, SW1 is set to position 2 and C1 discharges at a known rate dependent on the value of -V ref.

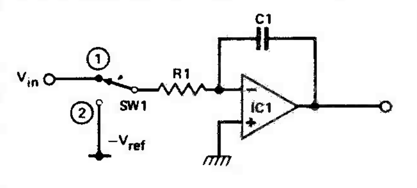


Fig.1 Integrator used for dual slope conversion.

The clock cycles during this phase are fed to a counter - the number that occur during the discharge will be proportional to the voltage on the capacitor at the start of this phase, and therefore to the input voltage.

By judicious selection of the timing periods, the output count can be made to indicate the input voltage directly. For instance, suppose that $-V_{ref}=-1$ and the charge period was selected to be 1,000 clock cycles. For an input of 1V, the output count would also be 1,000; for an input of 2V the count would be 2,000, and the counter would indicate the input voltage directly at a scaling of 1 count per mV.

Error Reduction

As long as the sum of the errors in clock frequency, capacitor leakage, resistor temperature drift and so on can be kept to within 0.05% during each conversion cycle, the converter will be accurate enough for a 3½ digit meter.

This is an outrageously demanding specification for long-term drift, but can be met without much trouble for the time of a single conversion cycle. The beauty of the circuit is that long term stability in these factors doesn't matter in the least. If the value of R1 drifts, for instance, C1 may charge to a slightly lower voltage for a given input, but the discharge will be proportionately slower, and the two factors cancel out leaving the count exactly the same.

Unfortunately, there is one source of error that will not cancel: voltage offset in the op-amp. Suppose that the op-amp has an input voltage offset of 1mV. Since the non-inverting input is grounded, the virtual earth point at the inverting input will be at -1mV. this means that an input of 0V will be seen as an input of 1mV (it will cause current to flow into the virtual earth since R1 will have 1mV across it), an input of -1mv will be seen as zero (since no current will flow in R1) and all readings will similarly be offset by 1mV.

In a practical circuit the input to the integrator would be buffered, the output would go to a comparator, and each would introduce its own time and temperature dependent offset into the circuit, probably adding up to several mV. In the 7107, with a 200mV full-scale, this would have disastrous results: each count on the display represents 100µV, so the last two digits of the display would be totally unreliable!

Offset errors are cancelled out by the 7107's auto-zero circuit, the principle of which can be seen in Fig.2. The circuit is the same as Fig.1 apart from the addition of C2 and some extra switching.

The conversion now has three phases. In the first SW1 disconnects R1 from the input and grounds it. At the same time, SW2 connects the output of the op-amp to its non-inverting input. C2 and C1 have no effect on the op-amp, since they are shorted by SW1, so the circuit stabilises with points A and B both negative offset voltage, and point C at 0V due to R1. Enough time must be allowed for C1 and C2 to discharge via R1; this 'auto-zero' phase has a period of 1,000 counts in the case of the 7107.

When the circuit enters the charge phase, SW2 is opened and SW1 connects R1 to Vin. The op-amp's offset voltage will be held by C2, so point C will still be at

0V. This means that an input of 0V will no longer cause a current in R1, and the offset has been cancelled.

It may not have escaped your notice that C1 will also have the op-amp's offset voltage across it. In this simple circuit, the right-hand side of C1 would have to be disconnected from IC1 and grounded during the auto-zero phase. In the 7107, the comparator which follows the integrator is also included in the

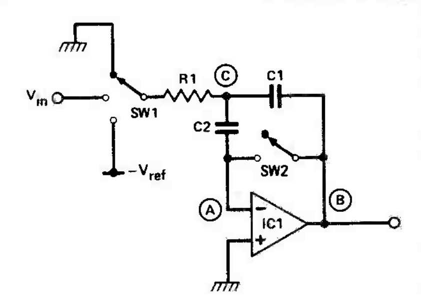


Fig.2 Modified integrator giving offset cancellation.

auto-zero feedback loop, which makes this unnecessary.

Figure 4 is the analogue section of the 7107, taken directly from the Intersil data book. It isn't as complicated as it looks! The integrator corresponds to our op-amp, C_{INT} to C1, C_{AZ} to C2 and R_{INT} to R1. The op-amp feeding R1 buffers the input, and the comparator provides a logic signal to denote the end of the discharge phase of C_{INT}. The circuit around the 6.2V zener is a voltage

HOW IT WORKS

The bulk of the work is performed by the 7107 digital voltmeter IC, which is essentially an A-to-D converter with internal circuitry to drive four 7-segment LED displays. The full scale range of the IC is twice the voltage difference between pins 35 and 36. For a 200mV full scale (a maximum reading of 199.9mV), this voltage is set by R2 to be 100mV. A reference voltage 2.8V below the positive supply voltage is available at pin 32, and this holds the voltage across R2 and RV1 at 2.8V so that the voltage set by RV1 will be stable.

R1 and C1 are the timing components for the internal oscillator. For reasons explained in the text, the oscillator does not need exceptional long term stability, so there is little point in using a crystal or choosing high stability components for timing. R3 and C3 form a very simple low-pass filter to cut down any noise at the input, and R3 also provides some degree of protection for the IC against accidental connection to excessively high voltages.

C2 holds the reference voltage used during the 'de-integrate' phase of the conversion (see text). The capacitor is charged up to the reference voltage during the first (auto-zero) stage of conversion. A bridge arrangement of switches inside the IC (Fig.4) allows the voltage stored to be used either way around, according to whether the input voltage to be measured is positive or negative. C4 is the auto-zero capacitor, C5 the integrating capacitor and R4 the integrating resistor. The function of these components is explained in detail in the text.

The sole function of IC2 is to provide a negative supply voltage for the 7107, so that the circuit will run from a single +5V supply. It is a hex inverter IC: one of the inverters is used to present a single gate load to the 7107's clock. This inverter drives the remaining five in parallel, which in turn drive the voltage pump consisting of C6, D1, D2 and C7. This generates about -3.5V, which is fed to pin 26 of the 7107.

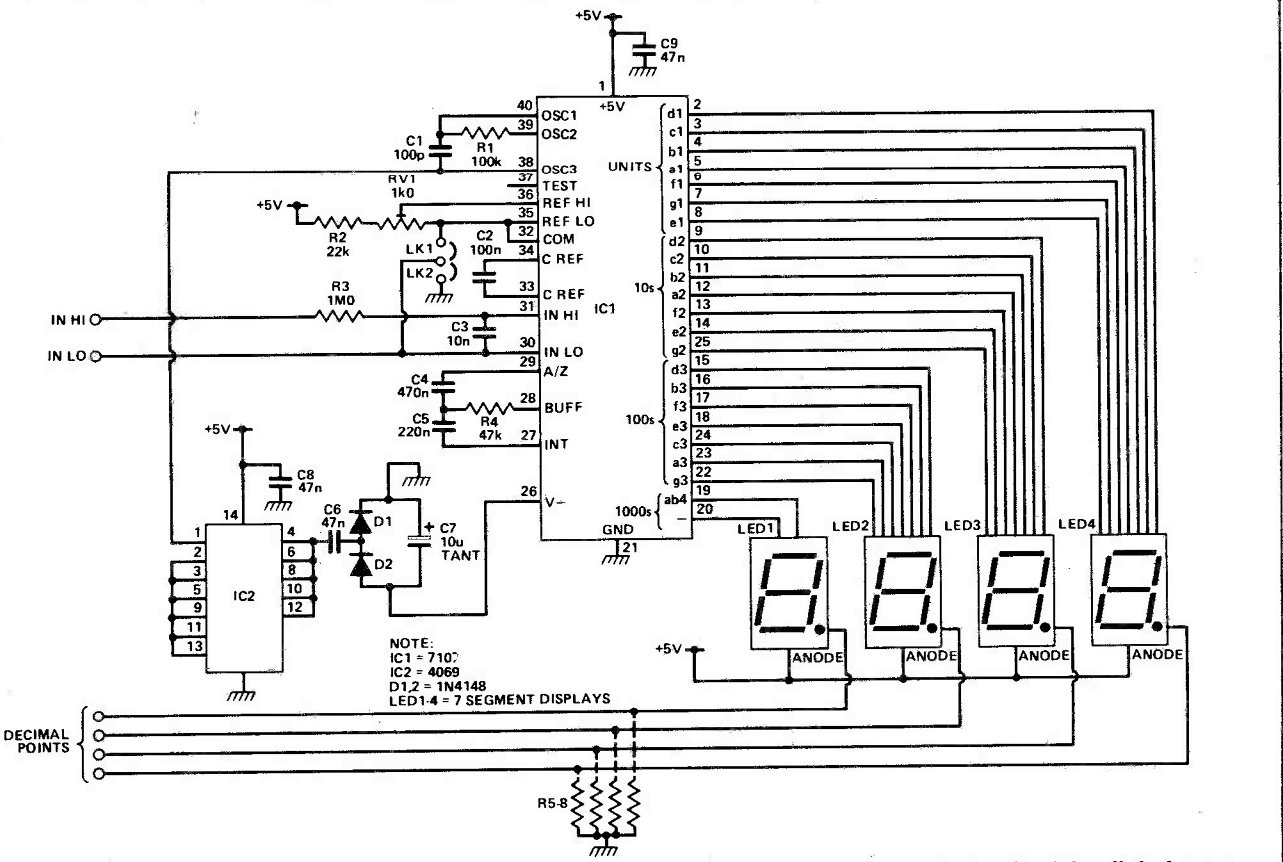


Fig.3 Circuit of the digital meter.

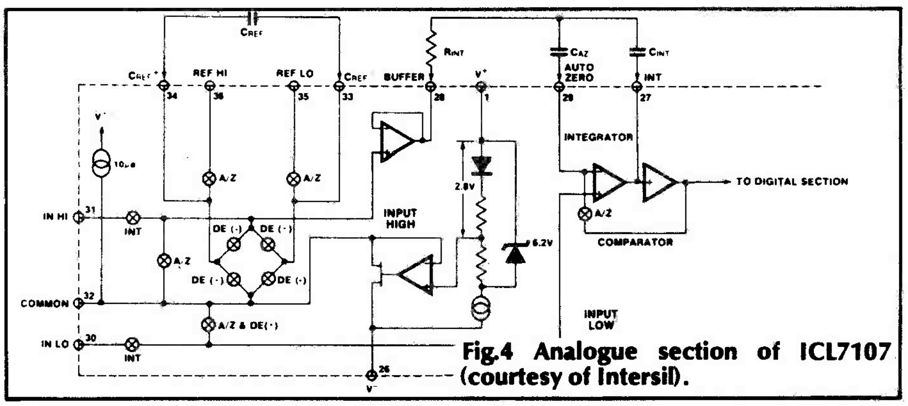


Fig.4 Analogue section of ICL7107 (courtesy of Intersil).

regulator which establishes a reference voltage 2.8V below the positive supply voltage, available to the internal circuit, and also to circuitry outside the IC via pin 32.

The remainder of the circuit is analogue switching - more complicated than in Fig.2 since it allows for negative inputs and a corresponding positive reference voltage. Switches marked AZ are closed during the auto-zero phase, INT during the integrate phase, and DE during the discharge or 'de-integrate' phase.

Two small points: in the 7107, both the inverting and non-inverting inputs of the integrator are connected to the 'common' reference voltage rather than to ground. All that is required for the auto-zero phase is that they should be at the same voltage.

Secondly, it may seem that the offset introduced by the input buffer will not be cancelled. It will. To see why, just imagine a voltage source equal to this offset voltage between the switch and R1 in Fig.2. The junction of C2 and C1 would end up at this offset voltage at the end of the auto-zero phase, and a subsequent 0V input, when offset by the buffer, would still result in no current in R1.

Construction And Setting Up

The two PCBs are assembled according to the overlay in Fig.5. The two boards can be mounted together in a 'sandwich', with the two track sides facing each other. Quarter-inch spacers between the boards will be adequate to prevent any short circuits, and the mounting screws will go through both boards and hold them firmly. The smaller display board can be fixed either at the top or bottom of the driver board, according to which you find most convenient. If the driver board takes up too much space behind the front panel, it can be mounted separately, the two boards being joined by a length of ribbon cable.

The meter requires a supply of 5V DC. In applications where the voltage to be measured is floating with respect to the meter's power supply (as in multi-meter type circuits), link LK1 should be made. If the circuit on which the voltage measurements are made is running from the same power supply, link LK2 can be made to measure voltages with respect to 0V. If differential voltages are to be measured, neither link should be made. In this case, bear in mind

PARTS LIST

RESISTORS all ¼W 5% carbon film	
R1	100k
R2	22k
R3	1M0
R4	47k
R5,6,7,8	180R (see text)
CAPACITORS	
C1	100p ceramic
C2	100n polyester
C3	10n ceramic
C4	470 polyester
C5	220n polypropylene
C6	47n polyester
C7	10μ6V tantalum

(C5 ideally should be polypropylene to prevent errors from dielectric absorption. If unobtainable, a polyester type can be substituted.)

SEMICONDUCTORS	
IC1	ICL7107
IC2	4069
D1,2	1N4148
LED1,2,3,4	0.5" common anode, seven segment displays.

MISCELLANEOUS

PCB, 0.1" connectors.

