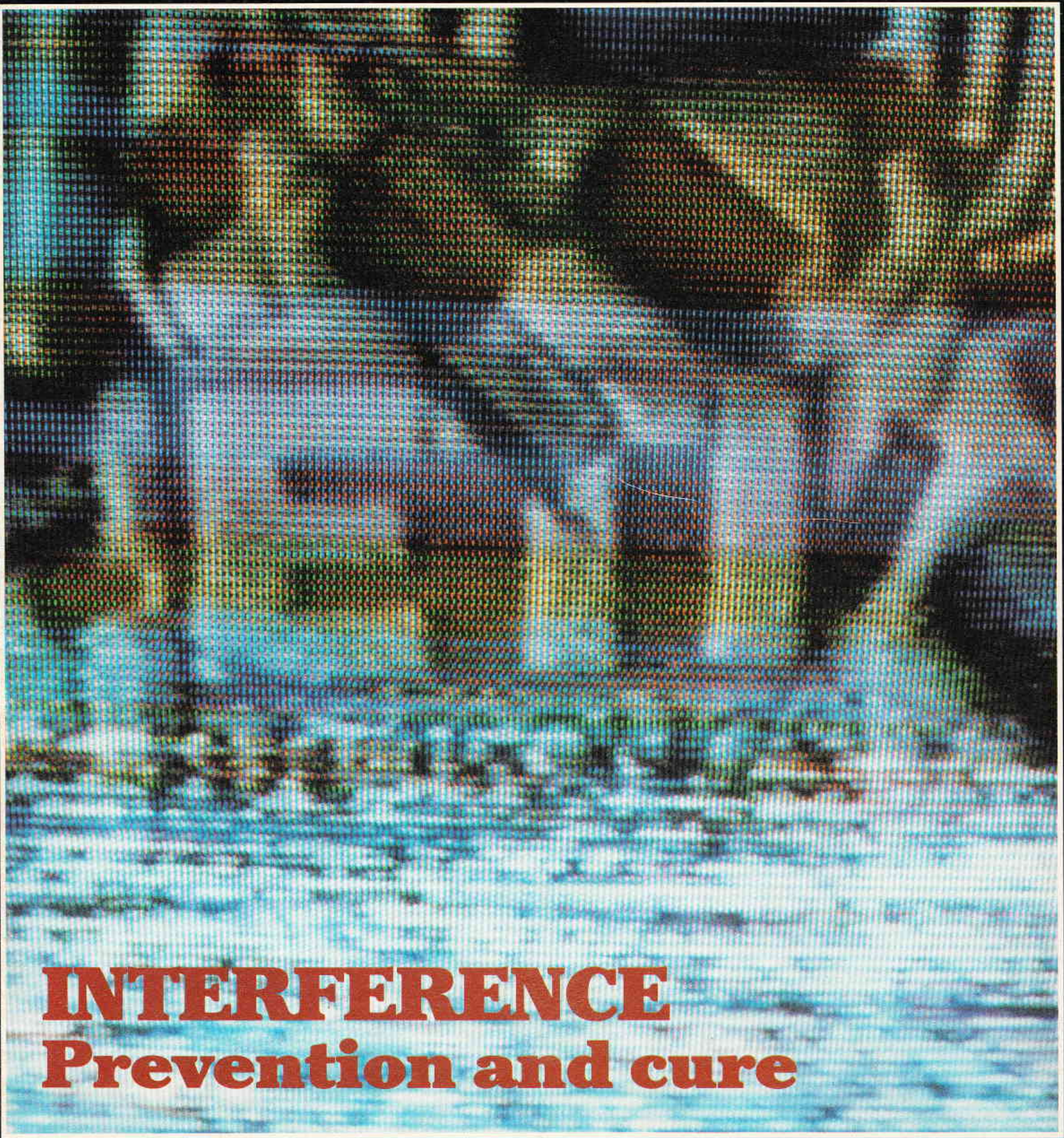
ETI
ELECTRONICS TODAY INTERNATIONAL

THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY

March 1989 £1.50

Telephone Indicator
MIDI Controller
Construction Set Computing



INTERFERENCE
Prevention and cure

AUDIO•COMPUTING•MUSIC•DOMESTIC

OMP POWER AMPLIFIER MODULES-TURNTABLES-DIMMERS-LOUDSPEAKERS-19 INCH STEREO RACK AMPLIFIERS

* PRICES INCLUDE V.A.T. * PROMPT DELIVERIES * FRIENDLY SERVICE *
LARGE S.A.E., 30p STAMPED FOR CURRENT LIST.

OMP POWER AMPLIFIER MODULES

Supplied ready built and tested.

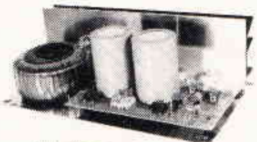
OMP POWER AMPLIFIER MODULES Now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models available to suit the needs of the professional and hobby market, i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE all models include Toroidal power supply, Integral heat sink, Glass fibre P.C.B., and Drive circuits to power compatible Vu meter. Open and short circuit proof.

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

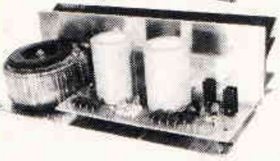
OMP100 Mk 11 Bi-Polar Output power 110 watts R.M.S. into 4 ohms, Frequency Response 15Hz – 30KHz –3dB, T.H.D. 0.01%, S.N.R. –118dB, Sens. for Max. output 500mV at 10K, Size 355 × 115×65mm.
PRICE £33.99 + £3.00 P&P.

NEW SERIES II MOS-FET MODULES

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



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



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

NOTE:— MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS. STANDARD — INPUT SENS. 500mV BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATABLE) — INPUT SENS. 775mV. BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

Vu METER Compatible with our four amplifiers detailed above. A very accurate visual display employing 11 L.E.D. diodes (7 green, 4 red) plus an additional on/off indicator. Sophisticated logic control circuits for very fast rise and decay times. Tough moulded plastic case, with tinted acrylic front. Size 84 × 27 × 45mm.
PRICE £8.50 + 50p P&P.

OMP VARISPEED TURNTABLE CHASSIS.

★ MANUAL ARM ★ STEEL CHASSIS ★ ELECTRONIC SPEED CONTROL 33 & 45 ★ VARI PITCH CONTROL ★ HIGH TORQUE SERVO DRIVEN DC MOTOR ★ TRANSIT SCREWS ★ 12" DIE CAST PLATTER ★ NEON STROBE ★ CALIBRATED BAL WEIGHT ★ REMOVABLE HEAD SHELL ★ ½" CARTRIDGE FIXINGS ★ CUE LEVER ★ POWER 220/240V 50/60Hz ★ 390×305mm ★ SUPPLIED WITH MOUNTING CUT-OUT TEMPLATE.

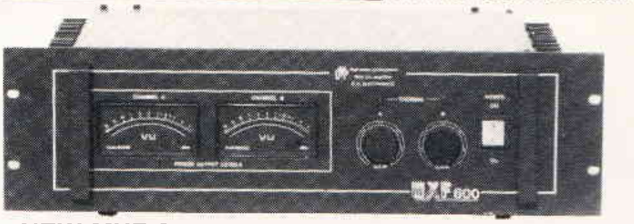
PRICE £59.99 + £3.50 P&P.

OPTIONAL MAGNETIC CARTRIDGES

STANTON AL500 PRICE £16.99 + 50p P&P
GOLDRING G850 PRICE £6.99 + 50p P&P

OMP MOS-FET POWER AMPLIFIERS, HIGH POWER, TWO CHANNEL 19 INCH RACK

THOUSANDS PURCHASED BY PROFESSIONAL USERS



NEW MXF SERIES OF POWER AMPLIFIERS
THREE MODELS:— **MXF200** (100w + 100w)
MXF400 (200w + 200w) **MXF600** (300w + 300w)
All power ratings R.M.S. into 4 ohms.

FEATURES: ★ Independent power supplies with two Toroidal Transformers ★ Twin L.E.D. Vu meters ★ Rotary indended level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low distortion ★ Aluminium cases ★ MXF600 Fan Cooled with D.C. Loudspeaker and Thermal Protection.

USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.

SIZES:— MXF 200 W19"×H3½" (2U)×D11"
MXF 400 W19"×H5¼" (3U)×D12"
MXF 600 W19"×H5¼" (3U)×D13"

PRICES: MXF200 £171.35
MXF400 £228.85
MXF600 £322.00

SECURICOR DELIVERY £12.00 EACH

LOUDSPEAKERS

LARGE SELECTION OF SPECIALIST LOUDSPEAKERS AVAILABLE, INCLUDING CABINET FITTINGS, SPEAKER GRILLES, CROSS-OVERS AND HIGH POWER, HIGH FREQUENCY BULLETS AND HORNS, LARGE S.A.E. (30p STAMPED) FOR COMPLETE LIST.

