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5 GEN - INFO 12 16 18 26 39 CO-PROCESSOR
4 PARTS 46 47 PRINTER SWITCH / BUFFER & SOFT TURN ON LAMP
53 ERRORS 54 LIST & REG 55 INFO

GAS ALERT
Protect Your Home

BBC MICRO OSCILLOSCOPE

SATELLITE TV
Antenna Theory

DRUM FLASH

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

electronics today INTERNATIONAL

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NEW ELECTRONIC GUARD DOG KIT

One of the best deterrents to a burglar is a guard dog and this new kit provides the barking without the bite! The kit when assembled can be connected to a doorbell, pressure mat or any other intruder detector and will produce a random series of threatening barks making the would be intruder think again and try his luck elsewhere. The kit is supplied complete with high quality PCB, transformer, all components and instructions. All you need is a mains supply, intruder detector and a little time. The kit even includes a horn speaker which is essential to produce the loud sound required. The "dog" can be adjusted to produce barks ranging from a Terrier to an Alsatian and contains circuitry to produce a random series of barks giving a more realistic effect.

XK125 Complete kit of parts £21.95

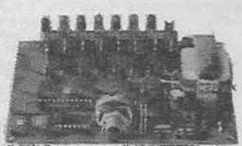
DISCO LIGHTING KITS

DL1000K – This value-for-money 4-way chaser features bi-directional sequence and dimming. 1kW per channel £17.50
DLZ1000K – A lower cost uni-directional version of the above. Zero switching to reduce interference £9.85
DLA/1 (for DL & DLZ1000K) Optional opto input allowing audio 'beat'/light response 70p
DL3000K – 3-channel sound to light kit features zero voltage switching, automatic level control and built-in microphone. 1kW per channel £14.25

The DL8000K is an 8-way sequencer kit with built in opto-isolated sound to light input which comes complete with a pre-programmed EPROM containing EIGHTY – YES 80! different sequences including standard flashing and chase routines. The KIT includes full instructions and all components (even the PCB connectors) and requires only a box and a control knob to complete. Other features include manual sequence speed adjustment, zero voltage switching, LED mimic lamps and sound to light LED and a 300 W output per channel.

And the best thing about it is the price.

ONLY £28.50



TEN EXCITING PROJECTS FOR BEGINNERS

This Kit has been specially designed for the beginner and contains a SOLDERLESS BREADBOARD, COMPONENTS, and a BOOKLET with instructions to enable the absolute novice to build TEN fascinating projects including a light operated switch, intercom, burglar alarm, and electronic lock. Each project includes a circuit diagram, description of operation and an easy to follow layout diagram. A section on component identification and function is included, enabling the beginner to build the circuits with confidence.

ORDER NO XK118 £13.75

MICROPROCESSOR TIMER KIT

Designed to control 4 outputs independently switching on and off at present times over a 7-day cycle. LED display of time and day, easily programmed via 20 way keyboard. Ideal for central heating control including different switing time for weekends. Battery back-up circuit. Includes box. 18 time settings.

CT6000K £42.90
XK114 Relay kit for CT6000, includes PCB, connectors and one relay. Will accept up to 4 relays. 3A/240V c/o contacts .. £4.30
701 115 Additional relays £1.80

VERSATILE REMOTE CONTROL KIT

This kit includes all components (+ transformer) to make a sensitive IR receiver with 16 logic outputs (0-15V) which with suitable interface circuitry (relays, triacs, etc – details supplied) can be used to switch up to 16 items of equipment on or off remotely. The outputs may be latched (to the last received code) or momentary (on during transmission) by specifying the decoder IC and a 15V stabilised supply is available to power external circuits. Supply: 240V AC or 15–24V DC at 10mA. Size (excluding transformer) 9 x 4 x 2 cms. The companion transmitter is the MK18 which operates from a 9V PP3 battery and gives a range of up to 60ft. Two keyboards are available—MK9 (4-way) and MK10 (16-way), depending on the number of outputs to be used.

MK12 IR Receiver (incl. transformer) £14.85
MK18 Transmitter £7.50
MK9 4-Way Keyboard £2.00
MK10 16-Way Keyboard £5.95
601 133 Box for Transmitter £2.60

HOME LIGHTING KITS

These kits contain all necessary components and full instructions and are designed to replace a standard wall switch and control up to 300W of lighting.

TDR300K	Remote Control Dimmer	£16.45
MK6	Transmitter for above	£4.95
TD300K	Touchdimmer	£8.50
TS300K	Touchswitch	£8.50
TDE/K	Extension kit for 2-way switching for TD300K	£2.70
LD 300K	Light Dimmer	£4.35

NEW POWER STROBE KIT

Designed to produce a high intensity light pulse at a variable frequency of 1 to 15Hz this kit also includes circuitry to trigger the light from an external voltage source (eg. a loudspeaker) via an opto isolator. Instructions are also supplied on modifying the unit for manual triggering, as a slave flash in photographic applications or as a warning beacon in security applications. The kit includes a high quality pcb, components, connectors, 5Ws strobe tube and full assembly instructions. Supply: 240V ac. Size: 80 x 50 x 45.

XK124 STROBOSCOPE KIT £12.50

DVM/ULTRA SENSITIVE THERMOMETER KIT

Based on the ICL 7126 and a 3½ digit liquid crystal display, this kit will form the basis of a digital multimeter (only a few additional resistors and switches required – details supplied) or a sensitive digital thermometer (-50°C to +150°C) reading 0.1°. The kit has a sensitivity of 200mV for a full-scale reading automatic polarity and overload indication. Typical battery life of 2 years (PP3) **£17.00**

XK113 MW RADIO KIT

Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5.5 x 2.7 x 2cms. Requires PP3 9V battery. IDEAL FOR BEGINNERS **£6.00**

PROPORTIONAL TEMPERATURE CONTROLLER KIT

Uses "burst fire" technique to maintain temperature to within 0.5°C. Ideal for photography, incubators, wine-making, etc. Max. load 3kw (240V ac) Temp. range up to 90°C. Size: 7x4x2.5cms.

MK4 £7.10

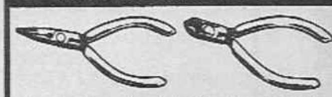
BARGAIN COMPONENT PACKS

Refill those empty component drawers at a fraction of the normal price and don't be caught without that odd resistor or capacitor to complete your project. All components supplied are to full spec. and are not seconds or surplus stock.

Pack A:	650 x .25 watt resistor 47R-10M	£4.25
Pack B:	60 x Radial electrolytics 1uf – 1000uf	£3.25
Pack C:	30 x Polyester capacitors a or 0.01 uf – 1uf	£4.50
Pack D:	35 x horizontal presets 1k-1M	£3.00
Pack E:	30 x IC sockets 8, 14, 16 pin	£2.00
Pack F:	25 x Red 5mm LEDS	£1.75
Pack G:	25 x Green 5mm LEDs	£2.00
Pack H:	30 x 5mm LEDs 10 Red, 10 Green, 10 Yellow	£2.50
Pack J:	50 x 1n 4148 silicon diodes	£1.00
Pack K:	40 x npn/pnp transistors BC/182/212 General Purpose	£2.25

FREE Solderless Breadboard (verobloc type). When you buy all ten packs. Prices exclude VAT (15%).

TOOLS ★ TOOLS ★ TOOLS



Good quality tools selected to offer outstanding value for money.

650 004 6in mini. Snipe Nose Pliers. Serrated jaws and return spring. **£2.10**
650 005 6in lap jointed side cutters. Insulated handles and return spring. **£2.10**
650 006 Light duty cutters. Cutting capacity 0.22–1.2mm copper wire. **£1.60**
TOOL KIT – Contains: side cutters, snipe nose pliers, wire strippers, flat blade screwdriver, philips screwdriver in black textured, reinforced and padded case which when opened out measures 240x205mm **£6.80**

650 007 Self-adjustable automatic wire stripper with built-in cable cutter. **£3.95**
850 012 Watchmakers Screwdriver Set. 1.0/1.4/2.0/2.4/3.0/3.8mm **£1.75**
650 019 Set of 4 Stainless Steel Tweezers. Straight nosed, straight noosed-reverse action, bent nosed, flat nosed. 110mm long. **£3.65**
650 502 Reliant 9–12V dc Drill. **£6.90**
650 500 Titan 12V dc Drill. **£10.25**
650 570 Saturn Mains Drill. **£16.50**

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SECURITY PRODUCTS

Install your own burglar alarm and save pounds. All parts available separately.

950 120	Stair Pressure Mat	1.70
950 125	Floor Mat 29x16 ins.	2.60
950 130	External bell box - an ideal deterrent on its own!	10.00
950 130	Xenon Beacon (12v)	10.50
950 140	Flush door/window contacts	1.22
950 143	Surface mounting contacts	1.05
960 160	Alarm Control Unit	

950 162 Alarm Control Unit
This unit incorporates all the features required to form the basis of a complete security system for the home or business. Operating off a 240v AC supply with facility to charge a 12v lead acid standby battery. The unit is housed in a white steel box 225x225x80mm. Full instructions supplied to connect normally open and closed sensors, bells, personal alarms etc. Separate entry and exit alarm delays. 2 zone operation complies with BS 4737 **price £39.95**

950170 DOOR PHONE
An attractively styled 2 station mains powered handset type door phone. Allowing conversation with visitors without opening the door. Free standing or wall mounted, connections to a 9 volt battery for standby. Electric doorlock release button which maybe used with our 701150 lock release mechanism. Ivory and Fawn body 210x100x70mm. **£27.95**

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A professional quality 3½ digit multimeter with 34 ranges. As well as the usual current, voltage & resistance this meter features transistor and diode test, continuity AND CAPACITANCE and TEMPERATURE ranges. Basic accuracy is 0.25%. Size: 170x87x42mm. Includes test leads, thermcouple and full instruction & recalibration manual.

AC Volts	200m-2-20-200-750
DC Volts	200m-2-20-200-1KV
AC Current	200u-2m-20m-200m-2A-10A
DC Current	200u-2m-20m-200m-2A-10A
Resistance	200-2K-20K-200K-2M-20M
Capacitance	2000p-2uF-20uF
Temperature	-10° to 1370°C
Conductance	200nS
hFE	0-1000 (NPN & PNP)
Continuity Buzzer	less than 200 ohms
(405208)	£55.00

LOGIC PROBE

A MUST for working with TTL & CMOS devices. Displays logic levels and pulses down to 25nS with LEDs and sound. Comprehensive instruction booklet supplied.

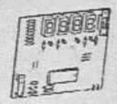
Working voltage	4-18V dc
Input Impedance	1M
Max. i/p frequency	20MHz

ONLY £9.50

RECHARGEABLE SOLDERING IRON

Powerful cordless iron complete with table-top/wall-mounting charging bracket. Reaches soldering temperature in 10 seconds. Includes lamp which lights when soldering. Comes with mains charging unit and 12V car battery adaptor. **Special Offer £15.95**

ELECTRONIC WEIGHING SCALES



This kit contains a Single Chip Microprocessor, PCB, displays and all electronics to produce a digital readout of weight in Kgs. or Sts. and Lbs. In normal use a toothed wheel (pattern provided) is made to rotate when a weight is placed onto the scales, interrupting two infa-red beams. The processor counts the number of teeth passing the sensor (up or down, depending on which beam is broken first) and shows the reading on the LED display in Sts. & Lbs., Lbs. or Kgms. A PCB link selects the scale for bathroom or two types of Kitchen Scales. A linear version of the toothed wheel could also be used. Other uses include up/down counters. A low cost digital ruler could be made by using a wheel with the correct tooth to diameter ratio.

ES1 .... **£5.50**

TK ELECTRONICS
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LOCAL AUTHORITY AND EXPORT ORDERS WELCOME
GOODS BY RETURN SUBJECT TO AVAILABILITY

• British Telecom is about to embark on the enormous task of digitally mapping the entire UK telephone network — cables, ducts and all.

At present BT basements are overflowing with 450,000 paper maps and diagrams.

After six years these will all be binned and the £19m digital map should be complete, enabling BT to get things wrong even more quickly than they do now!

In the first phase of the operation the principal towns will be mapped using BT's existing processor capacity, supplemented by four VAX computers from Intergraph. The Ordnance Survey will be collaborating with BT since it already has much of the necessary information in digital form.

The shareholders *will* be pleased.

• The semiconductor suppliers Top Ten of 1987 shows the Japanese companies continuing to gain ground, claiming 48% of the world market last year.

1987	1986	Company	% increase
1	1	NEC	21.0
2	3	Toshiba	29.1
3	2	Hitachi	20.5
4	4	Motorola	21.0
5	5	Texas Inst.	19.3
6	6	Fujitsu	39.1
7	8	Philips/ Signetics	26.9
8	11	Intel	51.4
9	10	Mitsubishi	30.4
10	9	Matsushita	22.6

Figures are taken from Dataquest's 1987 World Survey.

• A selection of seven slimline logic probes are now on the market from OK Industries.

The cheapest is the PRB-20 which has LEDs to indicate Hi, Lo and Pulse, capable of 25ns pulse detection with a 20MHz bandwidth. Threshold levels are switchable between TTL and CMOS.

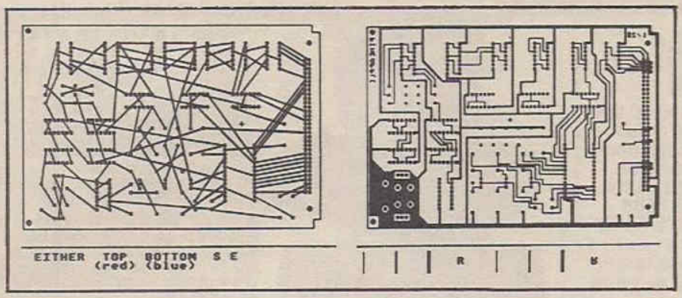
The top model is the PRB-100A with 5ns pulse detection — 100MHz bandwidth.
Prices before VAT range from £21.08 to £39.40.

Full details from OK Industries, Barton Farm Ind. Estate, Chickenhall Lane, Eastleigh SO5 5RR. Tel: (0703) 619841.

• The Smart Talker Speech Synthesiser (ETI January 1988) can now be obtained as a fully assembled board (including power supply components) for £55 inclusive.

The PCB is still available at £8.90 and the complete parts kit (excluding case) for £40.00.

Orders to: Russell Vowles, 3 Orchard Waye, Uxbridge, Middlesex UB8 2BN. Please add 75p postage.



A Juicy Bit Of Software

Pineapple Software has produced an update for its popular PCB drafting program for BBC micro (reviewed in ETI March 1987).

The update gives the program full auto track routing with up to 190 connections specified by the user then linked by the program. If the result is not quite what you'd hoped for components can be shifted about without redefining all your connection points, and to help the program in the right direction you can indicate a preferred track direction or even draw a few tracks yourself before the program does the rest.

The update is available to PCB owners for £55 from Pineapple Software, 39 Brownlea Gardens, Seven Kings, Ilford, Essex IG3 9NL. Tel: 01-599 1476.

DAT's The Way It Should Be

At last DAT players are 'officially' on sale in Britain about a year after they first appeared in Japan.

The Sony DTC1000ES is retailing at £1130+VAT and includes the controversial built-in copyguard that stops it recording at the 44.1kHz sampling rate of compact disc.

Since you can't record CD and commercial recordings aren't exactly widely available yet, the only use for this machine will be in the audio industry - and even then only among the less affluent.

Richer studios will be more interested in the PCM2500 which can switch sampling rates (including 44.1kHz) and can match various formats (AES/ EBU, SDIF-2 and Sony/Philips). It cannot however convert signals from one format to another.

Ironically, considering Sony's own stand on copy prohibiting, the PCM2500 can add a copy prohibit code while recording.

HHB is supplying both machines to the UK and should soon have stocks of the even more expensive PCM2000.

For full details contact: HHB, 73-75 Scrubs Lane, London NW10 6QU. Tel: 01-960 1160.

YOUNG ELECTRONIC DESIGNER AWARDS

•The 1988 Young Electronic Designer Awards are up for grabs if you can come up with a commercially viable device with an everyday application.

Last year's winners included a saucepan for the blind, a digital pressure gauge, a speech synthesiser and an animal stress meter (?).

There are three age groups (up to 15, 16-18 and 19-25) and applicants must be in attendance at a school, college or university in Great Britain.

Apart from the cash on offer, Texas Instruments are offering course sponsorship and a job to the winner of the 19-25 group. (Even more exciting is the possibility of getting on Tomorrow's World.)

Entry forms from: The YEDA Trust, 24 London Road, Horsham, West Sussex RH12 1AY. Tel: (0403) 211048.

• Stereo TV broadcasts have *not* been shelved indefinitely as recent press reports have been claiming.

Although the BBC Nicam broadcasts will not be off the ground for at least three or four years, the IBA will be introducing a service for London in 1989.

Other IBA transmitters will be updated to broadcast stereo as they become due for routine maintenance, which would put Yorkshire next on the list.

The majority of programmes going out in stereo will be prerecorded films and music shows because of the lack of facilities for producing stereo in the TV studios.

The IBA are also considering multilingual broadcasting, using the two channels as completely separate soundtracks (dual channel sound).

Meanwhile BBC tests continue and some live programmes are already going out in London in Nicam stereo (Wogan for example) since none of the post-recording problems of stereo sound are encountered.

As for the general belief that the BBC originally scheduled Nicam for introduction in early 1988, the BBC says that this is complete rumour probably started by manufacturers such as Ferguson when they introduced stereo TVs and VCRs.

• Meanwhile you may have noticed some peculiar transmissions going out on BBC2 in the early morning closedown period.

These flickering distorted images of volcanos and skydivers are part of a BBC scrambling experiment with two applications in mind.

The first is the possibility of leasing unused air time to business and medical users to transmit high quality video pictures nationwide on a similar basis to BBC Enterprises' Datacast service on Ceefax.

The second more disturbing application stems from the Peacock Report's recommendations for Pay-As-You-View television where a scrambling system would be put on BBC broadcasts. The licence-fee would be abolished and consumers pay only for the programmes they watch (it is still unclear if ITV programmes could be watched free under such a system).

Although the BBC opposes this concept as removing any incentive to produce minority programmes, the Government may pass legislation that would give them no choice.

(x)

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The **ORIGINAL FREE OF CHARGE** dial up data base. Buy, browse or place **YOUR OWN AD** for goods or services to sell. 1000's of stock items, spares and one off bargains. Updated daily. **ON LINE NOW.** CCITT, 8 bit word, no parity. For **300** baud modems call 01-679 1888 For **1200**-75 baud modems call 01-679 6183

FREE

Your monitor from its computer!! For only £29.95 it becomes a **SUPERB HIGH QUALITY * COLOUR * TV SET**

The fabulous **TELEBOX**, an **INVALUABLE MUST** for the owner of **ANY** video monitor with a composite input, colour or monochrome. Made by a major UK Co. as a **TOP QUALITY**, stand alone **UHF** tuner and costing **OVER** £75 to manufacture, this opportunity to give your monitor a **DUAL FUNCTION** must not be missed!! The **TELEBOX** consists of a compact, stylish two tone charcoal moulded case, containing ALL electronics tuner, power supply etc to simply plug in and convert your previously dedicated computer monitor into a **HIGH QUALITY COLOUR* TV SET**, giving a real benefit to ALL the family!! Don't worry if your monitor doesn't have sound - **THE TELEBOX** even has an integral 4 watt audio amplifier for driving an external speaker, **PLUS** an auxiliary output for superb quality television sound via your headphones or **HI FI** system etc. Other features include: Compact dimensions of only 15.75" w x 7.5" d x 3.5" h, latest technology, **BRITISH** manufacture, fully tuneable 7 channel push button tuner, Auto **AGC** circuit, **SAW** filter, LED status indicator, fully isolated 240v AC power supply for total safety, Mains ON-OFF switch etc. Many other uses.

LIMITED QUANTITY - DON'T MISS THIS OFFER!!!

ONLY £29.95 OR £24.94 if purchased with **ANY** of our video monitors. Supplied **BRAND NEW** with full instructions and 2 YEAR warranty. Post and packing £3.50 *When used with colour crt.

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'SYSTEM ALPHA' 14" COLOUR MULTI INPUT MONITOR
Made by the famous **REDIFFUSION Co.** for their own professional computer system this monitor has all the features to suit your immediate and future requirements. Two video inputs: **RGB** and **PAL** Composite Video, allow direct connection to **BBC/IBM** and most other makes of micro computers or **VCR's**, including our very own **TELEBOX**. An internal speaker and audio amp may be connected to computer or **VCR** for superior sound quality. Many other features: PIL tube, Matching **BBC** case colour, Major controls on front panel, Separate Contrast and Brightness - even in **RGB** mode. Separate Colour and audio controls for Composite Video input, **BNC** plug for composite input, 15 way 'D' plug for **RGB** input, modular construction etc.etc.

This Must Be ONE OF THE YEAR'S BEST BUYS. PC USER

Supplied **BRAND NEW** and **BOXED**, complete with DATA and 90 day guarantee. **ONLY £159.00** as above **OR IBM PC** Version **£165.00**
15 Day 'D' skt **£1.00**, **BNC** skt **75p BBC** interface cable **£5.50**

DECCA 80 16" COLOUR monitor. RGB input.
Little or hardly used manufacturer's surplus enables us to offer this special converted **DECCA RGB** Colour Video TV Monitor at a super low price of **only £99.00**, a price for a colour monitor as yet unheard of!! Our own interface, safety modification and special 16" high definition PIL tube, coupled with the **DECCA 80** series TV chassis give 80 column definition and quality found only on monitors costing **3 TIMES OUR PRICE**. The quality for the price has to be seen to be believed!! Supplied complete and ready to plug direct to a **BBC MICRO computer** or any other system with a **TTL RGB** output. Other features are: internal speaker, modular construction, auto degaussing circuit, attractive TEAK CASE, compact dimensions only 52cm W x 34 H x 24 D, 90 day guarantee. Although used, units are supplied in **EXCELLENT condition.**
ONLY £99.00 + Carriage.

DECCA 80, 16" COLOUR monitor. Composite video input. Same as above model but fitted with Composite Video input and audio amp for **COMPUTER, VCR** or **AUDIO VISUAL** use. **ONLY £99.00** + Carr.

REDIFFUSION MARK 3, 20" COLOUR monitor. Fitted with standard 75 ohm composite video input and sound amp. This large screen colour display is ideal for SCHOOLS, SHOPDS, DISCO'S, CLUBS and other AUDIO VISUAL applications. Supplied in **AS NEW** or little used condition **ONLY £145.00** + Carr.

BUDGET RANGE EX EQUIPMENT MONOCHROME video monitors.
All units are fully cased and set for 240v standard working with composite video inputs. Units are pre tested and set up for up to 80 column use. Even when MINOR screen burns exist - normal data displays are unaffected. 30 day guarantee.
12" KGM 320-1 B/W bandwidth input, will display up to 132 x 25 lines. **£32.95**
12" GREEN SCREEN version of KGM 320-1. Only **£39.95**
9" KGM 324 GREEN SCREEN fully cased very compact unit. Only **£49.00**

Carriage and insurance on all monitors £10.00

DC POWER SUPPLY SPECIALS

GOULD OF443 enclosed, compact switch mode supply with DC regulated outputs of +5v @ 5.5a, +12v @ 0.5a, −12v @ 0.1a and −23v @ 0.02a. Dim 18 x 11 x 6 cm. 110 or 240v input. **BRAND NEW** only **£16.95**
GOULD G6-40A 5v 40 amp switch mode supply **NEW £130.00**
AC-DC Linear PSU for **DISK** drive and **SYSTEM** applications. Constructed on a rugged **ALLOY** chassis to continuously supply fully regulated DC outputs of +5v @ 3 amps, −5v @ 0.6 amps and +24v @ 5 amps. Short circuit and overvoltage protected. 100 or 240v AC input. Dim 28 x 12.5 x 7 cm **NEW £49.94**

Carriage on all PSU's £3.00

KEYBOARDS

Manufacturer's BRAND NEW surplus.

DEC LA34 Uncoded keyboard with 67 quality gold plated switches on X-Y matrix - ideal micro conversions etc. **£24.95**
AMKEY MPNK-114 Superb word processor chassis keyboard on single PCB with 116 keys. Many features such as On board Micro, Single 5v rail, full ASCII coded character set with 31 function keys, numeric keypad, cursor pad and 9600 baud SERIAL TTL ASCII OUTPUT!! Less than half price
Only £69.00 with data. Carriage on Keyboards £3.50

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RECEPTIVE THEORY

In this third part of his series on satellite television, Keith Brindley considers the mathematical and theoretical side of signal reception and looks at ways of calculating antenna size

Satellite TV systems (or TVRO for the pedantic) are of course examples of communications systems and as such can be looked at mathematically in terms of signal strengths to enable us to define certain minimum standards which are governed by the user's operating requirements.

However these minimum standards are related to television picture quality and as picture quality is largely subjective, some way of relating subjective picture quality to objective signal strengths needs to be devised.

What's more the relation must be made in such a way as to make easy comparisons between similar systems.

The process of calculating a satellite system's quality in this way is known as a *link budget analysis* — so called because it's an analogy with a financial budget, comparing gains and losses in the link between satellite and receiver to give a final result in terms of picture quality.

No Accounting For Taste

The main problem in any communications system (but particularly in TVRO systems) is the level of noise which the receiver output contains. A communications system's noise level is typically quoted in relation to received signal level as a *signal-to-noise ratio* (S/N), where the S/N ratio is given in decibels (dB) by:

$$S/N = 10 \log \left(\frac{\text{signal power}}{\text{noise power}} \right)$$

Most readers will know this and no further time needs to be spent here. However, the S/N ratio depends on a number of other factors within the overall system, particularly regarding satellite television reception. So we need to consider further these related factors.

To do this we must consider some basic transmission calculations. A transmitting satellite rotating in the geo-stationary orbit (GSO) is sufficiently far away from the Earth to be considered an *isotropic* radiating source since it appears from an Earth viewpoint to radiate in all directions (Fig. 1a).

In reality of course this is not the case as all satellites use directional transponders (Fig. 1b) — they are only *effectively* isotropic (remember this term) as far as the earth-bound observer is concerned.

We can calculate an antenna's received signal from an isotropic source if we first calculate the flux density of the source at say a distance D_s because all the radiated signal must pass through an imaginary sphere of radius D_s around the source. The resultant flux density is given by:

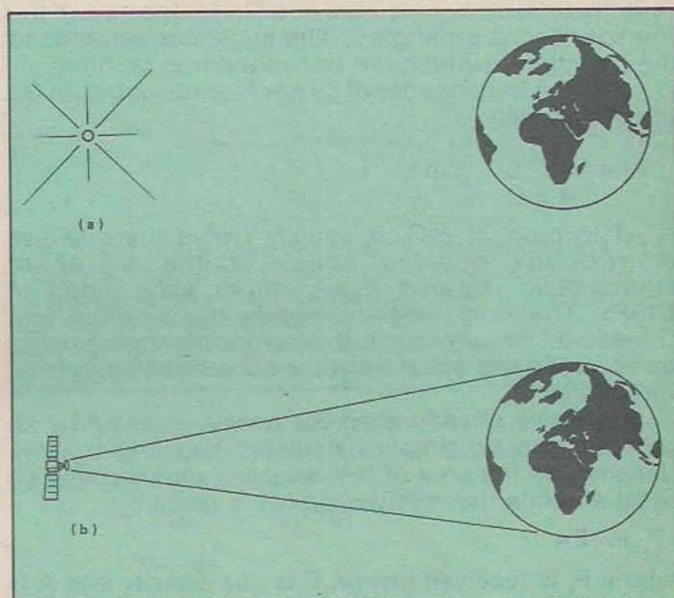


Fig. 1 Satellite transmissions viewed from Earth (a) A satellite is sufficiently far from Earth to appear as an isotropic transmitter (b) Directional transponders are always used on a satellite but the effect is still isotropic

$$F = \frac{P_t}{4 \pi D^2} \text{ Wm}^{-2}$$

where P_t is the transponder power.

If a receiving antenna is presumed to be positioned on the circumference of the imaginary sphere then two main points are illustrated by this relationship:

- flux density decreases with distances from the source (fairly obvious) as an inverse square
- flux density (in watts) received at the antenna can be simply calculated if the area of the antenna (in m^2) is known.

With a satellite's directional transponder a gain $G(\theta)$ occurs in a direction θ, where gain is defined as the ratio of power per unit solid angle radiated in a given direction to the average power radiated per unit solid angle. That is:

$$G(\theta) = \frac{P(\theta)}{P_o/4\pi}$$

where $P(\theta)$ is the power radiated per unit solid angle,

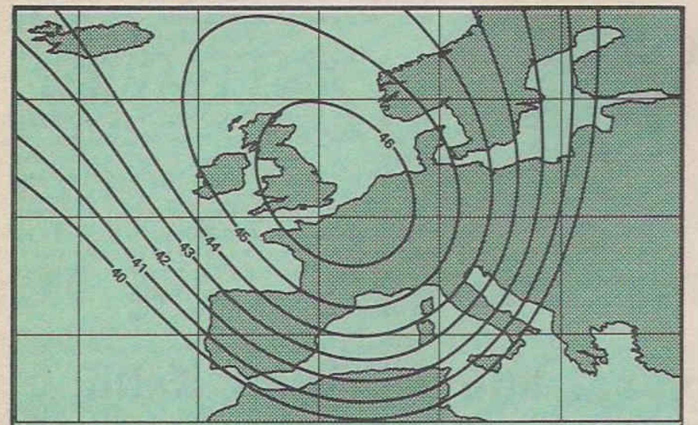


Fig. 2 EIRP footprint of Eutelsat F1. Orbital position in GSO is 13° east

P_o is the total power radiated and $G(\theta)$ is the gain of the transponder at an angle θ. The angle corresponds to the direction in which the transponder is pointing.

So for a transponder of power P_t watts and gain G_t, the flux density is:

$$F = \frac{P_t G_t}{4 \pi D^2} \ \mathrm{Wm^{-2}}$$

The product $P_t G_t$ is usually called the *effective isotropically radiated power* or the *equivalent isotropically radiated power* (both abbreviated to EIRP). The terms merely signify the fact the uni-directional transponder is looked upon by the observer as equivalent to a *real* isotropic source radiating in *all* directions.

As we've already seen the power received by an antenna can be simply calculated knowing the flux density and the area of the receiving antenna. For an ideal antenna the received power is given by:

$$P_r = FA$$

where P_r is received power, F is flux density and A is antenna area.

In practice however, no antenna is perfect and an efficiency, known as the *aperture efficiency* η, of between 60-75% is normal. This aperture efficiency is said to reduce the area of the antenna's receiving aperture to give an *effective antenna area* A_e where:

$$A_e = \eta A$$

For a practical antenna the received power is therefore:

$$P_r = FA_e$$

So in terms of EIRP received power of a practical antenna is given by:

$$P_r = \frac{P_t G_t A_e}{4 \pi D^2}$$

In other words, received power depends only on the satellite's EIRP, the antenna's effective area, and the distance between the satellite and the antenna.

We can consider this relationship another way, where the term:

$$L_s = \frac{1}{4 \pi D_2}$$

is known as the *spreading loss*, or the *path loss* (in fact it is not a loss in the strict sense at all — it merely accounts for the way energy spreads out as the transmitted wave travels away from the source). The received power can now be calculated as:

$$P_r = \frac{\text{EIRP} \times \text{effective antenna area}}{\text{spreading loss}}$$

and, because all these terms usually are quoted in decibels (that is, logarithmically) then:

$$P_r = \text{EIRP} + A_e - L_s \ \text{dB}$$

Again, this represents the ideal situation and in practice other losses such as attenuation due to weather (particularly rainfall) have to be taken into account.

Practical Example

To put things into perspective at this point, we can consider a real antenna site (such as in my back garden) and perform a few calculations to show the idea.

Figure 2 shows the footprint in terms of EIRP of the Eutelsat F1 satellite, positioned at 13° east in the GSO. Each ring of the footprint represents an EIRP 'contour' within which area the EIRP is numerically indicated in units of dBW. Over most of Britain the EIRP is 46dBW.

The units dBW simply means that the power level is referred to 1W. In other words 1W is signified by 0dBW. A positive dBW level means the power is greater than 1W, a negative dBW level means the power is less than 1W. Another common reference power is in units of dBm where the level quoted with those units is referred to 1mW — so that 1mW is signified by 0dBm. Both units are common in communications engineering.

Now in my back garden (in the wilds of the East Midlands) the distance from Eutelsat F1 and the antenna happens to be about 38747km. So the spreading loss in my back garden is:

$$L_s = \frac{1}{4 \pi D^2} = \frac{1}{4 \pi (38747 \times 10^3)^2}$$

$$= \frac{1}{1.8866 \times 10^{16}}$$

$$= 5.3 \times 10^{-17}$$

Expressed in decibels, this is: 10 log (5.3×10^{-17}) or −162.76dB.

Using a 1.5 metre diameter antenna, the actual area is πr^2 or 1.767m². With an aperture efficiency of, say, 60% (about right for most antennae), the effective antenna area is 1.06m², expressed logarithmically this is 0.25dBm².

It's difficult to define exactly the loss which may occur due to weather conditions but generally 2dB is about right.

Calculating the received power is now just a simple matter:

$$P_r = 46 + 0.25 - 162.76 - 2 = -118.51 \text{dBW}$$

which means that only 1.4 picowatts of signal power (work it out for yourselves) is received by the antenna — not a lot!

The received power we've worked out here is normally referred to as the *carrier power* and given the symbol C. In frequency modulation (such as existing satellite television services) and phase modulation systems the two are equal because the carrier level is constant, whether or not a signal is modulated onto the carrier.

Most signal-to-noise calculations for satellite systems use estimates of carrier power rather than signal power and subsequent signal-to-noise ratios normally are quoted as a *carrier-to-noise* ratio (C/N).

Noise

Having calculated the received carrier power, we now have to consider the noise present so that we can compare the two.

Noise in satellite television reception systems follows a classical receiver convention (shown in Fig. 3a) where the receiving antenna is connected to a demodulator through a high-gain amplifier. In a satellite reception system the high-gain amplifier is only one part of the low noise blockdownconverter (LNB). All important parts of the LNB are shown in Fig. 3b.

The noise we want to measure is that noise present at the demodulator input and this is made up of noise which is contributed by various parts of the system including the antenna itself, the waveguide and the high-gain low-noise amplifier (LNA). Although parts following the LNA also contribute noise, their effects are negligible in comparison and so can be ignored.