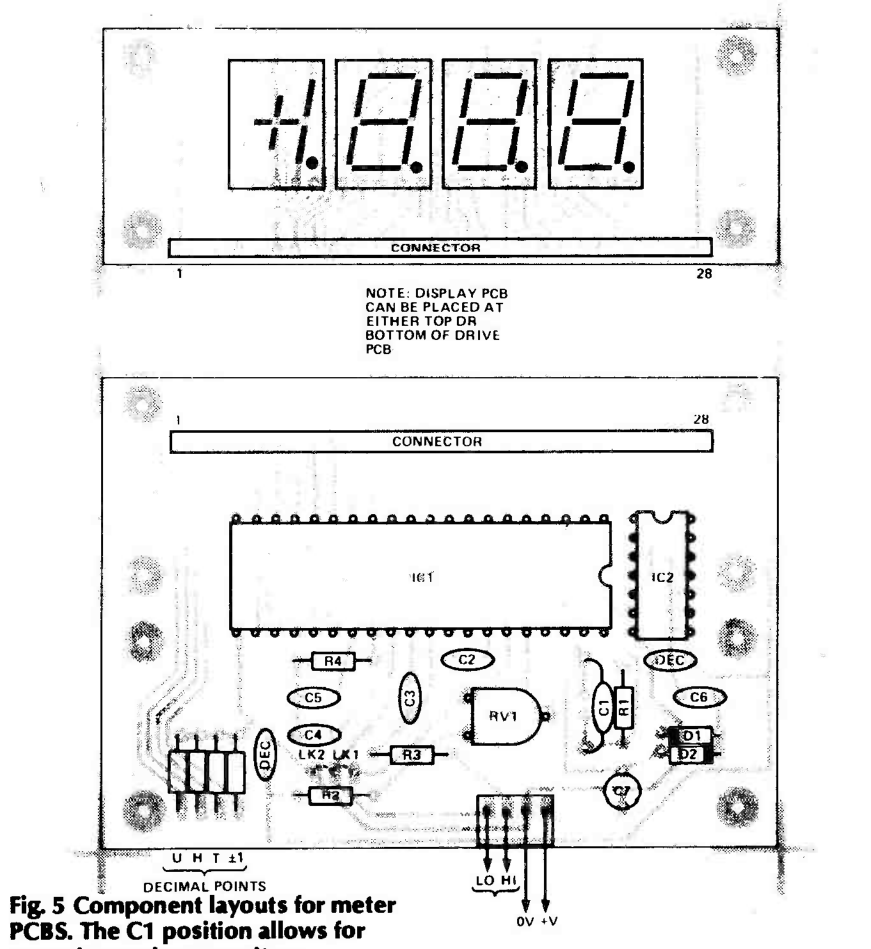


Fig. 5 Component layouts for meter PCBS. The C1 position allows for ceramic or mica capacitors.

that the common mode voltage range will be roughly +4.5V to −2.5V. If either meter input is taken beyond these limits, the readings will not be accurate, and if either input goes outside the range of +5V to -3V, IC1 may be permanently damaged.

Adjusting The Range

The full-scale reading of the meter, with the components shown, is 199.9mV. In some circumstances, you may prefer to choose a different range. Suppose that you decided to use the meter to measure pressure, using (for example) the 136PC15G1 pressure transducer. This device has a range of 0-15 PSI and an output of 6.67mV per PSI. One possibility would be to amplify the output to 10mV per psi, giving a meter display of 100 counts per PSI, so that 15PSI would give a reading of 1500. To avoid using an extra amplifier, the meter range can be adjusted; a full scale voltage of 133.4mV will give the required reading of 100 counts per PSI. Generally speaking, it is not a good idea to increase the meter sensitivity too far beyond 200mV full scale as it becomes more difficult to maintain the full 3½ digit accuracy, but reducing the sensitivity for higher inputs is always preferable to using voltage dividers since, besides keeping down the number of components, it minimizes the noise.

The full scale range of the meter will be twice the voltage appearing between pins 35 and 36. For the 200mV meter of Fig.5, this voltage is adjusted by RV1 to be 100mV. For small variations of the scale, say up to ± 10%, it is sufficient simply to adjust RV1. For larger variations, other component values must be changed. In general, for a full scale of n x 200mV, increase the value of R4 by a factor of n and divide the value of C4 by n.

For example, a range of 0 to 2V can be achieved by increasing the voltage between pins 35 and 36 to 1V (you will need to substitute a 20k preset for RV1 to allow this), multiplying the value of R4 by 10 to become 470k, and reducing C4 to 47n.

Applications

The frequency and capacitance meter circuits for the free PCB in the March and April, 1986, issues of ETI* can be used with this meter, and the 'bathminder' can easily be adapted for temperature measurement. Current readings can be made by the simple expedient of connecting a resistor across the input - a 1R0 resistor will give a range of 0 to 200mA and a 0R1 resistor will give readings up to 1.999 Amps.

For something a little more unusual, the circuit of Fig.7 will allow the meter to be used with a low cost strain gauge (see Buylines). A strain gauge is a device which changes its resistance in proportion to small changes in its length. The one we have suggested is made from a copper-nickel foil on polyester film, and will measure length changes up to ±4%.

Strain gauges are used in engineering to measure the effects of loading on mechanical structures - bridges, cranes, industrial machinery, and so on. The gauge is bonded to the surface of the part to be tested, and any strain as a result of the loading is converted to an electrical signal and sent to the measuring apparatus.

In robotics, a strain gauge can be used to give an indication of, say, the strain on a robot arm as a result of a weight that it is trying to pick up. The signal can be used to prevent the arm from attempting to pick up anything too heavy, or as part of a feedback mechanism to allow the robot to judge the weight it is carrying, and perhaps to help it to keep its balance.

A common application of strain gauges is electronic weighing. Transducers for this purpose, which incorporate strain gauges, are called load cells and are usually very expensive (£100 and up). However, the simple arrangement shown in Figs. 6 and 7 can give reasonable results - the strain gauge measures the extension of the lower surface of a sheet of steel, which will be roughly proportional to the weight placed on it over a certain range.

The gauge should be glued with epoxy resin or cyanoacrylate to a metal surface which has been thoroughly cleaned and is free of grease. Avoid touching the surface of the gauge that is to be bonded -

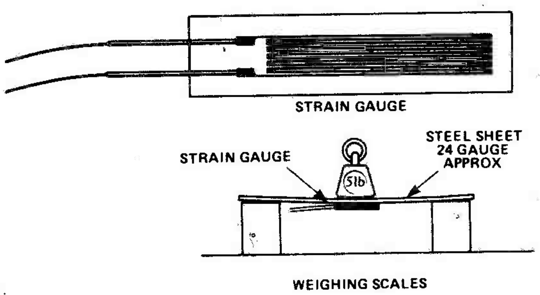


Fig.6 The structure and use of a typical strain gauge.

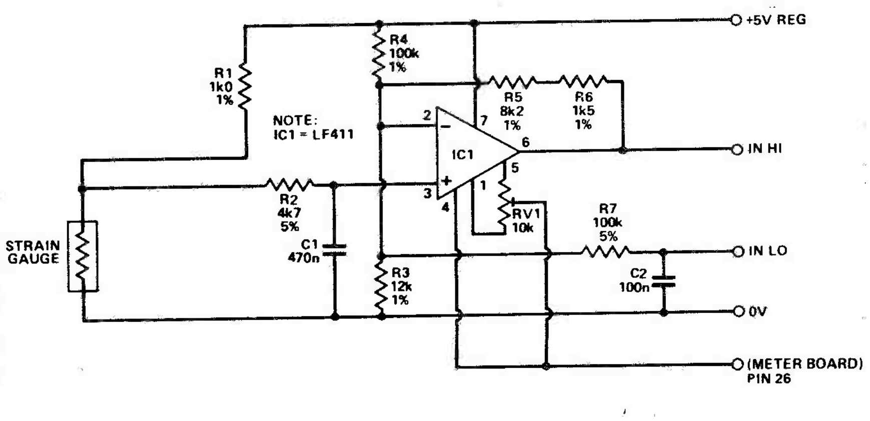


Fig.7 Circuit of strain gauge amplifier

it can be picked up and placed in position by means of adhesive tape applied to the top surface. Hold the gauge firmly in place while the glue is curing, and make sure there are no air bubbles underneath.

The components shown in Fig.6 are for a reading of 100 counts to 1% extension. The only adjustment to be made is to zero the meter reading with RV1 when the metal is unstressed. For weighing purposes, you will probably wish to adjust the gain of IC1 so that the meter scale gives a reading in grammes, pounds, or whatever. In this case, R5 and R6 can be replaced with a preset of a suitable value. Don't ask me what value - it depends on the mechanical arrangement of your weighing machine.

RV1 sets the full-scale voltage of the meter, and should be adjusted with a suitable accurate voltage source connected to the meter inputs. Alternatively, the meter can be calibrated against another voltage meter. Resistors R5 to R8 are for the decimal points on the displays. Only one resistor will be required, according to which decimal point you would like to light. The decimal point connections are also available at the edge of the board in case you have ambitions to make an auto-ranging meter, or suchlike.

BUYLINES

The ICL7107 is available from Watford and Cricklewood - see 'Linear ICs' in their ads in this issue. Polypropylene capacitors can be obtained from Maplin (see back cover for address).Their 220n polypropylene capacitor has order code FA22Y and costs 98p. This capacitor is a 1kV type, and is rather large for the PCB. If you can find a low voltage one, use that instead (and let us know where you get it from!).

There are many suitable displays for the meter. If you can order from RS, the stock number of the type we used is 588-320. Maplin's FR39N is also suitable - at £1.60 each plus postage.

Specialist Semiconductors of Founders House, Redbrook, Monmouth, Gwent can supply the HD1131R at four for £3.60 inclusive of postage. Finally, the FND507, which you may see advertised from various sources in this magazine, is also suitable.

The strain gauge we used was a low cost one from RS components. Their stock no. 308-118 type is for use on aluminium. Unless you are a 'trade' user, you will have to ask someone else to order for you. Trilogic, 29 Holm Lane, Bradford, BD4 0QA (Tel: 0274 684289), for instance, will order from RS components for ETI readers. Either type of gauge should cost around £3.

**Back issues of ETI can be obtained by sending £1.70 for each issue to: ETI Backnumbers Dept., Infonet Ltd., Times House, 179 The Marlowes, Hemel Hempstead, Herts. HP1 1BB. Please phone first to make sure the issue is available (0442 48432).*

ETI

UPGRADEABLE AMPLIFIER

Graham Nalty takes to the boards again with a moving magnet amplifier capable of up-staging itself.

A preamplifier for magnetic record cartridges has two basic functions. First, it changes the frequency response to cancel the RIAA equalisation put on every record as a means of reducing noise, and second, it raises the level of the signal until it equals that obtained from radios and tape recorders.

Equalisation

The preamplifier requires a gain which varies with frequency as shown in Fig. 1. Typically we need a gain of about 50 at 1kHz rising to 500 at 20Hz and falling to 5 at 20kHz. The most common method of obtaining RIAA equalisation is by feedback, in which equalisation is carried out in the negative feedback loop of the active circuitry. A typical example is shown in Fig. 2.

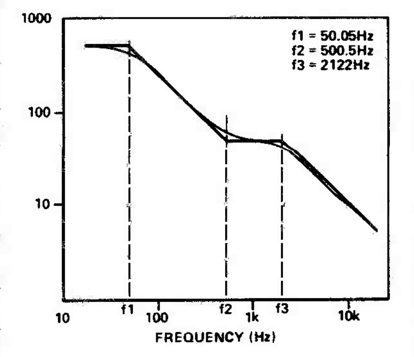


Fig. 1 The desired frequency response of an RIAA preamp.

This circuit uses a minimum of components, especially if built around an integrated circuit, but is becoming less popular amongst designers of higher-quality amplifiers because the amount of negative feedback varies with frequency. At low frequencies, where less negative feedback is applied, a very high open loop gain is needed to maintain an accurate frequency response. At high frequencies a high level of feedback makes slew-rate limiting and transient intermodulation distortion more likely.

The shunt feedback circuit of Fig. 2 has an additional problem as the high frequency response does not roll off to zero but to a gain of 1. The effect of this error is to emphasise extreme high frequencies, including sibilance and record scratches.

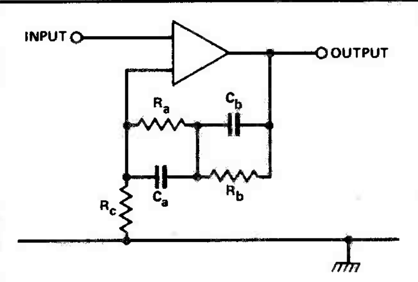


Fig. 2 A typical shunt-feedback equalisation arrangement.

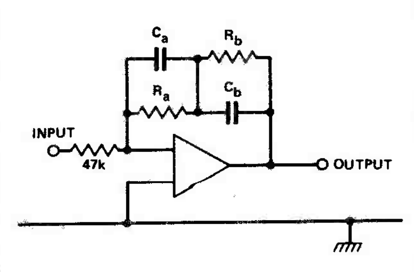


Fig. 3 A series-feedback equalisation arrangement.