McKENZIE:— INSTRUMENTS, P.A., DISCO, ETC.

ALL McKENZIE UNITS 8 OHMS IMPEDENCE

8" 100 WATT C8100GPM GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID., DISCO.
RES. FREQ. 80Hz. FREQ. RESP. TO 14KHz. SENS. 99dB. PRICE £28.59 + £2.00 P&P.
10" 100 WATT C10100GP GUITAR, VOICE, ORGAN, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 70Hz. FREQ. RESP. TO 6KHz. SENS. 100dB. PRICE £34.70 + £2.50 P&P.
10" 200 WATT C10200GP GUITAR, KEYBOARD, DISCO, EXCELLENT HIGH POWER MID.
RES. FREQ. 45Hz. FREQ. RESP. TO 7KHz. SENS. 103dB. PRICE £47.48 + £2.50 P&P.
12" 100 WATT C12100GP HIGH POWER GEN. PURPOSE, LEAD GUITAR, DISCO.
RES. FREQ. 45Hz. FREQ. RESP. TO 7KHz. SENS. 98dB. PRICE £36.66 + £3.50 P&P.
12" 100 WATT C12100TC TWIN CONE) HIGH POWER WIDE RESPONSE, P.A., VOICE, DISCO.
RES. FREQ. 45Hz. FREQ. RESP. TO 14KHz. SENS. 100dB. PRICE £37.63 + £3.50 P&P.
12" 200 WATT C12200B HIGH POWER BASS, KEYBOARDS, DISCO, P.A.
RES. FREQ. 40Hz. FREQ. RESP. TO 7KHz. SENS. 100dB. PRICE £64.17 + £3.50 P&P.
12" 300 WATT C12300GP HIGH POWER BASS LEAD GUITAR, KEYBOARDS, DISCO, ETC.
RES. FREQ. 45Hz. FREQ. RESP. TO 5KHz. SENS. 100dB. PRICE £85.79 + £3.50 P&P.
15" 100 WATT C15100BS BASS GUITAR, LOW FREQUENCY, P.A., DISCO.
RES. FREQ. 40Hz. FREQ. RESP. TO 5KHz. SENS. 98dB. PRICE £53.70 + £4.00 P&P.
15" 200 WATT C15200BS VERY HIGH POWER BASS.
RES. FREQ. 40Hz. FREQ. RESP. TO 4KHz. SENS. 99dB. PRICE £73.26 + £4.00 P&P.
15" 250 WATT C15250BS VERY HIGH POWER BASS.
RES. FREQ. 40Hz. FREQ. RESP. TO 4KHz. SENS. 99dB. PRICE £80.53 + £4.50 P&P.
15" 400 WATT C15400BS VERY HIGH POWER, LOW FREQUENCY BASS.
RES. FREQ. 40Hz. FREQ. RESP. TO 4KHz. SENS. 102dB. PRICE £94.12 + £4.50 P&P.
18" 400 WATT C18404BS EXTREMELY HIGH POWER, LOW FREQUENCY BASS.
RES. FREQ. 27Hz. FREQ. RESP. TO 3KHz. SENS. 99dB. PRICE £167.85 + £5.00 P&P.

EARBENDERS:— HI-FI, STUDIO, IN-CAR, ETC.

ALL EARBENDER UNITS 8 OHMS EXCEPT EB8-50 AND EB10-50 DUAL 4 AND 8 OHM. BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED FOAM SURROUND

8" 50 WATT EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz. FREQ. RESP. TO 7KHz. SENS. 97dB. PRICE £8.90 + £2.00 P&P.
10" 50 WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40HZ. FREQ. RESP. TO 5KHz. SENS. 99dB. PRICE £12.00 + £2.50 P&P.
10" 100 WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz. FREQ. RESP. TO 3KHz. SENS. 96dB. PRICE £27.50 + £3.50 P&P.
12" 60 WATT EB12-60 BASS, HI-FI, STUDIO.
RES. FREQ. 28Hz. FREQ. RESP. TO 3KHz. SENS. 92dB. PRICE £21.00 + £3.00 P&P.
12" 100 WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz. FREQ. RESP. TO 3KHz. SENS. 93dB. PRICE £32.00 + £3.50 P&P.

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

5¼" 60 WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz. FREQ. RESP. TO 20KHz. SENS. 92dB. PRICE £9.99 + £1.50 P&P.
6½" 60 WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz. FREQ. RESP. TO 20KHz. SENS. 94dB. PRICE £10.99 + £1.50 P&P.
8" 60 WATT EB8-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz. FREQ. RESP. TO 18KHz. SENS. 89dB. PRICE £12.99 + £1.50 P&P.
10" 60 WATT EB10-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 35Hz. FREQ. RESP. TO 12KHz. SENS. 86dB. PRICE £16.49 + £2.00 P&P.

OMP LINNET LOUDSPEAKERS

THE VERY BEST IN QUALITY AND VALUE

MADE ESPECIALLY TO SUIT TODAY'S NEED FOR COMPACTNESS WITH HIGH OUTPUT SOUND LEVELS, FINISHED IN HARDWEARING BLACK VYNIDE WITH PROTECTIVE CORNERS, GRILLE AND CARRYING HANDLE. INCORPORATES 12" DRIVER PLUS HIGH FREQ. HORN FOR FULL FREQ. RANGE 45Hz-20KHz BOTH MODELS 8 OHM, SIZE H18" × W15" × D12".

CHOICE OF TWO MODELS

POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET

OMP 12-100 (100W 100dB) PRICE £159.99 PER PAIR
OMP 12-200 (200W 102dB) PRICE £209.99 PER PAIR

SECURICOR DEL.:— £12.00 PER PAIR

OMP SLIDE DIMMER 1K WATT & 2.5K WATT

CONTROLS LOADS UP TO 1KW & 2.5KW. SUITABLE FOR RESISTIVE AND INDUCTIVE LOADS BLACK ANODISED CASE. READILY FLUSH MOUNTED THROUGH PANEL/CABINET CUT-OUTS. **ADVANCED FEATURES INCLUDE:—**

★ FULL 65mm SLIDE TRAVEL.
★ NEON MONITOR INDICATOR.
★ FLASH OVERRIDE BUTTON.
★ HIGH & LOW LEVEL PRESETS.
★ FULLY SUPPRESSED TO BS 800.

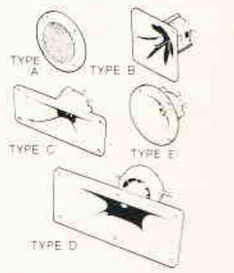
SIZES:— 1KW H128×W40×D55mm. 2.5KW H128×W76×D79mm.

PRICES:— 1K WATT £15.99
2.5K WATT £24.99 + 60p P&P

PIEZO ELECTRIC TWEETERS-MOTOROLA

PIEZO ELECTRIC TWEETERS — MOTOROLA

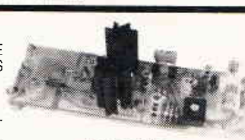
Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is **not** required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.**



TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. **Price £4.90 each + 50p P&P.**
TYPE 'B' (KSN1005a) 3½" super horn. For general purpose speakers, disco and P.A. systems etc. **Price £5.00 each + 50p P&P.**
TYPE 'C' (KSN6016A) 2"×5" wide dispersion horn. For quality Hi-fi systems and quality discos etc. **Price £6.99 each + 50p P&P.**
TYPE 'D' (KSN1025A) 2"×6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. **Price £9.99 each + 50p P&P.**
TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-fi monitor systems etc. **Price £5.99 each + 50p P&P.**
LEVEL CONTROL Combines on a recessed mounting plate, level control and cabinet input jack socket. 85×85mm. **Price £3.99 + 50p P&P.**

TRANSMITTER HOBBY KITS

PROVEN TRANSMITTER DESIGNS INCLUDING GLASS FIBRE PRINTED CIRCUIT BOARD AND HIGH QUALITY COMPONENTS COMPLETE WITH CIRCUIT AND INSTRUCTIONS


3 watt FM Transmitter

3W FM TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 38 × 123mm, SUPPLY 12V @ 0.5AMP. **PRICE £14.49 + £1.00 P&P**

FM MICRO TRANSMITTER (BUG) 100-108MHz VARICAP TUNED COMPLETE WITH VERY SENS FET MIC, RANGE 100-300m, SIZE 56 × 46mm, SUPPLY 9V BATT. **PRICE £8.62 + £1.00 P&P**