At the microwave frequencies involved in satellite communications systems, all objects with a temperature above 0K generate noise and so contribute to the total system noise. This *thermal noise* is usually calculated in terms of *noise temperature* by relating temperature to the thermal energy produced by the random movement of electrons, with Boltzmann's constant. Noise is generated by an object at each frequency, so the bandwidth of the receiver also bears directly on the amount of noise present at the demodulator input.

The noise power present at the demodulator input is given by:

$$P_n = kT_sB$$

where k is Boltzmann's constant (1.38×10^{-23}), T_s is the total system noise temperature in degrees Kelvin and B is the receiver bandwidth in Hz.

Total system noise temperature is a combination of the noise temperatures of antenna and LNB. LNB noise temperature may be given by the manufacturer or can be calculated from the LNB's noise figure (NF) which is usually quoted in decibels. LNB noise temperature is:

$$T\left(\text{antilog}\left(\frac{NF}{10}\right)-1\right)$$

where T is the temperature in degrees Kelvin (usually taken as 17° C — 290K).

Antenna noise temperature is a bit more difficult to estimate as it varies with antenna, elevation angle and received frequency but manufacturers should supply figures and results are typically in the range 40K to 90K.

In practical terms (my back garden again!) for an antenna with a noise temperature of 60K, an LNB noise figure of 2.5dB and a receiver bandwidth of 30MHz, we can now calculate the noise power present at the demodulator input. The LNB noise temperature is:

$$290\left(\text{antilog}\left(\frac{2.5}{10}\right)-1\right)=225.7K$$

so the total system noise temperature is 225.7K+60K= 285.7K.

The noise power at the demodulator input can now be calculated as:

$$P_n=1.38\times10^{-23}\times285.7\times30\times10^6$$

or, logarithmically in decibels:

$$=-228.6+24.6+74.8$$

$$=-129.2\text{dBW}$$

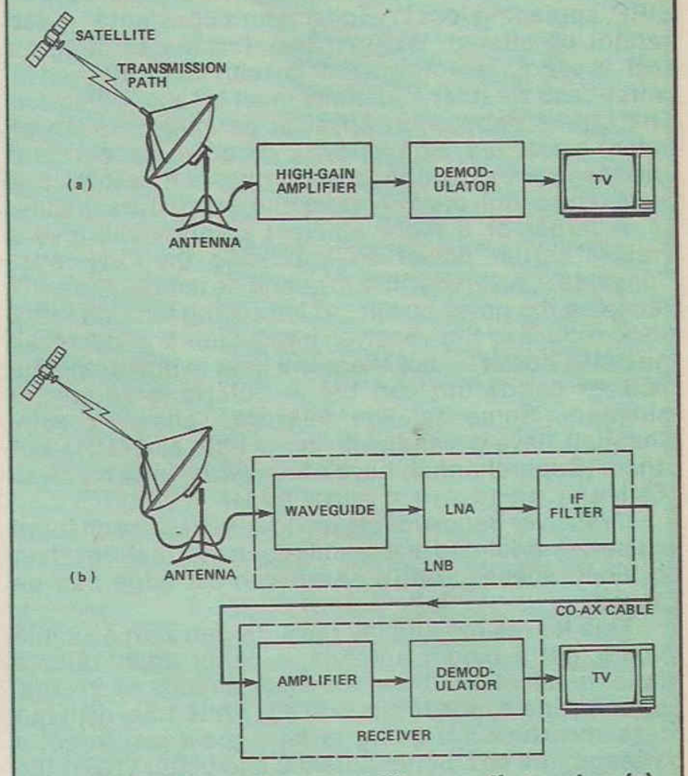


Fig. 3 Sources of noise in a satellite reception system (a) The basic system receives signals from the satellite via the antenna then amplifies the signal before demodulation (b) In practice the LNB contains a waveguide, a low-noise amplifier (LNA) and IF filter and is connected to the main receiver with coaxial cable

Knowing this and using our previous calculation for carrier power the available C/N ratio can be calculated as:

$$C/N=(-118.51)-(-129.2)$$

$$=10.69\text{dB}$$

Putting Us In The Picture

A simple C/N ratio like this doesn't mean a lot to the uninitiated so we need to look further into what it represents. Measurement of quality of a television picture is a highly subjective area (an adequate picture for one person is no good for another) but the International Radio Consultative Committee (CCIR) has defined a picture quality assessment plan which uses a five-point grading system. This, related to a system's CN ratio, is listed in Table 1 and shown in graphical form in Fig. 4.

From these we can see that a practical C/N ratio of 10.7dB (the system in my back garden) gives a picture which is classed as only just fair. Even more worrying than this, however, is the fact that such a low C/N ratio is probably close to the receiver's FM threshold margin (typically around 8-9dB) and so impulse noise interference showing up as black and white flashes or dots on the screen — the infamous 'sparklies' — could occur.

If this was a real system which I was about to buy, I'd want to know how I could improve the picture quality a bit. Let's go back to the calculations for C/N ratio to find out how. The overall ratio is given (in decibels by:

$$\frac{C}{N} = \frac{P_r}{P_n} = \frac{\text{EIRP}+A_e-L_s-\text{weather loss}}{k+T_s+B}$$

Some of the factors in the calculation are constant — EIRP, spreading loss L_s, Boltsmann's constant k — and cannot be altered. Weather loss (estimated at about 2dB, is of course not constant but cannot be ignored as worst-case weather situations must be accounted for. The others depend on physical parameters such as antenna size and efficiency, LNB noise temperature and receiver bandwidth, so a number of measures can be taken to improve C/N ratio and the picture quality.

A larger or a more efficient antenna will give a greater carrier power so improving the C/N ratio. Conversely, an LNB with a lower noise temperature will decrease the noise power, so improving the C/N ratio. Also, reducing the receiver bandwidth will decrease the noise power — but there is a limit to how small the receiver bandwidth can be! — 30MHz is about the minimum. Some satellite television channels (Sky Channel) have a bandwidth of as little as 27MHz but others (Superchannel) have a bandwidth of as much as 36MHz.

If receiver bandwidth is too low, not all the channel will be demodulated and results such as a tearing effect on video scenes with a sharp vertical edge can be caused.

This leaves me and my back garden with a simple choice: get a bigger antenna, a better antenna or a higher quality LNB. Now, the wife's already up in arms about having a monstrous brilliant white 1.5m dish out there and she's not going to let it grow just to get a better picture so a better antenna and better LNB is the answer.

Using an antenna with an efficiency of, say, 65% and an LNB with a noise figure of, say, only 1.5dB (some of the most recently produced LNB's can meet this requirement) we can now re-calculate the C/N ratio.

Effective antenna area is now 65% of 1.767m² (1.15m²) or in decibels: 0.6dB. LNB noise temperature is now:

$$290\left(\text{antilog}\left(\frac{1.5}{10}\right)-1\right)=119.6\text{K}$$

and total noise temperature is 119.6K+60K=179.6K or in decibels: 22.5dB. Final C/N ratio now becomes:

$$C/N=4+0.6-162.76-2-(-228.6+22.5+74.8)$$
$$=13.14\text{dB}$$

This result corresponds to a picture quality which is close to being good on the CCIR five point scale and I'll certainly accept it. Generally, a C/N ratio of about this 13dB figure should be aimed for when doing a link budget analysis. This should allow for extremes of weather conditions, minor antenna pointing inaccuracies and the like.

Figure Of Merit

Overall receiver performance is sometimes quoted as a *figure of merit* which is its gain over temperature (G/T). All receiver parameters such as antenna gain, total system noise temperature and so on are catered for in this G/T figure and so the figure of merit is related to the C/N ratio and one can be calculated from the other (approximately) according to the relationship:

$$C/N=EIRP+G/T-53\text{dB}$$

or inversely:

$$G/T=C/N-EIRP+53\text{dB}$$

So, the practical example of the system in my back garden (with improved antenna and LNB) has a figure of merit of:

$$G/T=13.14-46+53$$
$$=20.14\text{dB}$$

Next month, to round off this series, I shall look at three specific STV systems in detail.

Quality	Grade	Impairment	Approx C/N (dB)
Excellent	5	Imperceptible	20
Good	4	Perceptible but not annoying	15
Fair	3	Slightly annoying	10
Poor	2	Annoying	7
Bad	1	Very annoying	5

Table 1 CCIR picture assessment compared to satellite receiver carrier-to-noise ratio

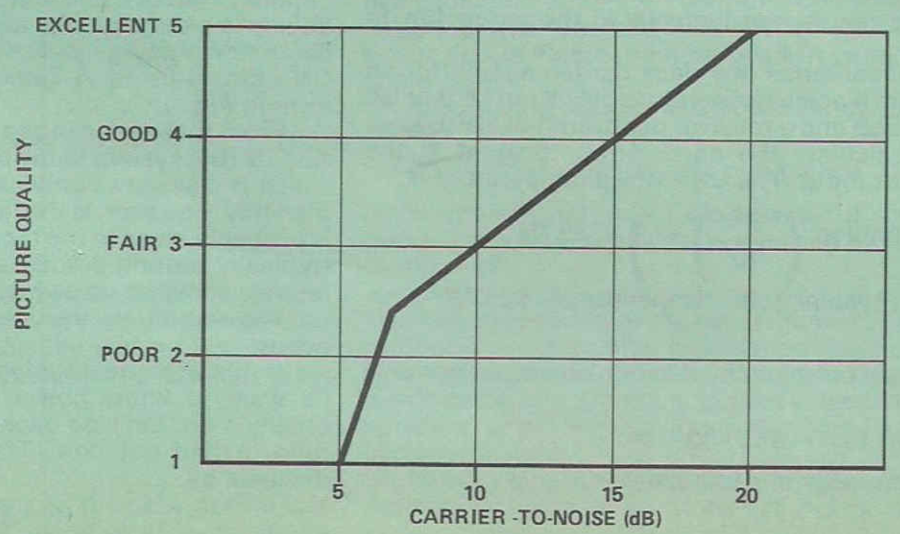


Fig. 4 CCIR picture quality assessment compared to carrier-to-noise ratio at the demodulator input of a satellite receiver

ETI

MICRO CIRCUITS

Malcolm Brown takes a look at two programs for the BBC micro and Amstrad CPC machines to help the amateur circuit designer.

In the March 1987 issue of ETI we took a look at several programs for the BBC micro to help you design and draw circuits and PCB foils. One of the winners of that selection was Diagram from Pineapple Software. Now Diagram has been been completely rewritten with many additions and improvements as Diagram II. First, however, we'll look at a new contender – a PCB design package for Amstrad CPC micro users.

PCB Drafting Utility (cassette) £19.99
£21.99 (disk)
CADsoft, 18 Ley Crescent,
Astley, Tyldesley,
Manchester M29 7BD.

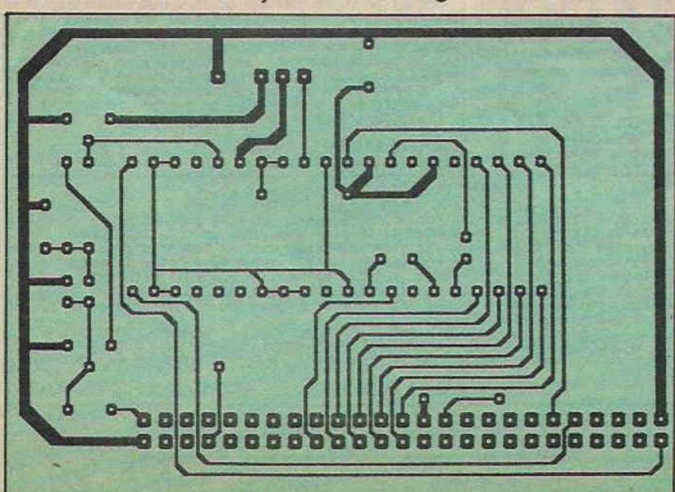
The humble Amstrad CPC range of micros provide a lot of computer for not very much money so it is about time they were used to help the struggling electronics enthusiast.

This package is a PCB design tool to produce paper artwork of foils for subsequent photographic transfer to celluloid for UV exposure and etching.

The program is available on cassette for CPC464 users and on 3in disk for those with a CPC664 or CPC6128.

The program is in two parts – the editor and the plotter. Both sections are based on Basic programs with machine code routines.

The editor is used first to create your PCB design. PCBs up to 25×25in can be designed. The screen display shows a greatly enlarged section – about 4×2½in – at any time. However, the whole PCB can be drawn on at a time if you can manage to do this 'blind'.



This is more useful than it seems at first because it means a track can run for more than the width of the screen and still be drawn in one go.

This is a drawing package which stores the start and end co-ordinates of the lines (tracks) and points (pads) and suffers from the problems associated with this method. Although the whole PCB is much larger than the screen window, you cannot scroll across it. Instead the screen must be entirely redrawn from a new viewpoint each time.

However, that aside, drawing a PCB with this package is easy enough. There are three structures which can be drawn – pads, tracks and DIL packages (which are really just collections of pads — so there's only two structures after all).

Tracks are drawn by rubber banding. The cursor is moved around in discrete 0.05in steps and the Tab key starts and stops line drawing. The lines drawn on the screen in this way do not directly correspond to the tracks on the final PCB. The final width of the tracks is set separately to 0.0125, 0.025, 0.0325 or 0.05in.

Pads are similarly positioned at the current cursor position and they too can be preset in size to 0.05, 0.065, 0.085 or 0.1in.

Both pads and lengths of track can be deleted from the foil by moving the cursor to any part of them and pressing the appropriate key.

Sets of DIL pads are placed on the foil with the function keys and they can be set either horizontally or vertically. The pitch between the rows of pins can be altered to just about any conceivable value but sensible defaults are provided. Setting a row separation of zero provides SIL package pads.

Once on the foil design, the DIL pads are treated as individual pads and must be deleted one at a time.

The program can cope with double-sided boards and both sides are displayed at the same time in different colours. Which side is 'active' — being drawn on at the time — is selected with the U and L keys (upper and lower). All pads are always placed on both sides of the board which can occasionally be a problem.

The completed board can be saved to disk for further editing later or for printout.

The plotter routine uses a standard Epson-compatible dot-matrix printer. Either or both sides of the board can be printed and the printing can be either way around on the paper.

Printouts are made at twice size in four-inch strips which must be joined later for photography and are produced in either a quick draft mode or in the higher quality final mode.

The sections of the foil are drawn out on the screen before dumping to the printer and it is here that the real quality is shown. In this mode the tracks and pads are expanded to their intended size and the pads take on the normal elongated oval shapes.

CADsoft's PCB Drafting Utility is adequate for most amateur use but it is not to the quality of Pineapple's PCB program (see that March 1987 review) for the BBC micro.

The Amstrad CPC micros have a far greater potential for this kind of work because of their vastly increased memory. However, some silly scrappy Basic programming mistakes (such as overwritten menu prompts and no disabling of the potentially lethal Escape key) means this program cannot be considered a truly professional tool.

Diagram II

£55+VAT (exchange deals available for Diagram I users).
Pineapple Software, Brownlea Road, Seven Kings, Ilford, Essex IG3 9NL.
Tel: 01-599 1476.

There are many drawing packages around for the BBC micro but this one uses an entirely new method of storing the picture to make it particularly suited to drawing circuit diagrams.

Many other drawing packages store the start and end co-ordinates of all the lines in the picture along with a code to determine whether a line is drawn or a rectangle or whatever. This can be wasteful of disk space and makes editing the picture slow and difficult.

Other programs (usually the more 'artistic' ones) store the memory mapped screen RAM. This is usually quite economical on storage space but useful editing is nearly impossible.

Diagram II uses neither of these methods. Instead, the picture is stored as an array of character codes (an extended ASCII coding system is used) with the bit map definitions corresponding to each code stored separately.

Of course with a picture (such as an artistic work) with a great deal of variation across it, this is an uneconomical method, to say the least.

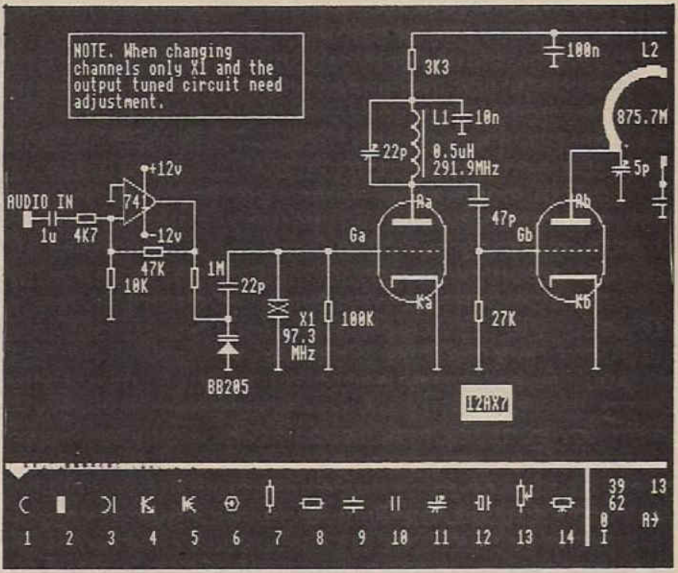
However, with a diagram consisting of a great many repeated symbols and sections (as is a circuit diagram) this method is economical and has a few other great advantages.

Most important is the speed in which the diagram can be drawn. This not only means that it can be produced on the screen and edited quickly but also that the section shown on the screen can be just a part of a much greater whole. Diagram II allows smooth scrolling across a complete diagram of up to 30 Beeb mode 0 screens.

This method also allows the complete multi-screen diagram to be easily displayed on one screen with each pixel representing each character of the full sized screen. A complete diagram of up to 8×8 screens can be displayed in this reduced form for checking the 'whole look' of the diagram.

Despite this unique system, when using the program you would not know that Diagram II is any different from other drawing packages. The mechanics of it all are very cleverly hidden. The cursor is used to move around the diagram and a line is left trailing behind. The program automatically lays down the correct line character needed at that point in the diagram. Turn a corner and a right angle turn character is printed, cross another line and a cross character is printed at the intersection.

A 'blob' can be left at line intersections just by



pressing Ctrl as you pass over the join. Now that just isn't possible with other types of drawing package. They require a precise positioning of a blob symbol after the lines are drawn.

This character system also means diagrams are naturally and easily kept aligned and 'square'. It is genuinely difficult to not draw neat and impressive diagrams using this software.

That's all very well for vertical and horizontal lines but Diagram II can also make use of 'rubber banding' to draw all the diagonal lines in between or for tracing an irregular shape. Amazingly, this still uses predefined characters, automatically selected and positioned to make up all the line sections.

As well as straight lines, Diagram II running on a Master or model B with Acorn's GXR ROM can produce circles, rectangles, ellipses, arcs and triangles, either filled or in outline, to build up large shapes. Without the GXR ROM only circles and filled triangles can be created.

Again, although drawing these shapes is performed with the cursor and is as easy as with any drawing package, the end result is made up of individual predefined characters which go to make up the complex shapes.

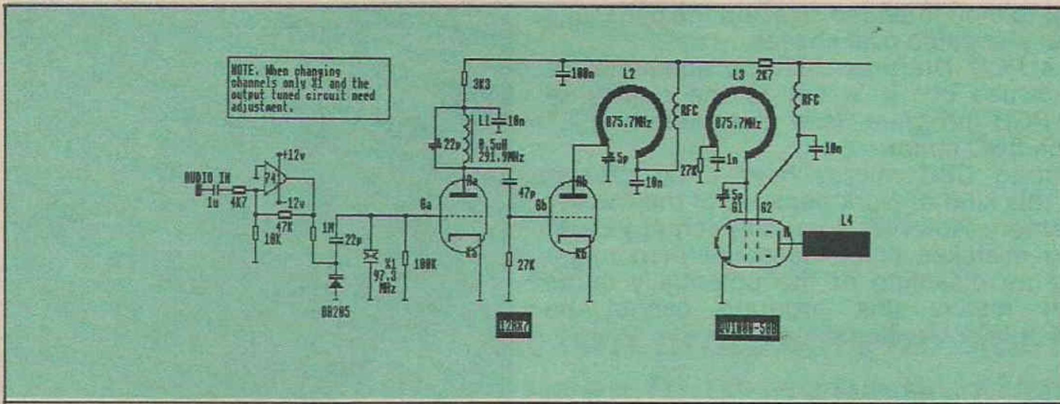
Text is positioned on the diagram simply by typing it in when the cursor is at the right position. Text can also be taken from a file created with Wordwise Plus and automatically fitted in a defined section of he diagram.

Diagram II can produce discrete symbols such as transistors, resistors and so forth. These are also made up of characters – up to 12 normal Beeb 8×8-pixel characters.

With a basic model B BBC micro, 335 characters can be defined, shared between the symbols. With a machine using shadow memory (such as the B+ or Master) 880 Beeb characters can be used.

A definite improvement over the old program is the ability to delete unwanted symbols and so free the characters for use with new ones. The complete set of symbols or just a limited subsection from one diagram can be saved to disk to use with another diagram – again a useful addition.

To design these symbols a very effective character definer is provided. There have been many such definers produced for the BBC micro but this is one of the best I've seen. It is fast and simple to use. As well as allowing the symbols to be defined one pixel at a time on an enlarged grid, complete symbols can be emptied



or flipped horizontally or vertically.

The character definer can of course be used to define new styles of text characters and these can then be inserted in the diagram just like 'normal' text, from the keyboard.

Each character has a 'direction' defined along with it. This controls the cursor movement after the character is positioned on the diagram. The direction can be defined in any of the four compass directions so that, say, a complete set of upside down characters could be typed right to left straight from the keyboard without fiddling with the cursor between characters.

Any area of the diagram can be defined with the cursor and then deleted, moved, copied to another part of the screen or saved to disk to be inserted into another part of the program or into another diagram altogether.

Borders can also be added in one single movement and existing diagrams changed in size for additions or shifted across an enlarged diagram.

The completed diagram is stored on disk or printed on a standard Epson compatible dot-matrix printer at just about any size from three screens to just one character across a sheet.

All the parameters entered to control the size, position and codes used for the printout can then be saved to disk to save time for later repeat runs.

The quality of printing is the last factor which makes Diagram II so outstanding. This package really is capable of producing top quality diagrams. It is difficult to see how this package could now really be improved. For anyone looking for ways to edit, store and print out professional circuit diagrams with a bare minimum of equipment, Diagram II is the only answer.

ETI

DOMAIN POINTS AGAIN

Paul Chappell pulls his phasors together to find a use for mathematics in circuit design

Last month's article was concerned with the mechanics of manipulating complex numbers with hardly a mention of how this might apply to electronics. This month I'll redress the balance and concentrate on applying complex number arithmetic to circuit calculations.

We haven't reached the end of the mathematics by a long way but it's just as well to keep the final objective in sight — to make AC circuit theory as easy as π.

The Story So Far

In an earlier article (November 1987 *Circuit Theory*) I demonstrated that in a capacitor with a sinusoidal voltage applied, the current would also be sinusoidal. The ratio of the voltage and current amplitudes at any given frequency is constant so the capacitor can be thought of as having a 'resistance' to sine waves.

Since the apparent resistance varies with frequency and the voltage and current waves are offset by 90°, it's not quite the same as ordinary resistance. It is given the name *reactance,* the symbol X_c, and for a capacitor C at angular frequency ω it has the value $-1/\omega C$.

For a sinusoidal current of amplitude I, the voltage amplitude will be given by $V=I\times X_c$, just as for an ordinary Ohm's law calculation $V=I\times R$. An inductor has similar properties and a reactance X_L of ωL.

The problem we found with using the straight voltage-to-current amplitude ratio as the 'resistance' of reactive components was that the 'resistances' didn't add for components in series and the usual parallel resistor calculations didn't apply to components in parallel. So the concept of an AC 'resistance' was rather limited in application!

We concluded that this problem arose because the 90° phase difference between voltage and current was not being taken into account. With the aid of complex numbers we are now in a position to correct this flaw and bring out the full power of the ideas.

A Practical Example

Let's take a look at the circuit of Fig. 1(a). To keep our feet firmly on the ground I haven't used normalised values — the frequency and components are those you might find in a real circuit. I haven't specified the input for the moment. All we know is that it's a sine wave of angular frequency 5×10^6 radians per second (roughly 800kHz).

The reactances of the inductor and capacitor at this frequency will be X_L=500 ohms and X_C=400ohms. This suggests that the entire circuit has an impedance of 1000R and that a 1mA amplitude current should produce a voltage across the circuit of 1V (both at 800kHz).

We already know that this doesn't happen and Fig. 1 shows why. Taking the cosine form of the input current and freezing the phasors at t=0 gives the situation depicted in Fig. 1(b) for the individual voltages across each component and Fig. 1(c) for the combined voltages. The voltage across the entire circuit (V_{in}) has an amplitude of 141mV against a predicted value of 1V. Our estimate was out by a factor of seven!

The diagrams show clearly what has gone wrong. To give the predicted 1V, the voltages would all have to be in phase so their phasors would add in a straight line. They aren't and they don't!

Ordinary numbers can't take into account the direction of the phasors. All they can do is tell you how long they are. Complex numbers can do both!

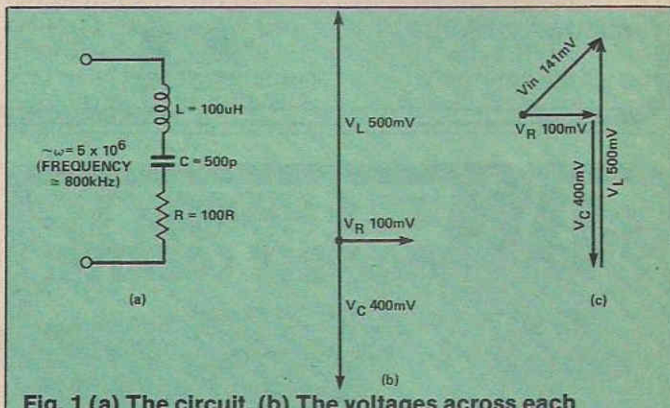


Fig. 1 (a) The circuit. (b) The voltages across each component. (c) The voltage across the entire circuit.

Let's begin again. First of all we'll relabel the circuit as shown in Fig. 2. We have now entered the *frequency domain!* This means every time I mention a current I or a voltage V, they are automatically assumed to be sinusoidal in form (which saves having to state the obvious every two minutes) with amplitudes I and V respectively.

This also means the components are labelled with their complex impedances rather than with their normal component values. We'll see how it works right now.

First of all, we'll set the input frequency to $\omega=5\times10^6$ radians per second. Now we can work out the impedances of each of the components. Z_L=j500, Z_C=-j400 (note the minus sign — remember that 1/j=-j) and Z_R=100.

To find the impedance of the entire circuit, just add up the individual impedances. 100+j500-j400=100+j100. If we agree to work in mV and mA, then a 1mA input current (remember: frequency domain so this means a sinusoidal input current of amplitude 1mA and *not* a steady 1mA current) in cosine form will be I=1+j0 (or just 1 for short!). The voltage will be $I\times Z_{in}=1\times$(100+j100)=100+j100 and we're through. Well, almost. My voltmeter doesn't actually register voltages of 100+j100!

To express the answer in more familiar terms, we have to translate back to the *time domain*. The voltage 100+j100 has a modulus (length) of 141 and an argument (angle) of $\tan^{-1}(100/100)=45°=\pi/4$. In full, we've discovered that an input current of $\cos(5\times10^{-6}t)$ at the input will give rise to a voltage $141\cos(5\times10^{-6}t+\pi/4)$ across the input terminals.

Now let's look at the pictures to see what's going on. First of all, we agree to draw our phasors in the *complex* or *z-plane*. The phasor representing a current of 1mA in cosine form points along the positive real axis and is described in complex number form as 1+j0 (we're working in units of mA and mV, remember).

This gives rise to a voltage of (1+j0)×(j500) across the inductor which comes to j500 or a phasor of length 500 pointing up the positive imaginary axis. There's no need to draw it again — it's there in Fig. 1(b)!

The voltage across the capacitor comes to -j400 — represented by a phasor of length 400 pointing down the negative imaginary axis (as in Fig. 1(b)). The voltage across the resistor you can work out for yourself!

Now we add up the three individual voltages (remember from last month that complex number addition corresponds to addition of phasors in the z-plane) giving the result shown in Fig. 1(c). The voltages due to a unit current add correctly so the impedances must also add correctly, since impedance is exactly that — the voltage per unit current.

Time And Frequency Domains

Just about every circuit you've ever seen in the pages of ETI is in the *time domain*. All this means is that if you know how the input behaves as a function of time, you can deduce the output — either by calculation, common sense or by reading the 'How It Works' section!

You might ask yourself what happens when the switch is pressed. What happens just after the pulse reaches IC5? When will the output of IC9 go high? All questions to do with time. First one thing happens, then another, then another ... OK, I won't labour the point any more!

Figure 1(a) is a time domain circuit. You could ask what its response is to a voltage step then draw the output as a graph of voltage against time and so on.

Now, we know that if the input to the circuit of Fig. 1(a) was a sine wave, every single voltage and current would also be a sine wave. So asking how the circuit behaves in time is silly. We know already — it gives sine waves.

If we know the voltages and currents in the circuit at any instant in time, we can deduce what they will be for evermore. So to inspect the circuit we suspend the operation at a single instant in time. All the currents and voltages can be visualised as phasors, immobile as frozen twigs on a February morning.

To help with the calculations, we draw a *frequency domain* circuit as in Fig. 2(a). The input voltage and current are represented by their frozen forms and the components are labelled with their complex impedances which makes it easy to calculate the lengths and angles of all the other frozen twigs.

Having studied the circuit to our hearts' content, we set the phasors spinning again and translate the circuit back into the time domain.

You'll notice that none of the expressions we've used in calculating impedances or whatever has a 't' in it. There is no reference to time. The variable we *do* have at our disposal is the angular frequency ω. Hence the name frequency domain. So far we haven't made use of the ability to vary ω, but that's about to change.

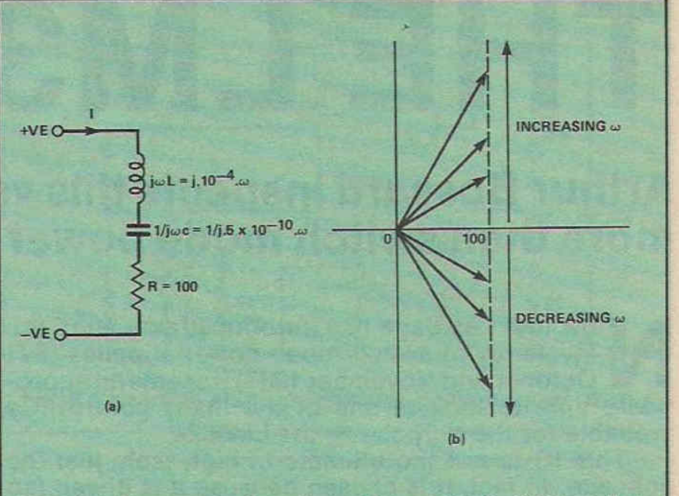


Fig. 2(a). Frequency domain version of Fig. 1. (b) Variation in the voltage across the circuit with frequency

Frequency

Sticking with the circuit of Fig. 1(a), let's see what we can find out about its behaviour at different frequencies. First of all, you'll notice the voltage across L is proportional to frequency. As ω increases, so will the voltage across L. As the frequency decreases, so will the voltage.

For the capacitor, exactly the opposite happens. Up the frequency and the voltage goes down. Reduce the frequency and the voltage rises.

If you think about the effect of this on Fig. 1(c) (assuming an input current of 1mA at various frequencies) as the frequency increases, V_C gets shorter and the V_L phasor gets longer. The resultant voltage across the entire circuit gets larger in magnitude and leads the current by a greater and greater angle.

Reducing the frequency increases V_C and reduces V_L so the overall voltage swings downwards and *lags* the current by a greater and greater angle. The effect on the voltage across the circuit as a whole is shown in Fig. 2(b) for various frequencies. (It's at times like this I wish I could produce animated graphics with all the phasors altering in length and the voltage phasor gliding along its path. Since we haven't found a way to do it on the pages of ETI, you'll have to use your imagination!)

For some value of ω, the voltage across the circuit will point along the positive real axis. It will be in phase with the input. It will also have its minimum amplitude at this point. (If you can see where this is leading, take the Mrs Beestly prize for supreme cleverness!)

Let's see if we can work out the frequency at which this happens. Looking at Fig. 1(c), it's clear that the condition for the voltage phasor for the whole circuit to point along the positive real axis is that $V_C=-V_L$. If this holds, the voltages across the inductor and capacitor will cancel and the voltage across the entire circuit will be equal to the voltage across R. In mathematical terms we require $1/j\omega C=-j\omega L$. Solving for ω we get $\omega=1/\sqrt{LC}$.

If you still haven't caught on, perhaps the more familiar $f=1/2\pi\sqrt{LC}$ will give you a clue!

We've just derived the condition for the circuit to be in resonance. The fact it was obtained so easily is a demonstration of the power of this method of analysis that you'll appreciate if you've ever tried to derive the same result in the time domain with the aid of a page of differential equations!

If you think this is good, you ain't seen nothing yet! Watch this space next month.

ETI

THE LM3524

Arthur Bossard inspects this versatile IC and finds it's good for more than switch mode power supplies

Now that Les Sage has introduced you all to the mysteries of switch mode power supplies (ETI October and November 1987) it seems an appropriate time to look at one of the many control ICs available for the purpose — the LM3524.

This IC is not the ultimate in high-tech, just the opposite, in fact. It is chosen because it is cheap (so you can experiment without heart palpitations at the thought of ten quid going up in smoke!). It is also readily available, doesn't need many external components to make it do its stuff and because it can be used for other control functions (or even as an LED flasher if your imagination deserts you!)

For those not familiar with switching regulators, the LM3524 is a good introduction since the basic functional blocks are not obscured by a mass of control circuitry. There's an over-current sensor, a logic input to shut down the IC in case of faults in other parts of the circuit, and that's your lot.

The functional blocks inside the IC are shown in Fig. 1. The heart of the IC is the oscillator which runs at a frequency set by the resistor and capacitor from pins 6 and 7 respectively. The capacitor is repeatedly charged at a constant current to 3.5V, then quickly discharged back to 1V, resulting in a sawtooth waveform at pin 7.

Forgetting the input amplifier, current limit and all the rest of the paraphernalia for a moment, imagine applying a DC voltage to pin 9 of the IC. (You can actually do it if you want to, as the internal amplifiers are transconductance types and won't be upset by it).