This problem can be solved by the series feedback circuit of Fig. 3, but only at the expense of increased input circuit noise. In this circuit, the impedance seen from the input is the resistor (47k) in series with the cartridge (about 1k0 plus inductance). In the shunt feedback amplifier the impedance is the cartridge in parallel with the 47k resistor and is much lower. Hence the noise level is much lower, but neither of these circuits can be considered ideal.

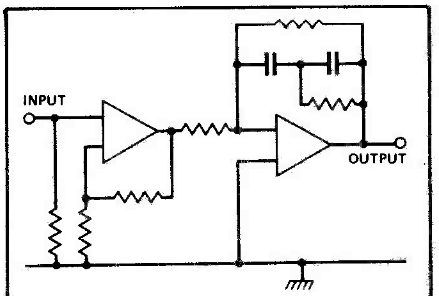


Fig. 4 Combined shunt and series feedback arrangement.

An elegant solution to this problem was put forward by Stan Curtis in ETI July 1981 (ref 1). Two stages of amplification are used. The first is a shunt feedback circuit (low noise) with a gain of 5 at all frequencies. This is followed by a series equalisation amplifier in which the virtual earth resistor is much lower than the 47k required

Frequency	Input	Output of first amplifier	Input to second amplifier	Output of second amplifier	Input to third amplifier	Output
20Hz	20mV	159mV	158mV	1.26 V	1.26 V	10 V
1kHz	158mV	1.26 V	1.26 V	10 V	1 V	17.9 V
20kHz	1.26 V	10 V	1 V	7.9 V	795mV	16.3 V

Table 1 Maximum peak signal levels in the circuit of Fig. 6.

Frequency	Input	Output of first amplifier	Input to second amplifier	Output
20Hz	20m	V447mV	447mV	10V
1kHz	200mV	4.47 V	447mV	10V
20kHz	447mV	10V	100mV	2.24V

Table 2 Maximum peak signal levels in the circuit of Fig. 7.

Frequency	Single passive network	Split Passive network	Feedback equalisation
20Hz	20mV	20mV	20mV
1kHz	200mV	158mV	200mV
20kHz	447mV	1.26V	2 V

Table 3 Comparison of the maximum input levels permissible with various equalisation arrangements.

for a single-stage series equalisation circuit. The basic circuit is shown in Fig. 4. The phase of the output is inverted, but where this causes problems an extra unity-gain series-feedback buffer amplifier can be added.

An alternative way to achieve correct response at extreme high frequencies is shown in Fig. 5. This again is a two stage circuit. The first stage has a constant gain at all frequencies and is followed by a passive high frequency roll-off network, turning over at 2122Hz. The 50Hz and 500Hz turnover frequencies are equalised by the shunt feedback network in the second stage of amplification. This configuration has been used by a number of manufacturers of amplifiers at the more expensive end of the market.

The passive equalisation arrangement of Fig. 6 is one which I have used in a number of different amplifiers over the years. The signal is amplified by about 7 or 8 times in each stage and the 2122 Hz turnover (HF roll-off) is carried out by a resistor and capacitor after the first stage. The signal is then amplified a second time and the bass equalisation (50Hz and 500Hz turnovers) is carried out by a second passive network. Noise and overload margins are optimised when the gains of the stages are

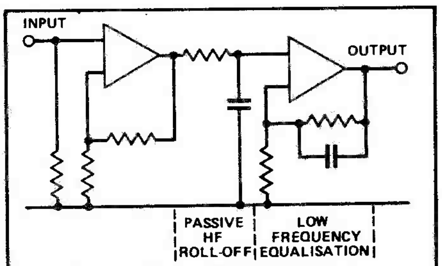


Fig. 5. An alternative two-stage equalisation circuit.

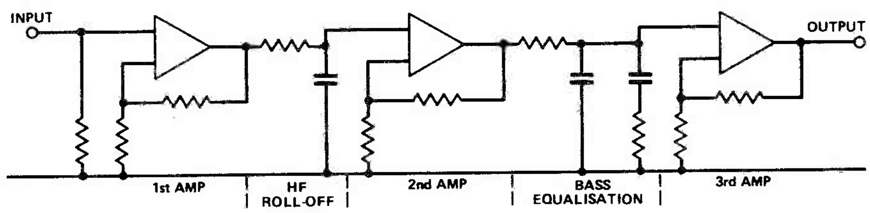


Fig. 6 Using three stages simplifies the component value calculations.

approximately equal. This has all the important factors — correct phase, accurate frequency response and uniform feedback at all audio frequencies. It has the advantage that the component values can be easily and quickly calculated.

This method can be applied to circuits which do not have any feedback in their active stages. The only disadvantage is that three separate stages of amplification are used. The intention in this design is to upgrade the pre-amplifier by providing separate power supplies for each stage of amplification, and with three stages this would quickly become very complicated.

We can cut things down by using the single-stage passive equalisation arrangement of Fig. 7 which requires only two stages of amplification. The required gain of each stage is now increased to 23. The disadvantage, shared with any other RIAA single network, is that component values are very difficult to calculate accurately. I would like to pay tribute to work carried out in this area by Stanley Lipshitz (Ref 2) whose paper on RIAA networks is a great help to circuit designers. The component values used here are derived from tables in Mr Lipshitz's paper.

Overload

An important part of the design of an RIAA preamp is to obtain an adequate overload margin. This is to make certain that the loudest signals from the cartridge are amplified accurately and reproduced without clipping or slew-rate limiting. Problems start when you realise that different cartridges give a different output for a given recorded level in the disc and that the maximum signal in the groove can vary from record to record. There is thus no defined maximum cartridge output level on which to base our designs.

In practice, most RIAA preamps

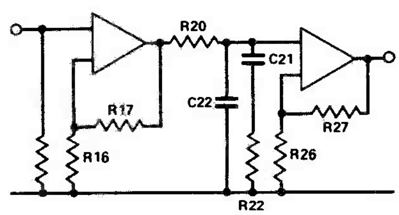


Fig. 7 The two-stage equaliser which forms the basis of this design.

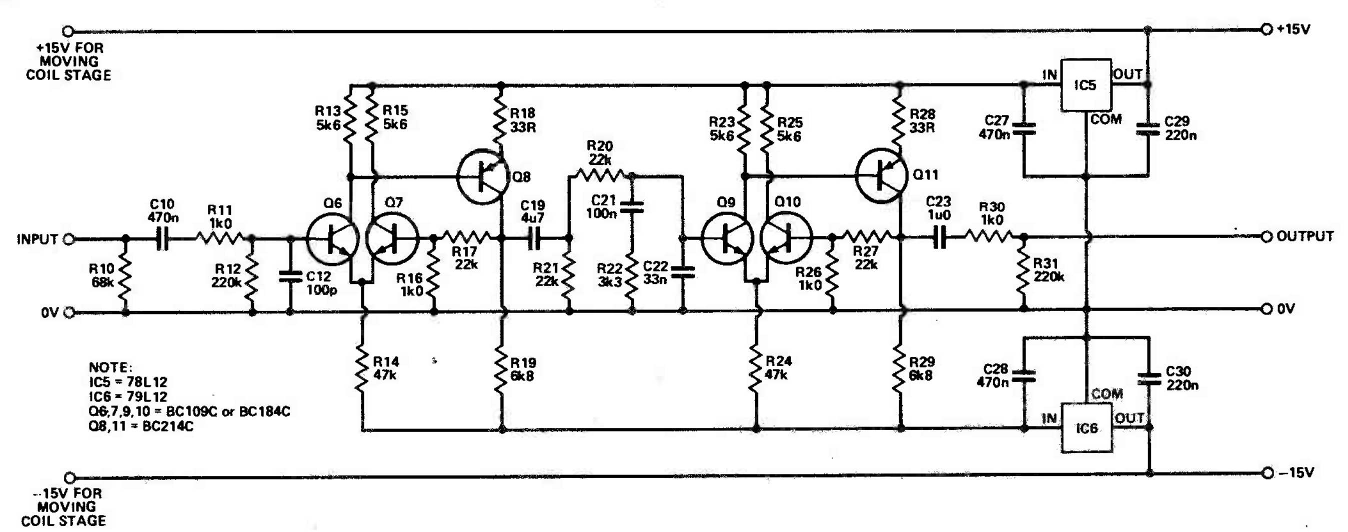


Fig. 8 Circuit diagram of the moving magnet stage in its standard version (one channel only). Note that the component numbering follows on from last month's moving coil stage.

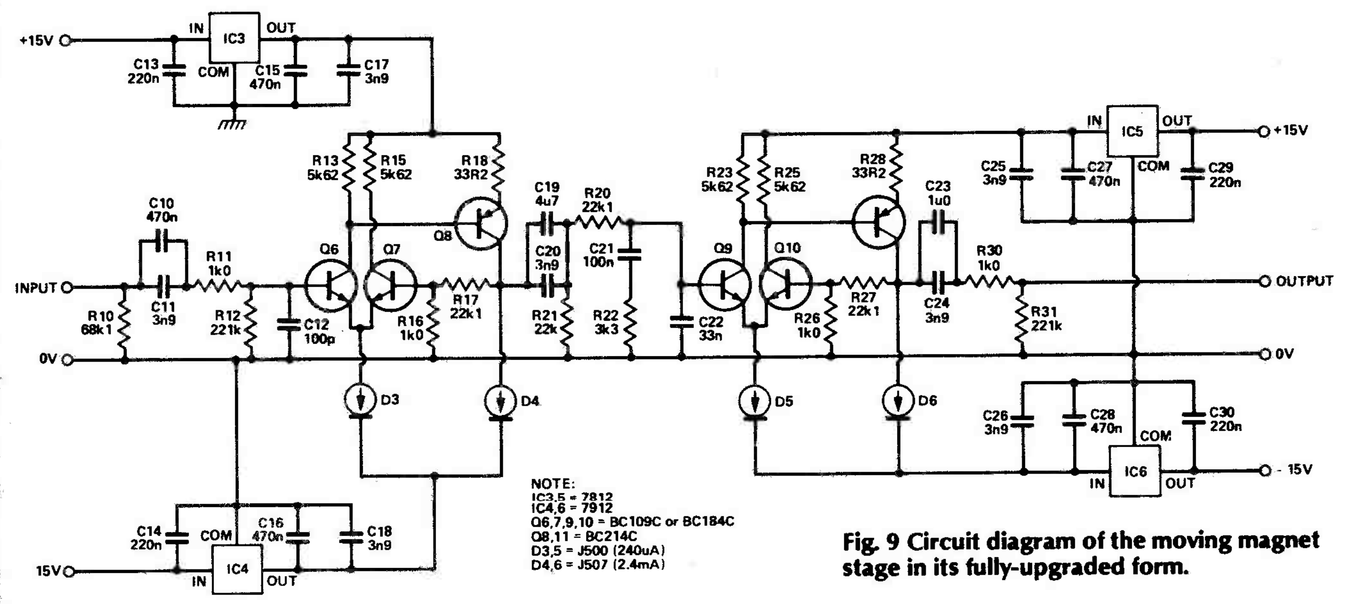


Fig. 9 Circuit diagram of the moving magnet stage in its fully-upgraded form.

are designed with an overload capability well above the maximum typical output of a cartridge. This can be a real benefit to the person who owns a higher-than-average output moving coil cartridge and a high gain head amp. In the past quite a bit of nonsense has been talked about overload margins by people who assume that a preamp with a larger overload margin will sound better. On other occasions reviewers have criticised a preamp because they have measured a lower overload margin. But unless a reviewer can actually feed a genuine signal from a cartridge into the preamp and show a clipped waveform, there can be no justification for criticising the overload margin.

To illustrate this point, I have calculated the maximum possible signal at each stage in a passive equalisation circuit at 20Hz, 1kHz and 20kHz assuming a) an overall gain of 500 equally divided between each stage of amplification and b) a maximum peak voltage of 10V in either direction (Tables 1 and 2). Notice how the overload point (underlined) varies with frequency. Table 3 compares the maximum possible input voltage of these passive circuits with a feedback equalisation circuit. The overload margin could be increased by lower gain in the earlier stages of amplification but this may increase the noise of the circuit.

The MM preamplifier to be described here uses two separate stages of amplification. RIAA equalisation is carried out by a passive network consisting of R20, R21, C21 and C22 located between the amplification stages. The signal reaching the RIAA stage is filtered by R11 and C12 to remove radio frequency interference. It is then amplified by the first stage amplifier formed from Q6, Q7 and Q8. The gain is determined by resistors R16 and R17 and is calculated at R16 + R17/R16 = 23.