STEREO DISCO MIXER

STEREO DISCO MIXER with 2 × 5 band L & R graphic equalisers and twin 10 segment L.E.D. Vu Meters. **Many outstanding features** 5 inputs with individual faders providing a useful combination of the following:— 3 Turntables (Mag), 3 Mics, 4 Line including CD plus Mic with talk over switch Headphone Monitor, Pan Pot L. & R. Master Output controls. Output 775mV. Size 360 × 280 × 90mm. Supply 220-240v.
Price £134.99 — £4.00 P&P

Access — POSTAL CHARGES PER ORDER £1.00 *MINIMUM*. OFFICIAL ORDERS WELCOME FROM SCHOOLS, COLLEGES, GOVT. BODIES, ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER. VISA ACCESS ACCEPTED BY POST, PHONE OR FAX — BARCLAYCARD VISA

B. K. ELECTRONICS Dept ETI

UNIT 5, COMET WAY, SOUTHEND-ON-SEA, ESSEX. SS2 6TR
TEL: 0702-527572 FAX: 0702-420243

POWER CONDITIONER

FEATURED IN ETI JANUARY 1988

The ultimate mains purifier Intended mainly for lowering the noise floor and improving the analytical qualities of top-flight audio equipment

The massive filter section contains thirteen capacitors and two current balanced inductors, together with a bank of six VDRs, to remove every last trace of impulsive and RF interference. A ten LED logarithmic display gives a second by second indication of the amount of interference removed.

Our approved parts set consists of case, PCB, all components (including high permeability toroidal cores, ICs, transistors, class X and Y suppression capacitors, VDRs, etc.) and full instructions

PARTS SET **£28.50** + VAT

A low cost (but high performance) mains conditioner is also available

MAINS CONDITIONER PARTS SET £5.40 + VAT
RUGGED PLASTIC CASE £1.80 + VAT

KNIGHT RAIDER

FEATURED IN ETI JULY 1987

The ultimate in lighting effects for your Lamborghini, Maserati, BMW (or any other car, for that matter). Picture this: eight powerful lights in line along the front and eight along the rear. You flick a switch on the dashboard control box and a point of light moves lazily from left to right leaving a comet's tail behind it. Flip the switch again and the point of light becomes a bar, bouncing backwards and forwards along the row. Press again and try one of the other six patterns. An LED display on the control box let's you see what the main lights are doing.

The Knight Raider can be fitted to any car (it makes an excellent fog light!) or with low powered bulbs it can turn any child's pedal car or bicycle into a spectacular TV-age toy!

The parts set consists of box, PCB and components for control, PCB and components for sequence board, and full instructions

Lamps not included

PARTS SET **£19.90** + VAT

RAINY DAY PROJECTS

All can be built in an afternoon!

JUMPIN' JACK FLASH (ETI March 1988)
Spectacular rock, stage and disco lighting effect! — £6.90 + VAT

CREDIT CARD CASINO (ETI March 1987)
The wicked pocket gambling machine — £5.90 + VAT

MAINS CONTROLLER (ETI January 1987)
Isolated logic to mains interface — £6.20 + VAT

MATCHBOX AMPLIFIERS (ETI April 1986)
Listen: 50W of Hi-Fi power from an amp small enough to fit in a matchbox!

Matchbox Amplifier (20W)	£6.50 + VAT
Matchbox Bridge Amplifier **(50w)**	£8.90 + VAT
L165V Power Amplifier IC, with data and circuits	£3.90 + VAT

TACHO/DWELL METER (ETI January 1987)
Turn your Metro into a Porsche! — £16.40 + VAT

HI-FI POWER METER (ETI May 1987)
Measures Hi-Fi output power up to 100W – includes PCB, components, meters

Mono power meter	£3.90 + VAT
Stereo power meter	£7.20 + VAT

FEATURED IN ETI AUGUST 1988

There's nothing quite so encouraging as having a quantifiable result to show for your training efforts. If you are not particularly fit, your resting heart rate will be around 80 beats per minute. As your jogging, aerobics or sport strengthens your heart, the rate will drop dramatically – possibly to 60bpm or less. With the S101, you can watch your progress day by day.

Breathing is important too. How efficiently do you take up oxygen? How quickly do you recover from 'oxygen debt' after strenuous activity? The S101 will let you know.

The approved parts set consists of: case, 3 printed circuit boards, all components (including 17 ICs, quartz crystal, 75 transistors, resistors, diodes and capacitors), LCD, switches, plugs, sockets, electrodes, and full instructions for construction and use.

PARTS SET **£33.80** + VAT

Some parts are available separately. Please send SAE for lists, or SAE + £2 for lists, circuits, construction details and training plan (free with parts set).

THE DREAM MACHINE

FEATURED IN ETI DECEMBER 1987

Adjust the controls to suit your mood and let the gentle, relaxing sound drift over you. At first you might hear soft rain, sea surf, or the wind through distant trees. Almost hypnotic, the sound draws you irresistably into a peaceful, refreshing sleep.

For many, the thought of waking refreshed and alert from perhaps the first truly restful sleep in years is exciting enough in itself. For more adventurous souls there are strange and mysterious dream experiences waiting. Take lucid dreams, for instance. Imagine being in control of your dreams and able to change them at will to act out your wishes and fantasies. With the Dream Machine it's easy!

The approved parts set consists of PCB, all components, controls, loudspeaker, knobs, lamp, fuseholders, fuse, mains power supply, prestige case and full instructions.

PARTS SET **£16.50** + VAT

Ben Sweetland's best seller GROW RICH WHILE YOU SLEEP is now in stock. **£2.95** (NO VAT)

THE MISTRAL AIR IONISER

The best ioniser design yet – this one has variable ion drive, built-in ion counter and enough power to drive five multi-point emitters. For the technically minded, it has nine main drive stages, five secondary drives, and a four section booster to give an output capability of almost fifteen billion (1.47 × 10[13]) ions every minute, or 2.45 × 10[11] ions per second. With extra emitters this can be increased still further!

PARTS SET £24.80 + VAT

The parts set includes case, printed circuit boards, 126 top grade components, all controls, lamps, hardware, a multi-point phosphor-bronze emitter and full instructions.

Some parts are available separately — please send SAE for lists, or SAE + £1 for lists, circuit and construction details and further information (free with parts set).

READY-BUILT MISTRAL

The Mistral Ioniser (and most of our other projects) can now be supplied built, tested and ready to go. For details, please contact *Peter Leah at P.L. Electronics, 8 Woburn Road, Eastville, Bristol BS5 6TT. Tel: 0272 522703.* Evenings Only

INTERNAL EMITTER £2.69 + VAT

Can be used in place of the P-B external emitter, or both can be used together for the highest ion output. Parts set includes PCB, ion emitters, components and instructions.

IPA BOARD CLEANER £0.98 + VAT

Essential for removing grease and flux residues from the Mistral PCB to achieve peak performance. Applicator brush supplied.

ION FAN £9.80 + VAT

An almost silent piezo-electric fan, mains operated, to pump ions away from the emitter and into the room. Increases the effectiveness of any ioniser by five times!

ION DISPERSION METER

FEATURED IN ETI FEBRUARY 1989

The Q-ion is a hand-held meter which sniffs out ions in the air. It can tell the good ones from the duds if you're thinking of buying a commercial ioniser, check the efficiency and output of one you've made yourself, help you set up fans and position the ioniser for best effect, do an ion-survey of your house or office — in short, it will tell you anything you want to know about ions in the air.

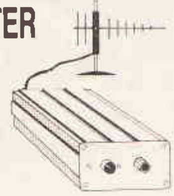
In direct mode the bar-graph readout will detect the presence of negative or positive ions and measure neg-ion strengths from 5 x 10[7] to 10[10] ions per second, which covers the levels you can expect when an air ioniser is in use. For the smaller concentrations of natural air ions, integrate mode will increase the sensitivity as far as you like.

Our approved parts set comprises: case, ion collector, printed circuit board, all components (including six ICs, schottky diode, cermets, VDR, zener, 37 resistors and capacitors, LEDs, plug, socket, earth lead, etc.) and full instructions.

PARTS SET **£16.40** + VAT

Some parts are available separately — please send SAE for lists, or SAE + £1 for lists, circuit, construction details and further information (free with parts set).

TV BOOSTER



Good TV pictures from poor aerials is what this project is all about. Keith Brindley's Aerial Booster gives a massive 23dB gain to ensure good viewing for campers and caravanners, from indoor aerials, or wherever a properly positioned high-gain antenna is not practical.