If the voltage at pin 9 is below 1V, the comparator output will always be high since its positive terminal is connected to the sawtooth waveform which is always above 1V. If the voltage at pin 9 is a little above 1V, the comparator output will go low briefly after each discharge of the capacitor. A higher voltage on pin 9 will keep the comparator output low for longer and an input above 3.5V will keep it low all the time.

So the comparator output is a rectangular wave with a duty cycle controlled from zero to 100% by the voltage on pin 9. If this wave were fed directly to a single output transistor, we would already have a very basic voltage controlled pulse-width modulator suitable for use in a switching regulator!

The LM3524 has two output transistors to allow for push-pull operation. Where this is not required, the two transistors are connected in parallel. The flip-flop switches between the two transistors on alternate cycles of the oscillator.

The gate input from the oscillator's output is a 'blanking pulse' to give a short period when both transistors are turned off, preventing cross-conduction at maximum duty cycle.

You can get a 'feel' for the operation of the IC so far by connecting up the circuit of Fig. 2. The LEDs flash alternately as the flip-flop switches from one output transistor to the other. RV2 sets the oscillator frequency and therefore the flashing frequency. RV1 controls the duty cycle of the out pulses.

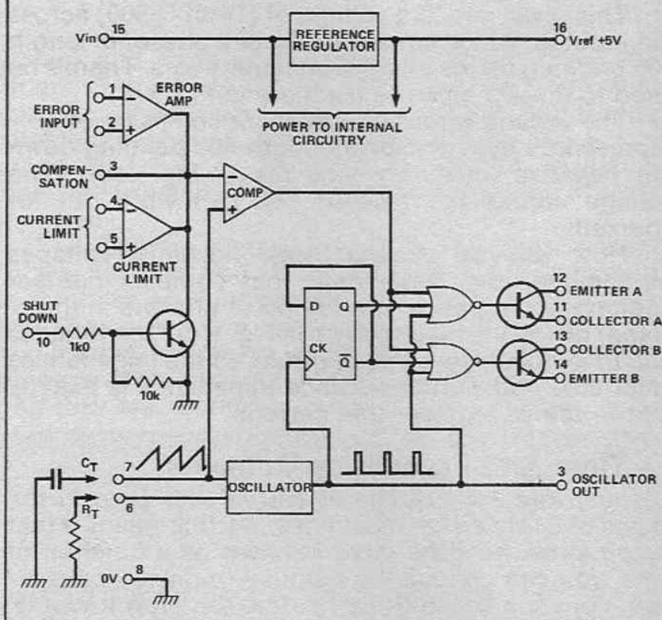


Fig. 1 The block diagram of the LM3524

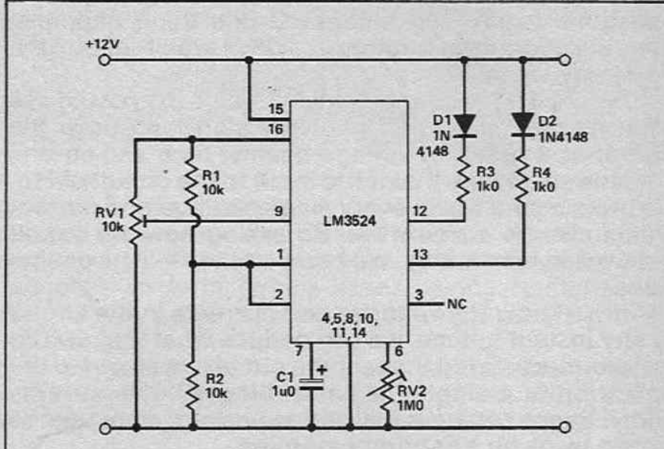


Fig. 2 Demonstrating the basic operation of the LM3524. An LED flasher!

At the ground end of its travel, as soon as one LED turns off, the other turns on (apart from the brief blanking pulse, which won't be visible). As the preset is rotated, the flashing becomes briefer, giving a more 'urgent' look to the display.

This could actually be quite useful for a warning display, or for use with model cars or trains to simulate danger signals.

Strictly speaking, the values of R_T and C_T (RV2 and C1 in Fig. 2) should not be above 100k and 100n respectively for reliable operation. What you'll find is that if you try to reduce the frequency too much the flip-flop won't switch over, so you'll be left with one flashing LED and another that doesn't light at all.

Switching regulator circuits

The basic step-down regulator configuration is shown in Fig. 3. This is broadly equivalent to a standard series regulator. The input voltage can be anywhere between 8V and an absolute maximum of 40V. The output (for the component values shown) will be 5V. The maximum input current, without an external drive transistor, will be 80mA.

For the small currents involved, L1 will have to be quite high in value to sustain conduction when the transistors are turned off. A value of about 10mH will be needed. D1 can be a 1N4148.

The value of C3 will depend on the amount of ripple that can be tolerated on the output. A value of 1uF is a reasonable starting point. Increasing the value will improve the smoothing but will make the circuit less able to cope with rapid changes of input or load.

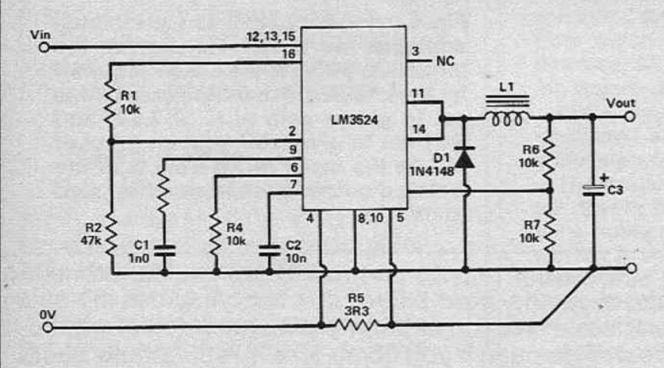


Fig. 3 The basic step-down regulator configuration

A Step Up

The basic step-up regulator configuration is shown in Fig. 4. Once again, L1 can be about 10mH, C3 1uF and for the low frequency and small currents involved D1 can be a 1N4148. The output voltage will be 27.5V for the component values shown. The input can be anywhere from 8V to about 20V.

The output voltage can be varied by changing the value of R5. If a current limit is needed, it can be connected in the same way as for Fig. 3.

The component values given are intended as a starting point for experiment — this isn't a project! You might like to try finding the limits of each circuit for the values given — particular of the inductor. What is the smallest different in output and input voltage that the circuits will cope with? What is the largest? (Bear in mind that the IC will be damaged by input voltages voltages (Fig. 3) and output voltages (Fig. 4) of over 40V.)

How does it cope with variations of the load? What is the disadvantage of using too large an inductor? Or too small? What happens if you use a 1N4001 in for the rectifiers? Or a schottky diode? What happens if you make the value of the smoothing capacitor 10uF or 1000uF?

My theory about electronics is that an hour spent in intelligent experimentation (where if something goes wrong you ask 'why?' — and make damn sure you come up with an answer!) is worth a week reading a text book. That's not to devalue theory but a touch of practical experience gives meaning to what would otherwise be dry and uninteresting facts.

If your amplifiers oscillate and your regulators don't regulate, it gives you the incentive to get to the bottom of what's going on!

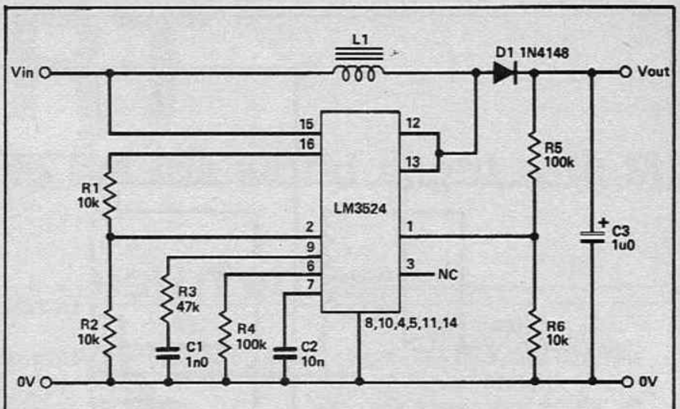


Fig. 4 The basic step-up regulator configuration

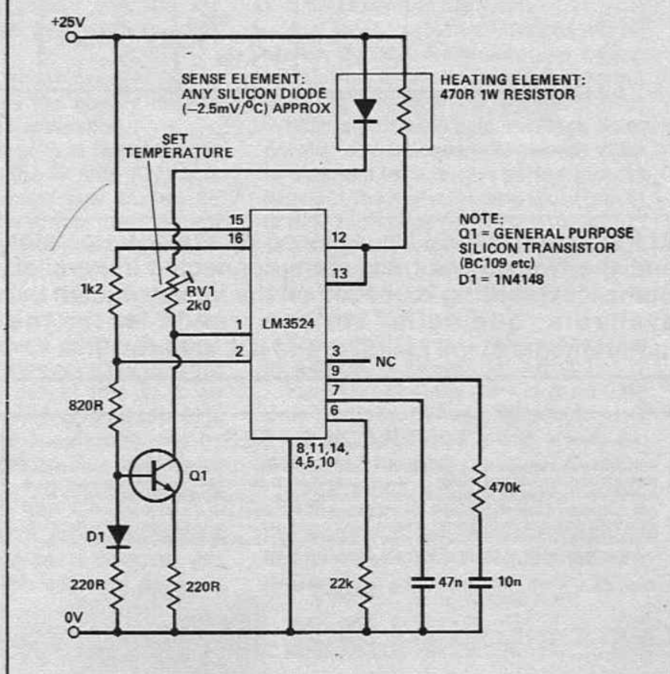


Fig. 5 Using the LM3524 as a heating controller. The sensor diode characteristic is only important if the set temperature is to be variable. For a fixed temperature, RV1 is used to set the required temperature and the controller then left alone.

Other applications

The LM3524 is quite a versatile little IC and can be used for other purposes besides switching regulators. One thing that occurs to me is that it could be used for temperature regulation of sensitive components — a crystal oven for example.

In its simplest form, the heating element could be a resistor connected to the output transistor collectors (Fig. 5). The temperature sensing element could be a common or garden diode, arranged so that increasing temperature causes a rise in voltage at pin 1 of the IC. The set point would be controlled by varying the DC offset at pin 1 or the voltage at pin 2.

Another possibility is to make optically isolated analogue outputs, such as the ones in the recent ETI EEG Monitor. A different approach would be to vary the mark-to-space ratio of the outputs in sympathy with the analogue signal. The circuit (Fig. 6) is similar

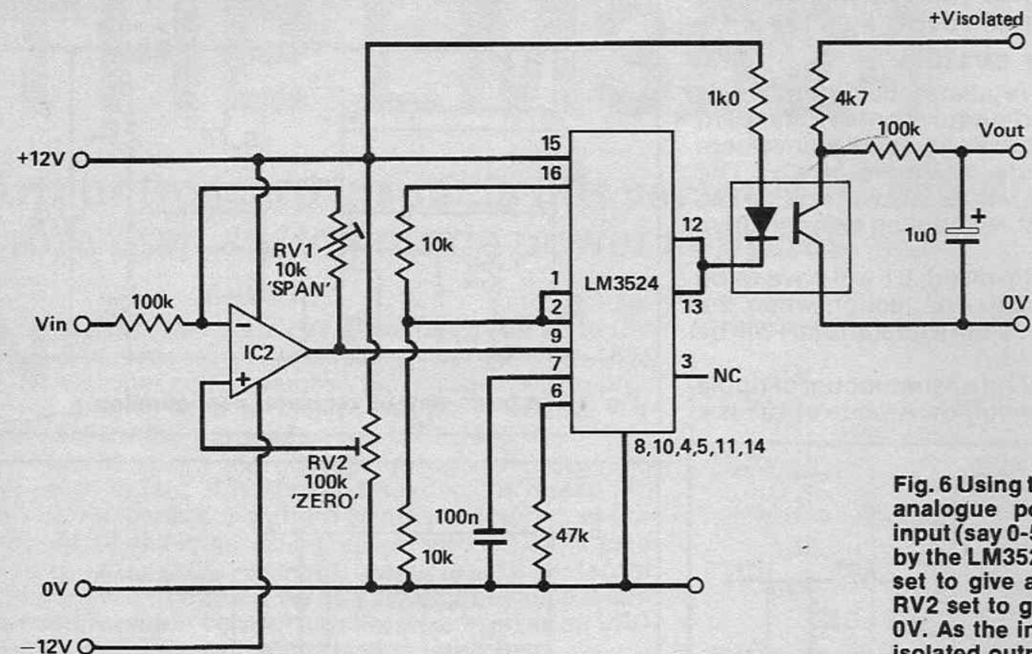


Fig. 6 Using the LM3524 as an isolated analogue port. IC1 transforms the input (say 0-5V) to the 1-3.5V required by the LM3524. For 0-5V input, RV1 is set to give a gain of ½ (0-2.5V) and RV2 set to give 3.5V with an input of 0V. As the input varies from 0-5V the isolated output goes from +V Isolated to 0V.

to Fig. 2 with the LEDs replaced by the opto-isolator and the two output transistors connected in parallel. Some level shifting is needed on the input to match the available analogue voltage range with the requirements of the LM3524, and IC2 achieves this.

Infra-red remote control? Once you start thinking about it, the possibilities for applying this IC seem endless. Have fun experimenting, and don't forget our Tech Tips page if you come up with something good.

ETI

GAS ALERT

Greg Thompson promises not to set the world alight with this top-spec gas detector design

Gas explosions in the home, caravans and the like are becoming virtually a daily occurrence. The ETI modular gas detection system will help to reduce these horrific accidents.

The system will detect and provide early warning of the presence of domestic gas, bottled gas based on methane and explosive vapours such as petrol fumes and other hydrocarbons.

Good Sense

Most inflammable vapour sensors are based on what is known as the 'hot-wire' principle. This involves a small heater element inside the sensor.

The sensor chosen incorporates the usual heater element which is designed to operate at 5V (±0.2V). The sensor output is quite simply a varying resistance.

This resistance remains stable whilst the sensor is in clean air but the resistance across the sensor drops when gas or explosive vapour is detected.

The heater element and resistive detector are two ideally independent circuits within the sensor.

HOW IT WORKS

Power enters the circuit via a protective fuse. The specified transformer supplies about 10.5V on the +V rail.

C1, R1 and C2 form a smoothing filter which acts as a safeguard should the unit be powered from an unsmoothed supply. IC1 is a 5V regulator from which the sensor and IC2 are powered. C3 is an additional smoothing capacitor.

LED1 and its series resistor R2 are positioned across the supply rails to provide power-on indication.

The heater element of the sensor is fed directly from the 5V rails. IC2a acts as a voltage comparator biased by resistor R_L and the sensor itself. R3 and C4 raise the input impedance and also stabilise the op-amp inputs.

When the sensor detects gas its resistance drops below that of R_L causing the voltage at the inverting input (pin 2) to swing negative which in turn causes the output (pin 1) to go high. The non-inverting input (pin 3) is biased to half the supply potential by R6 and R7 enabling the op-amp to make its comparative decision against the voltage at pin 2.

R10, C5 and R11, D1 form the time delay stage. When gas is detected, pin 1 goes high which will after approximately 13 seconds take pin 5 high (the non-inverting input of IC2b).

If the gas dissipates within 13 seconds, pin 1 returns low (its normal state). C5 then discharges through R11 and D1. Pin 1 must remain high for the full duration of the 13 seconds before the final alarm is triggered.

Any brief encounter with gas will be shown by the illumination of amber LED2. This is turned on whenever pin 1 goes high via R9 and Q1.

IC2b again serves as a voltage comparator also biased by R6 and R7. If gas is detected for a longer period than 13 seconds the non-inverting input (pin 5) is held high causing the output (pin 7) to also go high. When this happens Q2 and Q3 are also turned on thus switching on the buzzer, red LED3 and reed relay RLA1 via Q3.

The coil of the reed relay also serves as a series resistance for LED3.

Pin 8 and 14 of the relay form a single pole switch. These contacts are normally open and close when the device is triggered.

Push-button SW1 when closed will test the entire circuit. This takes pin 2 low via R4 in the same way that the sensor operates when it has detected a presence of gas.

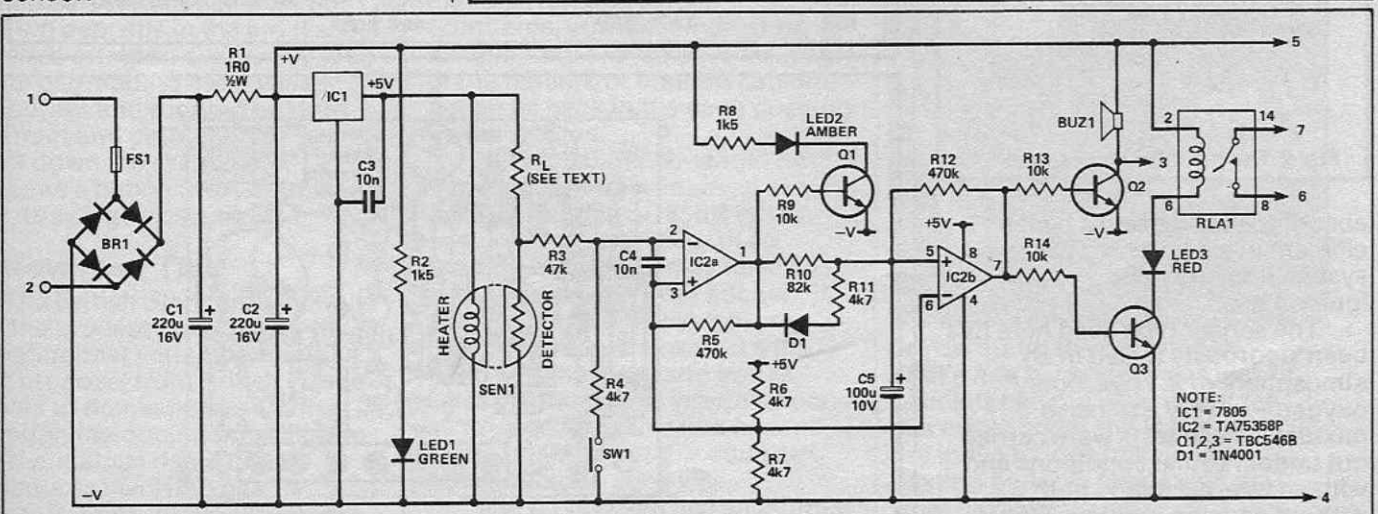


Fig. 1 The circuit diagram of the Gas Alert

As with all hot-wire sensors, respect must be given to current consumption. The heater element in this sensor will draw approximately 170mA when supplied by a 5V regulator. This current drain compares favourably with other available devices.

Talking of other devices, use of the 'two dome' sensor/compensator type detector should be avoided. These detectors consume more current and are rendered useless if allowed to absorb silicone. Gas alarms that are utilised in domestic applications can easily become contaminated with the silicone used in many household spray polishes.

It may seem strange or even

The Sensor

Whilst most of us are more interested in the electrical and environmental characteristics of the sensor, the physical philosophers and philosophically fit will be eager to learn how it works. You will see from Fig. 2 that the heater element passes through a small ceramic tube. This is coated with a layer of tin oxide, SnO_2.

If tin oxide is heated in a 'clean air' atmosphere, oxygen is absorbed into the surface layer. The rate of absorption remains constant at a given temperature. If, however, a contaminant combustible gas is introduced, this will also be absorbed.

The reaction of a combustible gas with the oxygen causes electrons to be released from the oxygen giving the tin oxide greater electrical conductance. This all takes place between the two electrodes at either end of the ceramic tube. The resultant factor is increased conductivity which is equal to the lowering of its electrical resistance.

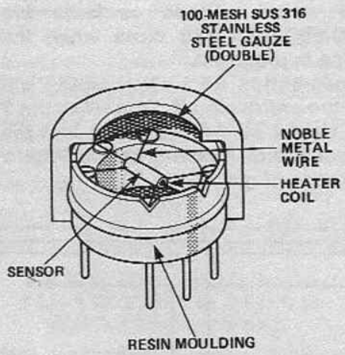


Fig. 2 The hot wire gas sensor

absurd to incorporate a heater element in a gas sensor as such a system appears to be a source of ignition itself.

The sensor type used here has been vigorously tested in an atmosphere of 2:1 hydrogen/oxygen — a very explosive mixture. These tests were carried out under normal conditions and with an internal spark, both without causing ignition. This is due to the extremely fine stainless steel gauze used in the construction of the sensor.

The sensor itself is an internationally proven and accepted device and we stress it cannot itself be a source of ignition. However, careful consideration must be given to the circuit and system in which it is used.

It's OK for your electric toaster to blow you off the face of the earth but if your gas alarm does the same, it's not on, is it?

It is worth pointing out at this stage that due to relatively high current power consumption it is neither practical nor recommended to operate such a gas detector from dry cell or NiCd batteries.

In our design we have incorporated an independent relay output in the form of a simple single pole make switch. The relay used is of the sealed reed type. This is important as relay contacts create a spark when thrown.

The relay output is included so the detector can be used to trigger existing alarm systems or any external device for that matter.

Some of the more ingenious readers may decide to develop subtle luxuries such as switching in your extractor fan to help to 'clear the air.'

You may well decide to do this by using the internal reed relay to throw an external mains relay. Mains relays are usually of the open type and will without doubt cause a spark sufficient to ignite a gas filled room. It's recommended that a triac switching circuit be used for switching in any mains powered add-on.

We could also add that the electric motor inside extractor fans will also produce an arc from its commutator brushes but for the moment we'll assume most extractor fans are sufficiently sealed and in any event are normally exposed to clean air on one side.

Having scared the living daylights out of you we will now

PARTS LIST

RESISTORS (¼W 5% unless specified)		**Q1-3**	**TBC546B**
R1	**1R0 ½W**	**D1**	**1N4001**
R2, 8	**1k5**	**BR1**	**W02**
R3	**47k**	**LED1**	**Green LED**
R4, 6, 7, 11	**4k7**	**LED2**	**Amber LED**
R5, 12	**470k**	**LED3**	**Red LED**
R9, 13, 14	**10k**		
R10	**82k**	**MISCELLANEOUS**	
		FS1	**500mA, 20mm fuse**
CAPACITORS		**RLA1**	**SPST 12v 1k0 coil DIL reed delay**
C1, 2	**220µ 16V radial electrolytic**	**SEN1**	**Hot wire gas sensor and matched resistor**
C3, 4	**10n ceramic**		
C5	**100µ 16V radial electrolytic**	**SW1**	**SPST push switch**
		T1	**7V mains transformer**
SEMICONDUCTORS		**BUZ1**	**Piezo buzzer**
IC1	**7805**	**PCB; 7-way terminal block; case; nuts and bolts.**	
IC2	**TA75358P**		

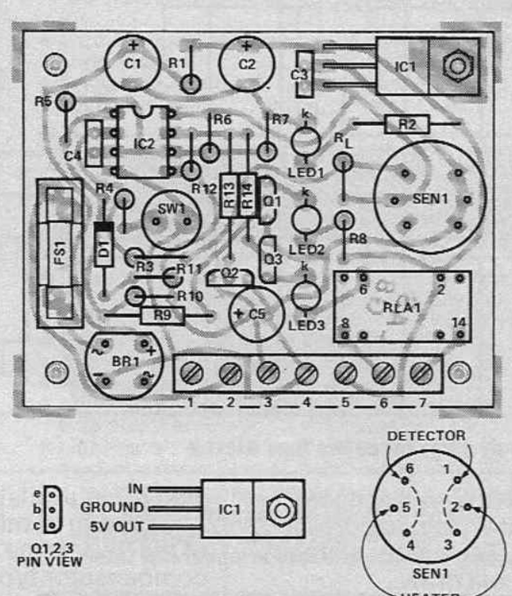


Fig. 3 The component overlay for the Gas Alert

tell you that the alarm will function well before an explosive mixture is allowed to accumulate.

The point at which a mixture of air and explosive vapour or gas will ignite is known as its lower explosive limit (LEL). Such mixtures are defined in parts per million (PPM).

This is the molecular count of explosive mixture per one million molecules of air. The LEL is dependent on the PPM — got it!

Our gas alarm system will trigger when an atmosphere of between 10% and 40% LEL has been reached. This may seem a rather large tolerance window but it includes all explosive atmospheres — methane (natural gas), butane, propane and so on, and other vapours (petrol, methanol, ethanol, propanol Navy Rum, etc).

Alarmingly Falsified

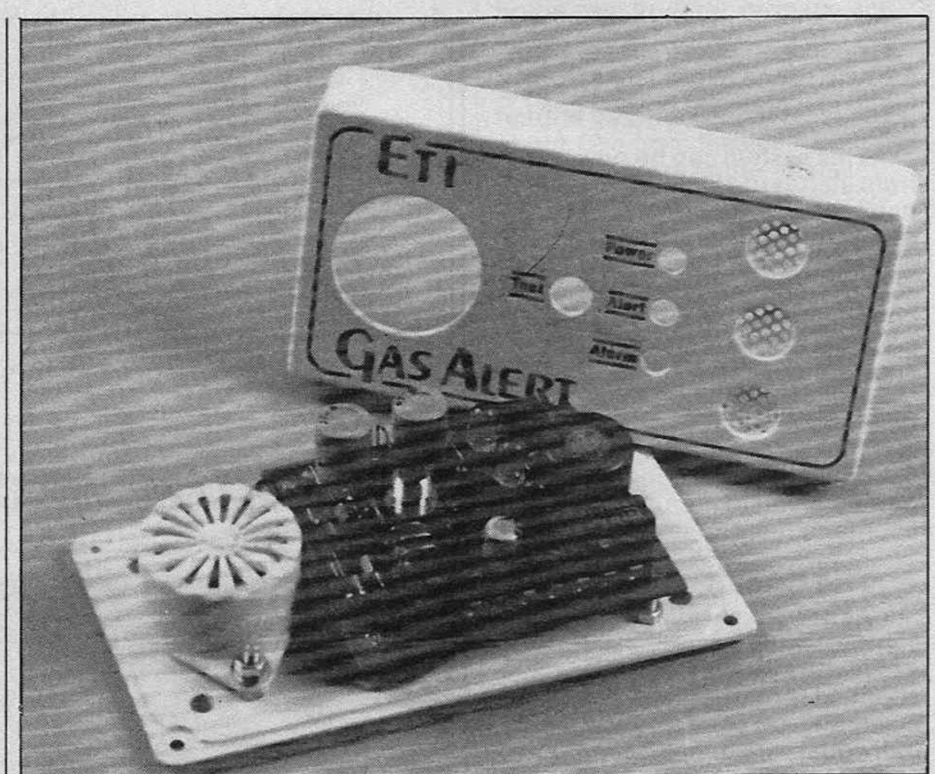
The time honoured expression 'false alarm' is a day-to-day saga in the majority of warning and detection devices of all types. Sophisticated electronic devices incorporating failsafe and fail failsafe are normally so safe that they fail to register anything or they are continually being triggered by just about everything except the gas they were designed for.

It's not a bit of good having a gas detection system triggered off by a quick squirt of hair spray or cooking deposits in the air. It's just switched off when everybody is so fed up of grabbing their wallets and purses and running out into the street and going four or five doors down the road to use someone's phone (next door is too near, they'll go up as well).

Now Hear This

The British Standards Institute is in the process of receiving (this is confidential you understand) a draft proposal from British Gas in respect of domestic gas alarms. Although the document will delve into meticulous detail of test procedures involving gas concentrations, temperature and air pressure, notwithstanding wind velocity, it would appear that some of the more important factors have been overlooked.

The whole purpose of an alarm is to let someone know something is happening. Quite sensibly, the Standard has opted for an audible alarm which it stressed must have a sound level output of 85dB at 3m. Having delved into the depths



of Einstein's archives to create test procedures it omits to specify the frequency of the sound the audible alarm should generate!

Well, British Gas, have you ever heard 85dB at 25kHz? No, that's not surprising because neither has anyone else on this planet. 25kHz is all very well for dogs, they'll be saved!

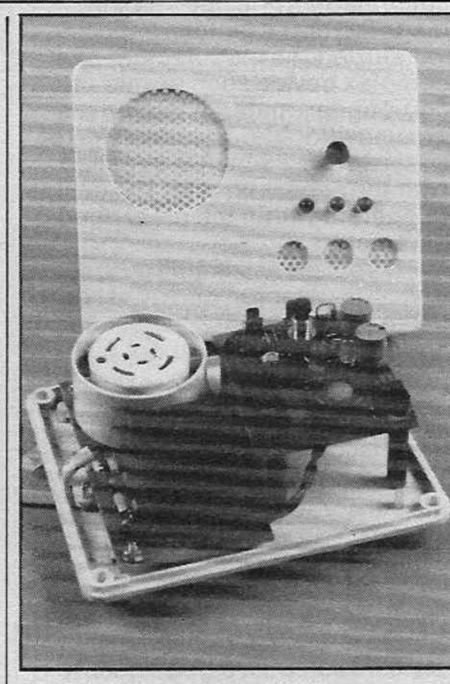
It may well be that if you buy a gas alarm that has been manufactured to British Standards, your first indication of an imminent explosion is the dog going berserk or your mynah bird flat on its back in the cage pushing up the daisies.

About 400-700Hz would be more suited. However even at a desired frequency, 85dB is certainly not over loud. In an average house you may have an alarm installed in your kitchen. If the kitchen door is closed, your bedroom door is closed, it's the middle of the night and you're asleep, it is open to interpretation as to whether you would hear an alarm operating at this sound pressure level.

The ETI system has an internal buzzer rated at 75dB at 1m but serious provision has been made for external louder audible sounders positioned wherever required. This is of particular importance in larger houses.

Sensors

In the near future British Gas may invite you (at your own cost, of course) to have a gas detection



device fitting in your kitchen. That's fine if you get a gas leak in your kitchen but what about the gas meter under the stairs, the gas fire in the lounge, the central heating boiler in the garage or what have you.

In the light of that, consideration should be given to the installation of more than one sensor in order to provide comprehensive cover.

The ETI gas alert is designed to operate from an AC or DC supply producing 12V. Up to now we have dealt with practical considerations for domestic installations and for this purpose a

240V mains transformer is used.

Boats and (more so) caravans are also prone to gas leaks from faulty low pressure bottled gas (LPG) systems.

This system can be powered from standard 12V lead-acid car batteries — the normal source of power for boats and caravans. The current consumption of around 200mA under normal working conditions, would not be considered a serious drain on such battery systems.

The consumption of the unit rises above 200mA when the alarm is triggered but the last thing you are going to worry about is a flat battery if you're about to spontaneously combust!

The Circuit

As previously mentioned, false alarms are not acceptable in any gas alarm system. The sensor supplied for this project requires no setting-up or calibration. Each individual sensor has been calibrated prior to leaving the manufacturer's factory.

During the manufacture of a complex device such as this component, material tolerances are unavoidable. The inclusion of a resistor (R_L) which is supplied with the sensor enables the device to operate within the prescribed parameters.

If you are assembling more than one detector, care must be taken to ensure each sensor and its companion resistor do not get mixed-up.

As a precaution it is worthwhile measuring the resistance of the resistor supplied and writing its value on the side of the sensor with a fine permanent marker. You will need to use an accurate digital meter if you choose to do this.

IC1 acts as two voltage comparators. As with the rest of the components, a good quality op-amp is chosen — the Toshiba TA75358. In fact this is a dual op-amp in an 8-pin DIL package — an LM358. It features distinct advantages in a circuit of this type.

It is specifically designed to operate on single supply rails, has very low current consumption and its output will swing fully low.

Whilst on the subject of Toshiba, the TBC546B transistors were chosen, again being a quality device and are equivalent to BC546. All right Tosh!

Construction

Assembling the Gas Alert should provide no particular problems, particularly if the recommended PCB (Fig. 3) is used.

In the recommended case, the component leads should be trimmed close to the board underside to enable the backpanel to be fitted.

The LEDs should be soldered in first with 8mm sleeves over the leads so that they stand proud of the board at the correct height to protrude through the case top.

The test button should be soldered in next. It must be positioned exactly vertical and with careful comparison to the height of the LEDs, again for correct positioning. Although it is a little awkward to have this test button protruding throughout construction, it must be fitted at this stage since the amount of heat required might damage more delicate components. The nut on the test button is unused and the pins need trimming off.

The voltage regulator IC1 is bolted flat to the board with its pins at right angles. A small heatsink may be placed on top (held in place by the bolt) but this is not imperative.

The fuseholders should be installed with the fuses in place. Solder in the tags and trim. Fit the bridge rectifier and check its polarity.