The output from the first stage is then equalised by the RIAA network and applied to the second active stage. This is based on Q9, Q10, and Q11 and also has a stage gain of 23, defined by R26 and R27. A buffer resistor R30 protects the amplifier from low

PARTS LIST

RESISTORS	STANDARD VERSION (2% unless stated)	UPGRADED VERSION Holco H8 0.5% 50PPM/°C unless stated)
R10	68k	68k1
R11, 30	1k0	1k00
R12, 31	220k	221k
R13, 15	5k6	5k62
R14	47k	see D3
R16, 26	1k0 1%	1k00
R17, 27	22k 1%	22k1
R18, 28	33R	33R2
R19	6k8	see D4
R20	22k	22k1
R21	22k 1%	39k2
R22	3k3 1%	5k62
R23	5k6	5k62
R24	47k	see D5
R29	6k8	see D6
CAPACITORS		
C10, 15, 16	470n polyester	470n polycarbonate
C11, 17, 18, 20, 24, 25, 26	—	3n9 polystyrene or silver mica
C12	100p polystyrene	100p polystyrene or silver mica
C13, 14	—	220n polycarbonate
C19	4u7 polyester	4u7 polycarbonate
C21	100n 5% polyester	56n 1.5% polystyrene
C22	33n 5% polyester	19n 1.5% polystyrene or silver mica
C23	1u0 polyester	2u2 polycarbonate
SEMICONDUCTORS		
IC3	—	7812
IC4	-	79212
IC5	78L12	7812
IC6	79L12	7912
Q6, 7, 9, 10	BC109C or BC184C	BC109C or BC184C
Q8, 11	BC214C	BC214C
D3, 5	—	J500 (240uA)
D4, 6	—	J507 (2.4mA)

MISCELLANEOUS
PCB; double-sided PCB pins, 10 off; T092 transistor pads, 6 off (on upgraded version only); PCB pillars; case, power supply, sockets, wiring, etc, according to choice and application.
All of the components listed above are for one channel only (with the exception of the case, power supply, etc). Two of each will be required for stereo.

Test points	Voltage
Output of IC3, IC5 — ground	+12V
Output of IC4, IC6 — ground	−12V
Across R13, R23	0.7V
Across R18, R28	0.1V
Emitters Q6, Q7, Q9, Q10 — ground	0.6V
R17/C19 junction — ground	Less than 0.2V
R27/C23 junction — ground	Less than 0.2V

Table 4 Test voltages at various points around the circuit.

BUYLINES

A complete kit of parts for the moving magnet stage will be available from the author at 6 Mill Close, Borrowash, Derby DE7 3GU. The cost is £11.50 for the standard version and £29.00 for the fully-upgraded version. Note that these prices are for one (mono) board and that two will be required for stereo. The PCBs can be purchased on their own for £10.00 (two boards) and all the other components can also be supplied separately if preferred. A full price list is available from the address above. All prices include VAT and postage.

A case for the complete preamplifier is also available (see photos here and in last month's article) and costs £49.00 inclusive. It is fully drilled and labelled ready to accept the modules described in this series of articles. The front panel can be supplied with or without provision for tone controls — please specify which you require when ordering.

impedance or large capacitance loads. Onboard regulators provide regulated supplies of +12V and −12V to the active circuitry and these require input voltages of ± 15V or greater.

The circuit of the standard economy version is shown in Fig. 8 with single 78L12 and 79L12 regulators powering both stages of amplification. Although 'C' gain transistors are specified, 'B' gain devices should be fine. Two per-cent tolerance is adequate for resistors, but I have specified 1% wherever the resistor affects the equalisation or gain. Capacitors are radial polyester and axial polystyrene types. Capacitor tolerance is important for the RIAA equalisation components so I have specified 5% types.

The circuit of the fully-upgraded MM stage is shown in Fig. 9 The improvements are:

a) the use of separate regulators for each stage of amplification
b) the use of metal-tab T0220 regulators to reduce temperature generated distortion
c) the replacement of all standard metal film resistors with Holco H8 0.5% 50ppm/°C metal film resistors
d) the use of polycarbonate capacitors instead of polyester capacitors
e) the bypassing of higher value capacitors with 3n9 to 10 n polystyrene capacitors
f) the replacement of R14, R19, R24, R29 with constant current regulator diodes (D3-D6) for better power supply ripple rejection
g) the use of close tolerance extended foil polystyrene capacitors for RIAA equalisation.
h) the use of 'C' gain transistors for Q9 and Q10 to give higher input impedance on that stage.

Construction

The moving magnet stage is assembled on a single-sided circuit board which carries one complete stage. The board is therefore mono and two will be required for stereo. Holes are provided on the board for the various upgrading options and also to allow several smaller polystyrene capacitors to be used instead of some of the less-readily obtainable larger ones. Make sure you know in advance which holes you need to use for the version of the preamp you are building.

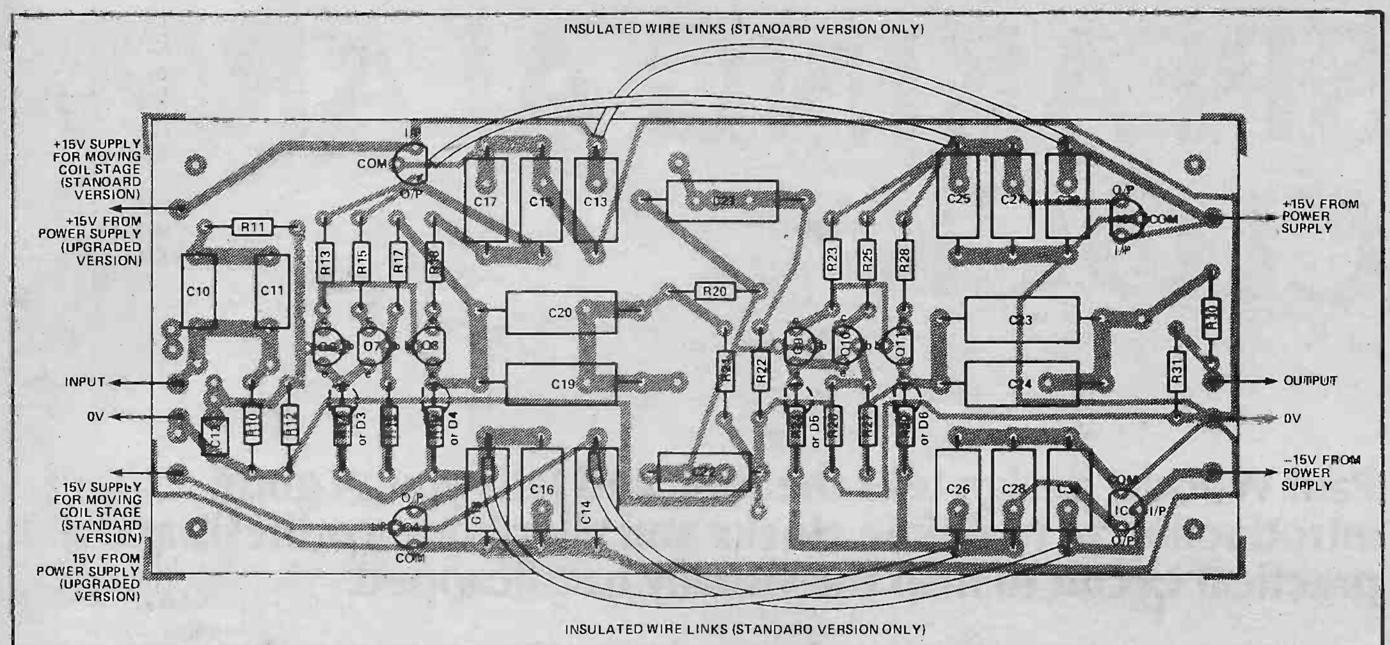
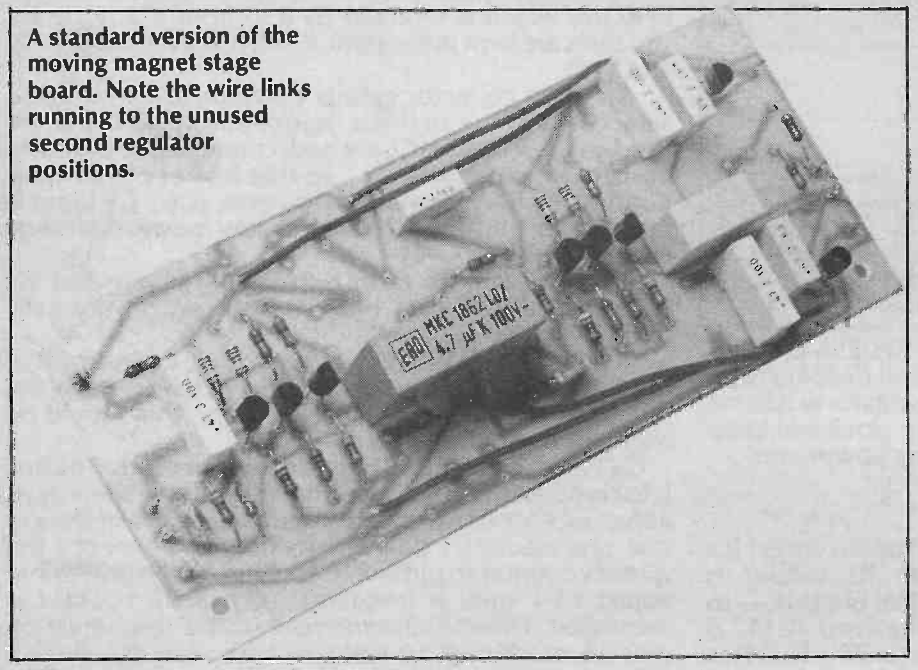


Fig. 10 Component overlay for the moving magnet stage PCB. Note that the supply rail connections at the left-hand end perform different functions in the two versions.

The use of PCB pins is recommended for the external connections to the board. The pins should be installed before any of the other components and tapped lightly through the board before being soldered. The rest of the components can then be soldered into place, starting with the resistors and then the semiconductors and the capacitors. Finally, if you are building the standard version, insulated wire links will be needed to carry the power lines across the board to where the second set of regulators would be on the upgraded version. The position of these links is indicated on the overlay.

When the board is complete, connect it to a power supply giving between ±15V and ±25V. Using Table 4 as a guide, check that the voltages around the circuit are correct. If all seems well, connect up a record deck and cartridge to the input and feed the output into the tape, tuner or auxiliary input of a preamplifier. With luck, you should be able to hear music! If you built last month's moving coil stage, you can now try hooking it into the inputs of this stage and connecting it to a moving coil cartridge. The moving magnet stage is so designed that two of them can be positioned side by side and the power connections can then be jumped across on short links to a moving coil board laid across their ends. This arrangement can be seen in the internal view of the complete preamplifier published last month.

The MM boards can be used with the Virtuoso preamplifier which is the subject of this series of articles or with any other preamplifier which has a dual-rail supply of between ±15 and ±25V available. The boards could also be installed in a small case with their own power supply and used as a stand-alone, plug-in disc stage. This would make a useful accessory for PA amplifiers and audio mixers which do not have a low-level, RIAA equalised input. If preferred, the regulators can be omitted and a battery used instead. For a 9V battery supply use two 33k resistors in parallel for R14 and for R24 and replace R19 and R29 with 3k9 resistors.



A standard version of the moving magnet stage board. Note the wire links running to the unused second regulator positions.

References

1. Curtis. S. System A preamp ETI July 1981.

2. Lipshitz. S. On RIAA equalisation networks. Paper presented to 61st AES convention, New York. November 1978. **ETI**

SPEAKING ALARM CLOCK

Paul Woods' design tells the time and tells you. A good introduction to real-time clocks and allophone synthesis and a practical circuit to help the visually handicapped.

The clock functions are controlled by four buttons. When particular buttons are pressed, the clock speaks the time, or the alarm setting. The buttons also allow these to be set and issue spoken phrases to tell users what they are doing.

Time is kept on a 12-hour clock, with 'am' or 'pm' announced as appropriate. When sounding, the alarm may be either cancelled, or muted for ten minute periods to allow for a snooze.

Audio output is about 2 watts — enough to arouse the soundest sleeper.

Figure 1 shows the block diagram of the speaking alarm clock. The circuit is based on a Z80 microprocessor, with supporting EPROM and RAM, which controls an MSM5832 clock IC and an SP0256-AL2 speech synthesizer. Output is provided by a TBA810AS audio power amplifier driving a 4 ohm load.

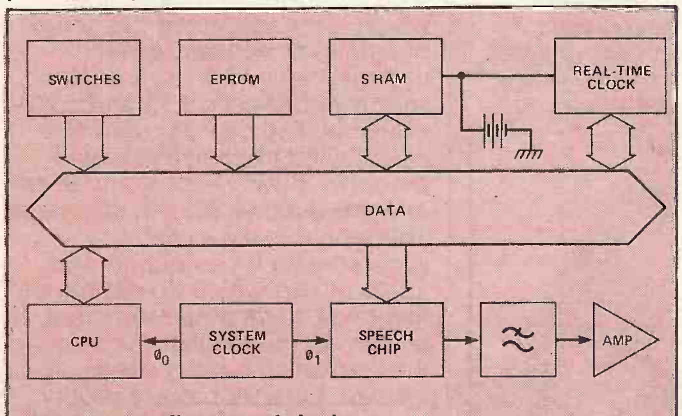


Fig. 1 Block diagram of clock.

Clock signals for the Z80 and the SP0256 are provided by a common crystal oscillator and divider chain. The MSM5832 uses a second crystal oscillator as its time reference. Battery backup ensures the clock will keep and remember the alarm setting during power cuts.

How it Works

Figure 2 shows the digital section of the circuit. Q1 is a crystal controlled Colpitts oscillator. Its output is divided by two by IC8 — a 74LS74A dual bistable — to give 3.07MHz for the speech synthesizer, IC11. A further division by two yields 1.54MHz for Z80, IC2. This low speed does not compromise preformance as most of the time the Z80 is waiting for a control switch depression or the speech synthesizer to finish saying an allophone.