Based on the OM335 hybrid amplifier, the booster has specifications to rival the best: wideband operation from 10MHz to 1.4 GHz, mid-band gain of up to 26dB and a wide supply range of 9V to 26V (it will run from car batteries for caravanners, dry batteries for campers, or a mains 'battery eliminator' in the home). No special UHF construction skills are needed — the project could be made by a careful beginner.

There are two parts sets for the project. AA1 contains the printed circuit board, OM335 hybrid amplifier, components and instructions. AA2 is the optional case set: rugged screened box, front and rear panels, waterproofing gaskets, feet, sockets and hardware.

AA1 PARTS SET **£12.80** + VAT

AA2 PARTS SET **£4.80** + VAT

BIO-FEEDBACK

FEATURED IN ETI DECEMBER 1986

Bio-feedback comes of age with this highly responsive, self-balancing skin response monitor! The powerful circuit has found application in clinical situations as well as on the bio-feedback scene. It will open your eyes to what GSR techniques are really all about.

The complete parts set includes case, PCB, all components, leads, electrodes, conductive gel, and full instructions.

PARTS SET **£15.80** + VAT

BIO-FEEDBACK BOOK **£4.50** (no VAT)

Please note: the book, by Stern and Ray, is an authorised guide to the potential of bio-feedback techniques. It is not a hobby book, and will only be of interest to intelligent adults.

POWERFUL AIR IONISER

FEATURED IN ETI JULY 1986

Ions have been described as 'vitamins of the air' by the health magazines, and have been credited with everything from curing hay fever and asthma to improving concentration and putting an end to insomnia. Although some of the claims may be exaggerated, there is no doubt that ionised air is much cleaner and purer, and seems much more invigorating than 'dead' air.

The DIRECT ION ioniser caused a great deal of excitement when it appeared as a constructional project in ETI. At last, an ioniser that was comparable with (better than?) commercial products, was reliable, good to build ... and fun! Apart from the serious applications, some of the suggested experiments were outrageous!

We can supply a matched set of parts, fully approved by the designer, to build this unique project. The set includes a roller tinned printed circuit board, 66 components, case, mains lead and even the parts for the tester. According to one customer, the set costs about a third of the price of the individual components. What more can we say?

Instructions are included

PARTS SET WITH BLACK CASE **£11.50** + VAT

PARTS SET WITH WHITE CASE **£11.80** + VAT

BURGLAR BUSTER

Be safe from intruders with our Burglar Buster alarm system! It has all the features you'd expect from a high-tech alarm: entry and exit delay, anti-tamper loop, delay warning and control-box protection.

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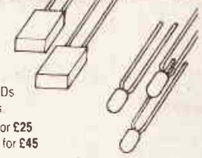

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FEATURED IN ETI AUGUST 1987

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Eire and overseas: no VAT. Carriage and insurance £4.50
Please allow up to 14 days for delivery

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March 1989

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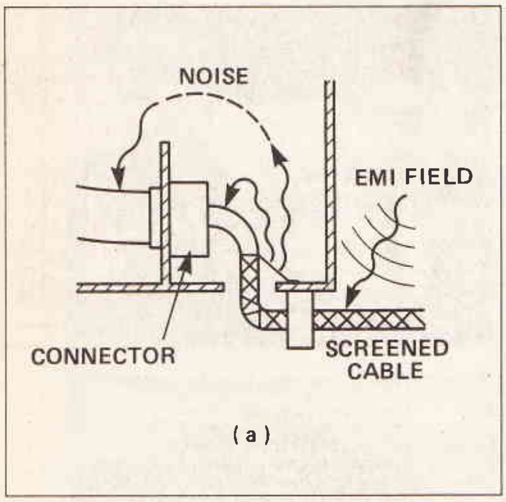
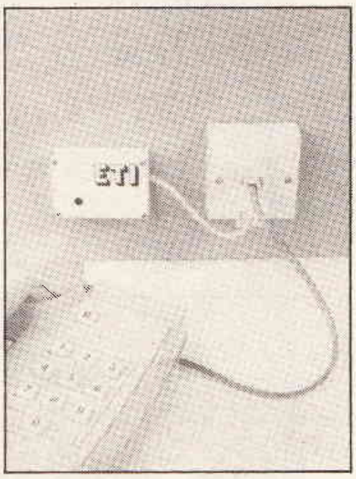
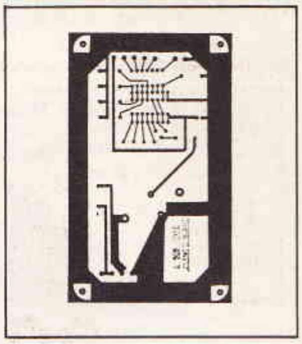


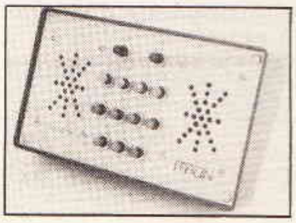
Page 11

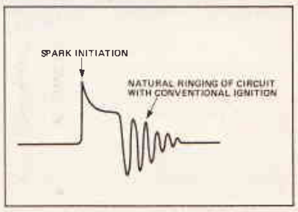


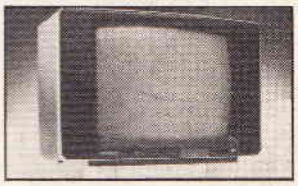
Page 36

REGULARS









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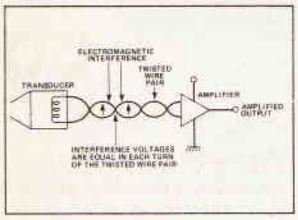
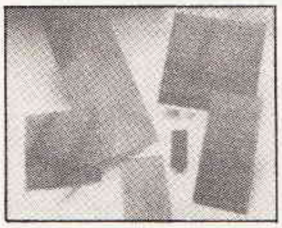
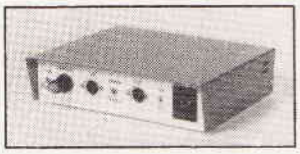
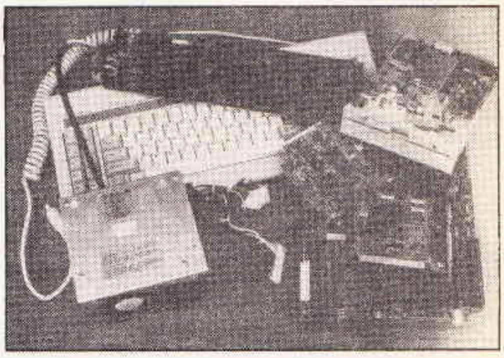
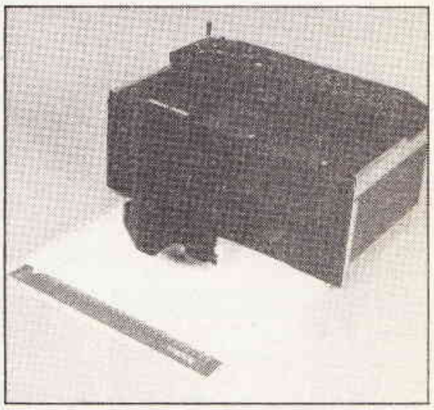
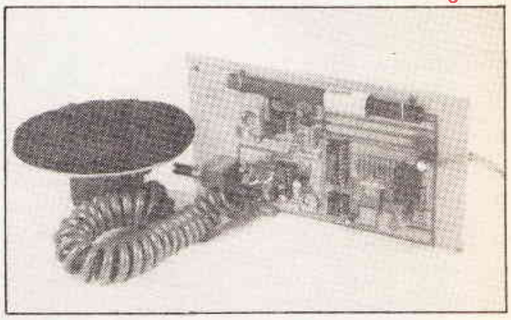


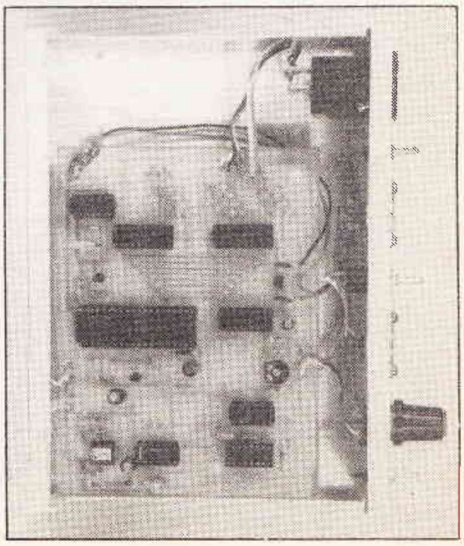





Page 14


Page 38

Page 49



Page 31

NEWS

DTI v EC ON EMI

A draft directive from the European Commission on interference and electromagnetic compatibility has come in for some interference of its own from the British DTI.