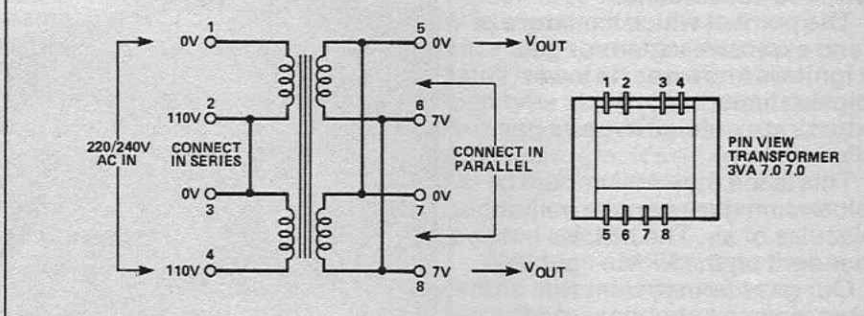
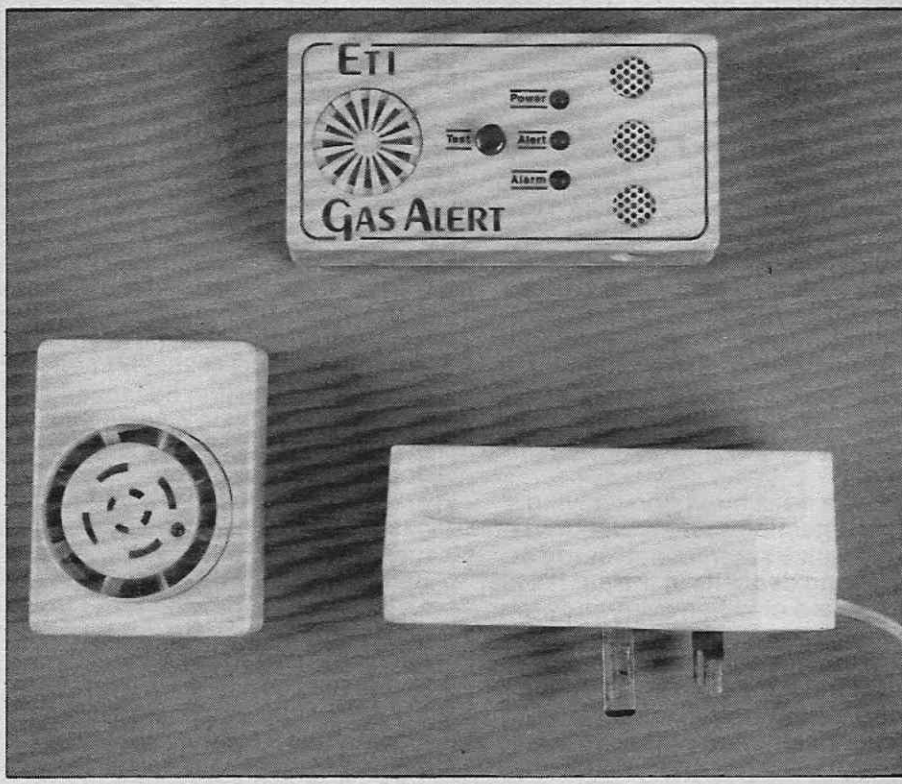
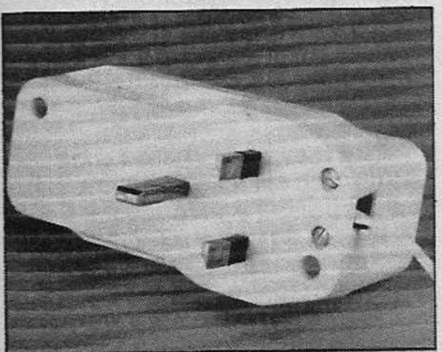


Fig. 4 The 7-0, 7-0 transformer supplied in the Live Audio Systems kit is specifically designed to power the hot wire sensor. For UK mains it must be wired up as shown

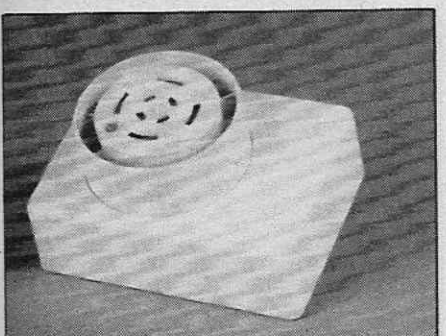


The Live Audio Systems Caravan/Boat Gas Alert along with mains transformer and external siren modules.

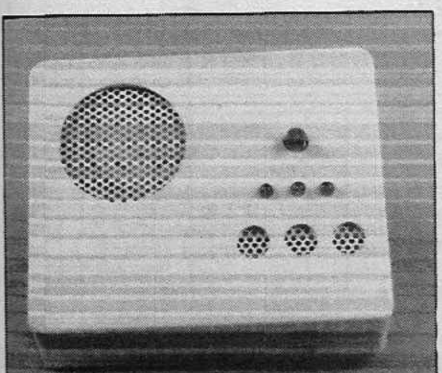
The Caravan/Boat Alert.



The mains transformer module.



The External 85dB siren.



The House Alert.

The transistors and ICs can now be fitted, again with attention to their orientation. Solder the relay into place, treating it like an IC. If the relay is not required, insert a 1K0 resistor between pinholes 2 and 6 to load LED3.

The transformer may be mounted with an additional fuse (500mA) in the mains live input if desired. Rectification and smoothing are performed on the PCB. The transformer can either be mounted in a plug-topped box or in the complete unit with the alarm sounder.

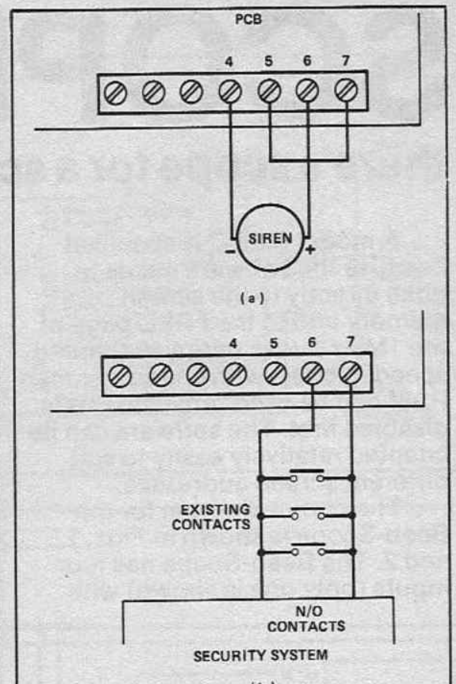


Fig. 5 Using the Gas Alert with (a) an external siren (9V) or (b) an existing security system

Note that the sensor is a rugged 6-pin device which requires no special handling precautions. However, a device such as this should be treated with respect. Neither the heater element nor the internal detector are polarised — they have no positive or negative supply requirement.

The pinout configuration ensures it cannot be inserted into the PCB incorrectly (there are two possible ways and either will do). You will see from the pinout that pins 1 and 3 of the sensor are connected internally, as are 6 and 4. So, pin 1 or 3 and pin 6 or 4 are the sensor's resistive detector. Pin 2 and 5 supply the heater element.

Testing

The unit can be tested by pressing a cigarette lighter over the sensor for about 15 seconds (don't light it unless you want to melt your PCB). The 'Alert' LED (LED 2) should light almost immediately and the alarm should sound after about 20 seconds.

If this doesn't happen (and the supply voltages are known to be operational) then check polarity of components, terminal numbers on the transformer and look for soldering errors.

Installation

Some thought should be given to siting the Gas Alert module or modules. Try to place them near likely sources of leaks — the kitchen, gas meter, gas fires and so on.

If used for detecting LPG bottle gas, (butane, propane and so on) the sensor should be 6-12in from the floor (LPGs are heavier than air). For domestic or other natural gas, the sensor must be about 12in from the ceiling as these gases are lighter than air.

The placing of the extension siren (if used) will depend on your habits! Don't put it under the stairs with the gas meter — unless you're in the habit of sleeping there.

For use in caravans, I recommend the module with sensor and 75dB sounder in a single box which simply connects to the caravan's 12V DC supply. Similarly for boats, where the unit could be installed in bilges or engine compartments to detect excess fuel vapours.

It is possible to mount the sensor away from the PCB (a case is available to do this — see Buylines). In this case resistor R_L should be wired across the sensor (to maintain the resistive calibration) not into the PCB. This separate unit can then be connected to the PCB using lightweight 3-core cable (do not use screening as one of the cores).

A louder extension siren can also be fitted, powered via the reed relay contacts. A suitable 85dB siren module is available (see Buylines).

ETI

BEEB-SCOPE

Richard Penney finds there's scope for a scope on his BBC micro

Oscilloscopes are an expensive piece of test gear for the electronics hobbyist. Flashy glowing knob-filled units can have pricetags stretching into the thousands and even the cheapest are well out of birthday present range.

This project is a low-frequency four-channel oscilloscope which is basically a fast analogue to digital converter that adds onto your BBC micro using the 1MHz bus.

A model B BBC is specified because the software needs to poke directly to the screen memory and to the FRED page of the 1MHz bus to optimise running speed. Models with shadow screen RAM can be used provided this is disabled first. The software can be adapted relatively easily to suit different screen addresses.

The circuit diagram for the Beeb-Scope is shown in Figs. 1 and 2. The Beeb-Scope has four inputs (only one is shown) with input resistance switchable up to 1M0 on DC coupling. On AC coupling a 1μ0 capacitor C1 is placed in series with this (such a large capacitor ensures there is minimal additional attenuation and phase-shift even at low frequencies).

The four inputs have range switches to select one of nine full-scale input voltage ranges — 0.5V, 1V, 2V, 5V, 10V, 20V, 50V, 100V and 'infinite.' On AC coupling these refer to the peak levels not

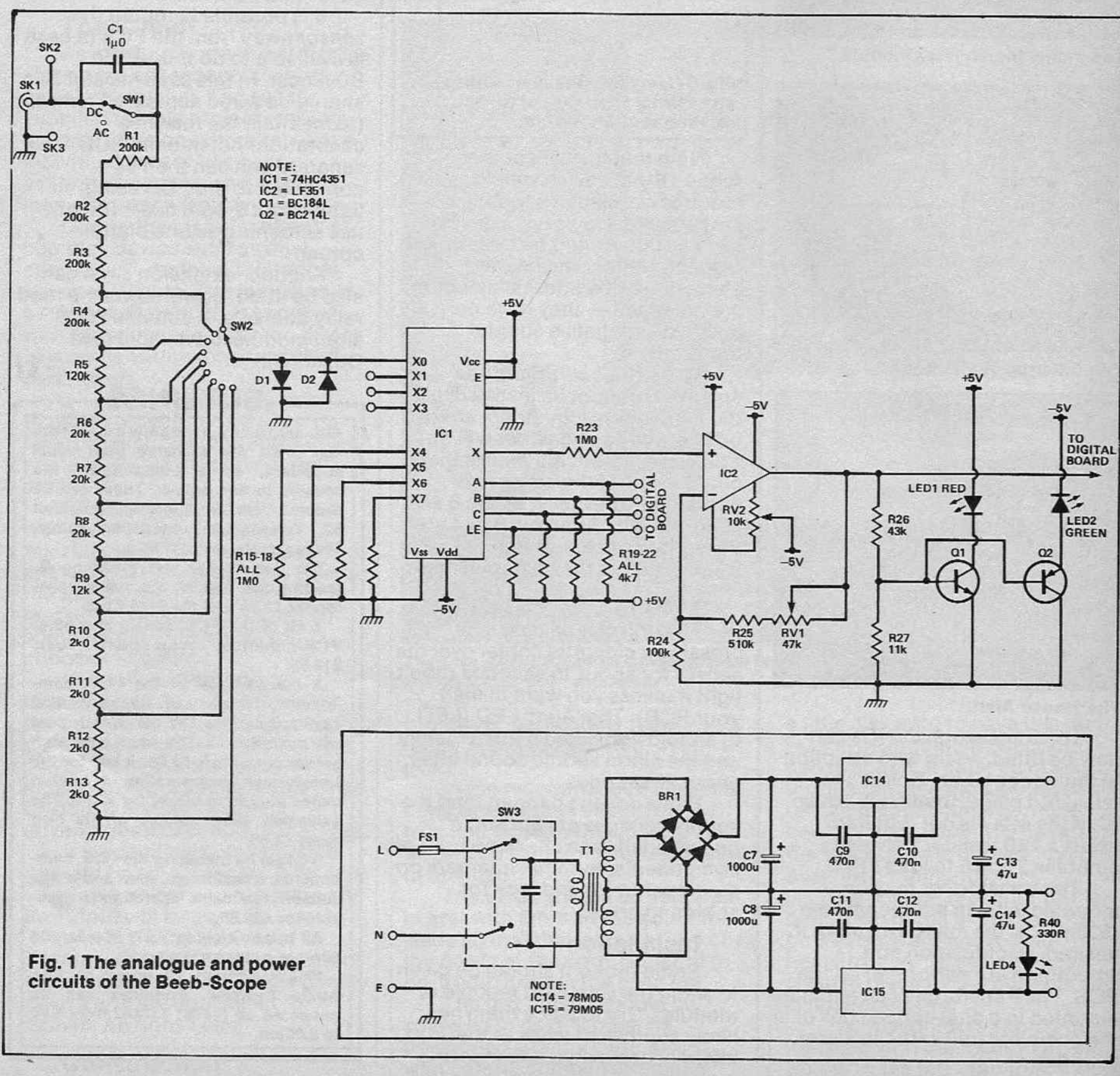


Fig. 1 The analogue and power circuits of the Beeb-Scope

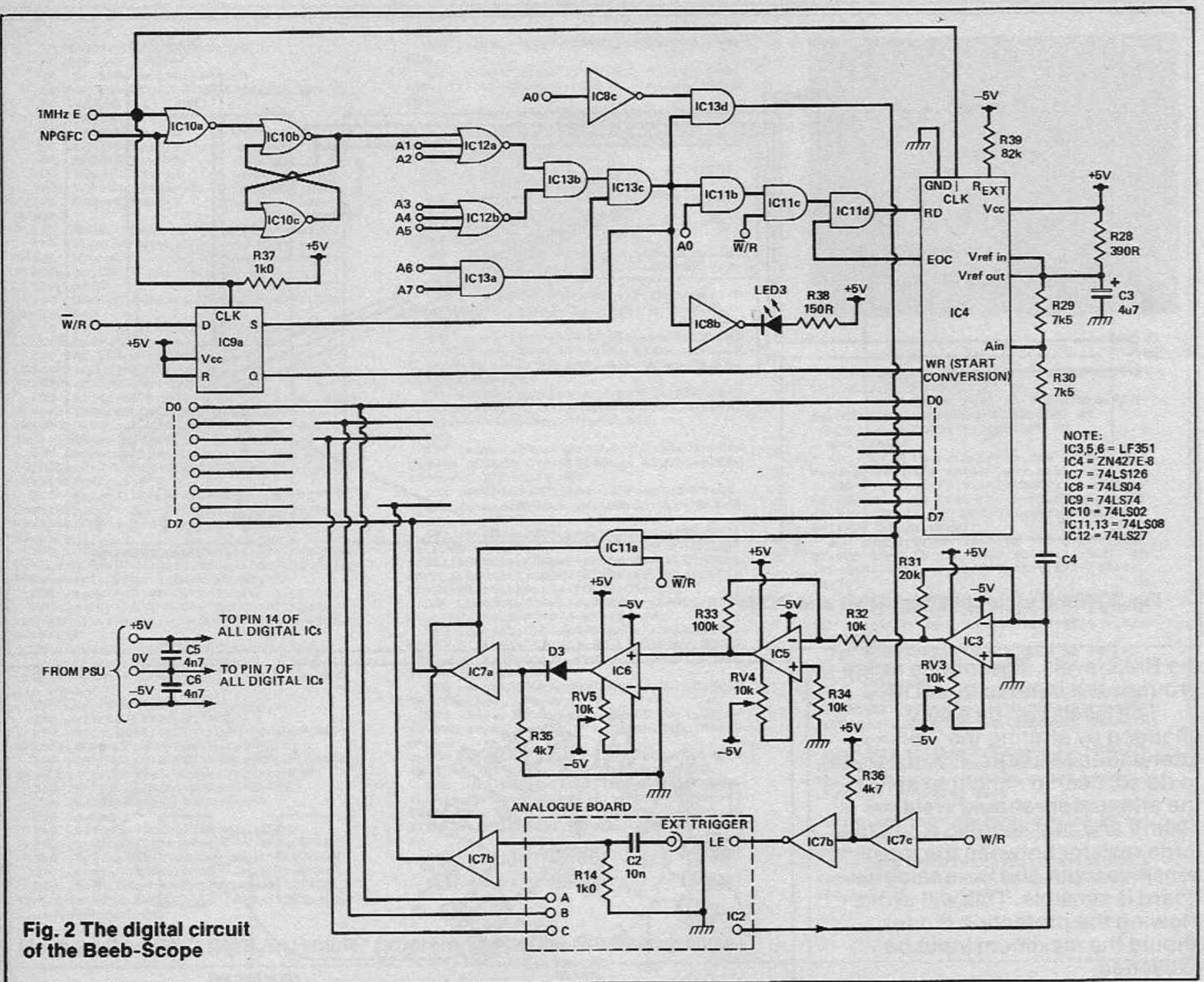


Fig. 2 The digital circuit of the Beeb-Scope

HOW IT WORKS

The circuit diagrams are shown in Figs. 2 and 3. For an explanation of the ciruit we shall concentrate on channel one of the unit.

Inputs come (directly or via a capacitor) from BNC socket (SK1) or terminal post (SK2, 3) to an input attenuator consisting of resistor chain R1-R13 tapped at various points by a rotary switch SW2.

This switch determines the input sensitivity and couples the input to analogue switch IC1 which provides channel switching under software control. The selected channel signal is amplified by a factor of 6.375 by IC2, thus boosting the input FSD (from the attenuator) of 400mV to 2.55V (suitable for the ADC chip on the digital board).

The gain is slightly variable (by RV1) to allow maximum accuracy to be obtained. Even uncalibrated. However, the unit is adequately accurate for most uses.

Overload indicators LED1, LED2 are driven from the output via a potential divider and two transistors. The first starts glowing for inputs above 80% FSD and one each is provided for positive and negative levels in excess of FSD.

The amplified signal now goes to the digital board where it feeds the analogue to digital converter (IC4). An operational differentiator is used to derive a rising-edge pulse.

Most of the ICs on the digital board are concerned with decoding the signals available on the 1MHz bus to ensure access to the device only on receipt of the correct addresses from the computer.

The data-bus is connected directly to IC4, as this has tri-state outputs. A simple potential divider is used to ensure that inputs in the range ±2.55V are fed to IC4 as 0 to 2.55V. The data bus is also connected (via various buffers) to the rising-edge and external trigger signals and to the channel-select pins of IC1 on the analogue board.

The external trigger input is simply a TTL input configured in a 'monostable' arrangement. An 'in-use' indicator is driven by this board, which lights when the board is being accessed by the computer.

The device is memory mapped to the BBC micro's 1MHz bus as shown in Table 1.

The power-supply is a simple unit using a PCB-mounting mains transformer and standard 78M05 and 79M05 voltage regulators to fulfil the ±5V power requirements of all the electronics.

&FCC0	Write:	Channel selection (0-7) start conversion (9µs)
	Read:	Bit 6=External trigger pulse Bit 7=Rising edge pulse (high=rising edge)
&FCC1	Write:	start conversion (9µs)
	Read:	Read digital voltage level

Table 1 Addresses used by the Beeb-Scope

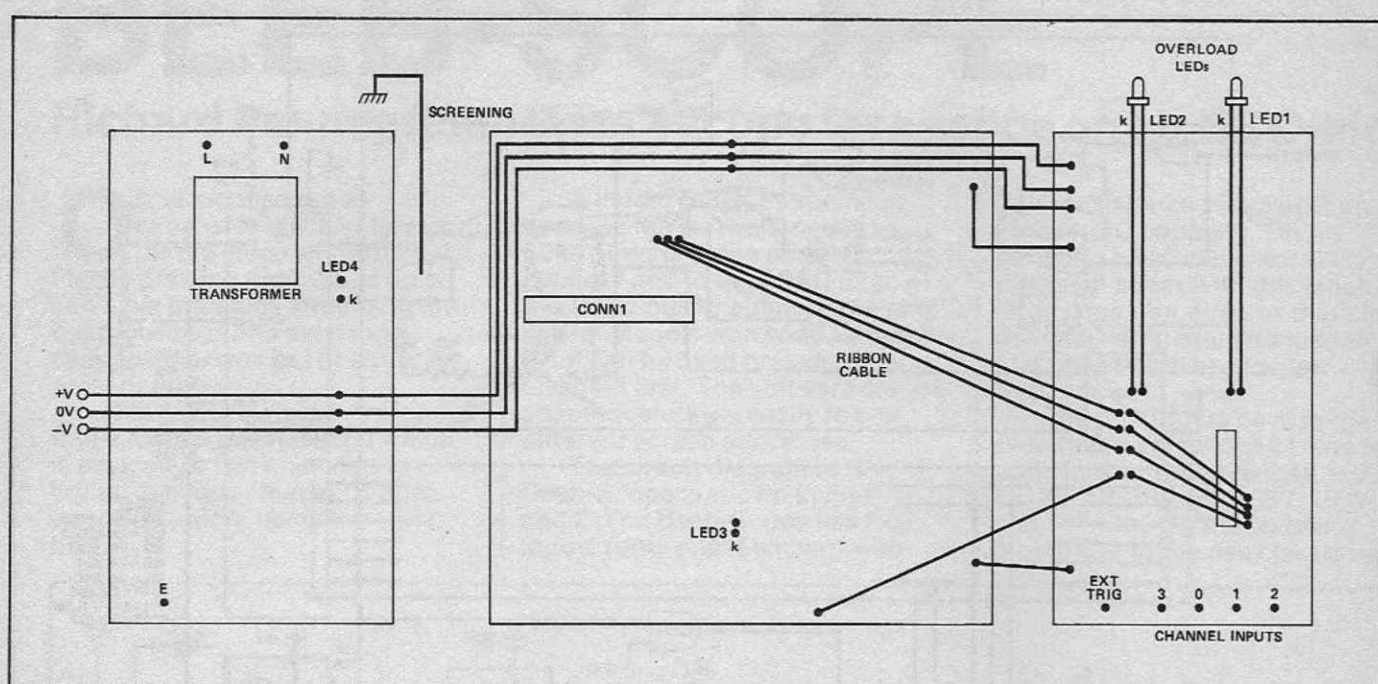
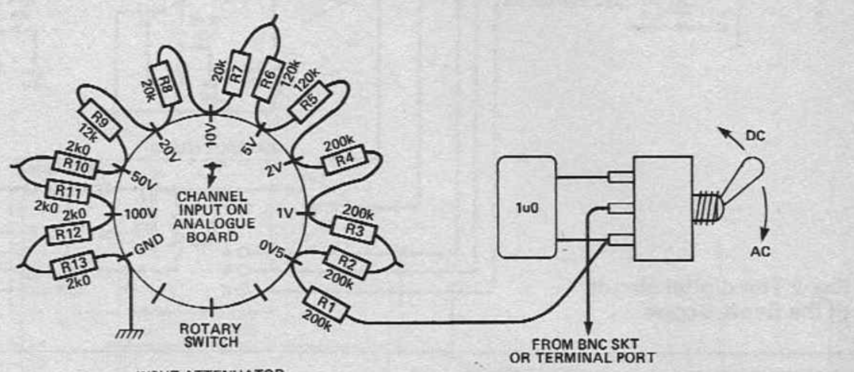


Fig. 3 Wiring for input attenuators and PCBs



the RMS levels. The infinite range grounds the input to the ADC.

The levels can be easily changed by altering the attenuation resistors. If you decide to do so, bear in mind that at FSD the attenuators should yield 400mV and that keeping a suitably large resistor between the most sensitive input and the analogue board is sensible. This will avoid blowing the protection diodes should the maximum input be exceeded.

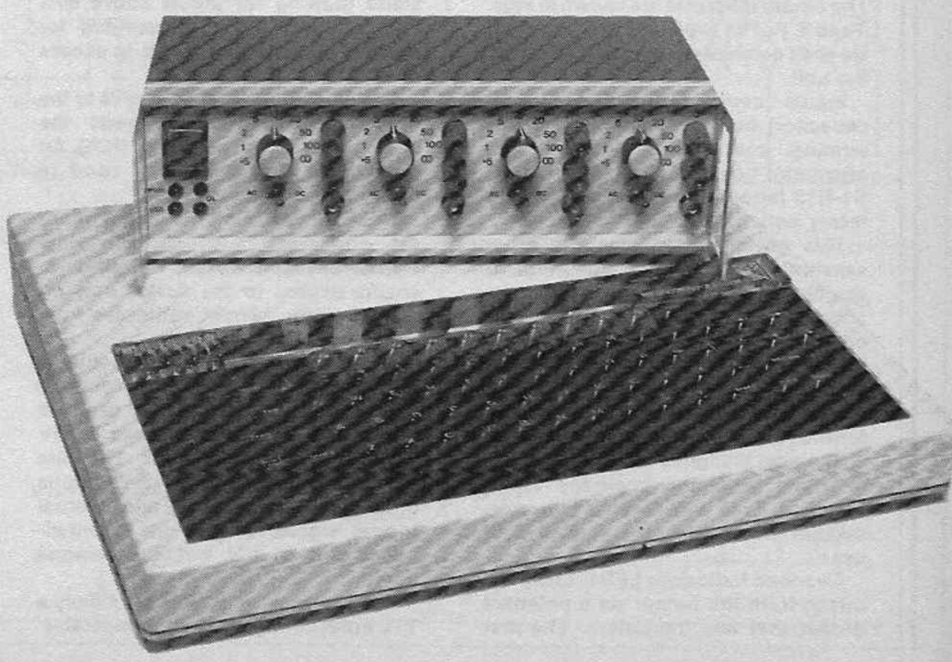
Calculating the resistor values is simply a matter of applying potential divider theory to the situation. Start with the least sensitive input and work up the resistor ladder.

Each input is protected by two 1N4148 diodes in inverse parallel.

Both the analogue switch (IC1) and ADC (IC4) are fairly tolerant of excessive inputs but the diodes provide a simple and effective way of avoiding damage, keeping inputs to the switch between ±0.65V. These diodes also protect the analogue switch, which is a CMOS device, against static charges when a particular channel is unused.

The primary purpose of the analogue switch is to alleviate the need for swapping over input leads when monitoring various signals and not to provide a full-blown dual (or rather quadruple) trace display.

A multi-trace display is only practical for low frequencies (under 500Hz) since if the switch is 'flicked' too rapidly, a meaningless



```
10 MODE4:VDU23;8202;0;0;0;
20 DIM mc% 4095
30 var=&78:zp=&70:par=&80
40 FOR A%=0 TO 2 STEP2:P%=mc%:[OPT A%
50 .scope
60 LDA#255:STA&6BC7
70 LDA#0:STApar+0      \ channel
80 LDA#1:STApar+1      \ sampling speed
90 LDA#0:STApar+2      \ expand
100 LDA#0:STApar+3     \ fast sampling
110 LDA#127:STApar+5   \ trigger level
120 LDA#0:STAvar+7     \ param. under cursor
130 LDA#4:LDX#1:JSR&FFF4:JSRpcurs:SEI
140 .scplp:LDXpar:LDApar+3:BEQslow:JSRfsamp:JMPslow+3:.slow:JSRsample:JSRexpand:JSRplot:JSRparam:JMPscplp
150 .plot
160 LDA#128:STAvar:LDA#0:STAvar+1:STAvar+2:LDX#0
170 .pllp:LDAoldd,X:JSRplotp:LDAdata,X:CLC:ADCpar+7:STAoldd,X:JSRplotp
180 INX:LSRvar:BCCpllp:LDA#128:STAvar:LDAvar+1:CLC:ADC#8:STAvar+1:LDAvar+2:ADC#0:STAvar+2:CPX#0:BNEpllp:RTS
190 .plotp:STAzp:LDA#0:STAzp+1:ASLzp:ROLzp+1:LDAzp:CLC:ADC#ypos MOD256:STAzp:LDAzp+1:ADC#ypos DIV256:STAzp+1:LDY#0:LDA(zp),Y:STAzp+2:INY:LDA(zp),Y:STAzp+3
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210 .expand:LDApar+2:BNEexptok:RTS:.exptok:STAzp+7:.exptlp2:LDX#127:LDY#254:.exptlp:LDAdata,X:STAdata,Y:DEY:DEY:DEX:BNEexptlp
220 LDX#0:.exptlp1:LDAdata,X:CLC:ADCdata+2,X:RORA:STAdata+1,X:INX:INX:CPX#254:BNEexptlp1:DECzp+7:BNEexptlp2:RTS
230 .sample:STX&FCC0:JSRwftrig:LDY#0
240 .samlp:LDA&FCC1:STA&FCC1:STAdata,Y:LDXpar+1:.samlp1:DEX:BNEsamlp1:INY:BNEsamlp:RTS
250 .fsamp:STX&FCC0:JSRwftrig:LDY#0
260 .fsmlp:LDA&FCC1:STA&FCC1:STAdata,Y:NOP:NOP:INY:BNEfsmlp:RTS \ main loop=22c's =90kHz
270 LDA&FE4D:AND#1:BNEntrig
280 .wftrig:LDY#0:STY&FCC1
290 .wft:LDX#4:.wft1:LDA&FCC0:NOP:NOP:BPLwft:NOP:NOP:NOP:NOP:DEX:BNEwft1
300 LDA&FCC1:STA&FCC1:SEC:SBCpar+5:CMP#2:BCCtrig:CMP#255:BCStrig:DEY:BNEwft
310 .ntrig:LDX#204:STX&6E48:RTS
320 .trig:LDX#0:STX&6E48:RTS
330 .param
340 LDX#198:JSRkey:BPLtrd:JSRmup
350 .trd:LDX#214:JSRkey:BPLtrl:JSRmdn
360 .trl:LDX#230:JSRkey:BPLtrr:JSRmlt
370 .trr:LDX#134:JSRkey:BPLtrn:JSRmrt
380 .trn:LDApar+8:BEQparamout:LDX#0:LDY#80:.del:DEX:BNEdel:DEY:BNEdel:BEQparam:.paramout:SEI:RTS
390 .key:LDA#129:LDY#255:JSR&FFF4:TYA:RTS
400 .pcurs:LDAvar+7:EOR#31:STAzp:LDA#0:STAzp+1:LDX#4:.pclp:ASLzp:ROLzp+1:DEX:BNEpclp
410 LDAzp:CLC:ADC#ypos MOD256:STAzp:LDAzp+1:ADC#ypos DIV256:STAzp+1:LDY#0
420 LDA(zp),Y:CLC:ADC#1:STAzp+2:INY:LDA(zp),Y:ADC#1:STAzp+3:DEY
430 LDY#55:.pclp1:LDA(zp+2),Y:EOR#255:STA(zp+2),Y:DEY:BPLpclp1:RTS
440 .mup:LDAvar+7:BNEmupok:RTS:.mupok:JSRpcurs:DECvar+7:JMPpcurs
450 .mdn:LDAvar+7:CMP#3:BNEmdnok:RTS:.mdnok:JSRpcurs:INCvar+7:JMPpcurs
460 .mlt:LDYvar+7:LDApar,Y:CMPminp,Y:BNEmltok:RTS:.mltok:SEC:SBC#1:STApar,Y:JMPcope
470 .mrt:LDYvar+7:LDApar,Y:CMPmaxp,Y:BNEmrtok:RTS:.mrtok:CLC:ADC#1:STApar,Y:JMPcope
480 .pchar:SEC:SBC#32:BPLpchok:RTS:.pchok:STAzp+4:LDA#0:STAzp+5:LDX#3:.pchlp:ASLzp+4:ROLzp+5:DEX:BNEpchlp:LDAzp+5:CLC:ADC#&C0:STAzp+5
490 LDY#7:.pchlp1:LDA(zp+4),Y:STA(zp+2),Y:DEY:BPLpchlp1:LDAzp+2:CLC:ADC#8:STAzp+2:LDAzp+3:ADC#0:STAzp+3:RTS
500
510 .cope:LDAvar+7:ASLA:CLC:ADCvar+7:ADC#set MOD256:STAzp:LDA#set DIV256:ADC#0:STAzp+1:JMP(zp):.set
520 JMPchan:JMPtimbas:JMPexpt:JMPfsts
530 .chan:JSRstuppos:LDApar:CLC:ADC#48:JSRpchar:JMPpcurs
540 .timbas:JSRpcurs:LDXpar+1:DEX:STXzp:LDA#0:STAzp+1:LDX#2:.tblp:ASLzp:ROLzp+1:DEX:BNEtblp:LDXpar+1:DEX:TXA:CLC:ADCzp:STAzp:LDAzp+1:ADC#0:STAzp+1:LDAzp:CLC:ADC#25:STAzp:LDAzp+1:ADC#0:STAzp+1
550 LDA#200:STAzp+6:JSRdec:LDA#20:STAzp+6:JSRdec:LDA#2:STAzp+6:JSRdec
560 LDAzp+2:CLC:ADC#8:STAzp+2:LDAzp+3:ADC#0:STAzp+3:LDAzp:AND#1:BEQtbok:LDA#53:JSRpchar:JMPtbok1:.tbok:LDA#48:JSRpchar:.tbok1:JMPpcurs
570 .expt:JSRstuppos:LDApar+2:CLC:ADC#48:JSRpchar:JMPpcurs
580 .fsts:JSRstuppos:LDA#ASC"N":LDXpar+3:BEQfstok:LDA#ASC"Y":.fstok:JSRpchar:JMPpcurs
590 .stuppos:JSRpcurs:LDAzp+2:CLC:ADC#48:STAzp+2:LDAzp+3:ADC#0:STAzp+3:RTS
600 .dec:LDX#0:.declp:LDAzp+1:BNEdecok:LDAzp:CMPzp+6:BCCdecok1:.decok:LDAzp:SEC:SBCzp+6:STAzp:LDAzp+1:SBC#0:STAzp+1:INX:BNEdeclp:.decok1:TXA:CLC:ADC#48:JMPpchar
610 .minp:]:!P%=&00000100:P%=P%+4:[OPT A%
620 .maxp:]:!P%=&0104FF07:P%=P%+4:[OPT A%
630 .data:]:FOR B%=0 TO 252 STEP4:B%!P%=0:NEXT:P%=P%+256:[OPT A%
640 .oldd:]:FOR B%=0 TO 252 STEP4:B%!P%=&80808080:NEXT:P%=P%+256:[OPT A%
650 .ypos:]:P%=P%+512:[OPT A%
660 ]:NEXT
670 REM This calculates the screen addresses for each possible Y position
680 FOR C%=0 TO 31:A%=&5800+(31-C%)*&140:FOR Y%=0 TO 7:S%=A%+(7-Y%):?(ypos+(C%*16)+Y%*2)=S% AND 255:?(ypos+(C%*16)+Y%*2+1)=S% DIV256:NEXT,
690 GCOL0,1:FOR Y%=0 TO 128 STEP (128/5):FOR X%=0 TO 256 STEP (256/16):PLOT 69,X%*4,512+(Y%*4):PLOT69,X%*4,512-(Y%*4):NEXT,
700 GCOL3,1:MOVE0,512:PLOT1,1020,0
710 RESTORE740:FOR A%=&5908 TO &5CC8 STEP &140:FOR B%=0 TO 52 STEP4:READ !(A%+B%):NEXT,
720 ?maxp=3:REM this should be set to the highest channel number
730 CALLscope
740 DATA &45552500,&25554547,&57552500,&55555577,&74545700,&57545476,&40404000,&70404040,&0,&0,&0,&0,&7E6E663C,&3C6676     \ channel
750 DATA &7E6E663C,&3C6676,&18183818,&7E1818,&C06663C,&7E3018,&18000000,&18,&67C607E,&3C6606,&44625452,&10181,&2804020,&29AAB3     \ time base
760 DATA &62457500,&754545,&55556200,&454567,&75555600,&565575,&0,&0,&0,&0,&44000000,&44281028,&7E6E663C,&3C6676     \ expand
770 DATA &32223900,&222223,&91A11B00,&B18989,&8000,&0,&0,&0,&0,&0,&0,&0,&7E766666,&66666E     \ fast
```
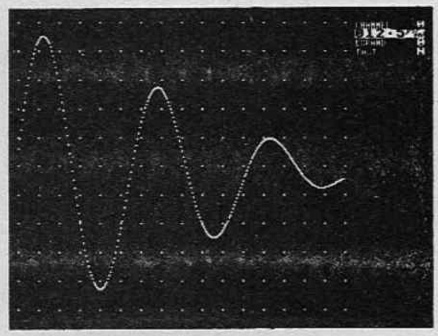



Listing 1 The BBC Basic/assembler program to operate the Beeb-Scope

output is obtained. The longer the delay between switching and sampling, the more this effect is avoided.