C1 and R5 generate a power up reset signal to the Z80. PB5 also resets the Z80 and PB6 generates an interrupt. Both of these switches were used to debug the EPROM and are not now used.

The peripheral ICs are memory mapped, so some of the Z80 bus control signals, principally IORQ, MREQ and M1 are ignored. This avoids having to decode IN and OUT instructions as every read and and write cycle must be to memory. RFSH is also unused because IC6 is a static RAM.

IC3 and IC4 — both 74LS138 demultiplexers — are used as address decoders. By combining with RD in IC3, and WR in IC4, they generate read select and write select signals respectively for 2Kbyte memory blocks (Fig. 7 shows how these are allocated). A14 and A15 from the Z80 are unused, so only the bottom 16k of memory may be accessed.

The alarm clock program is stored in IC5, a 2716 EPROM, which is selected by RS0 from IC3. Program variables are kept in the static RAM, IC6, enabled by RS1 and WS1.

An open collector gate is used for IC7 — used to select the RAM — so that a resistor pull up, R10, may be used on $\overline{CE}$. R10 and IC6 are both connected to the backup battery, rather than V_{cc}, so that loss of power does not destroy RAM contents. However, IC6's $\overline{CE}$ input is taken high, putting IC6 into a low power stand-by mode.

The four control push buttons are connected via IC1a to the Z80 data bus. These must be normally open switches.

IC10, the MSM5832 real time clock, keeps track of the time and the date. A 32768 Hz watch crystal is the time reference — for highest accuracy, this should be trimmed by adjusting CV1.

CV1 must be adjusted by one of two methods. The first is to compare the clock with a time signal over a few days, adjusting CV1 as necessary. Alternatively, build the circuit, and place IC1 only into its holder. Connect a frequency counter to pin 9 of IC10. Turn on the power and adjust CV1 until a frequency of exactly 1024Hz is measured. Direct measurement of the frequency on pins 16 or 17 of IC10 will give false readings, since a

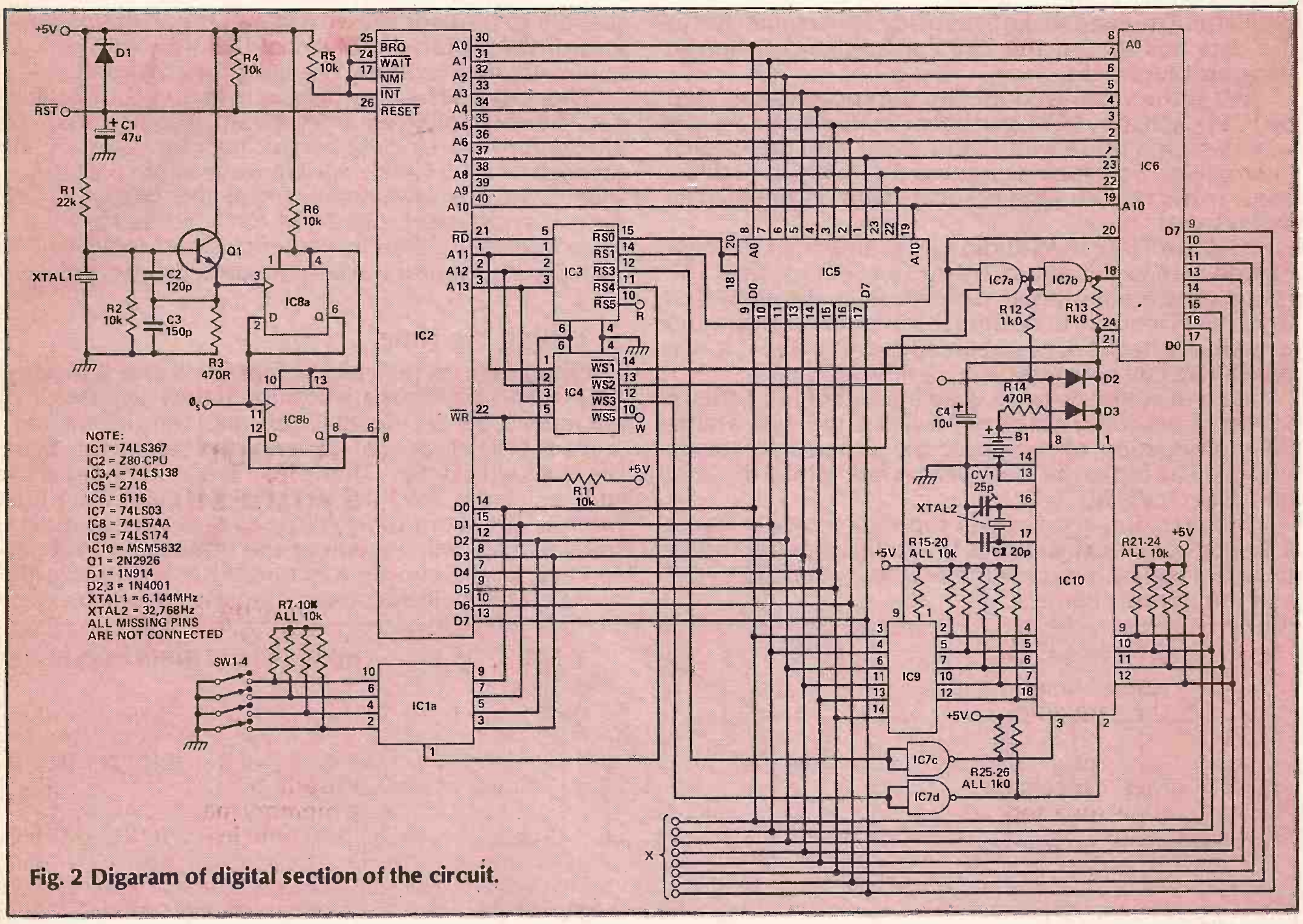


Fig. 2 Digaram of digital section of the circuit.

scope or frequency counter will load the crystal's high impedance circuit.

The clock IC requires a complicated sequence to access it. The HOLD (pin 18) must be at logic 1 before trying to read or write anything. This locks the time into the clock's internal registers, so that should a clock tick occur during the ensuing read cycles, it will not change the data being read by the Z80. Otherwise an incorrect time may be obtained, caused by a carry rippling through the clock's registers.

The stand by battery comprises three rechargeable Ni Cads. R14 trickle charges the battery, D2 prevents it from attempting to supply the entire clock when power is turned off. The AA battery size chosen is quite large and provides about a month's back-up, but the cells are readily obtainable. If a smaller battery capacity is used then R14 must be increased to reduce, proportionately, the trickle charge current.

The speech synthesizer and audio amplifier are shown in Fugure 3. The speech chip is selected by WS5. Its ROM expansion pins are left unconnected and an external clock is used in preference to the internal

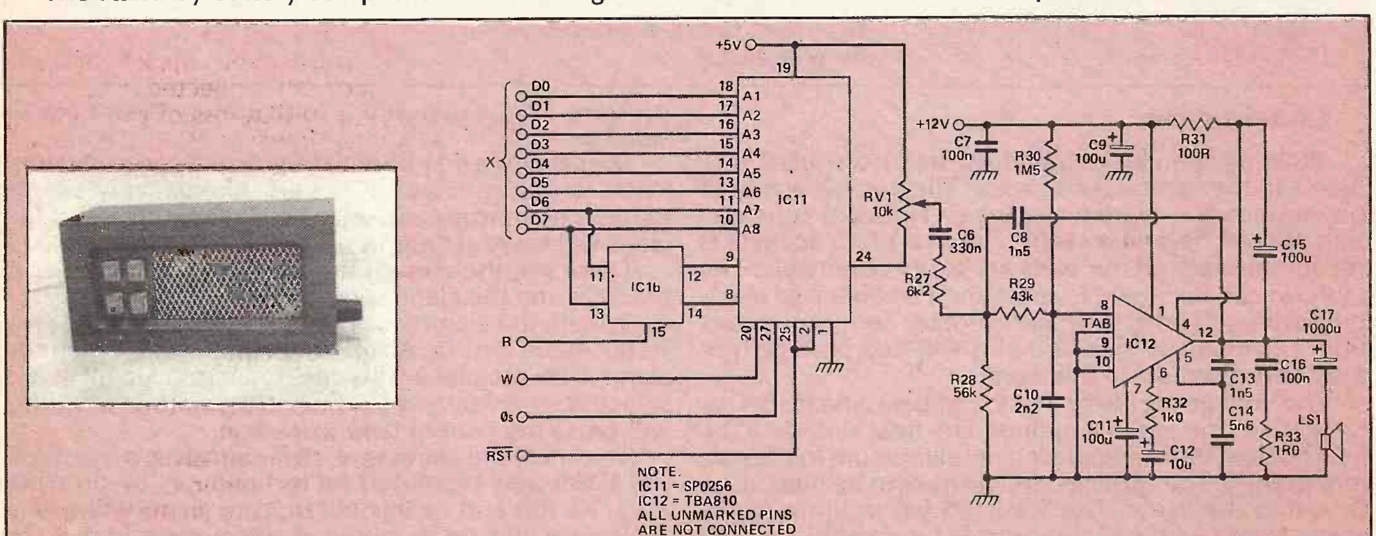


Fig. 3 Diagram of speech synthesis circuit (with complete prototype inset).

oscillator. The hand shake lines of IC11 are connected to the data bus so that the Z80 can recognize when to transmit allophones.

RV1 is the volume control for the speech generated by IC11. Actually, IC11 generates a supersonic square wave which is pulse width modulated with the speech information. So if looking around RV1 with an oscilloscope, expect to see a jittery square wave rather than an audio signal.

IC12 is a TBA810AS audio power amplifier. It is configured here to give about 2W into a 4ohm speaker. The circuit used is slightly non-standard since the high input signal level requires a considerable reduction in gain and a feedback network has been added to make it a two pole 5kHz low pass filter.

If a hi-fi system is to be used instead of IC12 then a 5kHz low pass filter will be necessary. Otherwise a faithful reproduction of the inaudible supersonic square wave will be fed to the loudspeaker rather than the audible speech signal.

The recommended power supply is shown in Figure 4. It supplies a nominal 12V to the audio amplifier and 5V to all the logic ICs except the two fed indirectly by D2 and the standby battery.

cessible to the user. Figure 6 shows the layout used for these in the prototype. SW4 could be hidden at the back to prevent inadvertently changing the clock settings.

There should be no problems in getting the circuit to run. The slow clock frequency will aid probing the circuit. Any fault in the clock generator may be noted by the absence of a 1.54 MHz square wave at pin 8 of IC8. A square wave is always present at the output of the speech synthesizer, pin 24 of IC11, so its absence is more interesting than its presence. Most faults will be found to be shorted tracks or incorrectly inserted ICs.

Telling the time

On turning on the clock the Z80 will check to see if the memory contents are corrupt. If they are, the clock will repeatedly say 'Reset Clock' until the clock is set.

To set the clock or alarm press the set button, SW4. The clock will say 'Set'. Then press 'clock', SW1, to set the time, or 'alarm', SW2, to set the alarm time. 'Set Clock Time' or 'Set Alarm Time' will be spoken as appropriate. Pressing SW1 will increment the hours, and SW2 the minutes, of the chosen function. After each press the current setting will be spoken. The new value is stored by pressing SW4 again and 'Clock Set' or 'Alarm Set' is said.

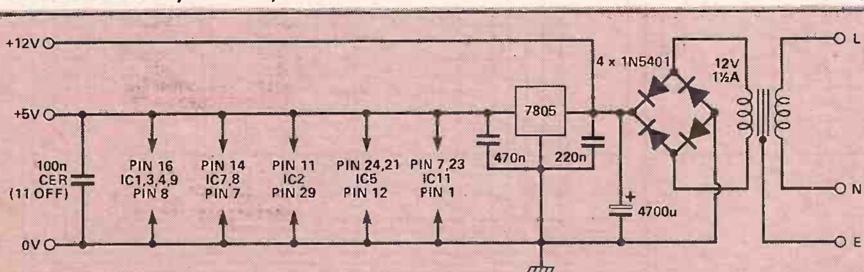
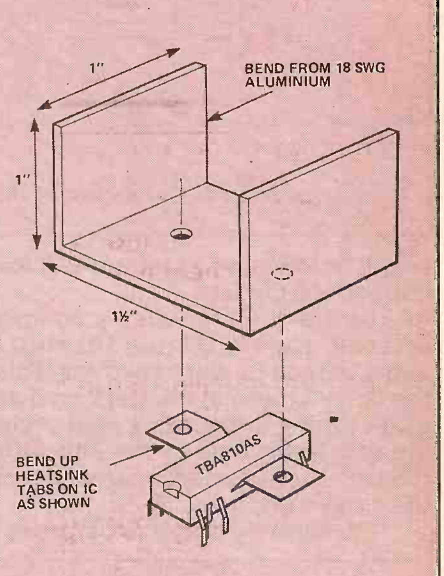


Fig. 4 (above) PSU circuit.

Fig. 5 (below) TBA810 heatsink.