The directive, due to become law early in 1992, would force manufacturers of any electrical and telecommunications equipment to prove that EM emissions are at a negligable level and would not present any basis for interference.

While the need to limit EMI is agreed by all, the DTI argues that such a directive wou[illegible] apply to such a vast amount of e[illegible]ent that it would be quite unw[illegible] There are also fears that compulsory testing of telecommunication terminals would seriously extend development and approval stages of production.

DIAL 0898 FOR PROFIT

The 0898 telephone prefix is causing a major dispute between British Telecom and Mercury Communications.

BT's premium services using the 0898 prefix charge at 38p a minute peak and 25p a minute standard. Lines are sold by BT to private companies for playback of recorded tapes ranging from the 'FT Cityline' (123456) to 'My Coconuts' (886222).

The revenue generated by such lines is one of the fastest growing areas of BT's operations so it is not surprising that Mercury wants to start similar services as soon as possible.

The present argument has occurred over the distribution of revenues. BT gives 20p per minute to the service provider (regardless of call rate).

However, if Mercury runs services as well, a third party is introduced, with BT customers calling Mercury services and Mercury customers calling BT services.

Who gets what is the question, now in dispute for several months and finally referred to the Office of Telecommunications.

The result will provide an interesting pointer for the two companies over the possibility of a future Oftel ruling on the much larger problem of normal calls crossing between the two systems.

OUR LOSS — EUROPE'S GAIN?

inmos

The sale of INMOS by Thorn EMI is the biggest nail yet to be hammered into the coffin of the UK's semiconductor industry.

The purchasing company is Thomson-SGS, the Thomson half being owned by the French government and SGS effectively by the Italian government.

Inmos never did achieve the success it deserved. The Labour government produced Inmos in 1978 as a spearhead for the UK electronics industry. An innovative development team designed the transputer and put the UK at the forefront of microprocessor technology with a pioneering reputation in the field of parallel processing.

But profits did not follow and the company was privatised by the Conservatives in 1984. Thorn EMI was an ideal purchaser, at that time on a huge programme of expansion, ripe to fund an innovative product in an expanding market.

In the event however, continued losses proved too much for Thorn and various potential buyers were involved in discussions stretching as far back as 1985, just a year after the original purchase.

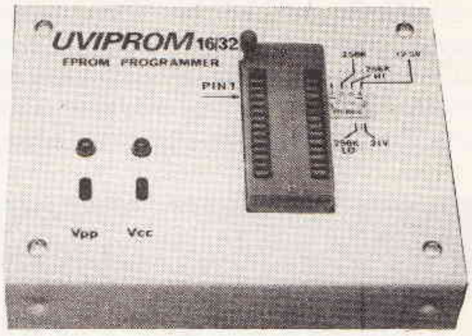
Enter SGS-Thomson, just fifteen months as a merged company — strong on memories but weak on processing and hungry to expand.

With the backing of two governments and by paying off Thorn with a substantial shareholding, there is little doubt that SGS-Thompson will be in a far better position to give Inmos the rope it requires.

Inmos has already swung into profit in the last six months and looks set to continue reaping the benefits of favourable markets and a recent streamlining of production.

In the interests of a strong and cooperative European semiconductor industry one must wish the combined company the best of luck, but the loss of a UK market leader reveals how bitter the taste of 1992 can be.

BUDGET BLOWS



Low cost EPROM programming is available for BBC owners with the UviProm 16/32 from Ground Control.

The unit, a development of the UviProm 16, plugs into the user port of a BBC B, B+ or Master and uses a switched mode power supply to generate programming voltages of 21V and 12.5V from the BBC's power busses.

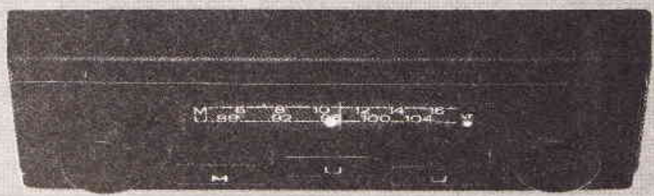
It will program 2764, 27128 and 27256 EPROMs including CMOS and A versions.

The software on ROM uses '*' commands from the BBC to read, blow, compare, view and test devices.

The inclusive price is just £30.00.

For full details contact Group Control, 4 Alfreda Avenue, Hullbridge, Hockley, Essex SS5 6LT. Tel: (0702) 230324.

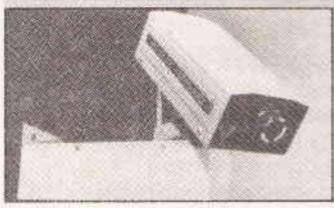
HIDDEN VALUE



Deception and crime prevention are the orders of the day with a couple of pseudo-products from Grundig and Volumatic.

Grundig has produced a dummy front panel that clips onto any of its car audio range, making the radio appear so cheap and old-fashioned that only the most hard-up thieves would bother breaking in to steal it.

With many people now removing their car cassettes each time they park, this sneaky piece of innovation should relieve that nightly finger-twiddling routine.



However, should your car hi-fi be too expensive to trust even to such artful subterfuge, Grundig also produces a quick release unit for many of their radio cassettes to reduce fitting and removal time to a minimum.

Contact Grundig, Mill Road, Rugby CV21 1PR. Tel: (0788) 77155.

Volumatic's Videoguard range of surveillance cameras has been augmented by a new camera that doesn't actually work but acts as a deterrant to thieves and hoodlums. The static camera retails at £65+VAT with a sweeping model for £95, a little pricey when you can buy working cameras secondhand for similar prices, but highly effective if used in conjunction with an existing system of genuine surveillance equipment.

Contact Volumatic, Taurus House, Endermere Road, Coventry CV6 5PY. Tel: (0203) 684217.

BT — CREDIT TO THE NATION

There is a new piece of plastic now available for credit junkies everywhere — the British Telecom credit card.

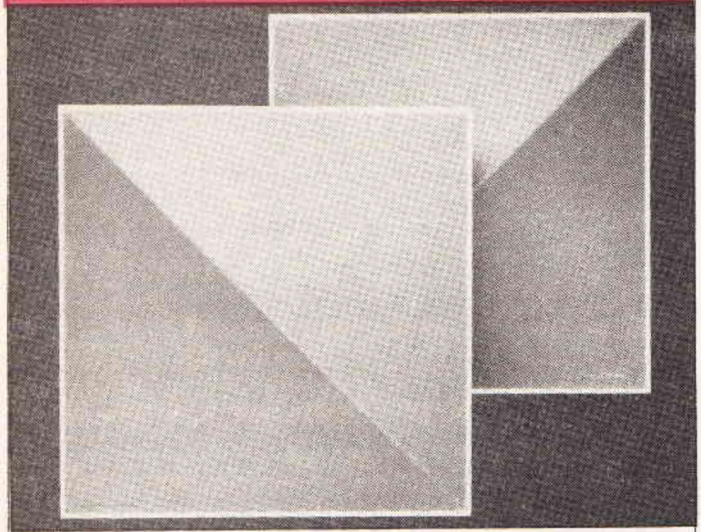
BT has run credit schemes before but always with the necessity of going through the operator, thereby raising the cost of the calls to operator rates.

The new card can be used from any private or public phone using tone dialling. After dialling 144 to connect to the service, users enter an account number and PIN, followed by the phone number required. Recorded prompts are given for each stage and as with most PIN systems you get three attempts before being disconnected from the system.

The calls are charged at rates somethat higher than normal rates (10p per unit) plus there is a charge between 20p and 30p for each call. The credit card charges are itemised in a statement supplied to office or home with the standard quarterly bill.

For more information contact BT on 01-356 5369.

FLATTER SQUARER AUDIO



Studio Power Loudspeakers has produced a stylishly finished loudspeaker design entitled the Sound Panel.

Incorporating a 6in bass drive and 2in cone domed tweeter, the units are mounted in convex square cabinets for wall-mounting or floor standing. Studio Power claims a sound with 'clarity and punch' with no loss of treble, a problem in some similar designs.

The speakers retail at £189.90 per pair.

Contact Studio Power, 65 Victoria Road, Guiseley, Leeds LS20 8DQ. Tel: (0943) 870057.

CD-ROM DICTIONARY

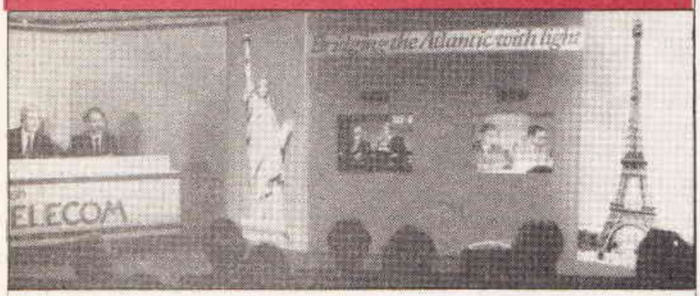
The enormous task of keeping the complete *Oxford English Dictionary* in pace with the ever changing English language is being tackled by the electronic publishing department at the Oxford University Press.