Once locked onto one channel the user is totally oblivious to this effect. The switching effect does not limit the device's use as a low-cost multichannel voltmeter.

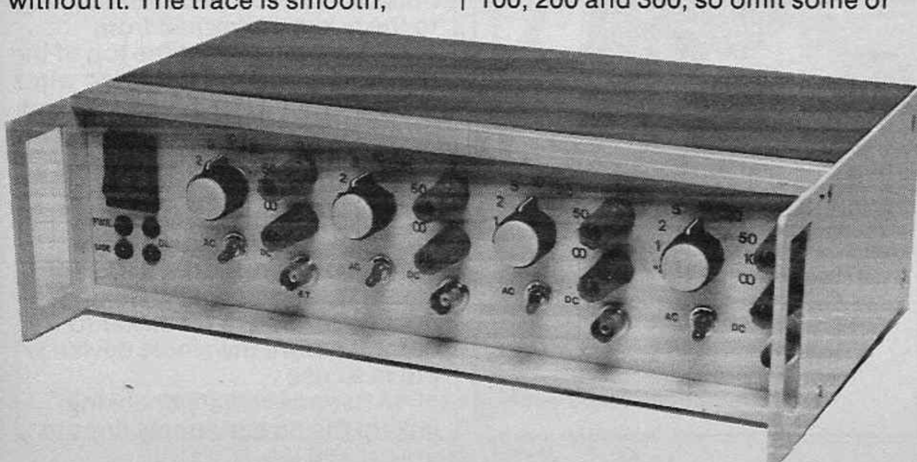
The circuit as it stands does not have a sample-and-hold module and the prototype functions perfectly normally without it. The trace is smooth, even when approaching the highest displayable frequency.

Construction

The prototype was built with four input attenuators although the analogue switch and software can cope with up to eight. To keep costs to a minimum, just one or two could be used.

The components used only in additional inputs (beyond the one illustrated in Fig. 1) have prefixes 100, 200 and 300, so omit some or all of these if you are using less than four channels.

More inputs can be added by replacing each of the 1M0 pull-down resistors R15-R18 (which represent channels 4, 6, 7 and 5 respectively) with further attenuators and protection diodes.



The Tedious Bit

Construction should be started with the input attenuators, made by soldering resistors directly to the tags of the rotary switches as shown in the wiring diagram (Fig. 3).

This is a tedious task (increasingly so with larger numbers of channels) but care should be taken to avoid errors which can be difficult to correct. Remember to set the stop on the rotary switch to allow nine positions.

Fun Bit

Assembly of the PCBs is quite straightforward. The power supply

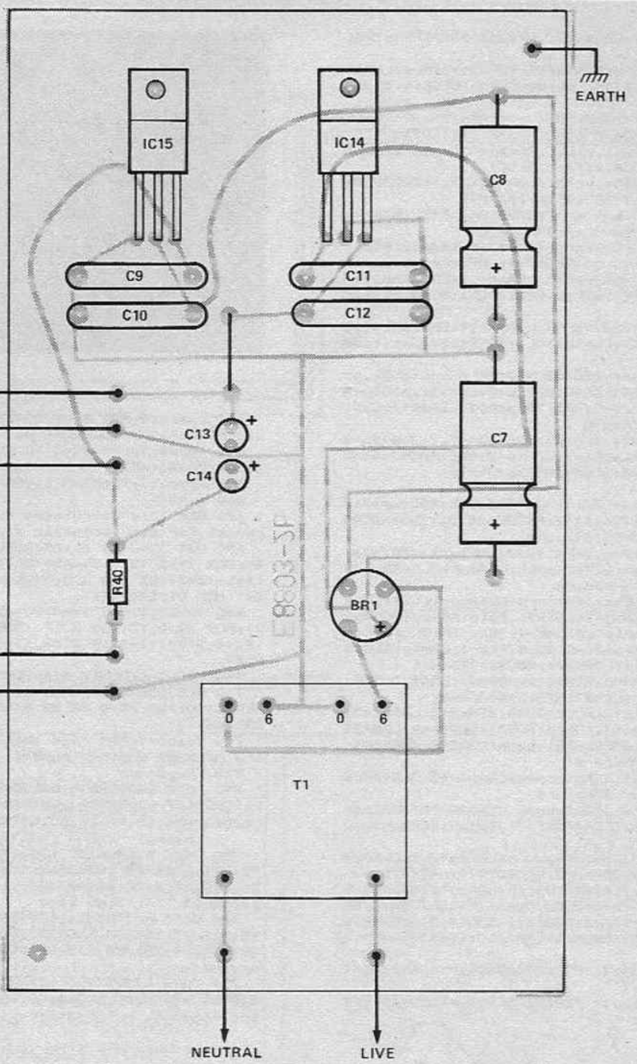
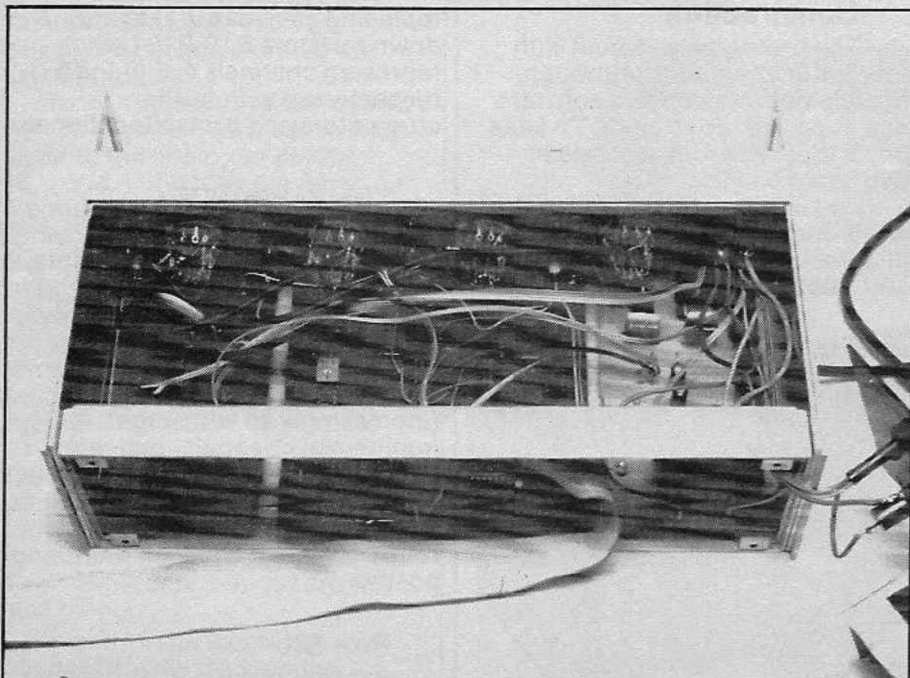


Fig. 4 The component overlay for the power supply board



board is probably the best to start on. (Fig. 4).

Assembly order here is not critical. However, it is wise not to insert the transformer until last. Bend the regulators so they lie flat against the board, to make them less vulnerable. This unit should be tested, to ensure the +5V and -5V supply rails are at the correct voltage.

Connect up a temporary (though not slipshod) mains supply. Care should be exercised, as 240V mains will be present on the underside of the transformer.

If all is well, the analogue board should be assembled next (Fig. 5). Again, assembly order is not critical as there is plenty of space on the board. Care should be taken when handling IC1 which is a CMOS device. This should be the last device to be inserted and an IC socket is essential.

The board can be partially tested at this stage by applying power and attaching a suitable signal (a signal-generator is by no means essential — a tape recorder is quite sufficient) to R23 and checking that this appears amplified at the output of the board and that the overload indicators light when they should do.

Lastly the digital board may be tackled (Fig. 6). Start with resistors, capacitors and diode, then insert the IC sockets, presets, links and finally the ICs themselves.

There are a number of links, including some on the underside of the board. There are five pairs of points which must be linked by insulated lengths of wire on the underside of the board. These are shown on the overlay as bracketed numbers. Link (i) to (i), (ii) to (ii) and so forth.

An extensive system of flying links is used above the board to carry power to the IC's. Wires are simply soldered at one end in the holes in the PCB and at the other to the bus-bars formed from tinned copper wire at the top of the board. Use suitably coloured wires to help avoid (possibly expensive) errors.

Testing

It is prudent to make a thorough check of this board before soldering in the IDC cable and to do all possible checking now, as errors are far easier to correct before the whole device is put in a case.

After preliminary checking, link up the power-supply lines to

PARTS LIST

RESISTORS (all ¼W 5%)

R1-4, 101-104, 201-204, 301-304	200k
R5, 105, 205, 305	120k
R6-8, 31, 106-108, 206-208, 306-308	20k
R9, 109, 209, 309	12k
R10-13, 110-113, 210-213, 310-313	2k0
R14, 37	1k0
R15-18, 23	1M0
R19-22, 35, 36	4k7
R24, 33	100k
R25	510k
R26	43k
R27	11k
R28	390R
R29, 30	7k5
R32, 34	10k
R38	150R
R39	82k
R40	330R
RV1	47k
RV2-5	10k

CAPACITORS

C1, 101, 201, 301	1μ0 polyester
C2	10n ceramic
C3	4μ7 16V radial electrolytic
C4	100p ceramic
C5, 6	4n7 ceramic
C7, 8	1000μ 16V axial electrolytic
C9, 10, 11, 12	470n polyester
C13, 14	47μ 25V radial electrolytic

SEMICONDUCTORS

IC1	74HC4351
IC2, 3, 5, 6	LF351
IC4	ZN427E-8
IC7	74LS126
IC8	74LS04
IC9	74LS74
IC10	74LS02
IC11, 13	74LS08
IC12	74LS27
IC14	78M05
IC15	79M05
Q1	BC184L
Q2	BC214L
D1, 2, 3, 101, 102, 201, 202, 301, 302	1N4148
BR1	WO1
LED1, 4	Red LED
LED2	Green LED
LED3	Yellow LED

MISCELLANEOUS

CON1	34-way IDC PCB header, 34-way IDC socket 34-way ribbon cable
FS1	80mA anti-surge fuse
SK1 4, 101, 201	BNC 50R socket
SK2, 102, 202, 302	Blue terminal post
SK3, 103, 203, 303	Green terminal post
SW1, 101, 201, 301	SPDT toggle
SW2, 102, 202, 302	Rotary 1P12W (9 positions used)
SW3	Mains neon rocker switch
T1	PCB-mounting mains transformer 6-0-6V 500mA

PCB; case (300 × 150 × 90mm); wire; fuseholder; nuts and bolts

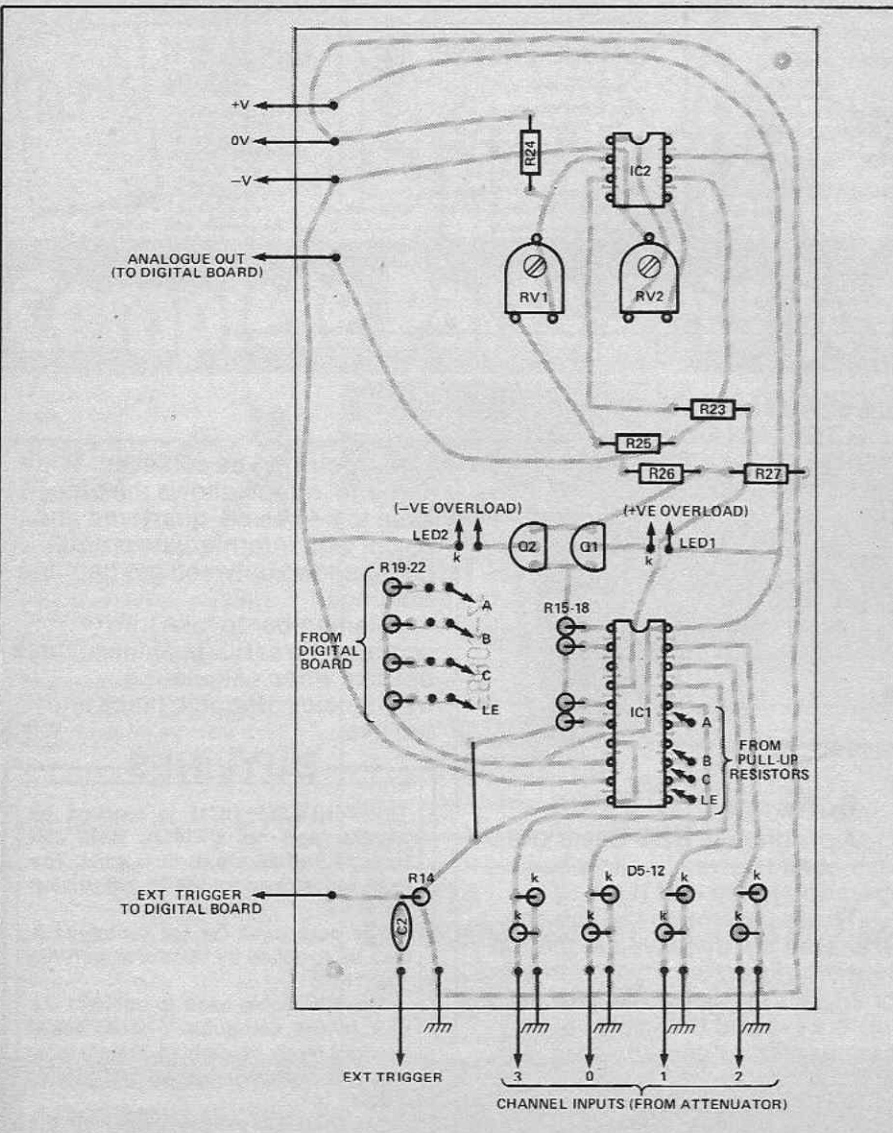


Fig. 5 The component overlay for the analogue board

each board (make sure of the polarity) and hook-up the ribbon cable to the computer. Apply an audio signal to each of the inputs in turn and check that by poking the channel number into &FFC0, you can obtain the signal at the output of the analogue board.

Now ground one input, select that channel (poke the required channel number to &FCC0) and then read &FCC1, which should yield a value between 122 and 134. Interference from nearby TVs and the like may prevent the value from being stable until the unit is properly screened.

With the unit in the case, glue a piece of metal (a scrap piece of aluminium is ideal if you have such a thing — about 50mm square) between the digital and power-supply boards and link this to earth. This will screen the ADC from the transformer and is noticeably beneficial.

Links from the attenuators to the analogue board should be made with screened cable (ordinary audio-frequency type is fine). Most types of wire can be used for the connections to the external trigger input, LEDs and general links between the PCB's.

Tuning

The operational differentiator now needs to be 'tuned.'

For each op-amp on the digital board, short together the two inputs of the op-amp (pins 2 and 3) using a screwdriver and adjust the pre-set until the output voltage

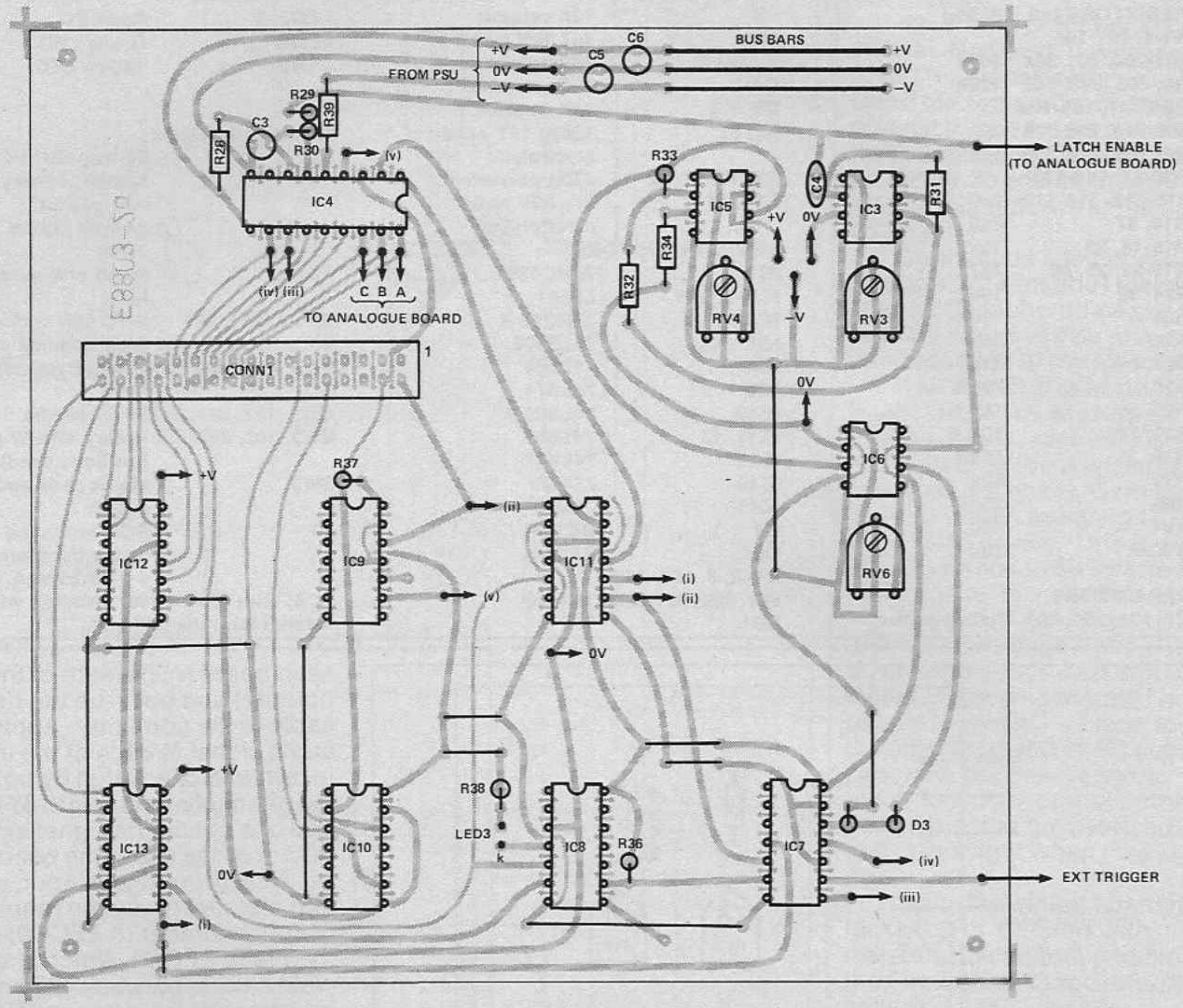
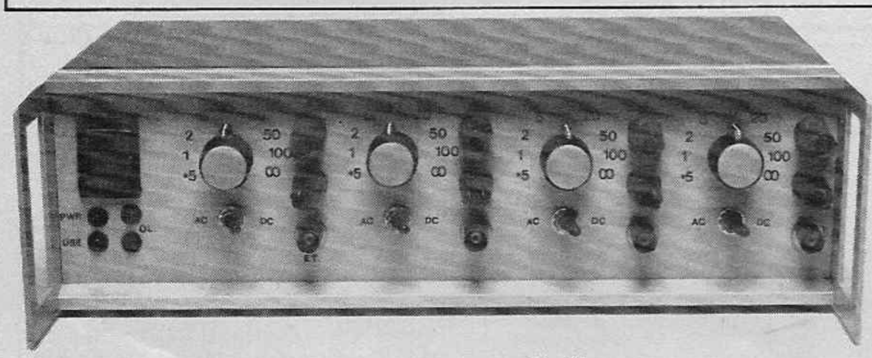


Fig. 6 The component overlay for the digital board



(pin 6 to ground) is as close to zero as possible).

The op-amp on the analogue board can be 'tuned' by linking R23 (either end) to 0V and adjusting the offset-null preset (RV2) until the output is as close to zero as possible. The gain of the op-amp can now be 'tweeked' by applying a known voltage, between 250mV and 350mV, to R23 (again, either end) and adjusting the preset (RV1) so that the input is amplified by a factor of 6.375.

Software

A program in BBC Basic and assembler is given to allow basic operation of the unit (Listing 1).

Those parameters which can be altered are displayed at the top right of the screen. The parameter for alteration is selected with the ⇧ and ⇩ keys and the value incremented or decremented with the ⇦ and ⇨ keys.

The time base is given in μs/point, there being 256 points across the trace. The 'Fast' option allow the fastest possible sampling (11μs/point) to be achieved. The 'Expand' option allows the time-base to be halved, quartered and so on, with intermediate points being added between the genuine readings.

Remember to take into account the settings of these three options when calculating frequencies, periodic times and the like. **ETI**

BUYLINES

The 74HC4351 (IC1) is stocked by Maplin (part no. UF14Q). Note that both 18 and 20-pin devices exist. The PCB is designed for the 20-pin version only.

The case used for the prototype is also as supplied by Maplin as part no. YM51F.

The IDC cable used to connect the unit to the computer is most easily brought ready assembled. Maplin offer a service for making up such leads, for a small fee.

The PCB is as ever available from the PCB service.

JUMPING JACK FLASH

Clap hands here comes Chappell (Paul) with a sound-activated trigger for light shows on the stage or curtain-drawing in the home

Back in the golden days when the world was young and electronics was fun, before designers became obsessed with creating ever more sophisticated multi IC circuits, a great deal of enjoyment was to be had from the simple pleasure of trying to squeeze the most spectacular performance from the smallest number of components.

If your sensibilities have been jaded by auto-ranging multi functional megachips and rubbed raw from exposure to high-tech gadgetry, just call on J J Flash to bring a breath of fresh air into your life.

Rumour has it that Jack Flash was born when some friends known collectively as Filament started to achieve notoriety around the local pub and club circuit with their special brand of rock music.

For a simple way to give impact to their stage presence, Flash had all the answers. A microphone in the bass drum would pick up the driving beat of the song and relay it to powerful lights which could be trained on any member of the band or even on the audience. For an outrageously OTT effect, a microphone and 100W lamp inside each drum would cause the drum itself to flash each time it was struck!

Of course there are those who would dispute this version of JJ's provenance. Many say that he was called into being as an aid to photography. Capturing a balloon about to burst and a bullet in flight are his finest achievements, they claim. Yet others insist that his main talent is in his versatility as a capable and powerful sound to action controller.

But what of the man himself? What did Flash claim to be? Perhaps we will never know the truth behind the legend but the

story of his life may shed some light on one of the most intriguing mysteries of our time.

Jumping Jack Flash Is A GaAs

One matter which is undisputed is JJF's circuit. It is shown in Fig. 1.

To the left, a microphone picks up sound vibrations and converts them to an electrical signal. This is amplified by an amount set by RV1 and fed to a circuit which responds only when the peaks are above a pre-set level. A timer IC (the good old 555) is triggered by the peaks and gives a pulse of controllable length at its output.

The pulse drives an opto isolated triac, which drives a power triac, which in its turn drives a lamp. All 500W of it!

The experience of operating the circuit in a small room is not to be missed — it gives a ridiculous sense of power to have every snap of your fingers accompanied by a blinding flash of light. Five hundred Watts in a living room is bright!

The length of the flash is set by RV2 — anything from the briefest supernova to several seconds of atomic blast. For a more restrained effect, you can use lower powered bulbs or coloured lamps.

For use on stage, the sensitivity control RV1 will have to be set very low and the microphone positioned so that it responds to the sound you want. To pick up a hand clap from the opposite side of the room, it will have to be set somewhere near the maximum.

Construction

The component overlay for the PCB is shown in Fig. 2. There is nothing to cause any difficulties here.

The only point to watch is the mounting of the triac which must make good contact with the heatsink if the circuit is controlling a respectable amount of power.

First lay it on the board with the hole in its tab over the mounting hole in the PCB. You can then judge exactly where to bend the leads. Bend them at right angles to the body of the triac (not too sharply, or you'll weaken them) then insert the triac leads temporarily into their holes to check that the tab hole is aligned with the PCB hole.

Take the triac away from the board, smear the tab with a little heatsink compound then bolt the triac to the heatsink and PCB *before* soldering the leads. A flat washer between the bolt and the triac tab will help to spread the pressure and to prevent the tab from becoming distorted.

Figure 3 shows a suitable power supply for the circuit. Fig. 4 is a suggested layout for the circuit in a small plastic hobby box. There is no need to use a PCB for the power supply unless you are really keen to make a neat job of it. The smoothing capacitors and transformer will support the rectifiers.

The microphone insert can be fixed to the case or can be remote from it at the end of a length of screened cable. If you splash out on a 3.5mm jack plug and socket, you can leave all your options open.

You'll notice the power supply has no regulator ICs. In the days

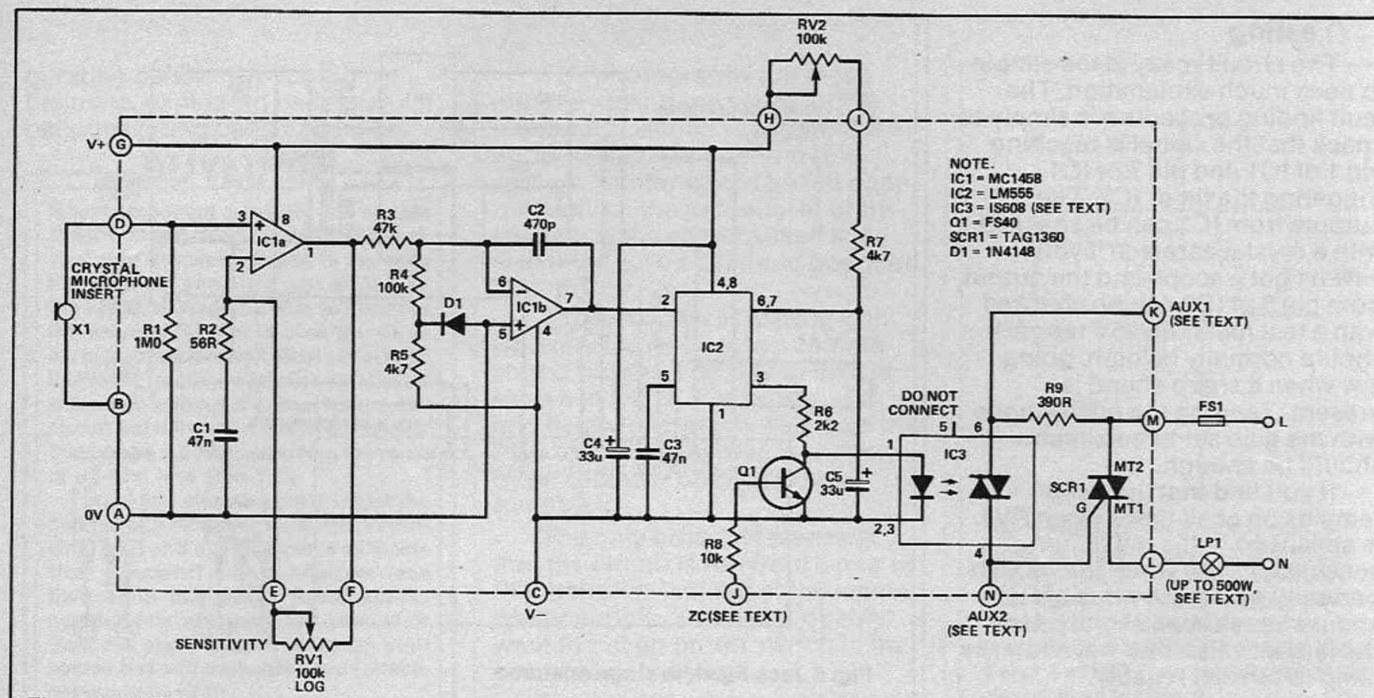


Fig. 1 Jack Flash in the nude

HOW IT WORKS

The signal from the microphone is amplified by IC1a.

Immunity to mains hum is achieved by the crude but effective expedient of giving C1 a low enough value to reduce the gain almost to unity at 50Hz while amplifying the fast spikes of percussive sounds anything up to about 2,000 times.

Components D1, R4, R5 and R3 hold pin 6 of IC1 slightly lower than pin 5 in the absence of a signal, keeping the output high. C2 tames the output of IC1b a little but no attempt is made to rectify or smooth the output since all IC2 requires is a signal which drops briefly below ⅓V+.

IC2 is the familiar 555 timer connected in monostable mode with time period adjusted by RV2. R6 limits the current to the opto isolator.

When connected as shown in Fig. 3, Q1 diverts the timer's output current from the isolator whenever any appreciable voltage is present across BR2, forming a simple zero crossing detector. The opto triac triggers the main triac via the surge limiting resistor R9. The main triac switches on the load.

when regulators had to be made from discrete components, they would only be used when absolutely necessary. These days they are included in every circuit almost as a reflex action. Just to be different (and since they are not necessary) I've left them out. Saves a quid, doesn't it?

When you come to test the circuit remember that everything beyond the opto coupler (IC3) is live, including the heatsink which is connected via the triac tab directly to the mains input. If you think anything may be wrong with the low voltage side of the circuit, disconnect the mains from the PCB (by removing the connections to points L and N) before checking it out.

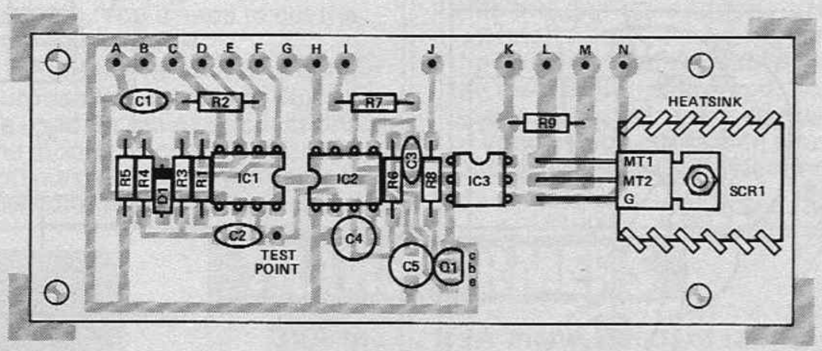


Fig. 2 Jack Flash's internal organs

PARTS LIST

RESISTORS (all ¼W 5%)

R1	1MO
R2	56R
R3	47k
R4	100k
R5	4k7
R6	2k2
R7	4k7
R8	10k
R9	390R
RV1	100k log pot
RV2	100k lin pot

CAPACITORS

C1	47m
C2	470p
C3	47n
C4	33µ 25V radial electrolytic
C5	33µ 25V radial electrolytic
C6, 7	1000µ 25V radial electrolytic

SEMICONDUCTORS

IC1	MC1458
IC2	LM555
IC3	IS608 or similar (MOC3021 etc)
Q1	FS40
SCR1	TAG1360
D1	1N4148
D2	1N4001
BR1, 2	low voltage bridge rectifier, any type

MISCELLANEOUS

X1	Crystal microphone insert (almost any microphone will do as a substitute).
T1	0-6V, 0-6V 6VA.

Connecting wire; mains wire; plugs; sockets; plastic box. Optional parts for the modified versions are shown in the relevant diagrams.

Testing

The circuit really is too simple to need much explanation. The fault finding procedure is simply to check that the signal is reaching pin 1 of IC1 and pin 7 of IC1, triggering the timer IC2. The outputs from IC1 can be checked with a crystal earpiece if you haven't got a scope and the output from pin 3 of IC2 can be checked with a test meter on 25V range. It should normally be high, going low when a sharp sound is present. Tapping the microphone with the gain set to maximum should be enough.

If you find that the lamp remains on at all times when RV1 is advanced to the maximum sensitivity (even when the room is perfectly quiet) the value of R4 should be reduced slightly. Use the largest value that will allow the lamp to turn off reliably.

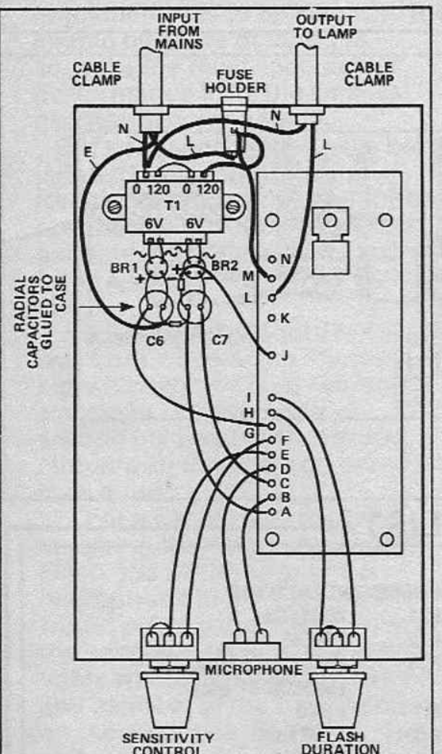


Fig. 4 Suggested layout

Transistor Q1 and the connection to the J terminal form a zero crossing detector to cut down on the interference generated by SCR1. If this feature is not required, D2 and the link to terminal J can both be omitted.