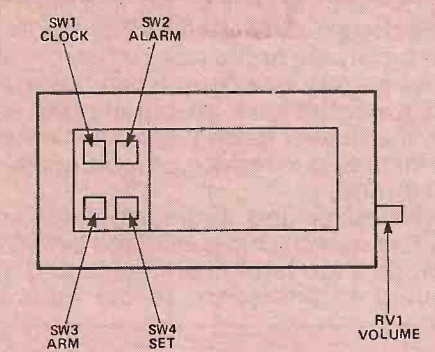


Fig. 6 (left) Layout of the controls on the prototype.

Construction

Building the clock should present no special problems to the careful constructor. The original was built on veroboard — wire-wrapping or Eurocard construction should do just as well. The use of IC sockets is recommended. All the parts are easily obtainable. The EPROM can be blown from Listing 1 or obtained ready programmed along with all the other semiconductors from Technomatic for £8.00 plus VAT and postage (see their advertisement in this issue).

The voltage regulator, IC15, requires a heat sink, as does IC14, the audio amplifier. The heat sink for IC14 may be bent from a scrap piece of aluminium to the pattern in Fig. 5. The cooling tabs will have to be bent up as shown in the figure. The TBA810S has a different tab shape from TBA810AS, but should be useable.

SW1 to 4, together with RV1, must be mounted on the outside of the case, all other switches should be inac-

The set mode may be left at any time by pressing 'arm' SW3, on which 'Cancel' is said. Alternatively simply depress no buttons and after a ten second timeout the clock will leave set mode.

Once set, the current time is spoken when SW1 is pressed, and the alarm setting when SW2 is pressed.

To turn the alarm on, or off, press SW3, and the new state, 'Alarm On', or 'Alarm Off', will be said. When the alarm is on the clock will repeatedly say 'Alarm' at the selected time. Pressing SW1 when the alarm is sounding will cause the current time to be said.

To cancel the alarm when it is sounding, press SW3. The alarm may be muted for ten minutes by pressing SW2. At the end of this period, the alarm will sound again, and may be re-muted as often as desired. If the alarm signal has not been cancelled after about three minutes, then the alarm will cancel itself.

Software

Figure 7 is a memory map for the clock. The EPROM and RAM occupy the bottom two 2Kbyte blocks, with the peripheral ICs at 2Kbyte intervals. The memory addresses are not fully decoded, so a peripheral IC will respond to any address within its block.

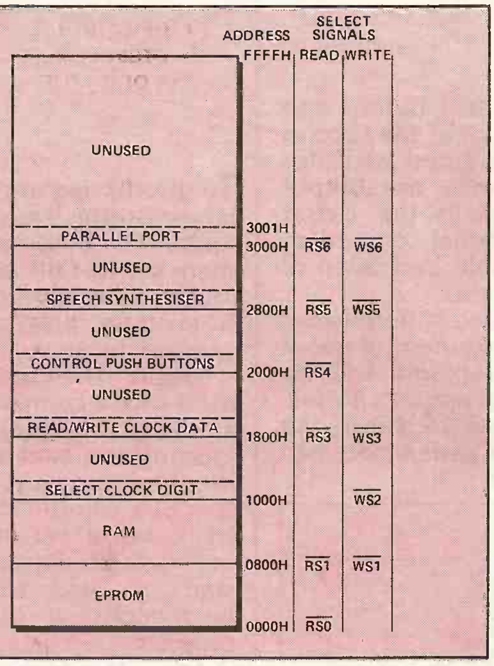


Fig. 7 Memory map of clock.

A photocopy of the fully-annotated disassembled listing of the program (with comments) is available from ETI Photocopy Serivce (SAC), 1 Golden Square, London W1R 3AB, if you enclose a stamped, self-addressed envelope and a cheque or PO made out to ASP Ltd. for £3 (inclusive). The listing runs to 22 sheets of fanfold paper.