The original dictionary is already available on CD-ROM (OUP £500) with over a quarter of a million headings and entries up to 50000 words long.

The OUP now faces the never-ending entry of the 12000 new words that are accepted by the dictionary each year and the merging of the OED supplement with the original version.

It hopes an accurate electronic version will be available by 1991.

ATLANTIC CROSSING



Christmas communications between the UK and the US made use of the world's first transatlantic optical fibre cable, opened on December 14th by BT in London, AT&T in the States and France Telecom in Paris.

In true Neil Armstrong tradition, Isaac Asimov spoke the first words to pass through the cable. "Advances in communications technology have always led to advances in human understanding" he said, a significant improvement on previous technological opening gambits such as 'Come here Mr Watson' and the ever popular 'Testing testing, one two'.

The cable, TAT-8, can handle 4000 calls, effectively doubling telecommunications capacity across the Atlantic. The main cable from New Jersey to the UK/France branching point has two fibre pairs plus a third for back-up.

The system rate is 140Mbits/s (line rate 295.6Mbits/s) using a wavelength of 1310nm. Repeaters boost the signals every 55km along the ocean floor — cables are armoured to a depth of at least 1000m with some reduced protection (against sharks) to 2600m.

For further information contact BT on 01-492 2626.

CLOSING OUR HORIZONS

Britain has again alienated itself in the halls of the European Space Agency, this time over its reluctance to agree funding on the Horizon 2000 project.

The extensive programme (involving the launching of astronomy satellites and solar system probes) requires a 25% increase in ESA space science spending by 1994 which Britain, alone among the thirteen ESA members, claimed was excessive and unacceptable.

However, the reaction to our announcement was strong enough to reverse the British decision when the final vote was taken on December 15th.

Suggestions that Britain should perhaps consider whether it wanted to remain in the agency were successful in reducing our demands to the instigation of an independent review of costs and management.

JOBS

Budding electronics enthusiasts are not as thick on the ground as might be hoped.

ETI has been approached by the Chemistry Department of University College London which is despairing in its search for development and maintenance technicians.

'O' level equivalents are needed in maths and physics/chemistry but the overriding requirement is a genuine enthusiasm for electronics.

Despite advertising by all the normal channels the department has had virtually no success. The posts carry five weeks holiday and pay between £5427 and £6038 depending on age (16-18).

Any ETI readers interested should contact Miss B Mann, Personnel Tech Staff CE7, University College, Gower Street, London WC1E 6BT. Tel: 01-387 7050.

METER

A powerful RS232-equipped clamp-on meter is new on the market from Livingston Technical Sales.

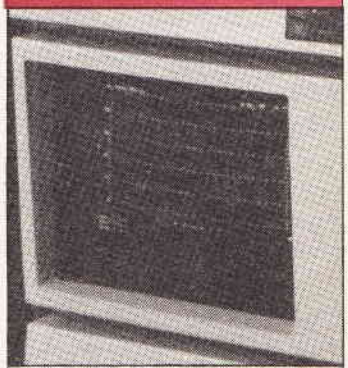
The Hall effect Bell UM-7900 measures nine parameters: true RMS volts and amps, direct current, phase, power factor, plus true, real and apparent power.

Results can be displayed on the 3½-digit LCD or can be communicated via the RS232 interface to a printer or monitoring system.

Remote control of the device is also possible via the RS232 port.

Such sophistication does not come cheap. The UM7900 costs £659+VAT. Contact Livingston, 2-6 Queens Road, Teddington TW11 0LR. Tel: 01-977 0055.

SECURITY INTERFERENCE



Horrendous security implications are created by the problems of electromagnetic emissions when related to computer security.

The Government standard for protection is known by its NATO codename — Tempest. GCHQ is responsible for regulating the 50 or so manufacturers involved in the Industrial Tempest Scheme (ITS).

Equipment such as that produced at MSL in Hitchin (see *ETI News* July 1988) can detect and process radiated signals from keyboards, screens, printers and cables while remaining hundreds of feet away from the monitored system.

Happily, both the US and UK governments have kept a tight rein on the sale of such equipment with the vast majority of test rigs in the UK going to GCHQ itself in Cheltenham. Curiously, however, systems which are adequately protected against EMI have until now been similarly restricted.

In these enlightened post-Spycatcher days, GCHQ has informed members of the ITS that it is keen to see British companies protecting sensitive data areas and has released the barriers around the Tempest community. It has even produced a second Tempest standard slightly less stringent than the original that brings protection costs significantly lower.

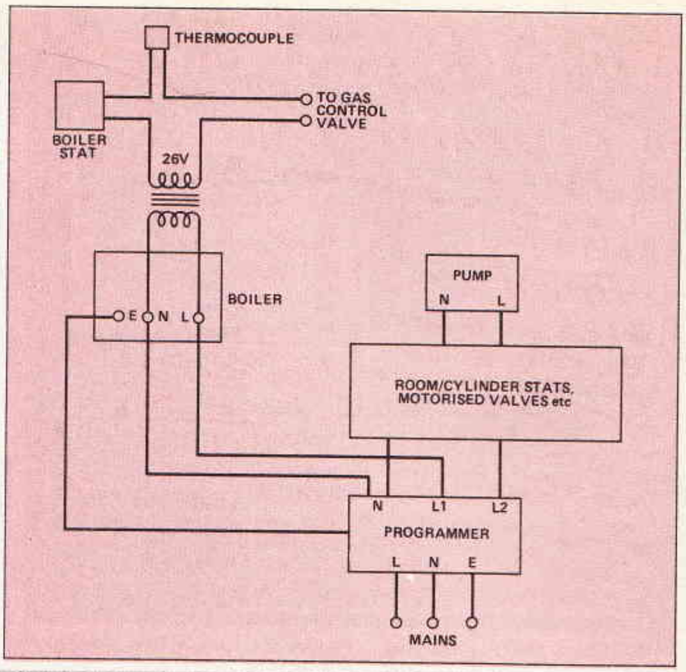
Considering the success of 'computer security' advisors specialising in the City over recent years, the Tempest phenomenon seems likely to herald a new era in data security investment.

READ\WRITE

THERMOSTAT THREAT

With reference to the above Electronic Thermostat project in the December issue of ETI, I was absolutely horrified when I read this article. I have been concerned with electronics, and central heating in particular for some years and seldom have I come across such irresponsible advice.

I enclose the circuit diagram of a typical control system.



In the first place I must point out that the low voltage circuit on gas (and some oil) boilers is designed to operate the main gas valve via the boiler thermostat (not room thermostat). The sensor for this is contained in a pocket in the boiler jacket. However, what is more important is that this circuit is also part of the 'fail safe' system. A small sensor is located within the pilot flame and as long as that flame continues to burn the circuit is held closed by the sensor. Should the pilot flame be blown out then the sensor cools and the circuit opens and the device is made safe.

Obviously any interference with this circuit is in contravention of laid down procedures for the installation of central heating appliances and, should an accident happen, would render the majority of insurance covers void.

Secondly, it is the 'off-boiler' circuits which control both the point at which various controls are switched in and out and these include low limit stats, room stats, cylinder stats, motorised valves and timeclocks. The majority of these circuits are normally at full mains voltage.

It is in this latter part of the circuit that devices of this type should be installed although I would question the need for such a device. There is nothing wrong with a desire to obtain the most accurate form of control, whatever the system. However, as any central heating engineer will tell you, the reaction time of a normal system is so slow that a normal mechanical device is well within the tolerances of the total system and, don't forget, that it is the reaction time of the total building which is the deciding factor in any system not any one room. I am afraid this is another electronic 'miracle' device which falls into the category of using a 24lb hammer to crack a peanut.

T Wright
York

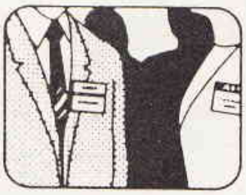
Andrew Armstrong replies: In reply to your first point, at the beginning of the article I specifically referred to the use of the controller to replace thermostats which operate at 24V. These comprise the majority of the admittedly small number of systems which I have examined. I would assume that many systems installed in recent years use 24V on the external circuits for safety reasons. It would certainly seem risky to use mains on a room thermostat unless its cover were made stronger than most I have seen in use.