Other Applications

If your pulse doesn't race at the thought of JJF's electric stage performances, perhaps your mind is on photography. Sound triggers for cameras were all the rage a while back, allowing spectacular photographs of such things as

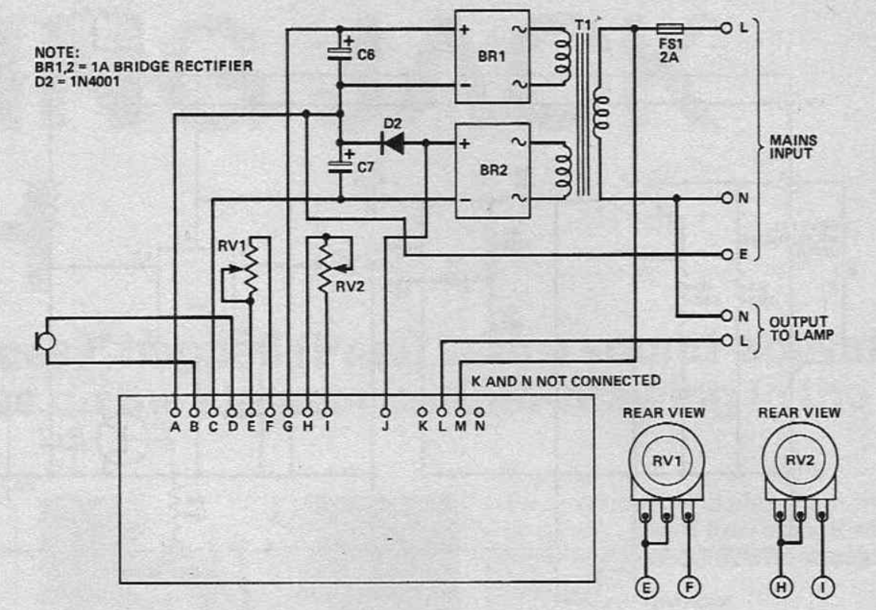


Fig. 3 Jack Flash in stage costume

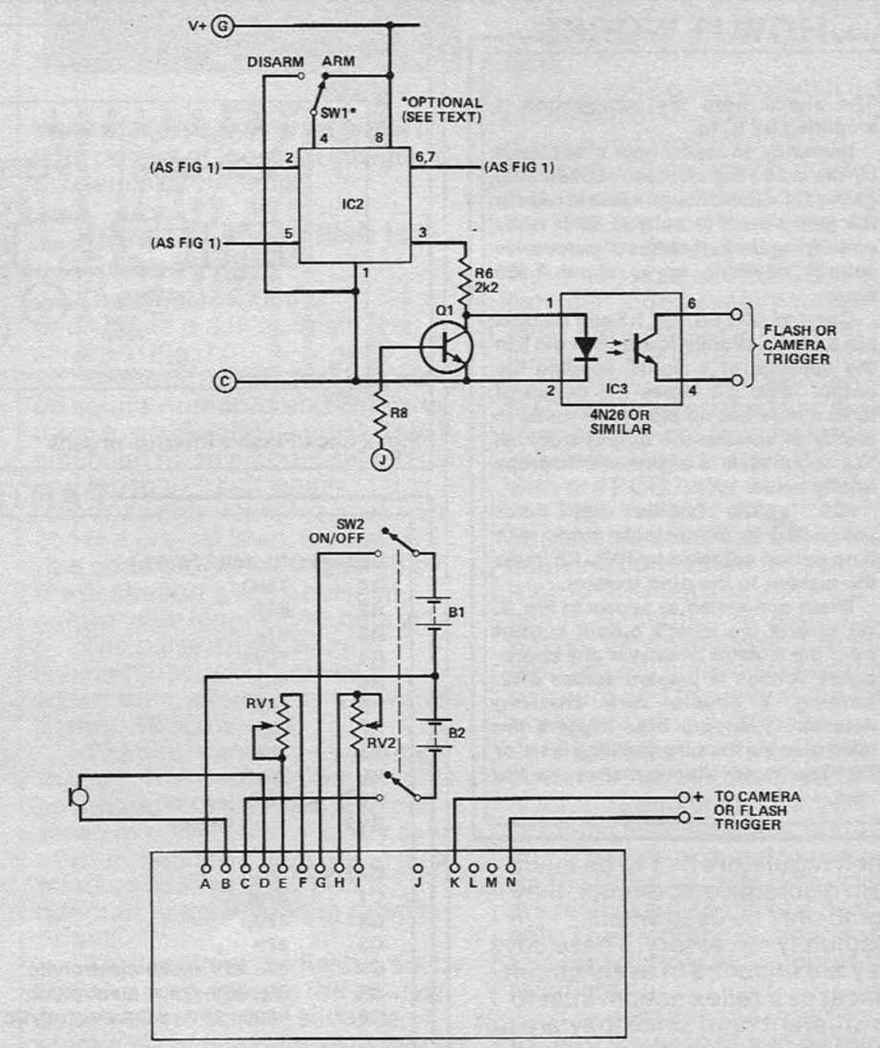


Fig. 5(a) Circuit modifications for the sound trigger. SW1 is optional (see text). Q1 and R8 are not required, but there is no need to remove them. All parts of the circuit not shown are the same as for Fig. 1. (b) Connections to the PCB for photographic sound trigger

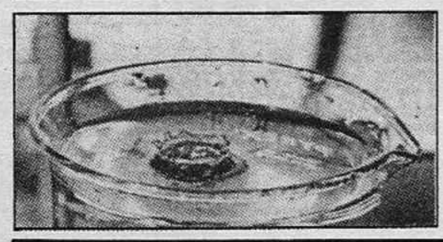
bursting balloons, popping balloons, exploding balloons, balloons going bang and so on.

BUYLINES

Most component suppliers will be able to provide suitable parts for this project. The only awkward device is the opto triac (IC3). If you use a type other than the IS608, it would be wise to increase the value of R9 just in case the surge current rating is lower. Most samples of the more readily available MOC3021 will work without modification to the circuit but if it does not turn on reliably this can be cured by reducing the value of R6 (not less than 1k0).

To get you started a parts set for the main circuit including PCB, triac, heatsink, pots and microphone is available from Specialist Semiconductors (see their ad in this issue). Power supply components are available separately from the same source, although your spares box will probably have suitable components in it.

The PCB will be available from our Readers Services in due course.



The photographs are made either by using the sound of the exploding balloon to trigger flash lights in a darkened room (the camera shutter would be left open throughout the procedure) or by triggering the camera itself if it was fitted with a solenoid operated shutter.

A touch of the soldering iron will transform JJF into a camera sound trigger. The way to do it is shown in Fig. 5. The power triac and heatsink are removed from the PCB and the opto triac is replaced by an ordinary opto-isolated transistor.

The only other difference is that the circuit is run from a pair of PP3 batteries instead of the mains power supply. You will probably want to put an on-off switch in the power supply as well.

The circuit can be armed by simply turning up the sensitivity. Otherwise, a switch in the 'reset' line of IC2 will give an arm/disarm function. You'll need to cut the PCB track for this.

For general sound switching purposes, the circuit of Fig. 1 can be used for mains applications and the modifications shown in Fig. 5 will make the circuit suitable for low voltage applications. The other feature you may want to add — latching — is shown in Fig. 6. With this configuration the circuit will latch when a sound triggers the switch and will remain on until the reset button is pressed. So — open your curtains with a whistle or your garage doors with a toot! Or just have fun experimenting.

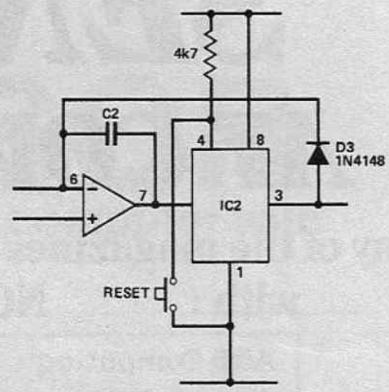


Fig. 6 Making the trigger latch. A diode is added between IC2 pin 3 and IC1 pin 6. The track between pins 4 and 8 of IC2 is cut and pin 4 is taken to V+ via a 4k7 resistor. A reset button is added between pins 1 and 4 of IC2. The remainder of the circuit is as for Fig. 1

ETI

SPECTRUM CO-PROCESSOR

Graeme Durant continues to build his add-on computer with this ingenious 256K RAM card

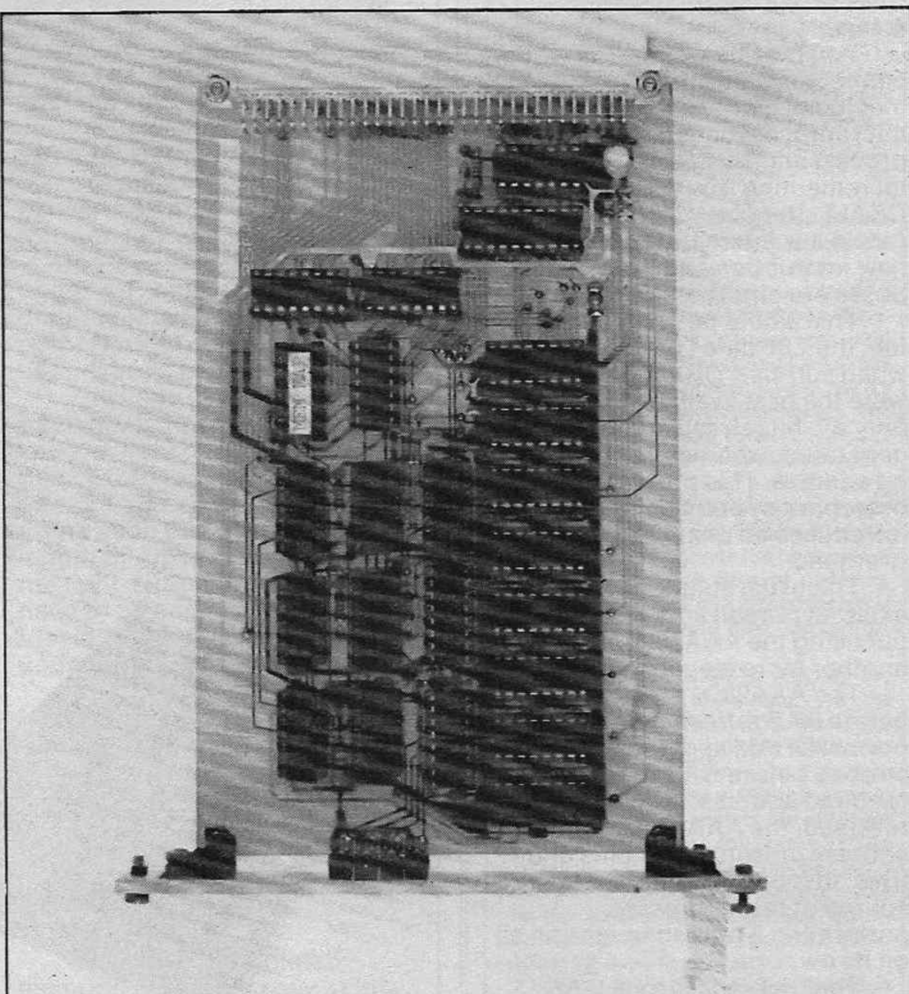
Having covered the design and construction of the Z80 CPU card last month, it is now time to move on and look at the main dynamic RAM cards.

These provide the co-processor with a large area of storage which may be used for program or data. Each DRAM circuit is built on a standard 160 × 100mm eurocard sized double-sided PCB and consists of 256K of store.

Since the Z80 has an address range restricted to 64K, the DRAM card uses a paging mechanism to enable the Z80 to accommodate this increased address range.

Connections to the board are once again made via a DIN41612 connector, the pinout being the same as for the CPU card described last month.

This DRAM card was also designed to be strictly general purpose and it can be used in any Z80 or Z80A based application you like — for example upgrading the available memory in a Z80 based home computer.



DRAM

Dynamic RAM has traditionally been tricky stuff to use. Although DRAM is cheap and can offer large storage capacities on small chips, it has the awkward requirements of periodic refresh and a multitude of carefully timed control signals. These have often been enough to turn the average hobbyist to the alternative expensive and bulky static RAM devices.

Early DRAM devices needed everything doing for them. All refresh strobes and addresses had to be externally generated. As generations of dynamic memory have come and gone, the external hardware overhead has been reduced. Now DRAM has in effect 'grown-up.' It is much more self sufficient and needs a lot less in the way of external prodding to facilitate refresh and data access.

The 'state of the art' DRAM as far as performance goes must be the AAA2800 series of CMOS 256Kbit devices, designed by Inmos and produced by NMB in the newest, most advanced CMOS VLSI manufacturing plant in Japan.

These memories combine low-power operation, fast access times and a number of versatile operating modes, making them the world's fastest monolithic 256K DRAM available.

One of the most interesting features included as far as the amateur is concerned is the so called '$\overline{CAS}$ before $\overline{RAS}$' refresh mode which makes the process of refresh simplicity itself. So the timing signals required to drive the AAA2800 series are very straightforward. It is for these reasons that the AAA2800 family was chosen for use in this design.

One special feature of this circuit is that all the timing on the board is derived from the main CPU clock using synchronous logic techniques. So it is usable in any Z80 or Z80A based system regardless of the clock frequency.

Also, expensive LSI DRAM controller chips and unreliable RC generated relays are completely avoided. The design is based on ordinary TTL logic and operates reliably under all conditions with no setting up required at all.

Refresh Schemes

The usual method used to achieve the obligatory DRAM refresh process is termed $\overline{RAS}$-only refresh. This is shown in Fig. 1.

Since the refresh operation only requires that each row within the memory array is accessed, $\overline{CAS}$ is held inactive high and $\overline{RAS}$ is strobed whilst a suitable row refresh address is supplied to the memory chips. To ensure correct operation of the AAA2800, all 256 rows must be refreshed every 4.4ms.

You may be wondering why we cannot just use the built-in refresh mechanism provided by the Z80 microprocessor itself — the processor provides an incrementing row address for the DRAM after every instruction fetch (while it is internally decoding the new instruction and the system buses are otherwise unused).

This would be great but for the fact the Z80 dates back to the days when sub-64K DRAM devices were the best available, and so only a 7-bit refresh address is generated, whereas we need an 8-bit address. This problem can be overcome by software but that introduces an unacceptable time overhead.

The usual solution is an external refresh address generator but using the AAA2800 we have another more elegant option.

The AAA2800 provides a $\overline{CAS}$ before $\overline{RAS}$ refresh mode. During normal DRAM accesses, $\overline{RAS}$ is strobed before $\overline{CAS}$ to latch-in the required address. If this order is reversed, the AAA2800 ignores the address present on its pins and uses an internal 8-bit counter as a source of row addresses, performing a refresh operation all on its own.

The trick is to strobe $\overline{CAS}$ before $\overline{RAS}$ (Fig. 2) every time the Z80 authorises a refresh cycle and the result is a completely transparent refresh scheme with no wasted time overhead and no external refresh logic required.

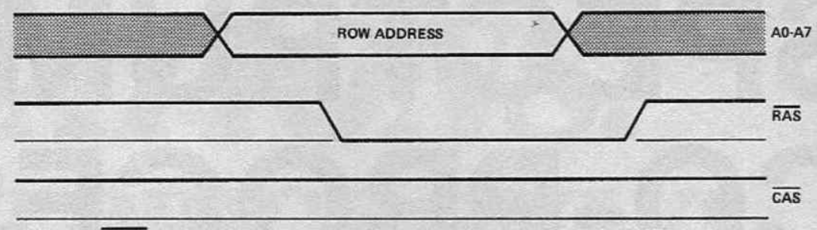


Fig. 1 $\overline{RAS}$ only refresh

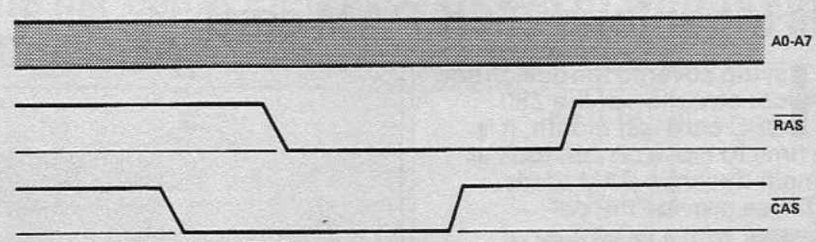
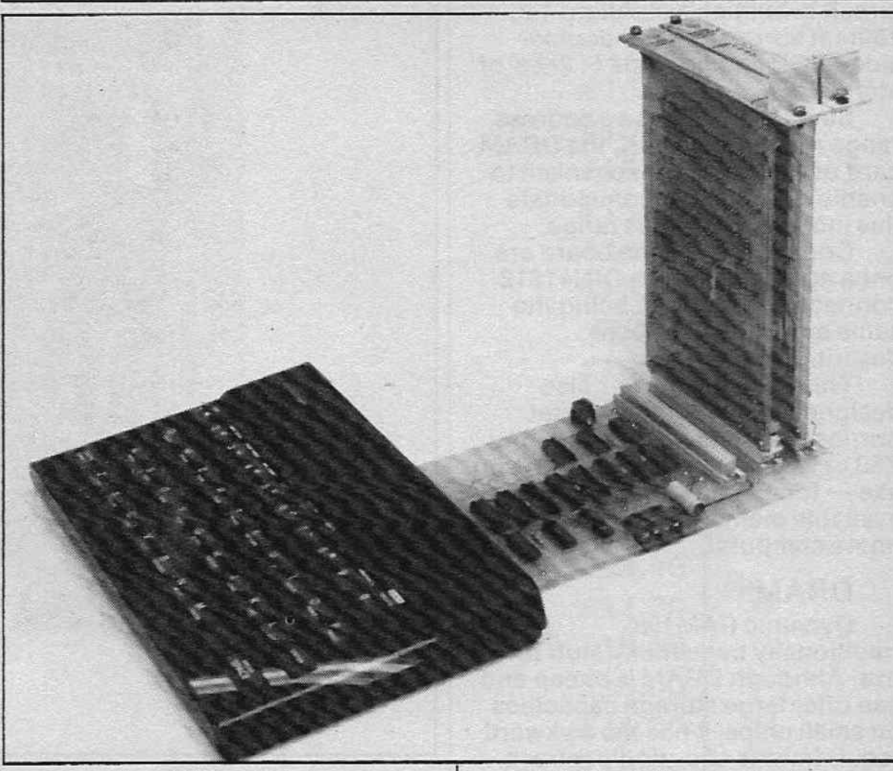


Fig. 2 $\overline{CAS}$ before $\overline{RAS}$ refresh



Paging

In common with most 8-bit microprocessors, the Z80 is capable of directly addressing only 64K of memory. However, this limited address range can be extended by *paging*. The large block of storage to be addressed is partitioned into areas called pages, each 64K locations or less in size.

The processor addresses the contents of a page directly, because its address range can handle the entire page in one go. However, the actual page accessed is selected, one at a time, by some other means.

The usual method of page selection is via a *bank select* register. This is a multi-bit latch which holds the currently selected page number and can be updated by the processor to change pages. The memory hardware responds to the contents of the bank register by enabling only the memory page required for access on the Z80 buses.

In a Z80 based system, this register can be addressed as an I/O port so it is conveniently separate from the memory map — thus avoiding the possibility of being able to page itself out!

The disadvantages of simple paging schemes like this revolve around the fact that the memory space is no longer randomly accessible.

The addressing of a location is now a two stage process, requiring an update of the bank register as well as the memory access itself. This can prove awkward if the program being executed is stored in the paged memory when jumps and subroutine calls may entail page changes.

Unless the machine's operating system has some kind of monitoring capability to handle such situations, the simplest way round this problem is to provide a small area of permanently enabled memory which is accessible regardless of the current page selected.

When code execution requires a change of page, a routine residing in this unpaged memory is called to change page and then to jump to the required location in the new page. This is the scheme used in this design. A memory map PROM (IC19) is used to permanently disable a section of each page in the paged memory, to allow the unpaged memory to sit undisturbed.

This unpaged memory consists of the operating system EPROM and the scratchpad RAM on the CPU card, described last month. The PROM allows unpaged program areas to be selected in steps of 256 locations so the least possible DRAM space is wasted in any given application.

For this co-processor design, the bottom 5K locations of each 64K page are disabled by the PROM but this can be easily changed for other applications by blowing different map PROM data.

Construction

The construction of the RAM card should not create too many problems, particularly if the suggested PCB layout is used. Like the Z80 CPU card described last month, this board is double sided but for reasons of expense, through-plating is not used to interconnect the two layers.

The through connections are shown in the overlay diagram (Fig. 4) and must be made by either wire links through the board, by the passive component leads, or by means of the IC pins. The various techniques for employing these methods were described last month. Once again 'turned pin' DIL sockets should be used to allow through connections via the IC pins.

As high currents are likely to flow in the memory power and ground lines, multiple through connections are provided to reduce the impedance of these links. These take the form of two or three closely situated through links. All must be made to ensure reliable operation.

This board also includes a large number of supply decoupling capacitors and it is important not to omit any of these. Each RAM chip has its own associated capacitor, connected close to the power and ground pins. These capacitors must be long leaded axial types to fit the suggested PCB foil and these ensure low supply impedances at high frequencies where noise problems might otherwise exist.

Short M2.5 nuts and bolts should be used to fix the edge connector to the PCB for added strength. Note that two of the connector pins must also be soldered on the topside of the PCB to link through the board.

At this stage you must decide whether to program the card for operation as pages 0-3 or pages 4-7. This determines what you do with the link pads on the PCB.

If you want the card to appear as pages 0-3 then point A should be connected to point C on the circuit diagram by soldering a through link at pad X.

If the card is to appear as pages 4-7, point B on the circuit diagram must be connected to point C with two through connections at pads Y and Z.

The page indication LEDs are fitted next. Since these are closely spaced, light can easily spill from one LED to the next, spoiling the effect. This can be avoided by fitting each LED with a short length of rubber sleeving to trap the light. Note that these LEDs need to be soldered in on the topside of the PC board as well as underneath.

The address mapping PROM IC19 must be fitted to the board before power is applied for the first time. The *How It Works* section explains the PROM programming. See *Buylines* for details of pre-programmed PROMs with the correct specification.

Testing

Testing the completed memory card is not easy at this stage. If you are intending to build up the whole co-processor project, the procedure for testing all the hardware together will be given next month. If, however, the DRAM card is intended for your own particular application then testing must consist of connecting the card into your target system and powering it up, not forgetting to initialise the bank select register.

If data can be reliably stored and retrieved, your DRAM card is fine. If there are problems, first check that you have soldered everything in, particularly on the topside of the board, then ensure all the on-board control signals are active and that addresses and data are reaching the DRAM chips.

Like all microprocessor based projects fault finding is extremely difficult without the right gear, and a decent logic analyser will set you back five grand or so. Having said that, a little perseverance with a scope should pay dividends.

Next month we shall look at the final bit of hardware to complete the Spectrum co-processor design — the interface card through which the co-processor can communicate with the Spectrum. We shall also start to examine the software side of things, so don't miss the next exciting episode!

BUYLINES

Most of the components used on this card should be available from usual component distributors. There are a number of parts which cannot easily be substituted with any old manufacturer's components due to required dimensions or specifications.

The miniature axial ceramic capacitors used throughout this project are available from Verospeed as order code 92-50952H. Verospeed can be contacted at Stansted Road, Boyatt Wood, Eastleigh, Hants SO5 4ZY. Tel. (0703) 644555.

The ultramin 100µ radial electrolytic capacitor was obtained from Maplin as order code RK50E. The DIN41612 backplane connector is also available from Maplin (order code FJ51F). The turned pin IC sockets suitable for use with this PC card are as supplied by most competent stockists but try Maplin's range if uncertain.

The Dynamic RAM chips used in this design are not commonly available due to their relative newness. Since this design makes use of their special $\overline{CAS}$ before $\overline{RAS}$ refresh mode, other manufacturer's devices cannot be substituted. The whole range of AAA2800 series RAMs are available from NMB's UK distributor, Mogul Electronics. The circuit was designed to work with any of the range of five AAA2800 series parts (AAA2800, 1, 2, 3 or 4) having access times of 120ns or faster. As the cost of DRAM is continually fluctuating, it is best to choose the cheapest of these parts at the time of ordering. Mogul Electronics can be contacted at Central Court, Knoll Rise, Orpington, Kent BR1 0JA.

Unprogrammed 24S10 PROMs are readily available from many of the regular advertisers in ETI. However, since readers might find it difficult to get these bipolar devices programmed, ready blown PROMs suitable for use in this co-processor project are available from the author for price £6.00 inclusive of postage. Please send cheques or postal orders made payable to the author to 52 Bishops Court, Trumpington, Cambridge CB2 2NN. Allow 28 days for delivery.

Finally, the printed circuit board is available from the PCB service.

HOW IT WORKS

The heart of the circuit (Fig. 3) is of course the eight dynamic RAM devices, IC22-29. The rest of the circuit can be considered as two distinct areas around this DRAM — the paging/address logic and the circuits which manage the memory chips by generating the required control signals.

Looking first at the paging/address logic, this enables the memory card for access when both a valid page on the card is selected and a valid location within that page is addressed.

The bank select register, consisting of three D-type flip-flops (IC14 and IC33b) is mapped onto the Z80 output port at address 254 by IC20 and IC31a, b, d. The data value sent by the Z80 to this port will determine which page is chosen.

IC18 decodes the port data to see whether one of the four pages on this card is selected. IC33b stores the result, its Q output being low if the current page is on the card. At the same time, IC14 stores the states of the two least significant port data bits.

If the required page does reside on this card then these two bits signify which page from the four is selected and will form two extra address bits to the DRAM devices.

IC21 is used as a two-to-four line binary decoder to light up one of four LEDs to indicate which page is currently selected. This decoder is disabled if the current page is not present on the card so all the LEDs are blanked.

For circuit simplicity inverse logic is used for page selection. Sending 255 to the bank register switches in page zero, 254 switches in page one and so on.

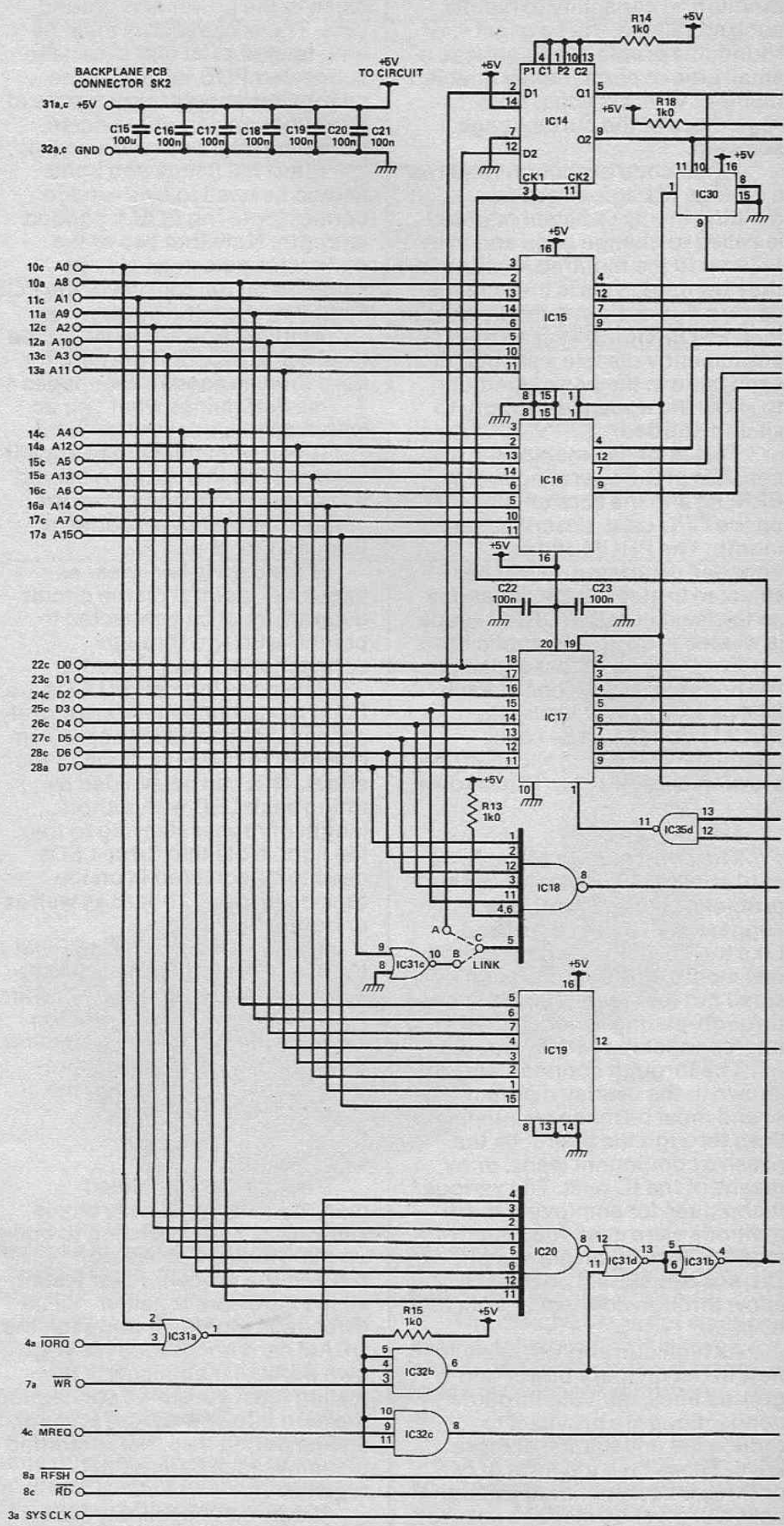
The user has the option of making the card either pages 0-3 or pages 4-7. This is achieved by means of a link on the PCB. If point A is linked to point C, the output of IC18 will be active low when the most significant six bits of data to the bank register port are high. So, pages 0, 1, 2, 3 are decoded onto the card. If point B is linked to point C then port bit D2 is inverted before it gets to IC18 and pages 4, 5, 6, 7 are decoded onto the card.

In this way, up to eight pages of DRAM (two DRAM boards) may be used in the system. The 8-bit port decoding however, allows up to 256 memory pages to be controlled from the processor and if more pages are required then further data bits must be inverted on their way into IC18. This would of course entail modifications to the PCB design itself.

IC19 is an address decode PROM used to disable the memory card when certain addresses occur, allowing other unpaged memory (such as EPROM) to reside in the system.

Its address inputs are connected to the CPU's eight most significant address lines and so the PROM changes its addressed location every 256 Z80 locations.

The PROM is programmed to produce a logic low at its least significant bit output (pin 12) when the



card is to be disabled. For example, if the first 1K locations are to be reserved for an unpaged EPROM, IC19 should be programmed with the first four locations containing zeros in the LS bit position leaving the rest of the device holding all ones.

For this design, where the first 5K locations must be disabled, IC19 must have its first 20 locations programmed to E(hex) and the following 236 locations programmed to F(hex).

The rest of the circuitry manages the memory devices themselves allowing

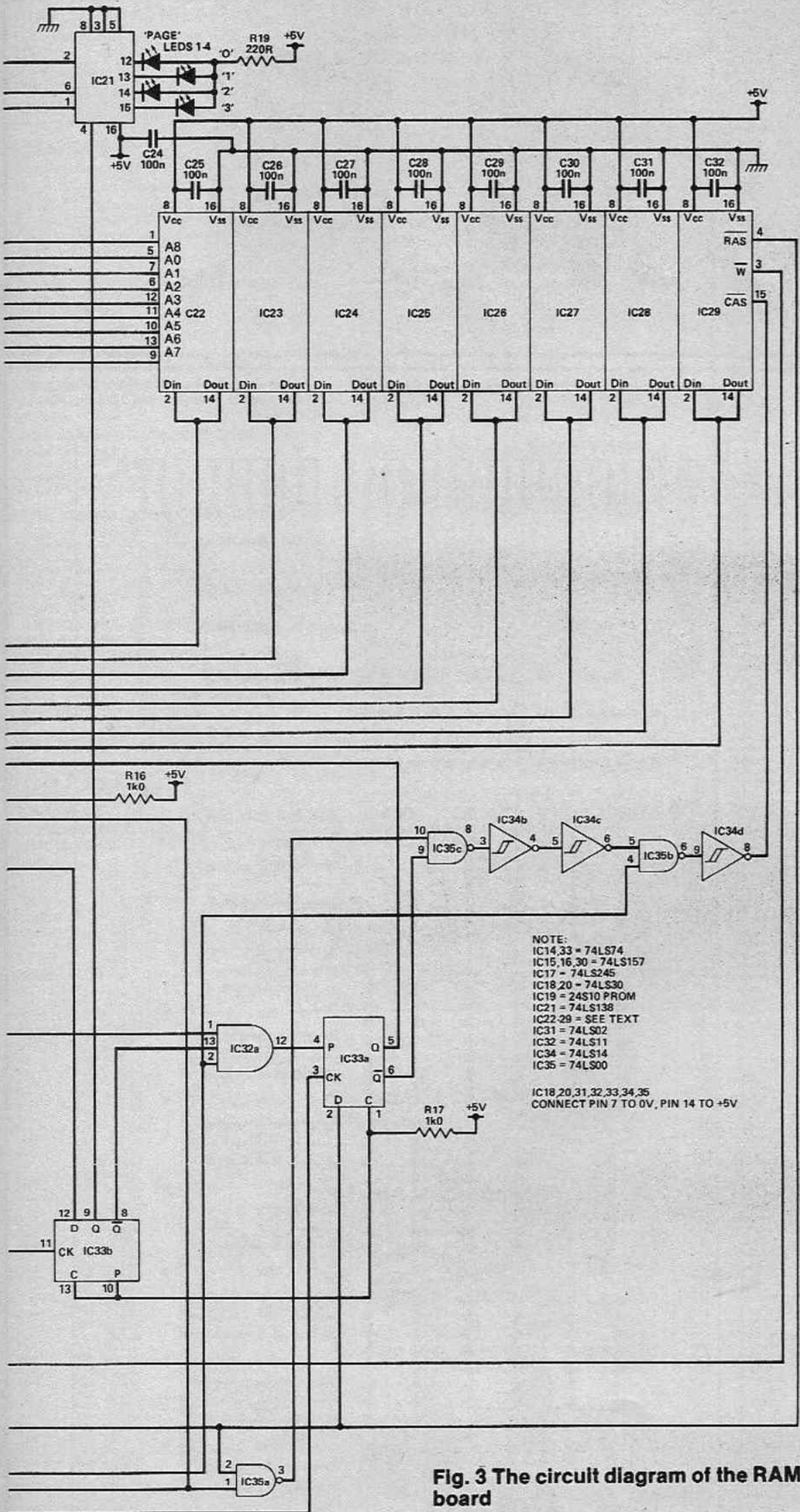


Fig. 3 The circuit diagram of the RAM board

them to be accessed for data storage or retrieval and also handles the refresh requirements.

Dynamic RAM expects to receive its address signals in two halves (the row and column addresses) multiplexed in time onto one set of address pins. The DRAM devices require three correctly overlapped control signals, $\overline{RAS}$, $\overline{CAS}$ and $\overline{W}$ to make use of this address information. $\overline{RAS}$ is the strobe which latches in the row address, $\overline{CAS}$ latches in the column address and $\overline{W}$ is the write enable control.

A further signal is required to drive the address multiplexers themselves, selecting whether the row or column addresses are being supplied to the DRAM.

In this design the $\overline{RAS}$ signal is directly obtained by using the Z80 memory access strobe signal $\overline{MREQ}$ via buffer IC32c. The DRAM write control signal $\overline{W}$ is the Z80 write strobe $\overline{WR}$ buffered by IC32b.

The generation of the DRAM $\overline{CAS}$ and the multiplexer select signal, is a little more complicated. Their precise timing has to tie in with $\overline{RAS}$ and $\overline{W}$.