The listing printed here (Listing 1) is a complete hex dump of the program. It's in Intel format — ignore the first four bytes of each line and enter from address 0000H.

```
:10000000319608CD9A01CD0302CDD503CD31012A19
:1000100000087CB5280A2B2200087CB506952812AA
:100020003A0020E60FFE0F28E006040F300410FB14
:1000300018D73A02084F87878190C6054F87878176
:10004000215D005F1600195E2356234E2346ED43C3
:1000500000008237E320208210900E5E8E99901003E
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:100080000300388130346033200059901881301 46A3
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:1000A000032000 5A50332000546030000000A80188C0
:1000B0001303DF01881303460300000098A033200A4
:1000C000052B010000000B032C01043D023200054A
:1000D0002B0132000 52B0132000599010000000BB5
:1000E00003000000C70200000099013200059901D9
:1000F000320005320028F5C50E013A0028A120FA89
:10010000C1F1C9219F04CD12032103087EFE0028FE
:1001100073E0011360418083E01113904CD87014D
:1001200077EBCDDC033E00CDF300C93E003203087F
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```

Fig. 8 (above and top right) Intel format hex dump of clock program.

TECH TIPS

Variable Rate Joystick Autofire

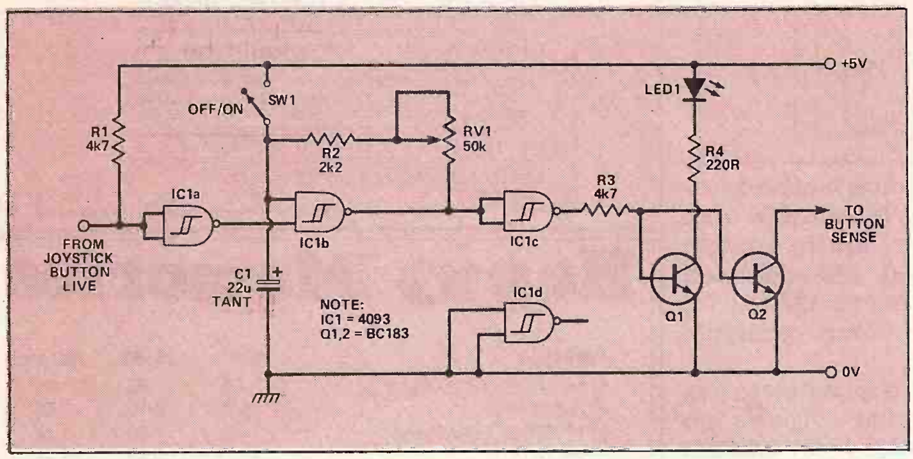
Matthew Burt
Bournemouth

Later models of digital joystick on the market have an autofire feature. This circuit adds variable rate autofire to those joysticks without it.

With computers having nine-way D connectors for their joysticks, it is possible to obtain the 5V direct from the computer connector. The input of this circuit needs to be connected to the live side of the joystick button and the output to the button sense input on the computer.

Three sections of a CMOS 4093 IC are used. The first buffers and inverts the input signal, the second is configured as a gated oscillator and the third drives the output transistors. SW1 kills the circuit and restores normal operation. LED1 gives a visible indication of the button firing rate.

The current drawn is dominated by the LED's requirement of about 15mA, so no problems will be found using the computer's 5V rail. With the components shown the firing rate can be varied between about 1 and 40Hz.



Program Cuer

L.M. Loong
Hong Kong

To save having to store many short tape cassettes I once used with my Apple II+ computer, I re-recorded them on to C60 tapes but then I found it annoying not knowing when one program ended and another began.

Ideally the cassette recorder used with a computer should have a digital counter for ease of locating the start and end of the required program. However, the lack of a counter can be mitigated by a voice recording the loading details before the program starts to load and the running instructions at the end of the program.

As the loudspeaker is automatically disconnected when the jack plug to the computer tape input is inserted, the following simple modification will permit a small amount of audio to be routed to the loudspeaker, and thus the user can monitor the start and finish of any program.

The only requirement is a resistor of about 180 or 220 ohms,

Low Cost Door Alarm

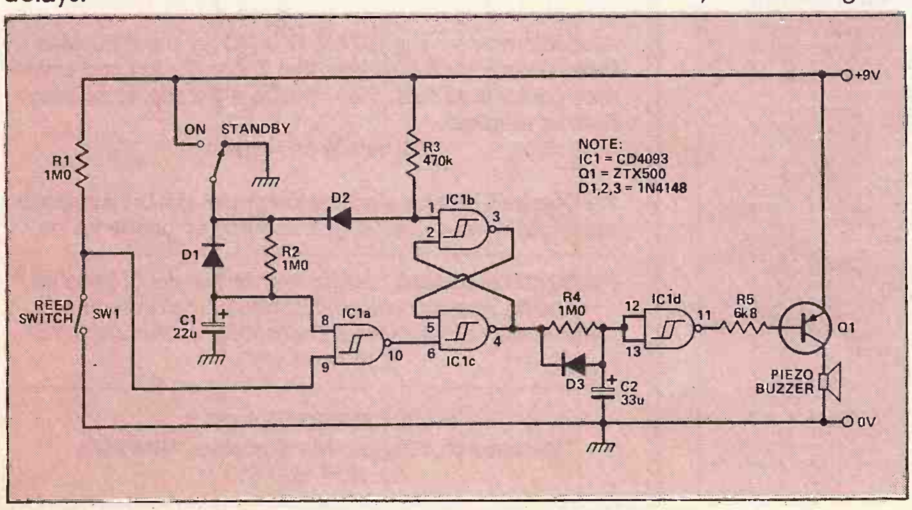
S.B. Tweedy BSc
Tynemouth

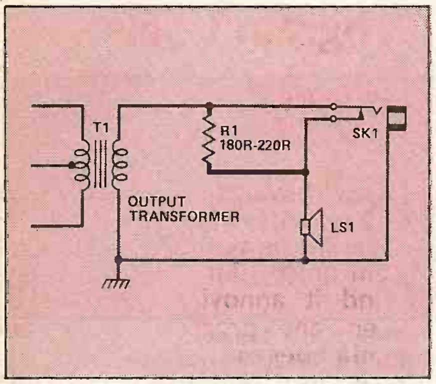
This circuit is designed around a low cost CMOS IC and provides a battery operated door burglar alarm with both entry and exit delays.

The unit should be housed in a small plastic box and mounted on the back of the door to be protected, and a small bar magnet on the door frame, within range of the magnetic reed switch in the alarm box. The unit is therefore self contained and requires no wiring to install.

To use the alarm, turn the keyswitch from STANDBY to ON and leave the house, closing the door within 15 seconds (set by R2,C1). The alarm will now arm itself and is triggered by the door being opened. The R-S flip flop built around IC1b and e is set and C2 begins to charge via R4 to produce the entry delay (20 seconds). If the unit is not switched back to its standby mode, the voltage in C2 reaches the threshold value of IC1d and the piezo buzzer is energised by Q1. The unit can be reset at any time by switching the keyswitch back to the STANDBY Mode.

The supply current of the unit in either mode without the alarm sounding is small enough to provide long term operation from a 9V PP3 battery.





and a rating of a quarter of a watt. This is connected across the normally closed contacts of the jack socket.

Plug the cable to the computer input into the cassette recorder and play back any tape, computer or music. Then bridge between any two contacts on the socket with the two ends of the resistor until sound can be heard coming from the loudspeaker at a very low volume when the volume control is turned up to it's usual position for loading tapes into the computer.

Cut the resistor leads to length and fit insulating sleeving to them before soldering the resistor across these two points. The job is then complete.

Speaker Mute

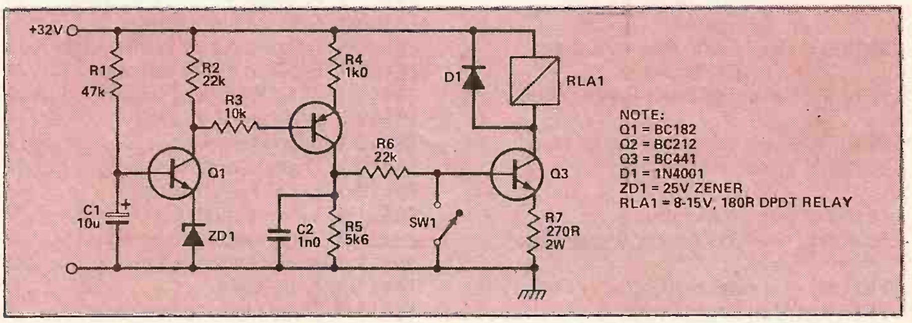
K.S.Ng
Rotherham

The reader may presently have an amplifier which exhibits a minor fault in that an annoying thump can be heard when switching on. The circuit here has been designed to eliminate that. It also does a bit more. When the amplifier is switched off its reservoir capacitors discharge slowly, but the speakers are disconnected early so that the input signal cannot be heard 'sizzling' down.

When switched on, current passes through R1 and charges up C1. Q1 remains switched off until the voltage across C1 exceeds that of ZD1, in about 0.5 second. When Q1 conducts, the rest of the circuit activates the relay, which in turn switches the speakers on.

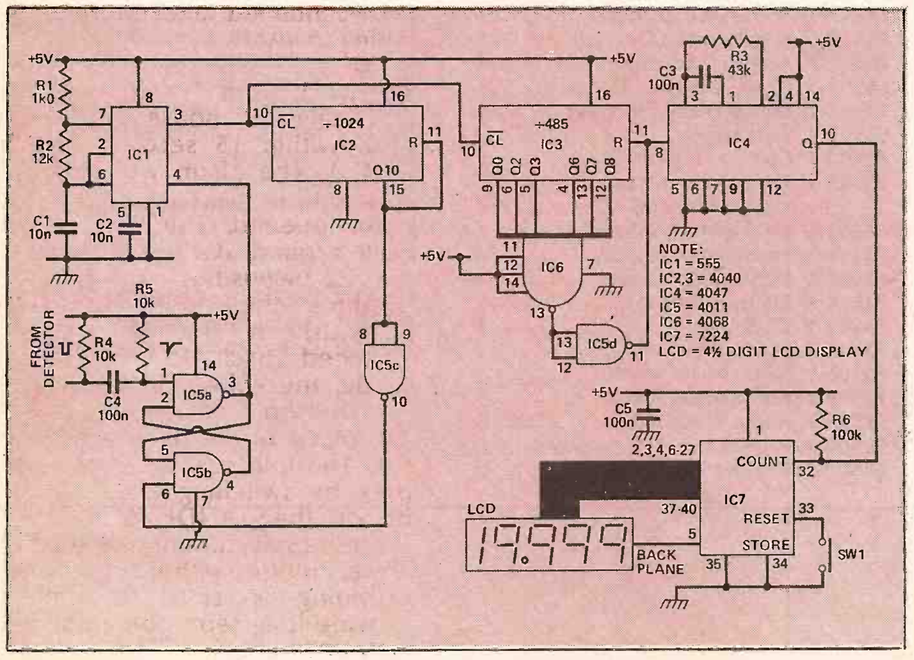
When the amplifier is switched off and the supply votage falls below the value of D1, Q2 will stop conducting. Then Q3, the relay and the speakers will be switched off immediately. A simple remote switch SW1 attached to the base of Q3 can mute the speaker output.

My amplifier's power output section has a 32-0-32V supply, so ZD1 was chosen to be 25V. With any other amplifier, the value of ZD1 should be around 2/3 of the power output's +ve supply rail. Also R7 should be chosen to suit the relay's operating parameters against the supply voltage.



Electronic Odometer

L. Robertson
Aberdeen



This device was designed to measure distances up to 19.999km on a normal (26 inch) bicycle wheel, the circumference of which is 2.111m.

The circuit requires a detector mounted on the wheel so that a negative-going pulse on each rotation sets the latch formed by IC5a and b, enabling the astable, IC1. IC2 counts IC1's output pulses until Q_{10} goes high (after 1024 pulses), at the same time resetting itself and the latch.

The 1024 pulses are simultaneously counted in IC3 whose outputs are gated to reset the chip after 485 pulses. This counter will have reset itself twice and will be at binary 54, so for each revolution the output is 254/485 or 2.111.

The pulse to reset IC3 is stretched by IC4 (a monostable) and fed to IC7, a counter IC which drives the LCD display.

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E8406-9 AD Stereo Power Meter . . . . . . F
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E8411-9 Stage Lighting Interface . . . . . . F
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E8412-4 Active - 8 Protection Unit . . . . . F
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E8502-1 Digital Delay Expander . . . . . . N
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E8503-2 THD Meter mV & oscillator bds (2 boards) . . . . K
E8503-3 THD Meter Mains PSU . . . . F
E8504-1 Framestore Memory . . . . M
E8504-3 Framestore Control . . . . N
E8504-4 Buzby Meter . . . . E
E8504-5 CCD Delay . . . . F
E8505-5 Stereo Simulator . . . . F
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E8506-2 Audio Mixer PSU . . . . F
E8506-3 Audio Mixer RIAA . . . . D
E8506-4 Audio Mixer Tone Control . . . D
E8506-5 EPROM Prog MKII . . . . O
E8508-1 RCL Bridge . . . . N
E8508-2 EX42/BBC Interface . . . . E
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E8509-1 Spectrum . . . . F
E8509-2 Direct Injection Box . . . . E
E8510-9 Sunrise Light Brightener . . . . . . K
E8511-1 MTE Waveform Generator . . . H
E8511-2 Millifaradometer . . . . H
E8511-3 Cymbal Synth . . . . J
E8511-5 Chorus Effect . . . . H
E8511-7 Enlarger Exposure Meter . . . . . F
E8511-8 Switching Regulator . . . . E
E8511-9 Second Line of Defence . . . . . M
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E8512-2 MTE Pulse Generator . . . . H
E8511-3 Specdrum L
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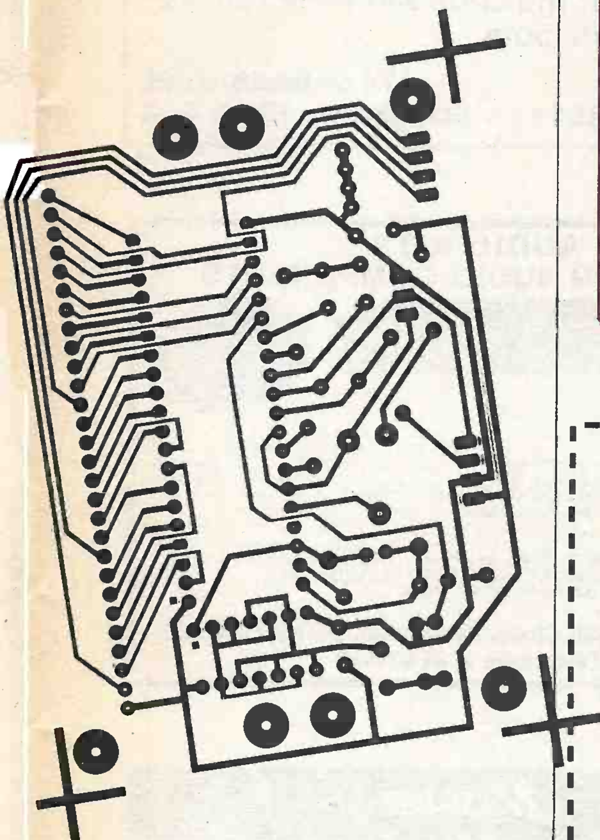

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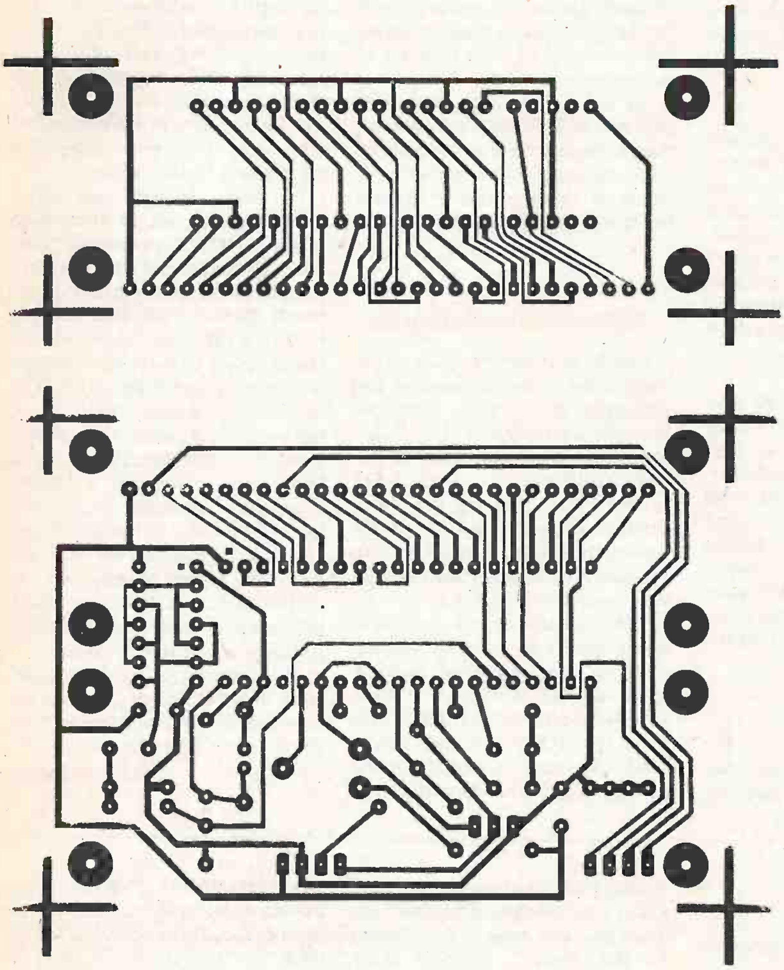
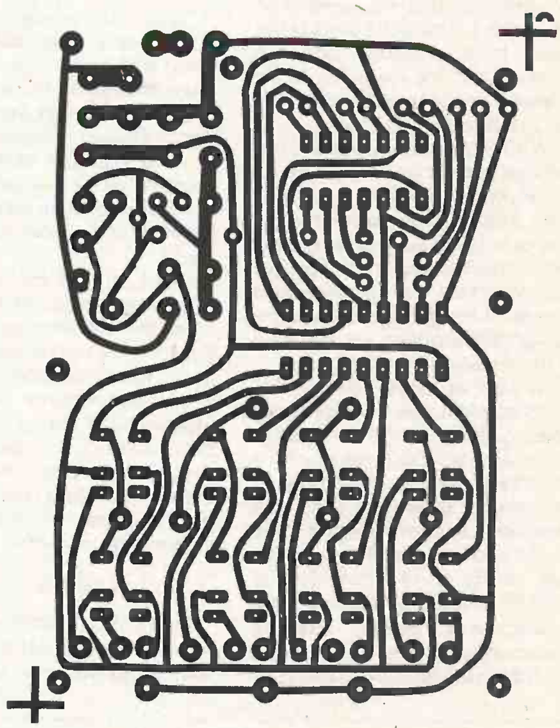
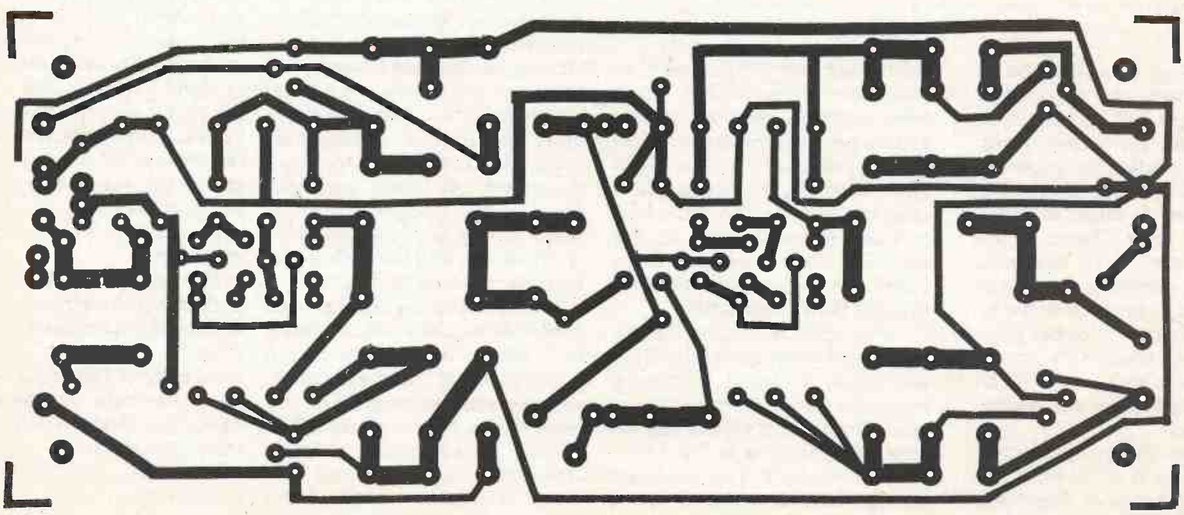


The foil patterns for the Digital Panel Meter boards.



The foil pattern for last month's BBC Motor Interface board, reproduced here because the foil pattern in the July issue shows it at the wrong size!



The foil pattern for the Upgradeable Amplifier moving magnet stage.

ETI

OPEN CHANNEL

The recent demise of an Ariane rocket (which suffered a booster failure and had to be destroyed minutes after take-off) begs a serious question: is the future of space communications via satellite in doubt? If it is (which I think is the case) then a second question arises: what are we going to do without space communications via satellite?

With America's space shuttle service out of commission for an indefinite period and problems with Ariane, there appear to be few other possibilities for getting new satellites up into orbit for commercial communications needs. Although this shouldn't be too great a problem yet, it will be if the situation persists.

As new as these communications services are, the world has already come to rely on them in no small way. If current satellites aren't replaced as they come to the end of their useful life and new services aren't launched, the world's communications systems will slowly grind down. In the limited time since satellite communications began, existing communications have been transferred to satellites and new satellite communications systems have been inaugurated. In short, communications now rely on satellite services to such an extent that they could not easily return to using earlier technologies.

Perhaps (but only perhaps) the problems with the space shuttle and Ariane will soon be sorted out. Let's hope so.

OSI

Open systems interconnection development has had a recent boost with Burroughs announcement that they are to set up a European Network Systems Division in Bracknell. Burroughs aren't slow to see that early involvement in OSI is essential if they are to improve or even maintain their position in the communications world.

Eventually, of course, all participating companies will benefit from the development of OSI (which allows all connected computers to communicate), although it has taken some other large organisations a long time to see the potential. Burroughs move into the European market with this division shows how the company intends to realise OSI's potential worldwide.

Optical Fibres

By 1991, it appears, a whole new network of optical fibre links will be laid between Europe and North America, forming a new high-transmission-rate service between the two continents. Five organisations (BT in Britain, AT&T in the USA, Teleglobe in Canada, Telefonica in Spain, and the French PTT) have agreed to develop the network and are anxious to hear from organisations in other countries who would wish to share in development costs.

An extremely high transmission rate of 565 Mbits per second, transmitted at a wavelength of 1.55 microns ensures that the network (codenamed TAT9) will be the most up-to-date of its kind.

High-definition Television

Finally, European broadcasters have won a battle against the Japanese and North American broadcasters who wish their high-definition television (HDTV) system to be the world standard. At a recent CCIR meeting the introduction of HDTV, a completely new system, was blocked and the European MAC television system was given the go-ahead.