Admittedly some thermostats do run at mains voltage and the controller is not suitable for these. It is important to check before building the project to avoid wasting time and money on something which is unsuitable for the job. Now that I have moved from a house with a 24V warm air heating system to one with a mains controlled boiler system, I shall design a mini-project or Tech Tip of a suitable adaptor which will replace the thermostat contacts with relay contacts, and operate the electronic controller at as low a voltage as it requires.

As regards the accuracy of a mechanical thermostat, the one in my living room was bad enough to inspire me to build the electronic replacement. The room temperature fluctuated over a range of about 4°C with the mechanical thermostat and under 2°C with the electronic control. This was tested over a period of two years. While it may not have saved enough fuel to pay for itself, it did make the room more comfortable.

I grant that the response time of the heating system is long enough to reduce the control accuracy but practical experience and computer simulation of industrial environmental control systems shows that an accurate controller with a small hysteresis is an advantage.

DIARY



Sound 89 — February 21-22nd
Heathrow Penta Hotel, London. Contact Sound and Communications Industries Federation on (06286) 67633

Which Computer? Show — February 21-24th
National Exhibition Centre, Birmingham. Contact Cahners Exhibitions on 01-891 5051

Radiowave Propagation — March 5-10th
Danbury Park Management Centre, Chelmsford. Third IEE vacation school. Contact IEE on 01-240 1871

Patents In Practice — March 8th
Institute of Civi Engineers, London. Seminar organised by Institute of Physics. Contact the Institute on 01-235 6111

Magneto Optical Data Storage And Recording — March 13th
Cafe Royal, London. Conference on this blosoming technology. Contact IBC Technical Services on 01-236 4080

Cadcam 89 — March 14-16th
NEC, Birmingham. Contact EMAP International Exhibitions on 01-404 4844

Document Image Processing —March 14-16th
Queen Elizabeth II Centre, London. Contact Blenheim Online on 01-868 4466

Internepcon Production — March 14-16th
NEC, Birmingham. Electronics manufacturers show. Contact Cahners Exhibitions on 01-891 5051

Annual European Conference On Fibre Optics — March 16-17th
Kensington Palace Hotel, London. Contact Frost and Sulivan on 01-730 3438

Cable And Satellite 89 — March 16-19th
Olympia, London. Contact Montbuild on 01-486 1951

Corporate Electronic Publishing Systems — March 21-23rd
Olympia, London. Contact Cahners Exhibitions on 01-891 5051

Open Systems — March 21-23rd
Queen Elizabeth II Centre, London. Contact Blenheim Online on 01-868 4466

Connectors 89 — March 23rd
Crest Hotel, Walsgrave, Coventry. Contact A F Hayes & Co. (0533) 881208

IEE National Conference On Telecommunications — April 2-5th
University of York. Contact the IEE on 01-240 1871

Low Energy Ion Beams Conference — April 2-6th
University of Surrey. Contact The Institute of Physics on 01-235 6111

Automan — May 9-12th
NEC, Birmingham. Automated manufacturing show. Contact Cahners Exhibitions on 01-891 5051

Energy 89 — May 16-18
NEC, Birmingham. Contact Emap Maclaren on 01-660 8008

Scitech 89 — May 17-21st
Alexandra Palace, London. Exhibition of all the best British science and technology. Contact British Science And Technical Trust on 01-992 0684

Image Processing And Its Applications — July 18-20th
University of Warwick. Third International Conference. Contact IEE on 01-240 1871

Holographic Systems, Components And Applications — September 11-13th
University of Bath. Second International Conference. Contact IEE on 01-240 1871

Vacuum Microelectronics — July 24-26th
University of Bath. Conference sponsored by The Institute of Physics, IEE and IEEE. Contact The Institute of Physics on 01-235 6111

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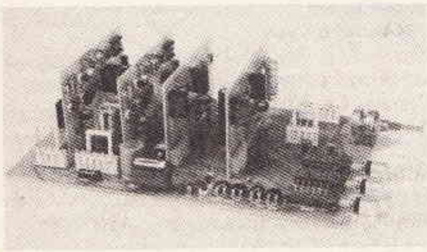

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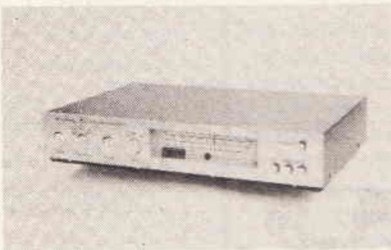

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Next Month in

ETI

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The April ETI

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- ***½ lb strawberries***
- ***¼ lb redcurrants***
- ***¼ pt custard***
- ***⅓ pt double cream***
- ***1 tblsp castor sugar***

Place the strawberries and redcurrants in a pan and cook with the sugar and a little water until soft. Purée the fruit through a sieve or in a blender.

Whip the cream until thick and fold the sweetened fruit purée into the cream and custard.

Divide the mixture into individual glasses or sundae dishes and cool in the fridge. Serve chilled and decorated with halved strawberries and piped whipped cream.

* * *

Alternatively, if you don't fancy a fool and it's food for thought you're after, help yourself to a large slice of the April ETI instead.

Next month's ETI includes many tasty morsels. There's the third and final part of the Intelligent Plotter project with the actual on-board intelligence added and the whole thing brought together.

The EASi Alarm system is a novel approach to a perennial problem which is both extremely expandable and simple to install. Artificial Intelligence comes under the ETI scrutiny — what it is and why everyone's so interested in it.

And last but not least, next month's issue contains the full details of the ultimate thinking man's neck apparel — the Pan-Atlantic Tie.

The recipes mentioned here are in preparation but might just be too yummy to publish.

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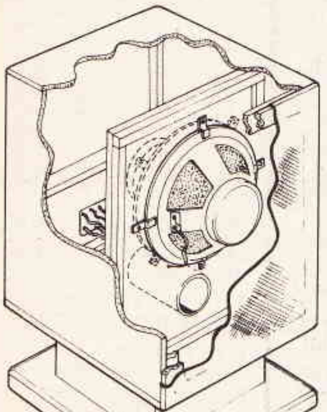

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ELECTROMAGNETIC INTERFERENCE

(And How To Get Rid Of It)

EMI

From a scratchy click in your speakers to total computer data loss, electromagnetic interference is the scourge of all electronic equipment. Keith Brindley takes a close look and finds ways to reduce its effects.

Electromagnetic interference (EMI) is, with a few notable exceptions, a totally man-made form of noise (the most well-known exception is the interference caused by a lightning strike). Being man-made it is possible, therefore, to devise ways of reducing its effects to a negligible level. (Non-man-made noise such as thermal or sky noise, on the other hand, is random and more difficult to control.)

In theory at least, we need only understand what EMI is and what causes it to be able to formulate techniques to control it. So, what is it?

EMI can be considered as being interference in the classic sense — noise generated by a noise source, picked up by a noise victim, via a noise path (Fig. 1).

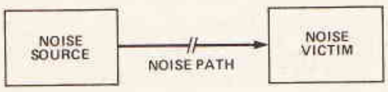


Fig.1 EMI as classic interference

The noise path can be any form of transmission media. This is pretty self-explanatory. If there is no source, the EMI can't be picked up. If there is no noise path, the noise can't be transmitted from source to victim. If there is no victim, it doesn't matter whether the noise is there or not.

Even from this simplified explanation it's pretty obvious that there are three main points at which EMI can be reduced — at the noise source, in the noise path or at the noise victim. The problem, however, is that it is often difficult to differentiate between the three parts.

There are a number of main causes of EMI, including:

- radio transmitters. The ether is full of radio transmissions at frequencies of just a few kilohertz, up to several gigahertz. These are at varying levels of saturation. Obviously the greater the saturation, the greater the risk of significant EMI taking place. At levels below $100mVm^{-1}$ there is negligible risk of EMI. Between $100mVm^{-1}$ and $3Vm^{-1}$ there is a risk of EMI depending on the physical dimensions of the victim equipment. At levels above $3Vm^{-1}$ there is significant risk from EMI.
- non-radio, high frequency generators. Many items of electrical equipment are sources of high frequency EMI. Computers, arc welders, microwave ovens and so on can generate EMI by radiated and/or conductive means and so are potential noise sources.
- electrostatic discharge. One of the main culprits of electrostatic discharge is the man-made carpet. Simply walking over it can create a static potential in the human body which will discharge as the person touches equipment maintained at a different potential. The situation is aggravated in dry atmospheres.
- lightning. A lightning strike creates a huge electromagnetic field, which may induce voltage surges in power and communications lines.
- transient EMI sources. There is a vast range of sources such as dimmer switches, fluorescent lights, power tools, car engines and power supplies, all of which can act as EMI sources.
- power line interference. Although nominal AC mains voltage is 240V, minor and long-lived variations of as much as ±10% are common. Transient spikes may also occur due to the previous two EMI sources.