D-type flip-flop IC33a is clocked at high speed by the system clock and on each rising clock edge passes the state of $\overline{MREQ}$ to its Q output. The relative timing of $\overline{MREQ}$ with the clock is such that the Q output of IC33a follows $\overline{MREQ}$ with a delay of about 50ns minimum (assuming a 4MHz clock).

This delayed signal is used to drive the select line of the memory address multiplexer formed by IC15, 16 and 30. The 50ns switchover delay after $\overline{RAS}$ ensures the row address hold time is not invalidated.

The address multiplexed into the DRAM consists of 16 bits of address from the Z80 and two bits of address from the bank select register, IC14. This results in the required configuration of four 64K pages with each page being directly accessible to the CPU.

The $\overline{Q}$ output of IC33a goes on to form $\overline{CAS}$ via IC34b, c, d and IC35b, c. The DRAM chips used in this design (in common with most dynamic memories) require for normal access that $\overline{CAS}$ goes low after $\overline{RAS}$ and that the $\overline{W}$ strobe has settled before $\overline{CAS}$ goes low.

The delayed $\overline{RAS}$ signal from IC33a is guaranteed to occur after $\overline{RAS}$ itself. Similarly IC35a detects when the Z80 $\overline{RD}$ or $\overline{WR}$ strobes are active. When this happens it signifies that the DRAM $\overline{W}$ control is also present. The output of IC35c will go low only when both the delayed $\overline{RAS}$ and the output of IC35a are active, thus fulfilling the timing requirements for $\overline{CAS}$ in relation to $\overline{RAS}$ and $\overline{W}$.

The output of IC35c is given a little extra delay by IC34b,c to ensure the recently multiplexed column address has had time to settle. This signal then passes via IC35b and IC34d to drive the DRAM CAS line.

IC33a can be disabled via its asynchronous preset input by IC32a, thus holding $\overline{CAS}$ inactive when a memory access is not required on this card.

This occurs when either the current page is not on this card (IC33b $\overline{Q}$ is low), when an invalid address has been received (detected by IC19) or when a refresh operation is taking place (Z80 $\overline{RFSH}$ line low).

When the Z80 authorises a refresh cycle to occur, it drives the $\overline{RFSH}$ line low before the $\overline{MREQ}$ ($\overline{RAS}$) strobe. This $\overline{RFSH}$ strobe forces CAS low via IC35b to accomplish the automatic $\overline{CAS}$ before $\overline{RAS}$ refresh cycle. The result is that refresh occurs trans-

HOW IT WORKS CONT.

parently to the user during the time the Z80 is internally decoding its next instruction.

Data from the Z80 data bus is buffered onto this card by IC17, an octal tranceiver chip. The direction control for this device is simply derived from the Z80 $\overline{RD}$ strobe via IC35d and its enable control is the same signal as the multiplexer select — this being active low during the time that data is moving into or out of the card.

Since each of the AAA2800 devices used is configured as a 256K by one bit memory, each chip handles one bit of the Z80 data word and the address information is fed to all the DRAM chips in parallel.

Numerous supply decoupling capacitors are used throughout the circuit (especially around the RAM chips themselves) to avoid problems with high frequency supply noise. A high value electrolytic capacitor C15 acts as a bulk energy store to reduce problems associated with remotely connected power supplies.

PARTS LIST

RESISTORS (all 0.25W 5% unless otherwise stated)

R13-18	1k0
R19	220R 0.5W 5%

CAPACITORS

C15	100µ 6V ultramin electrolytic radial
C16-32	100n ceramic

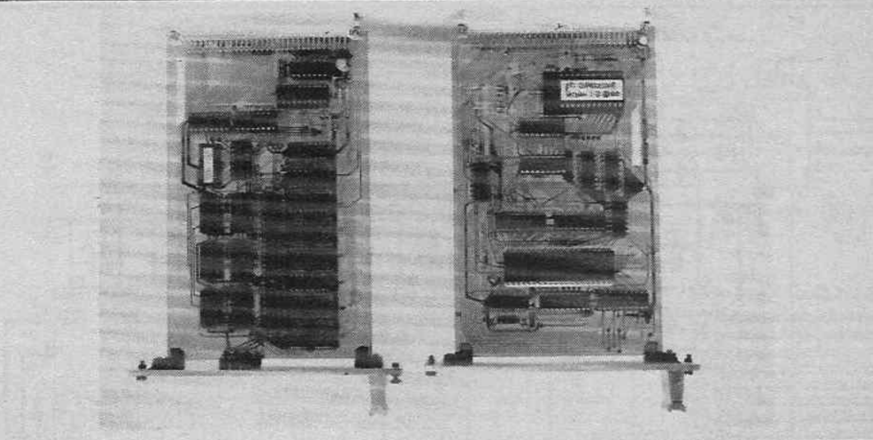
SEMICONDUCTORS

IC14, 33	74LS74
IC15, 16, 30	74LS157
IC17	74LS245
IC18, 20	74LS30
IC19	24S10 PROM
IC21	74LS138
IC22-29	AAA280
IC31	74LS02
IC32	74LS11
IC34	74LS14
IC35	74LS00
LED1-4	green LEDs

MISCELLANEOUS

SK2	DIN41612 type C 64-pin right angle PCB mounting plug

PCB; IC sockets; tinned copper wire for through connections; M2.5 nuts and bolts for DIN connector.



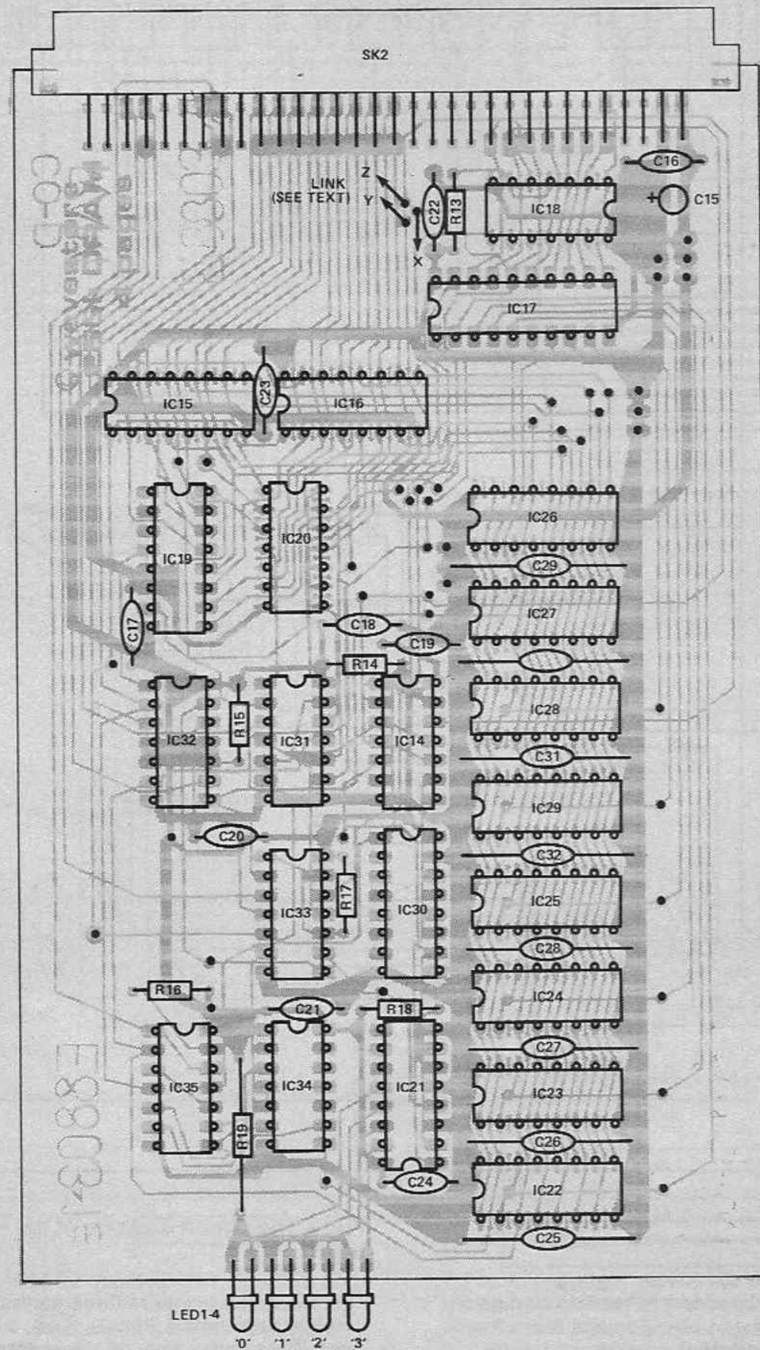


Fig. 4 The component overlay for the RAM board

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• 1MB 80 T 96 TPI Cased with PSU & Leads	£110.00	£3.00
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1MB 135 TPI D/S Slimline	£75.00	£1.50
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Miracle Technology WS3000 V21,V23 AA AD	£275.00
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SOLDER	.65	.90	1.25	2.00
PCB	.75	1.10	1.75	-
PCB R/A	1.30	1.90	2.60	-
COVERS	.60	.65	.68	.80
IDC PLUG	3.15	3.75	3.00	-
SOCKET	3.40	3.90	3.00	-

RIBBON CABLE

per metre	Grey	Colour
10 way	0.40	0.70
16 way	0.65	1.10
20 way	0.80	1.30
26 way	1.00	1.70
34 way	1.35	2.30
40 way	1.65	2.60
50 way	1.95	3.30
64 way	2.80	4.20

CENTRONICS CONNECTORS
36w IDC Plug 2.95 Skt 4.10
36 way Plug Solder 3.00

IDC CONNECTORS

	SKT	PCB Plug	R/A Plug	EDGE Plug
10 way	0.61	0.65	0.65	
16 way	0.70	0.85	0.85	
20 way	0.88	1.10	1.10	
26 way	0.98	1.20	1.20	
34 way	1.12	1.50	1.50	3.20
40 way	1.35	1.65	1.65	
50 way	1.65	2.50	2.50	

PRINTER LEADS
Memotech 8.50 QL 6.85
Amstrad 8.80 Dragon 7.95 BBC 7.40

MODULATORS

UM1286 2.00
UM1233 3.00

HEADER PLUGS DIL IDC
14 PIN 0.72 28 PIN 1.43
16 PIN 0.80 40 PIN 1.95
24 PIN 1.10

DIL SWITCHES
4 way 0.68 8 way 0.80
6 way 0.75 10 way 0.95

74LS & 74F / TTL74 / TRANSISTORS

		74LS175	0.50	74LS368	0.35	74F74	0.40	7430	0.30	7446	0.85	7486	0.60
		74LS181	1.80	74LS37	0.18	74F85	1.96	74367	0.75	7448	1.40	7490A	0.50
74LS374	0.65	74LS182	2.00	74LS373	0.65	74F125	1.05	7438	0.35	7450	0.25	7491	0.60
74LS00	0.17	74LS183	1.50	74LS378	0.75	74F138	1.05	7440	0.30	7470	0.90	7492	0.30
74LS02	0.18	74LS190	0.55	74LS38	0.18	74F161	2.95	7441	0.60	7474	0.36	7493	0.35
74LS03	0.18	74LS191	0.65	74LS390	0.50	More available		7442	0.62	7475	0.45	7494	0.85
74LS04	0.17	74LS192	0.65	74LS393	0.45			7443	0.90	7476 + 7485	0.90	7496	0.60
74LS08	0.18	74LS193	0.65	74LS395A	0.90	**TTL74**		**TRANSISTORS**					
74LS09	0.18	74LS194A	0.65	74LS40	0.18								
74LS10	0.18	74LS196	0.56	74LS42	0.40	7400	0.22	AC128	0.30	BF200	0.35	MPSA55	0.25
74LS107	0.30	74LS197	0.65	74LS47	0.60	7401	0.22	AC142	0.33	BF244	0.35	MPSU05	0.50
74LS109	0.30	74LS20	0.65	74LS48	0.60	7402	0.22	AC176	0.25	BF256B	0.45	TIP29A	0.32
74LS11	0.18	74LS21	0.18	74LS49	0.90	7404	0.30	AC187/8	0.23	BF257/8	0.40	TIP29C	0.32
74LS112	0.30	74LS22	0.18	74LS51	0.20	7406	0.40	AD149	0.75	BF259	0.30	TIP2955	0.50
74LS113	0.30	74LS240	0.70	74LS54	0.20	7407	0.40	AD161	0.40	BF324	0.25	TIP30	0.32
74LS114	0.30	74LS241	0.70	74LS541	0.90	7408	0.30	AD162	0.40	BF336	0.30	TIP30C	0.35
74LS122	0.35	74LS242	0.70	74LS55	0.20	7409	0.25	AF124-127	0.55	BF337	0.35	TIP3055	0.50
74LS123	0.40	74LS245	0.70	74LS640	1.35	7410	0.30	AF139	0.38	BF421-423	0.22	TIP31A	0.45
74LS125	0.30	74LS244	0.60	74LS641	1.25	74100	2.20	AF239	0.40	BF469-472	0.40	TIP31C	0.40
74LS126	0.30	74LS247	0.80	74LS642	1.20	74114	0.20	BC107B-110	0.11	BF870-872	0.30	TIP32A	0.45
74LS12	0.18	74LS248	0.90	74LS643	1.75	7412	0.25	BC114	0.20	BFR41	0.22	TIP32C	0.40
74LS132	0.35	74LS249	0.90	74LS644	1.75	74121	1.75	BC140	0.20	BFR51	0.20	TIP33C	0.85
74LS133	0.35	74LS251	0.45	74LS645	1.75	74123	0.65	BC147-159B	0.12	BFR90	0.60	TIP34A	0.65
74LS136	0.28	74LS253	0.50	74LS668	0.80	7413	0.35	BC170	0.07	BFR91	0.75	TIP34C	0.90
74LS137	0.70	74LS256	0.80	74LS669	0.80	7414	0.60	BC182-239C	0.09	BFR94	0.88	TIP36	1.25
74LS138	0.30	74LS257	0.45	74LS670	1.30	74141	0.70	BC256A	0.30	BFX29	0.28	TIP41A	0.45
74LS139	0.30	74LS258	0.45	74LS673	7.50	74147	1.50	BC307B-338	0.20	BFX84	0.33	TIP41B	0.50
74LS13	0.28	74LS259	0.80	74LS674	7.50	74153	0.65	BC441/461	0.33	BFX85	0.45	TIP42A	0.50
74LS14	0.40	74LS26	0.18	74LS682	2.35	74155	0.68	BC477	0.20	BFX87/88	0.45	TIP42B	0.50
74LS145	0.80	74LS260	0.60	74LS684	2.75	74157	0.99	BC516/7	0.30	BFY17	0.30	TIP42C	0.50
74LS147	1.10	74LS266	0.22	74LS685	2.75	74159	1.50	BC547B-559	0.11	BFY41	0.30	TIS90	0.20
74LS148	1.00	74LS27	0.18	74LS686	5.00	74160	0.80	BD124P	0.85	BFY50	0.30	TIS91	0.30
74LS15	0.18	74LS273	0.65	74LS687	2.75	74161	0.80	BD131	0.50	BFY51	0.30	2N2219A	0.27
74LS151	0.45	74LS279	0.50	74LS689	2.75	74163	0.85	BD132	0.50	BFY52	0.33	2N2221A	0.27
74LS153	0.55	74LS280	1.60	74LS73	0.28	74165	0.85	BD133	0.48	BFY90	0.76	2N2368	0.24
74LS155	0.45	74LS283	0.60	74LS74AN	0.22	7417	0.40	BD135	0.45	BSX20/21	0.25	2N2369A	0.15
74LS156	0.45	74LS290	0.70	74LS75	0.27	74170	1.55	BD136-140	0.30	BSX26	0.30	2N2483	0.22
74LS157	0.45	74LS293	0.70	74LS76	0.27	74173	0.99	BD245B	0.55	BSX29	0.30	2N2646	0.55
74LS158	0.45	74LS295	1.10	74LS78	0.27	74174	0.88	BD517	0.70	BU104	1.70	2N2904A	0.25
74LS160	0.50	74LS298	0.95	74LS83	0.45	74180	0.85	BF115	0.40	BU105	1.50	2N2906/7	0.25
74LS161	0.50	74LS299	2.00	74LS85	0.55	74181	2.00	BF154	0.25	BSY95	0.35	2N2926	0.11
74LS162	0.55	74LS30	0.18	74LS86	0.28	74182	0.80	BF167	0.30	BUY69	2.10	2N3053	0.25
74LS163	0.50	74LS32	0.18	74LS90	0.30	74184	1.55	BF177	0.30	MJE2955	0.98	2N3054	0.55
74LS164	0.50	74LS322	3.00	74LS92	0.40	74188	2.10	BF178	0.35	MJE3055	1.60	2N3055	0.48
74LS165	0.80	74LS323	2.75	74LS93	0.35	74190	1.05	BF181	0.25	MJE340	0.38	2N3819	0.35
74LS166	0.75	74LS33	0.22	74LS95B	0.50	74191	2.00	BF184	0.30	MJE370	0.95	2N3904	0.15
74LS168	1.20	74LS352	1.00	74LS96	0.75	74193	1.20	BF185	0.30	MJE520	0.45	2N3905/3906	0.15
74LS169	0.75	74LS353	0.80	74F00	0.38	7420	0.30	BF196	0.13	MJ2955	0.50	3N128	0.99
74LS170	1.00	74LS365	0.35	74F02	0.38	7422	0.30	BF197	0.18	MJSA05	0.35	MANY MORE	
74LS173	0.60	74LS366	0.35	74F10	0.38	74251	1.10	BF198/9	0.16	MPSA12	0.35	AVAILABLE	
74LS174	0.50	74LS367	0.35	74F14	0.75	74284	2.50						

LINEAR ICs

AY-3-1014A	2.75
AY-3-1015D	2.75
AY-3-8470	2.00
AY-3-8475	3.00
AY-3-9710	3.15
AY-3-9725	4.00
CA3011	1.10
CA3018	0.75
CA3028A	1.00
CA3046	0.60
CA3052	1.90
CA3054	1.00
CA3065	2.00
CA3080A	2.00
CA3080E	0.55
CA3085	1.30
CA3088	0.50
CA3088E	2.00
CA3089Q	2.00
CA3090AQ	2.30
CA3100S	2.00
CA3130E	0.75
CA3140T	0.70
CA3161E	1.50
CA3162E	4.50
CA3189E	2.25
CA3193E	1.50
CA3240E	0.90
CA3260E	2.50
CA3290E	1.10
HA1366W	1.70
LA3300	1.90
LA4032P	2.45
LA4400	3.50
LA4420	2.25
LA4422	3.20
LA4461	3.50
LC7120	3.00
LC7130	3.00
LC7131	3.00
LM1889N	3.00
M51513L	2.00
M51515L	3.00
MB3712	1.80
MC1315P	2.90
MC1330P	1.90
MC1349P	1.50
MC1460G	2.90
MC1463R	4.80
MC1469R	3.00
MFC6040	0.90
ML237B	2.50
ML238B	4.50
NE535T	1.10
NE5501N	0.90
NE5534N	1.00
SAB3209	3.75
SN76008N	2.25
SN76110N	1.20
SN76115AN	1.60
SN76131N	1.25
SN76396N	1.65
SN76600P	1.30
SN76660N	0.80
SN76707N	2.10
SN76708N	3.00
TA7204P	1.30
TA7205AP	0.90
TA7208P	1.30
TA7222P	1.30
TA7310P	1.30
CA3020	2.00
HA1388	2.50
LM1357P	1.95
LM301AN	0.30
LM310N	2.40
LM311	0.45
LM319	1.50
LM324N	0.35
LM339N	0.35
LM348N	0.55
LM358N	0.45
LM380N-14	0.80
LM381	1.50
LM3900	0.45
LM558	1.60
LM710CN	0.90
LM711CN	0.90
LM741	0.50
LM747CN	0.80
MB3756	4.00
NE555	0.20
NE556	0.55
NE566	1.30
TBA120S	0.60
TBA920	1.75
TDA1011	2.00
TDA1022	4.00
TDA2006	3.10
TDA2190	2.40
TDA2591	2.75
TDA2670	1.50
TL071CP	0.38
TL072CP	0.60
TL074CN	1.00
TL081CP	0.30
TL082CP	0.50
TL084CN	0.90
TBA990Q	2.75
TC9100	7.50
TC9109P	7.50
TCA270SB	3.00
TCA650	3.50
TCA660B	3.50
TCA740	2.40
TCA900	1.90
TCA910	1.90
TDA1003A	1.90
TDA1035T	2.50
TDA2002	2.75
TDA2010	3.00
TDA2030	1.80
TDA2522	2.50
ZN425E8	3.40
ZN426E8	2.90
ZN427E	5.90
ZN428E8	4.40
ZN447E	8.75
ZN449E	2.90
ZN435E	5.00

COMPUTER ICs

1691	12.00
1770	20.00
1772	15.00
1793	15.00
2793	15.00
2797	15.00
6502A	4.25
6551A	5.50
6522A	4.00
6800	2.00
6802	2.60
6803	8.25
6808	5.00
6809E	6.50
6810	1.50
6818	3.90
6820	1.50
6821	1.50
6840	3.70
6845	5.50
6847	6.25
6850	1.10
6852	2.40
6854	6.25
68000 P8	14.00
76489	2.50
8035	3.15
8080A	4.15
8085A	2.75
8088	9.75
8131	4.50
8155	3.50
8156	3.50
8212	1.50
8214	4.75
8216	1.50
8224	2.90
8226	2.90
8228	3.00
8243	2.80
8251A	3.25
8253	3.25
8255	3.50
8256A	11.00
8257-5	3.90
8259	3.90
8271	32.00
8272	12.00
8272A	14.00
8283	4.40
8284	5.25
8288	10.00
8T26A	0.90
8T27	1.45
8T28	1.75
8T31	3.45
8T95	0.85
8T97	0.85
8T98	1.40
8748	12.00
9216	12.00
MC1488	0.65
MC1489	0.65
MC3242	6.50
MC3446	2.25
MC3447	3.00
MC3486	2.15
MC3487	2.15
Z80ACPU	2.00
Z80BCPU	7.50
Z80ACTC	2.00
Z80ADART	7.00
Z80ADMA	8.25
Z80APIO	2.75
Z80ASIO	8.00
Z80ASIO-1	8.00
Z80ASIO-2	8.00
ULN2002	0.70
ULN2003	0.70
ULN2004	0.70
TMS9901	5.75
TMS9902	5.95
TMS9914	16.00
TMS9918	10.00
TMS9928	5.00
TMS9929	5.00

MEMORIES

62256P15	12.50
2114-2	2.75
2716-350N/S	4.25
2732-450N/S	4.25
2732A-200	5.00
3732-2 32K	1.25
2764-25	3.25
27C64-25	6.50
27128-200	4.00
27128-250	3.50
27256-25	4.25
4116-3	0.75
27512-25	19.00
4164P-15	1.85
41256-15	2.95
27512-25	9.00
50258-12	4.50
6116LP3 150N/S	2.00
6116P4 200N/S	2.00
HM6264LP12	4.00
HM6264LP15	3.00
TC5501P	4.00
TC5514AP3	2.95
TC5516APL2	2.90
TC5517BP	2.95
TC5565PL15	3.55
UPD41464C-15	8.00

DIODES

AA119	0.08
AA129	0.10
1N4001	0.04
1N4002	0.04
1N4003	0.05
1N4004	0.05
1N4005	0.06
1N4006	0.06
1N4007	0.06
1N4148	0.02

SPECIAL OFFERS

	EX VAT	P&P
Seagate 20MB Hard Disc	240.00	3.00
Panasonic KXP1081 Printer	169.00	7.00
TEAC 1.2MB Disc Drive	109.00	2.00
AT 200W Power Supply	85.00	2.00
XT 150W Power Supply	65.00	2.00

1N5401	0.10	79L05	0.33
1N5402	0.10	79L08	0.40
1N5404	0.12	79L12	0.33
1N5406	0.14	79L15	0.40
1N5408	0.17	79L24	0.80
OA47	0.14	7918	0.40
OA90	0.10	7924	0.40
OA91	0.13		
1S941	0.07		

74HC & 74HCT

HC00	0.28
HC02	0.28
HC03	0.28
HC04	0.28
HC08	0.28
HC107	0.35
HC109	0.40
HC10	0.28
HC112	0.40
HC113	0.40
HC11	0.28
HC125	0.40
HC126	0.40
HC132	0.70
HC133	0.28
HC137	0.70
HC138	0.70
HC139	0.70
HC14	0.70
HC15	0.70
HC153	0.50
HC158	0.50
HC160	0.80
HC161	0.80
HC162	0.80
HC165	0.85
HC173	0.80
HC174	0.80
HC175	0.80
HC194	0.80
HC195	0.80
HC240	1.00
HC241	1.00
HC242	1.00
HC244	1.00
HC245	1.00
HC257	0.80
HC266	0.70
HC273	1.00
HC32	0.35
HC390	1.00
HC393	1.00
HC42	0.50
HC51	0.28
HC534	1.00
HC540	2.00
HC541	2.00
HC74	0.50
HC75	0.50
HC85	1.00
HCT240	1.75
HCT241	1.75
HCT244	1.50
HCT245	2.20
HCT640	2.40

CRYSTALS

32.768 KHz	0.95
100.0 KHz	4.00
1 MHz	2.65
1.8432 MHz	1.90
2.0 MHz	2.00
2.4576 MHz	1.75
2.5 MHz	1.90
3.0 MHz	2.00
3.2768 MHz	1.30
3.579545 MHz	0.90
3.6864 MHz	1.70
4.00 MHz	1.20
4.194304 MHz	1.30
4.433619 MHz	0.90
4.9152 MHz	1.20
6.00 MHz	1.30
6.144 MHz	1.30
6.4 MHz	1.30
6.5536 MHz	1.50
7.159 MHz	1.30
7.3728 MHz	1.50
8.0 MHz	1.30
10.0 MHz	1.50
12.00 MHz	1.75
15.00 MHz	1.75
16.0 MHz	1.75
18.432 MHz	1.75
20.0 MHz	1.75
32.00 MHz	1.30
36.00 MHz	1.30
48.00 MHz	1.30

VOLTAGE REGS

7805	0.35
7808	0.35
7808CK	0.56
7812	0.35
7815	0.35
7815CK	0.56
7818	0.35
7824	0.38
78L05	0.30
78L08	0.45
78L12	0.30
78L15	0.30
78L24	0.65
7905	0.40
7908	0.40
7912	0.40
7915	0.40

CMOS

4000	0.18
4001	0.18
4002	0.18
4006	0.60
4007	0.18
4008	0.55
4009	0.35
40103	4.05
40104	1.10
40106	0.35
40107	0.50
40108	3.15
40109	0.90
4010	0.35
40110	2.15
40114	2.30
4011	0.18
4012	0.18
4013	0.25
4014	0.45
4015	0.38
40161	1.90
40163B	0.65
4016B	0.22
40174B	0.65
40175B	0.65
4017B	0.40
40181B	2.10
4018B	0.50
40192B	0.65
40193B	0.85
40194B	0.65
4019B	0.30
40106B	0.35
4020B	0.45
4021B	0.50
4022B	0.55
4023B	0.18
4024B	0.30
40257B	1.90
4025B	0.18
4026B	0.85
4027B	0.25
4028B	0.35
4029B	0.45
4030B	0.18
4031B	1.10
4033B	1.20
4034B	1.30
4035B	0.60
4038B	1.00
4040B	0.40
4043B	0.40
4044B	0.45
4045B	1.00
4046B	0.55
4047B	0.45
4048B	0.40
4049B	0.22
4050B	0.22
4051B	0.45
4052B	0.45
4053B	0.55
4054B	0.65
4055B	0.65
4056B	0.75
4060B	0.60
4063B	0.70
4066B	0.22
4067B	2.10
4068B	0.18
4069B	0.18
4071B	0.18
4072B	0.18
4073B	0.18
4075B	0.22
4076B	0.50
4077B	0.22
4078B	0.50
40813	0.18
4082B	0.18
4086B	0.55
4089B	1.10
4093B	0.22
4094B	0.65
4095B	0.65
4096B	0.65
4097B	2.50
4099B	1.00
4502B	0.45
4503B	0.40
4508B	1.05
4510B	0.45
4511B	0.45
4512B	0.45
4514B	1.05
4515B	1.05
4516B	0.45
4517B	2.60
4518B	0.45
4520B	0.45
4522B	1.10
4526B	0.65
4527B	0.55
4532B	0.60
4536B	2.25
4538B	0.65
4543B	0.60
4555B	0.40
4556B	0.40
4584B	0.35
4585B	0.00

DIL SOCKETS

TP Turned Pin LP Low Profile

	LP	TP
8 PIN I.C. SOCKET	0.05	0.20
14 PIN I.C. SOCKET	0.07	0.35
16 PIN I.C. SOCKET	0.08	0.38
18 PIN I.C. SOCKET	0.09	0.43
20 PIN I.C. SOCKET	0.10	0.48
24 PIN I.C. SOCKET	0.13	0.52
28 PIN I.C. SOCKET	0.14	0.55
40 PIN I.C. SOCKET	0.18	0.85
24 PIN ZIF	4.16	
28 PIN ZIF	4.87	
40 PIN ZIF	7.02	

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TECH TIPS

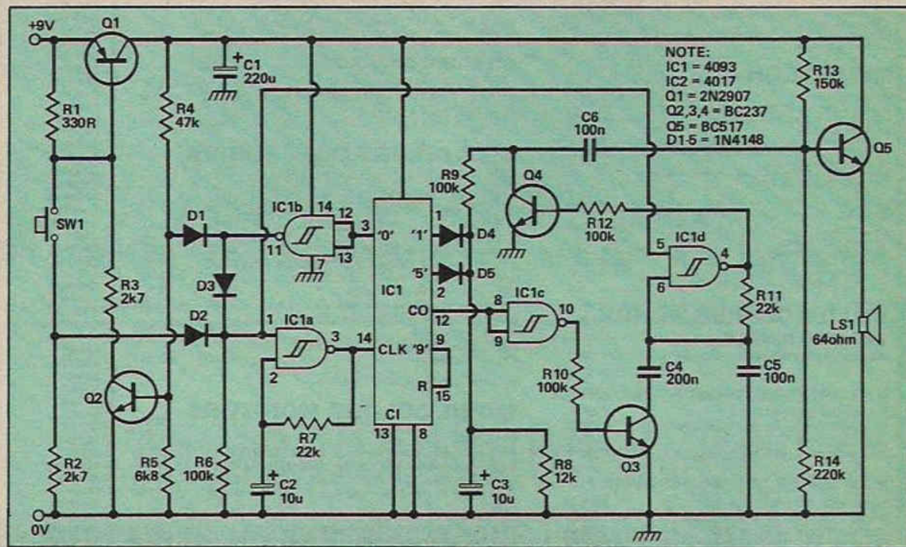
Door Chimes

G Landry
South Africa

This circuit is not just another two tone doorbell but is envelope modulated to give a realistic 'ding-dong' chime sound. It also has the battery saving feature of consuming *no* power in standby mode.

Pressing SW1 turns on Q1 to power the rest of the circuit. IC1a is a low frequency oscillator providing clock pulses to the decade counter IC2. Q2 is switched on when the counter passes zero and maintains the power for a complete cycle.

The fast attack, slow decay envelope is formed by D4, C3 and R8 at the first count. Q4 modulates the output of audio oscillator IC1d which is fed to amplifer Q5 and the loudspeaker.



At count 5 from the counter, another envelope is started from D5, C3 and R8. The carry out pin goes low and C4 is introduced in parallel with C5 to produce the lower 'dong' sound.

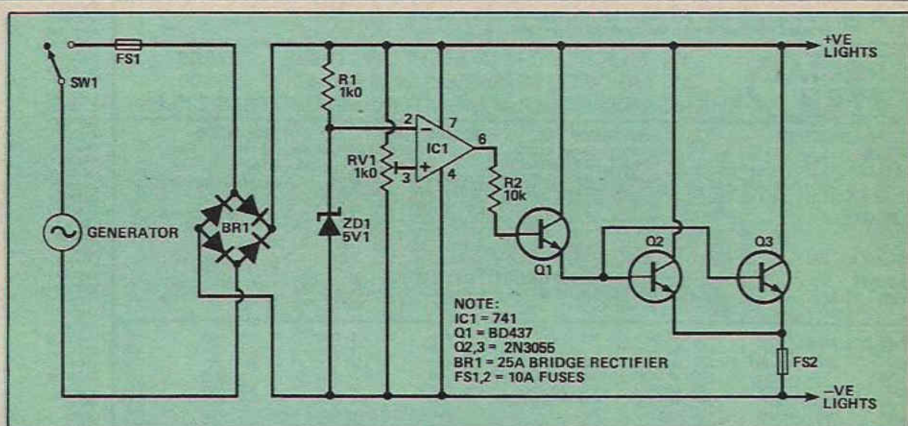
At count 9, the counter is reset, Q1,2 are turned off via IC1b and the circuit is ready for another ring.

Motorcycle Regulator

D Noble
Kyle

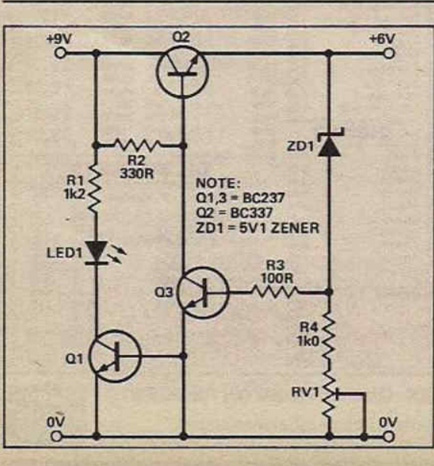
This circuit was devised to provide regulation for the lighting circuit added to an off-road motorcycle without lights.

The principle is straightforward. Any extra energy from the bike's generator is dumped. The 741 acts as a comparator. The output is low when the supply voltage is less than the desired value. When the supply voltage is greater than the desired output, the output of the 741 goes high and the transistors are switched on, taking current from the generator and reducing the output voltage.



The switch on voltage is set by RV1. A bridge rectifier was chosen to provide greater power at low revs (tickover).

The transistors are mounted on a large heatsink and the whole circuit coated with a paint to keep out water.



Battery Regulator

G Landry
South Africa

This voltage regulator circuit provides a 6V output from a 9V battery input and can maintain the output with an input as low as 6.5V. Up to 180mA can be supplied.

On application of power, Q2 switches on via R2. Q3 drives Q2 to ensure the voltage across ZD1 and the base-emitter voltages of Q2 and Q3 are constant with varying supply voltages and output currents.