MAC (multiplexed analogue component) is really an adaptation of the existing service, whereas HDTV is an 1125-line television picture with a field rate of 60 Hz. HDTV thus suits North American and Japanese mains power requirements eminently but it doesn't suit the European mains frequency of 50 Hz. Even though the Japanese and North Americans say the conversion problems only require some development work, there remains the further problem of non-compatibility with existing television equipment. The European argument is that users of existing receivers will not wish to throw their televisions in the dustbin simply to buy a more expensive television receiver — even if it does give a better picture.

Pictures received on MAC receivers are not of such high quality as HDTV receiver pictures (nobody denies the HDTV superiority in this respect), but they are much better than the existing system's pictures. More importantly, users of existing receivers will merely need an adaptor to receive the signal, albeit at no better picture quality than at present. And the adaptor is most likely to be included in a satellite reception converter, thus cushioning its impact to the purchaser. Users with the money and the desire for higher quality pictures will also buy a MAC receiver, probably as part of a complete package with the converter.

This setback for HDTV is, however, only the end of a battle. I am sure the HDTV proposers will say the war has yet to be won.

Keith Brindley

REVIEW

BASIC ELECTRONICS THEORY WITH PROJECTS AND EXPERIMENTS (2nd Edn.)

Delton T. Horn.
TAB Books Inc. PO Box 40, Blue Ridge Summit, PA 17214. 665pp, Price: £17.00 (paperback)

Delton T. Horn could only be an American name, and this colonial offering might well be likened to mom's apple pie: rather awful pastry surrounding an excellent filling. In his opening chapter Mr Horn rushes through essential theory like John Cleese in the European Tour Sketch, managing to confuse elementary ideas as he goes. For example, when describing a wet cell: "Copper gives up electrons easily (it's an excellent conductor) . . .". Such an unsound start does not inspire confidence.

Fortunately things do improve, although there is an irksome tendency to gloss over important detail while labouring fairly minor points. I suspect that few people will benefit from the picture of an American mains socket; apart from anything else the photographs have all the clarity of an EEC directive and just as much grain. Similarly, the five pages of diagrams showing the numbers 0 to 9 on a seven segment display are, like the proverbial drunkard's lamp-post, used more for support than illumination.

These criticisms apart, the important chapters are well written and follow a logical, traditional sequence as Mr Horn takes the reader from Ohm's law to ICs. An interesting feature is the inclusion of multple choice questions at the end of each chapter: although entertaining, these seem designed to test whether one has read the book rather than one's knowledge of electronics. They also rely heavily on a "none of the above" option, which suggests some lack of thought in their preparation.

I can be more enthusiastic about the experiments and projects which are presented in the three chapters within the main body of the text. These describe do-it-yourself demonstrations of the theory, showing that this is in fact a self instruction guide for the beginner, not a reference book for the initiated. Although there must be hundreds of books on basic electronics, and perhaps thousands on home construction, very few bridge the gap between theory and soldering iron so effectively and the author is to be congratulated for this.

With the closing chapters the reader is whisked off at speed once more, this time through a catalogue of all things electronic, and again the emphasis is on the superfluous and irrelevant. The section on computers imparts little more than the fact that home micros are small plastic boxes with keyboards. I'm as impressed as the next man with the latest advances in micro-electronics, but this does not stop me from getting browned off at being told how wonderful it all is at every turn.

Since Basic Electronics Theory is a beginner's book, a few words are needed before anyone rushes off to spend £17 on their favourite grand-child. Because the author is, through no fault of his own, American, he uses all-nu (sic) star-spangled spelling and calls valves 'tubes'. I find this sort of thing galling in the extreme, but that is simply a personal prejudice. More seriously the descriptions of television are based on the US system as opposed to PAL and the notes on AM stereo broadcasting do not apply in this country.

The book is neither cheap nor perfect, but nonetheless deserves to do well in competition with its rivals. If Mr Horn is planning a third edition, I should advise him to concentrate on pages 21 to 564 at the expense of the rest: as every Briton knows, exceedingly good cakes do not have too much pastry.

Nicholas Hacking

PLAYBACK

The Compact Audio Cassette has been the standard format for home recording for many years. As it developed from rather lo-fi beginnings, the once-popular open-reel machines declined into near oblivion. So the audio cassette became the unchallenged medium as improvements in tape formulations, cassette mechanisms and recording heads transformed it into the hi-fi unit we know today.

The boom in Compact Disc, with its many advantages over the vinyl LP, has stirred up interest in applying digital techniques to tape. Would digitally recorded tapes offer the same order of improvement over conventional cassettes as CD does over vinyl? Is the reign of the analogue audio cassette near its end?

Until now, digital recording equipment has been rather bulky and expensive. The snag is that, instead of a frequency response of around 10kHz or just over, a full audio range digital signal needs a response of over 2 MHz. To handle that sort of bandwidth we need a video recorder, and to encode the signals we must use an analogue-to-digital converter.

However, with an eye to the next consumer boom product, the tycoons from the land of the rising sun are busily working on the prototypes for domestic integrated digital recorders. Formats are already proliferating. Basically there are two systems, the R-DAT and the S-DAT. The Rotary Digital Audio Tape System, uses helican scan heads like a video recorder, whereas the Stationary Digital Audio Tape System, employs a stationary head.

Simultaneous Tracks

How does the S-DAT system get the necessary bandwidth? By laying down 20 simultaneous tracks using a head which employs thin-film semiconductor technology. Tape speed is the same as for conventional audio cassettes, but R-DAT uses tape at only one-sixth of that rate. The cassette size of R-DAT is marginally smaller than S-DAT, (both are smaller than the compact audio cassette) so the advantage of the much slower tape speed shows up in longer playing time.

So tape costs would be lower with the R-DAT system, but the simpler mechanism of the S-DAT should make for cheaper recorders. At present, Sony and Pioneer are supporting R-DAT, while Sanyo and Sharp have chosen S-DAT. Here we go again then, two rival incompatible systems. Will they co-exist like the video formats, or will each queer the pitch for the other, as happened with the quadrophonic systems.

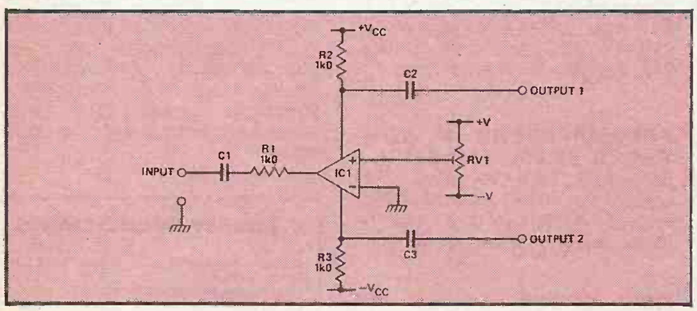
A further complication is that there are four versions of R-DAT and five of S-DAT, each one being of slightly lower standard than the previous one in terms of sampling rate and quantisation steps. The top grade in each format has a 48 kHz sampling rate and 16-bit quantisation which gives 65,536 sampling levels.

Will different manufacturers adopt different standards within the same format? There will probably be general agreement so as to present a united and compatible system format to the consumer, but it is just as likely that someone will produce a cost-cutting lower-standard machine, or perhaps all of them will. Who knows?

Really though, digital tape does not offer the same advantage over conventional cassettes as the CD does over vinyl. Vulnerability to damage, tracing and tracking distortions, surface noise and size all made the vinyl disc obviously inferior to the CD. The lower recording distortion and noise of digital processing is less apparent to the average user.

In the case of tape, continued development of the audio cassette (particularly in the field of metal evaporated tape formulations that can be used on any high grade deck having a high bias setting) has pushed distortion and noise levels down to the point where it is difficult to tell the difference between them and a digital recording. Coupled with format uncertainties, it seems doubtful whether there will ever be a mass sale of digital tape to match that of the CD disc.

Vivian Capel



ALF'S PUZZLE

A few months ago, Alf came across a circuit which looked as if an op-amp was being used back to front - the input went to the op-amp's output, and the output from the circuit was taken from one of the op-amp's inputs. As it transpired, the output of the op-amp was not really used as an input to the circuit, but this month there's no doubt about it at all. The input is applied directly to the output of the op-amp, and there's nowhere else for it to go. Not only that, but the outputs from the circuit come from the power supply pins! What does the circuit do, and how does it work?

The op-amp used in the circuit is one in which the supply current is independent of the supply voltage - Alf used an LM358 to make sure that his idea would work (the other half of this dual op-amp was left unconnected). RV1 should be adjusted so that the output of the op-amp is at 0V. Those are the only hints Alf will allow me to give you, I'm afraid, so from now on you're on your own.

If you manage to work out what the circuit does, don't bother to build it. Although it works, after a fashion, it was devised to be puzzling rather than practical, and Alf will give a more sensible version next month. Don't be too sure you've got the answer - this one even took Auntie Static a while to work out, which caused Alf great glee.

Last month's puzzle was a competition, and since we are still sorting through the replies, Alf will give both answers next month.

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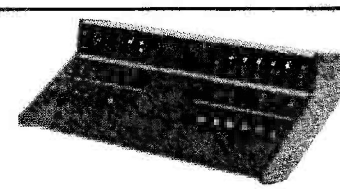

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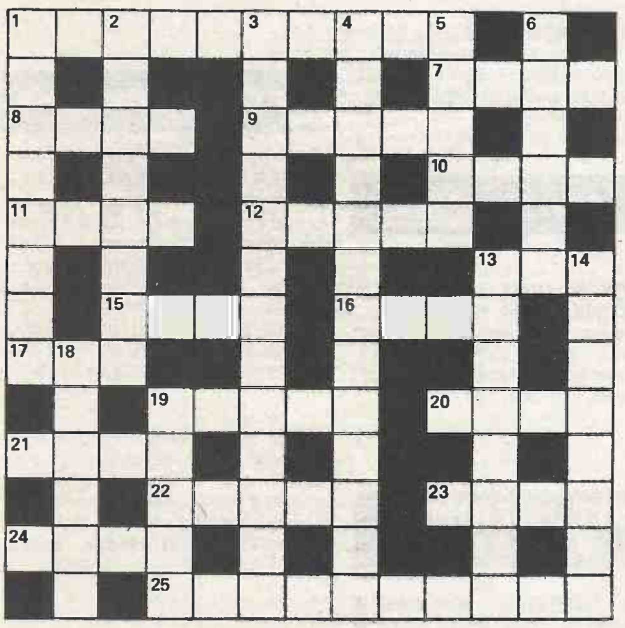

ACROSS

1) Electrical insulator between the plates of a capacitor (10).
7) Break into a protected data bank, or attack with an axe (4).
8) Two bytes treated as a single unit (4).
9) Frequencies within the range of human hearing (5).
10) Attached to the spindle of a potentiometer as a means of turning it (4).
11) One twelfth of a foot (4)
12) A test lead incorporating an active or passive circuit (5).
13) BASIC command word, used for strong remarks in a program (3).
15) Something other than radio waves that comes from the sky! (4)
16) In semiconductor terms, the opposite of a free electron? (4)
17) Total harmonic distortion (abbr.) (1,1,1).
19) Inert gaseous element, Atomic No. 86 (5).
20) An adjustable support for a microphone (4).
21) Information (4).
22) Two terminal semiconductor (5).
23) Construction for raising an aerial above ground (4).
24) Video cassette format (4)
25) Typically, two magnetic contacts sealed in a glass tube (4, 6).

DOWN

1) Found on a VCR to indicate damp in the machine (3, 5).
2) European standard plug-in PCB for rack mounting (4-4).
3) 22 across used for restricting a waveform or setting a voltage in a circuit (8, 5).
4) Bands of frequencies used for transmission of signals (5, 8).
5) Inductor (5).
6) Eight terminal valve (6).
13) ______ Frequency, the natural frequency at which oscillations will occur most readily and with maximum amplitude in a given reactive circuit (8).
14) The condition which exists when a load impedance does not correspond to a source impedance (8).
18) Part of a valve, also called the filament (6).
19) Abbreviation of and equipment for Radio Detection and Ranging (5).

Solution to Crossword No. 6

ACROSS

3) Epson
7) Sonar
8) Even
9) Edge
11) Bypass
14) DPDT
15) Rise time
17) CRT
18) FSD
10) Vertical
21) Coil
22) Editor
25) USER
27) Loom
28) Modem
29) Erase

DOWN

1) Sony
2) Data
4) Pye
5) Needle
6) Heads
10) Digitise
11) Black
12) Port
13) Slew rate
16) Adder
18) Flat
19) Volume
20) Robot
23) Iron
24) Open
26) RMS