The output voltage can be trimmed between 5.7V and 6.7V with RV1 as the zener voltage is dependent on the current through it.

Q1 is switched on and lights LED1 to indicate that regulated output is available. If the supply voltage drops below 6.5V then Q1 and Q3 turn off, the LED goes out and Q2 is driven hard on connecting the output to the supply with minimum power dissipated in the idle regulator.

Printer Switch

M Pill
Nazeing

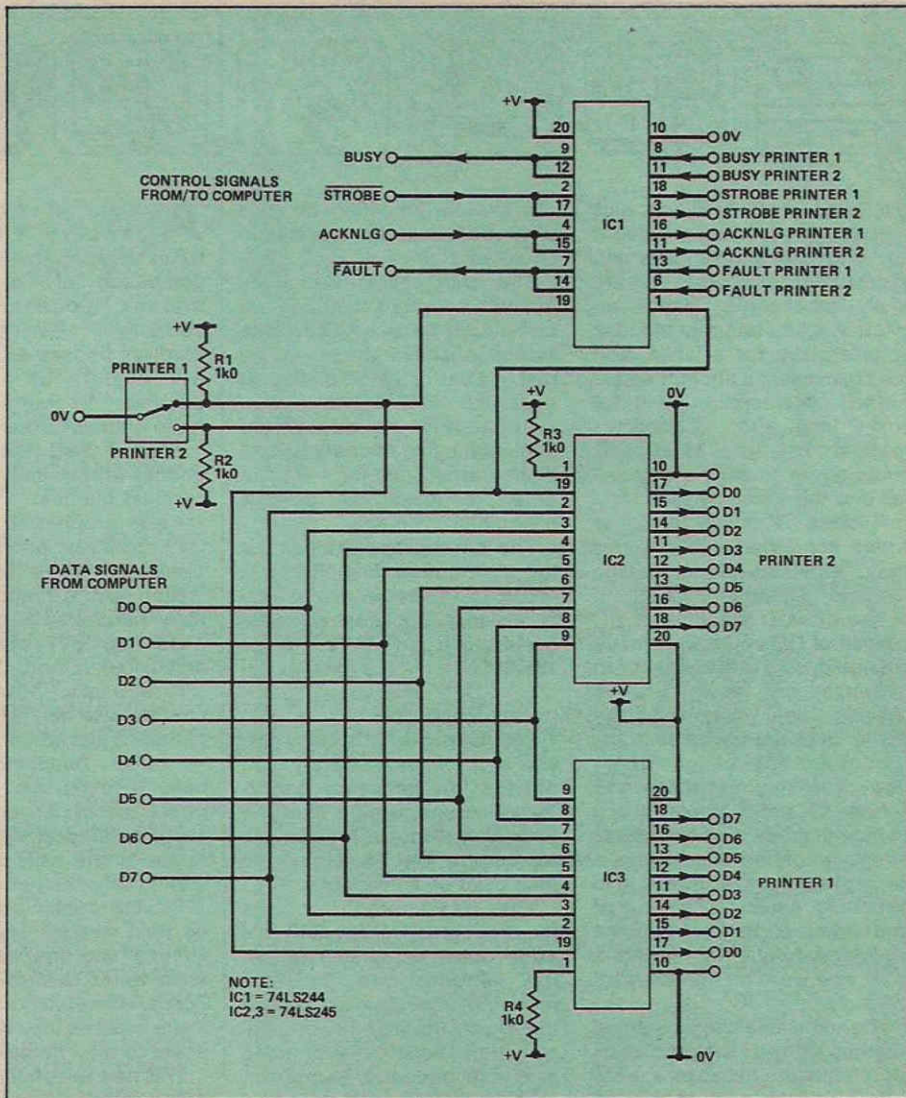
This design offers a convenient way of enabling two different printers or a printer and a plotter to be used with a computer which has only one parallel printer port. It uses tri-state buffers to switch the signals from the computer to the printer currently required.

Which printer is active at any one time is determined by the toggle switch connected to the 'enable' inputs of the buffers. With the switch in the position shown in the diagram Printer 1 will be active, as the buffer control pin is pulled low by the switch, activating the buffer outputs. The buffers feeding Printer 2 will conversely be open circuit due to the action of R2. The printer control lines are treated in a similar fashion to the data lines.

An added advantage of using buffers in this way is the driving capability they add to the printer port. The printer ports on most computers tend to be unbuffered. This can lead to corruption of data when long cables are used.

The circuit will need a 5V supply which in most instances can be obtained from the computer and fed down an unused wire in the cable.

The circuit could be expanded to drive more than two printers or even reversed to allow two computers to share one printer.



Soft Turn-On Dimmer

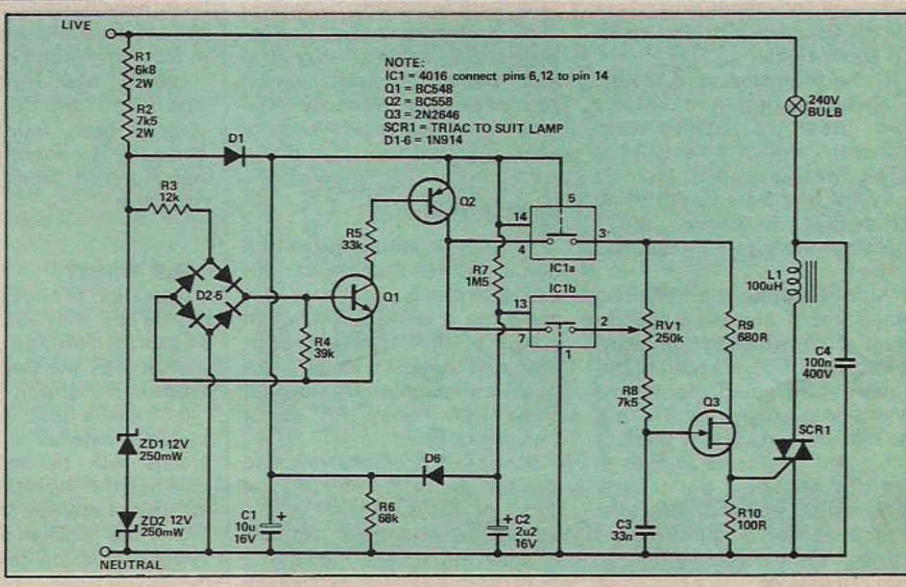
F Choy
Singapore

High current surges through the low resistance of a lamp's cold filament when power is first applied. This can be fatal to the lamp, particularly if switched-on at or near the voltage peaks.

Such a disaster, however, can be avoided by incorporating soft turn-on, that is, to let a lamp be dully lit for a few initial moments, pre-heating its filament. This circuit provides a warm-up period (determined by R7 and C2) of about one second during which analogue switch IC1b opens leaving the wiper of RV1 unconnected.The timing resistance from Q3 is therefore the full resistance of RV1, corresponding to minimum lamp intensity while C2 charges via R7.

After one second, C2 is charged up to the threshold of IC1b closing it for as long as power remains on. Now the wiper of RV1 is effectively shorted to its upper end resulting in a conventional phase control lamp dimmer. IC1a is switched on by the rectified mains through D1 so the potentials on each side of switch IC1b are equal.

When power is removed, R6 discharges C2 via D6 in preparation for a new warm-up period. The rest of the circuit provides a 12V supply and synchronisation for Q3.



ETI

PLAYBACK

In many areas of electronics good design ideas are thought up and sometimes patented years or decades before they are really practicable. Maybe an effort is made to apply the idea commercially for a while, and the unsuccessful attempt deters further consideration of it for some time after it becomes feasible. The idea of class D audio power amplifiers may well fall into this category.

A class D' power amplifier works somewhat like a series pass, switched mode voltage regulator. Of course, the output of the class D amplifier is AC instead of DC and is constantly changing, so it is not possible to optimise the design for a specific output voltage but many of the ideas are the same.

Another application which bears a striking resemblance to a class D audio amplifier is a switched mode uninterruptible power supply. In this system, a variable mark/space ratio switching signal is generated and filtered to remove the switching frequency leaving a 50Hz sine wave on the output of the supply.

The same idea can be applied to audio signals. The problem is more difficult because a wide frequency range must be accommodated. Also, a distortion level acceptable on a power supply would be far too much for an audio signal.

If the problems were solved, the resulting design would have two great advantages over currently available amplifiers. The power dissipation would be very low and there would be no crossover distortion. Why? Because there is no crossover region.

At zero output the switching stage would provide a squarewave at the switching frequency, and the mark/space ratio of this square wave would alter in time with signal excursions. There is no discontinuity at any point.

I admit the same is true of class A amplifiers but for any substantial power rating the heat generated is a problem and the noise of the cooling fan can spoil the music.

Duplication

Recently, over a pint at the local, a friend who works for a consultancy asked my views on high frequency audio amplifier design. Apparently they had been asked to design an audio distribution amplifier for use with audio cassette duplication equipment.

The draft specification may interest or shock audiophiles, particularly those who advocate amplifier bandwidths exceeding that of a bat, or distortion figures of around 1E-6 per cent.

Apparently the duplication equipment has to work at 128 times normal running speed in order to make the process economic.

The bandwidth specified for the distribution amplifier was 400Hz to 1.6MHz, which corresponds to a single speed audio bandwidth of 3.125Hz to 12500Hz.

Low Response

I do not regard this as impressive at the high frequency end, but the low frequency performance is anomalous. This low frequency response is needed to record the low frequency cue tone used on some tapes.

The basic amplifier was required to drive ten 50R coaxial cables, terminated at both the sending end and the receiving end. This attenuates the signal to half its original amplitude, so a corresponding gain is required in the amplifier.

The normal operating signal level was specified as 4V peak to peak, with an overload margin of 26dB on this level. This corresponds to a maximum signal of 80V peak to peak, which represents 80W into the maximum combined load of 10R.

Specification

This specification may well be partly the result of a specification writer's nightmare but assuming it is realistic I would imagine that an amplifier designed to meet it would use a quasi-complementary output stage with hunky RF power transistors.

How likely is such a device to exhibit distortion figures of 0.01% or less, I wonder?

Here is just another example of how the source material is mistreated before it reaches the punter.

If this type of signal handling is rife in the music publishing industry then it would seem to make that last fractional improvements in hi-fi equipment rather academic.

Andrew Armstrong

OPEN CHANNEL

A couple of months ago (January ETI) *Open Channel* reported on the second generation of cordless telephones, codenamed CT2, currently in development. CT2 cordless phones are digital and will operate at similar frequencies to current cellular radio phones (around 900MHz).

Then I said the first CT2 phones will be similar to existing cordless phones.

I also prophesied that future CT2 cordless phones will be developed as a single base station with a number of portable handsets — rather like existing private branch exchanges without the wires.

It appears, however, that another use for CT2 cordless phones is just around the corner — called *Telepoint* in which base stations are located in public places. Anyone having a portable handset within a short range of the base station can then access the network.

Typical public places would be train stations and shopping centres and the base station areas would be known as *Phone Zones*. Users won't need cash to make a call as they will be billed direct to their home addresses.

This new telephone service (if it gets off the ground) is to be operated by Ferranti and has been developed by a company called Libera, although Libera is in fact part-owned by Ferranti.

Libera has reported that operators in France have already been found and the company is currently recruiting operators in other European countries.

But When?

Operation is hoped for by the middle of the year but this depends on appropriate licensing by the Department of Trade and Industry.

It appears that licensing of systems installed *inside* public places will be more easily obtained than licensing required for system use, say, in the street.

One big problem in the DTI's system licensing procedure is the fact that little or no standards have yet been produced for the proposed system — basically because it's such a new concept. I would hope this should present few problems to the DTI as the system appears to have found market-places both at home and abroad, long before any foreign competition has even thought of a similar product.

This move by Ferranti into telephone operation services is interesting, particularly when viewed with two other happenings. First, the company's recent merger with American International Signal and Control.

ISC is a large supplier of defence equipment and services, so any experience Ferranti gains from telephone and communications operation will be a big plus in the defence market.

The second notable happening is Plessey's buy-out of Ferranti's semiconductor division. Plessey is reported to have paid £30m for this and will now be by far the largest chip producer in the United Kingdom. As far as Plessey is concerned this can only have advantages in terms of economy and pricing.

Six months ago Ferranti was basically a chip manufacturer and finding life very difficult. Today it is a systems supplier. It will be interesting to watch Ferranti's fortunes in the near future.

No Competition

Plessey, of course, has recently merged its telecommunications division with that of GEC to prevent self-destructive competition.

Rumours abound that Ericsson, too, wants to get in on the act to make a European telecommunications force which will further reduce competition.

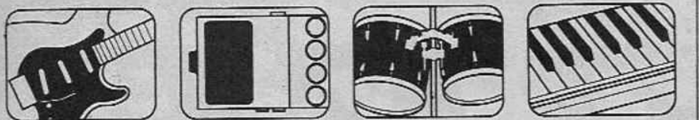
If such a merger came off, there would be little to prevent the combined companies from upping prices considerably.

Although this would suit Plessey, GEC and Ericsson, it would not be agreeable to companies (like British Telecom) which as a matter of principle always prefer to foster competition in equipment procurement by inviting tenders from as many individual suppliers as possible.

Given the truth of such rumours Plessey/GEC should take care not to give too much thought to a merger with Ericsson. BT and other customers are not going to change procurement policies just for their benefit. Non-European suppliers will be asked to tender and competition may then be even fiercer.

Keith Brindley

KEYNOTES



Rubbish! I am referring to the deluge of inaccurate advertising and parrot-fashion media reporting that digital audio technology drags in its turbulent wake.

While not being in quite the same league as relativity or quantum mechanics, the subtleties of analogue/digital conversion have certainly proved sufficiently complex to cause wholesale confusion.

Good CD players sound better than bad CD players, despite having identical 96dB signal to noise (S/N) specifications.

In response, the well-meaning but conditioned equipment reviewer instinctively points the finger of blame at the output sample-hold (if present at all) and lowpass filter (often quoted as an anti-aliasing filter, which it isn't — aliasing occurs only at ADC *inputs*).

In most cases, the accusing finger should instead be directed toward the DACs, which in the case of CD players rarely break 85dB.

Ignore the issue of oversampling, as found in some CD players. Oversampling is simply a technique which allows convertor accuracy to be traded off against conversion speed without sacrifice in S/N performance.

Given that precision audio DACs are at best rather suspect, it is worth considering next the other end of the digital chain, the ADC. After all, what comes out cannot be any better than what went in.

In short, audio ADCs are quite definitely not yet firing on all 16 cylinders. Almost all ADCs in current audio use are based on the successive approximation (SA) technique, in which a DAC and voltage comparator placed within a digital feedback loop home in on the input voltage over a number of clock cycles.

A 16-bit SA ADC must perform 16 internal D/A conversions per sample and so cannot be expected to be as accurate as a simple DAC because higher speed generally results in lower precision.

Most 12 and 16-bit ADCs used by the audio industry are Burr-Brown SA types, notably the 16-bit PCM75. This £30 device is quoted as having a dynamic range of 90dB when used in conjunction with a perfect sample-hold (which Burr-Brown are unfortunately not able to provide). With a precision discrete component error-cancelling sample-hold and with a lot of care, feeding and loving attention, the PCM75 can reach down as far as 88dB — on a lab bench, when the wind is blowing in the right direction.

In the harsher environment of a commercial production line a figure of 80dB is more typical.

SA is not the only viable approach to A/D conversion but other approaches currently offer little or no advantage. For example, Sony's 16-bit CX20018 dual ADC employs a dual-ramp integration conversion process to achieve a respectable 86dB according to the data sheet but what gives the game away is the fact that Sony use the Burr-Brown convertors in their own professional recording products.

Most of the inaccuracies of convertors are attributable to resistor ladder tolerances (and thermal drift), settling times, stray capacitance and ground loops. A hidden and easily overlooked source of error in precision convertor circuits is actually the stability of the clock. A timing jitter of one part in 65,536 can correspond to the loss of as much as one bit of precision in a 16-bit system.

A well designed crystal oscillator is more stable than this but what about glitches and variable loading effects in the intermediary logic and on the digital supply rails? This source of error applies equally to DACs and ADCs.

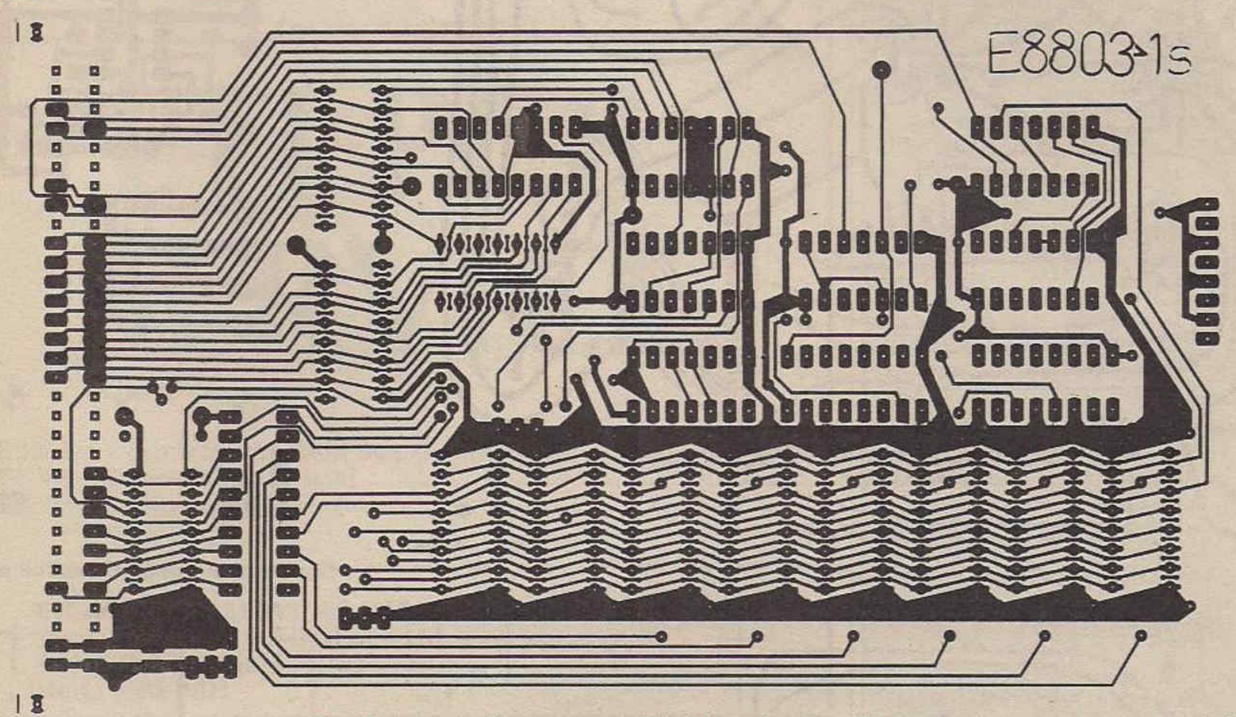
Purveyors of 16-bit audio equipment are able to perpetuate their 96dB mythology only by dint of the considerable difficulties involved in accurately measuring S/N beyond about 80dB.

In practice the measured performance depends as much on the measurement configuration as it does on the quality of the convertor circuit itself, so it is hard to categorically prove or disprove claims.

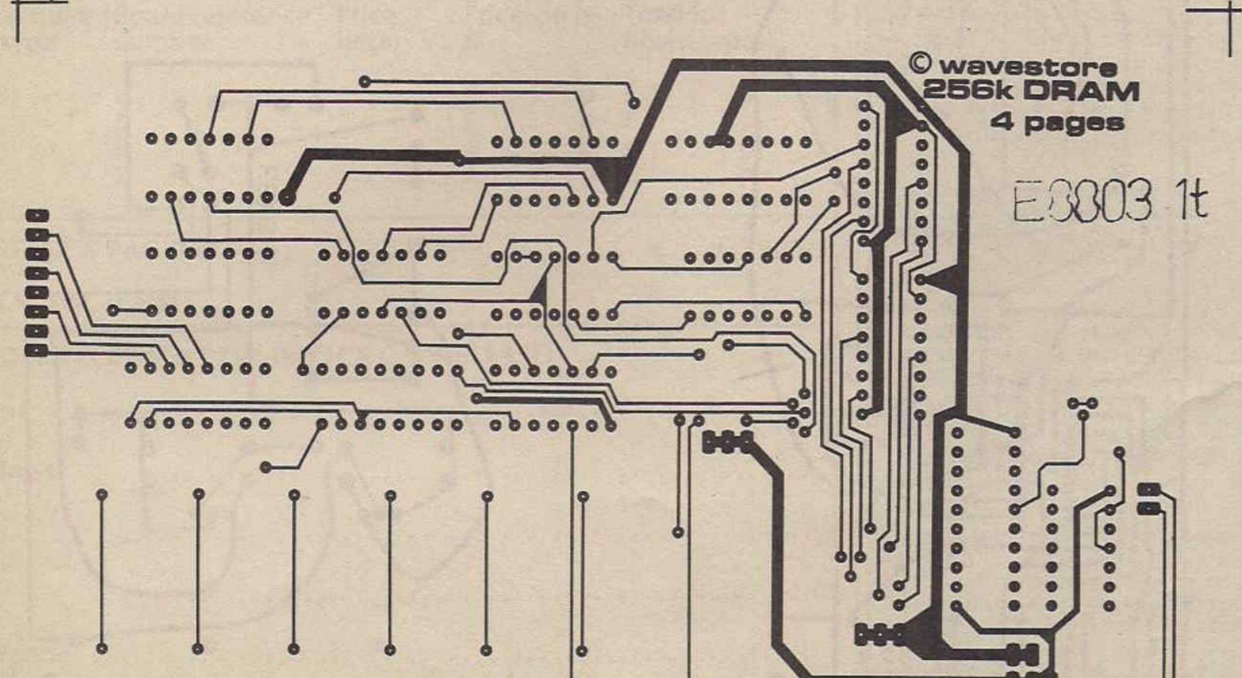
Reading a professional audio magazine recently, I happened across an advertisement from TC Electronic of Denmark for a 2U rack-mount delay/effects processor sporting '18-bit resolution, 1MHz sampling rate' at 'a quarter of the price of any truly competitive unit' to boot. Changing the subject, do you see that flock of pigs up there?

Bruno Hewitt

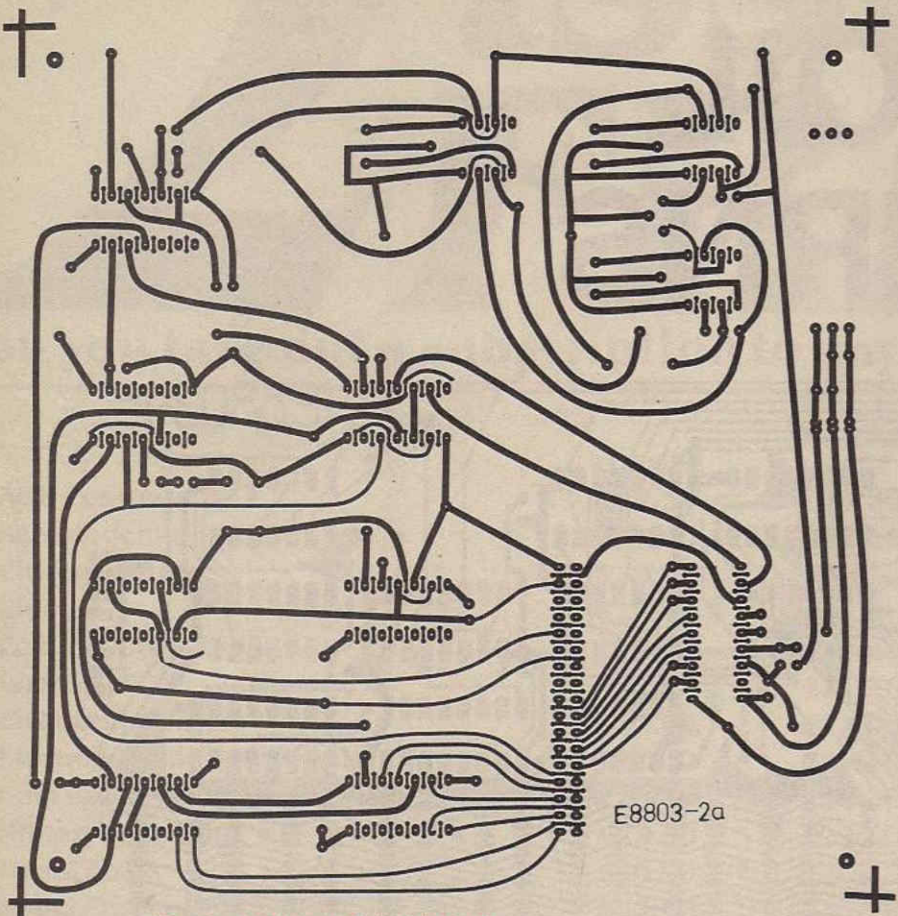
PCB FOIL PATTERNS



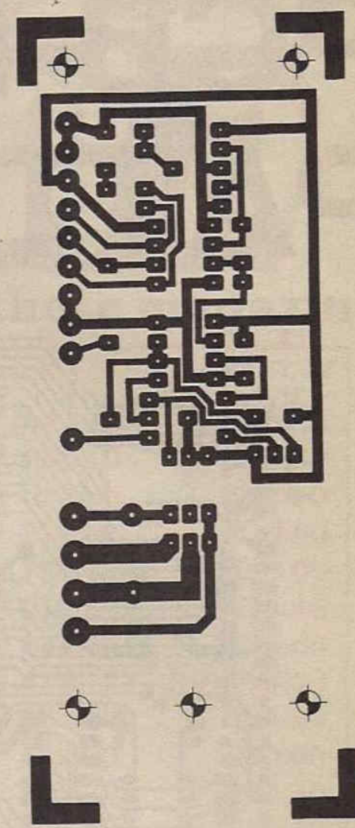
The Spectrum Co-processor RAM board solderside foil



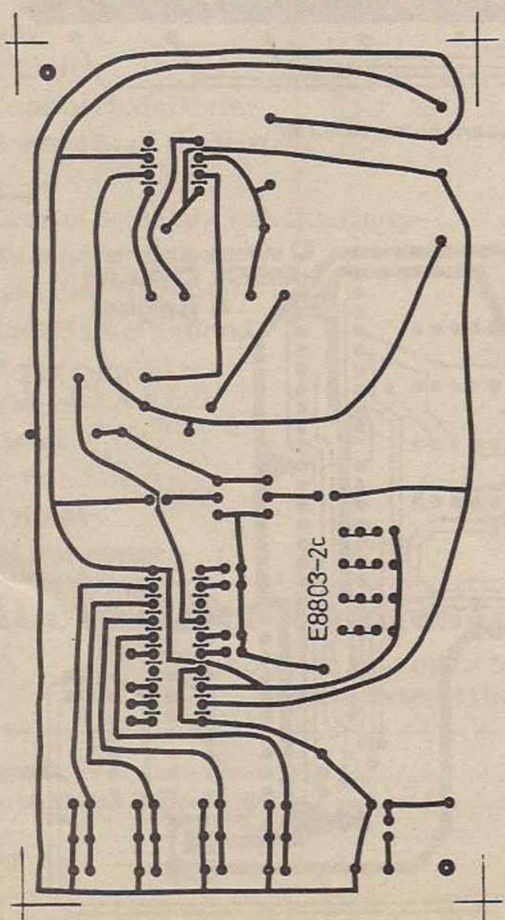
The Spectrum Co-processor RAM board topside foil



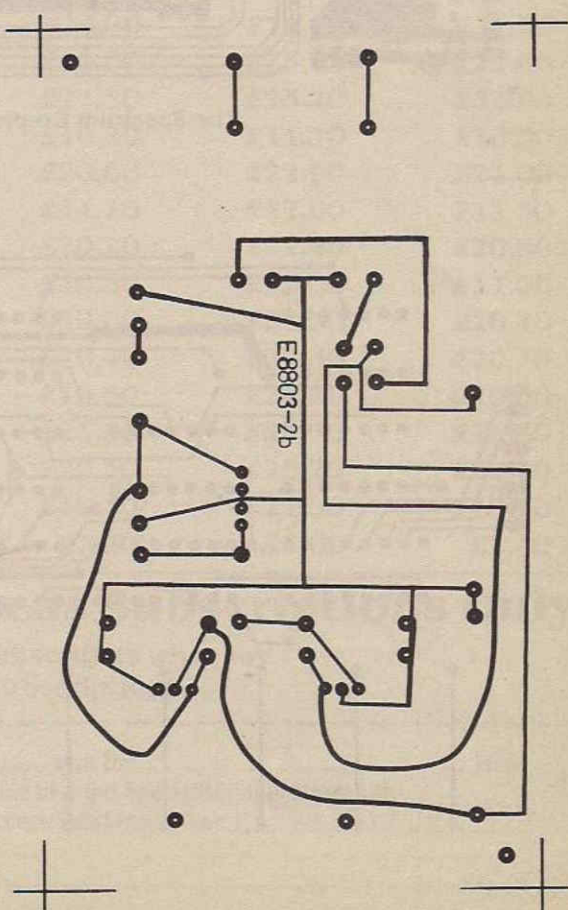
The Beeb-Scope digital board



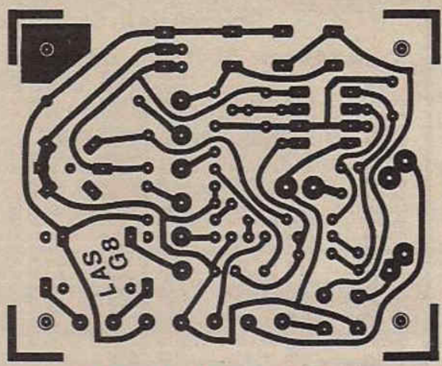
The Jumping Jack Flash foil pattern



The Beeb-Scope analogue board



The Beeb-Scope power supply board



The Gas Alert PCB foil

Telephone Alarm (July 1987)
In the component overlay (Fig.2) IC1 and IC2 should be swapped. The capacitor to the right of IC1,2 is C1 and the inductor between them is L1. The unmarked resistor to the left of L1 should be a wire link. In the circuit diagram (Fig.1b) IC4a,b should be AND gates. IC5 should be NAND gates. The parts list is correct.

Kappellmeisters (July 1987)
The position of the speaker port in the front panel was omitted from Fig.2. This should be a 7¼x4½in ellipse centred across the panel with its top edge 2½in below the panel top.

Knight Raider (August 1987)
In Fig.1(a) pins 4 and 5 of ICI are swapped. IC2-3 show the correct pin-out.

Car Alarm (August 1987)
In Fig. 1 Q7 is not numbered and its emitter is shown unconnected. This connects to earth. The transistors in the parts list went a little awry. Q2-6 are BC237 and Q7 is a TIP31.

Boiler Controller (September 1987)
In Fig. 2 (a) the primary of T2 is shown connected to Earth. This should be neutral. In Fig. 2(b) one of the bridge rectifier diodes, D6-9, is shown the wrong way around. This is correctly shown in Fig. 5.

EEG Monitor (September 1987)
In Fig.3a the pins of IC1 connected to the power rails are shown swapped around. In Fig.4a R7 is unlabelled and is between C3 and C6. In Fig.5 C20 should be £10 and R18 is unlabelled. It lies between R17 and R19.

ETI Concept (October 1987)
The Power Board parts list wrongly lists R6 as 270R. This should be 270k. Also, note that the power board's 0V rail must *not* be connected to Earth or the 0V rail of the CPU board.

Printer Buffer (November 1987)
The software for the EPROM had three errors listed. The byte at 039A should read 20, at 039B 14 and at 0492 30. All numbers are in Hex.

Dream Machine (December 1987)
The transistors used in this project are ST1702. BC108s can be substituted.

RGB Auto-Dissolve (January 1988)
In Fig. 5 there are marked two D6's. The right hand one should be D5 (they are both 1N4148's anyway). In the text the reference to zener diode D5 should read zener diode ZD1.

PASSIVE INFRA-RED ALARM (January 1988)
Fig. 2(a) shows the base of Q1 connected to ground and to R14. It should be connected only to R14.

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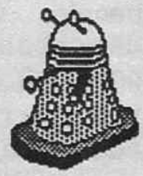

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FOR NEXT MONTH'S NEW LOOK ETI

The April issue marks the start of ETI's 17th year of publication and to celebrate the event we have given the whole magazine a facelift.
Next month's ETI has a totally new look, inside and out. Nevertheless it is still crammed to the covers with the usual mixture of features and projects that go to make ETI the best electronics mag around.

The April issue sees the start of the hi-est of fi Virtuoso power amp project to complement the Virtuoso pre-amp of last year. The Spectrum Co-processor is in its third installment and we have the start of a new series of easy projects for the beginner to electronics or the expert short of spare time.

John Linsley Hood gives us the low down on capacitors — what they are, how they're made and how to use them in audio design. Plus there's all the regulars — Circuit Theory, Chip In, Playback, Keynotes, Open Channel, News, letters and much, much more.

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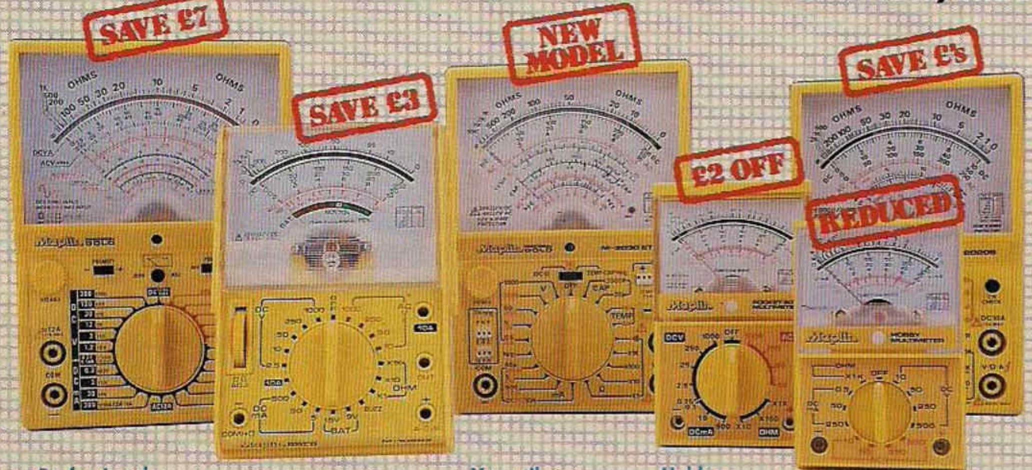

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