In all of these possibilities, EMI falls into one of only two types: radiated, or communicated.

EMI Reduction

Knowing now what EMI is, and the typical causes, we can begin to formulate ideas about how to reduce its effects. First, is to stop the EMI from leaving the source at all. Second is to improve the noise path — to prevent the EMI from passing along it. Third is to stop the EMI from entering the victim. All fairly obvious. But what isn't obvious is that the method chosen depends on the type of EMI.

For example, if the EMI is caused by a radio transmitter (say, your 100 watt per channel hi-fi amp picks up CB conversations) then there is nothing you can do about either the noisy CB transmitter or the noise path — so you have to improve your amplifier's resistance to the EMI. On the other hand, if your amplifier produces a click through the speakers whenever your kitchen fluorescent light is turned on, you *can* do something about the EMI source and noise path.

Generally, like the first example, the EMI source is going to be remote and so impossible to effectively reduce at the source. So the following EMI reduction techniques are those which are taken at the EMI victim.

Radiated EMI

Primary prevention is always sought through the use of an earthed, conductive enclosure (typically a metal box) to house the potential victim. Steel enclosures have better absorption loss than aluminium or copper for thicknesses above 1mm. Below 1mm thick, copper or aluminium have similar qualities. Enclosures which provide some 90dB or so of EMI attenuation are possible and provide the ultimate in EMI protection.

Ideally the enclosure should be continuous, without holes, connectors or seams. Outside EMI radiation can thus not pass through the enclosure to the victim inside. However such an ideal enclosure is impossible. Ventilation holes, cable-through holes, connectors, controls and what have you are always needed and of necessity must pass through the enclosure, providing breaks in the shielding through which EMI may pass.

The usual steps to ensure maximum possible EMI prevention is obtained with a metal enclosure are to

- make sure all through-holes are as small as possible, preferably using correctly sized cable glands
- use perforated grids to cover ventilation holes
- ensure all joints in the enclosure are adequately seamed, and allow good electrical bonding
- where covers are electrically separate (say, you are using a painted metal box with separate lid) use braided copper jumpers bolted to both cover and main frame.

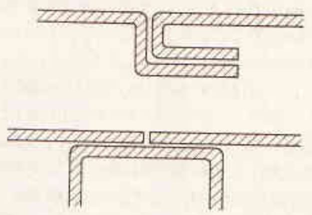


Fig.2 Seaming techniques for metal enclosures and internal shields

In the case of severe EMI radiation, use grid with perforation holes no greater than 2mm in diameter and ensure several copper jumpers are used, where the spaces between them never exceed one tenth the wavelength of the expected EMI. So if the potential EMI is known to be around a frequency of 27MHz (CB frequencies) then jumpers should be no further apart than about a metre. If the EMI is around 300MHz then jumpers should be less than 10cm apart.

In many cases a metal enclosure is unsuitable — for aesthetic or cost reasons. Several EMI reducing procedures can be followed when plastic or wood enclosures are used. Plastic and wood provide no shielding whatsoever against EMI of course, so the procedures generally try to incorporate an internal shield of some description.

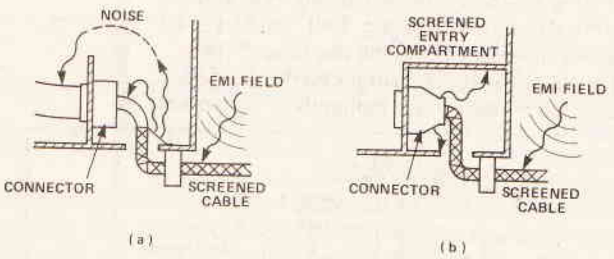


Fig.3 (a) Radiated EMI can enter a screened enclosure via a screened lead but (b) can be prevented with good practice

Plastic boxes are now available which are coated at manufacture stage with a metal acrylic layer, effectively allowing good shielding (50 — 90dB depending on EMI frequency) with a good appearance and still remaining cheap.

Aerosol sprays exist which allow the user to incorporate a metallised conductive coating onto the inside of plastic enclosures. EMI attenuation up to about 50dB is possible.

Alternative procedures usually incorporate internal shields over parts of the equipment: either over parts prone to EMI pickup (PCBs, cables) or over radiating parts (power supplies, CRTs etc).

These internal shields, and indeed full metal enclosures, benefit from good seaming techniques (Fig. 2) to ensure that EMI does not occur through the seam itself.

Cabling Techniques

Much EMI can be caused by incorrect cabling within the enclosure. EMI in this context is simple crosstalk — radiation from one cable to another. This may be from one part of the system to another or may be due to external EMI entering the equipment via cable inlets.

The first step is to organise all cables into three distinct groups:

- power cables, carrying AC mains. These are potential EMI sources.
- DC control and power cables. These can be EMI sources *or* victims.
- Signal and logic cables. These are generally EMI victims but may be sources too.

Next, cables in the three groups must be routed round the equipment separately and as far away from each other as space allows.

If signal and logic cables run parallel to cables of the other two groups (it's on parallel runs that crosstalk will be maximum), make sure that distances apart are at a maximum. As a rule-of-thumb allow a space of 2.5cm between digital cables and power cables for every metre of parallel run. Similarly, ensure that analogue signal cables are 25cm away from power cables, for every metre of parallel run.

Where cables of more than one group enter the enclosure, separate entry holes must be made, and cable routes outside the equipment should follow the same separation techniques just prescribed.

Regarding cable entries, it should not be assumed that outside radiated EMI cannot enter the enclosure via the cable itself — even if the cable is screened. Fig. 3a shows how radiated EMI can enter the enclosure via the cable screen, while Fig. 3b shows a method of cable entry which prevents this.

Cables carrying low-level digital or analogue signals fall into three main wire types — ribbon cable, coaxial cable and twisted pair. In all, each signal wire should have its own return running beside it, thus reducing signal loop area. (The larger the loop area, the greater the risk of EMI via inductive coupling.)

Ribbon Cable

Figure 4 shows how signal wires within the ribbon should ideally have earthed wires between. The earthed wires create the effect of a screen between the various signals.

Coaxial cable effectively allows a electrostatic screen or shield, much like the screen afforded by a metal enclosure. In many cases it can be extremely useful in reducing the effects of EMI. However, problems (worse than the original EMI) can occur if care is not taken. To work correctly, the screen must have zero resistance to earth. In this way any coupled EMI is effectively shorted directly to earth.

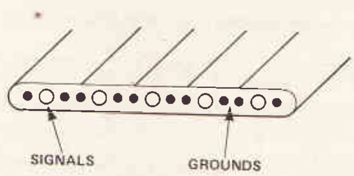


Fig.4 Signal wires in ribbon cable should be separated by earthed wires, effectively screening signals

If, however, the shield has a finite resistance to earth (which is always the case when a long connecting lead is used between remote parts of a system because the cable has resistance) then the EMI will generate a noise voltage between the screen and true earth. Interference may even be worse than without coaxial cable! With short lengths of screened coaxial connecting cable this is not usually a problem, however.

Interference may also be caused by sloppy use of coaxial cable if the idea of 'earth' is not fully understood. Figure 5 shows a transducer connected to an amplifier by coaxial cable, in which the cable's screen is earthed at the tranducer *and* at the amplifier. Earthing, however, is not a guarantee that voltages at two different earth points will be identical. If even just a tiny difference in potential between the two earth points exists then a current will flow along the screen, itself causing interference. This situation is known as an 'earth loop'.

As a rule-of-thumb, when coaxial cable is used to connect parts of a system the screen should be connected at only one end (generally the receiving end) of the cable run. There are exceptions, particularly at high frequency.

Figure 6 shows a twisted pair, in which each signal wire runs with its return. These can be highly effective against EMI produced in differential mode or balanced analogue circuits but are virtually useless in common mode circuits. The protection against EMI is given simply because interference voltages induced in each turn of the twisted wire pair are equal and hence cancel other out.

PCB Techniques

Many of the techniques used in EMI reduction through cable routing and use can be adopted when designing equipment PCB. PCB is, after all, just a connecting method between components of the system.

For example, earth loops can occur in analogue circuits where two or more amplifying stages are in series (Fig. 7a). The problem is that the two separate earth points may have slightly different potentials and a noise current will flow — even if the two earth points are formed by the same conductor which may be a single piece of printed circuit track.

In low amplification circuits this will probably cause few problems but high amplification circuits will be unstable. The only solution is to provide a common earthing point for all parts of the circuit — shown in Fig. 7b.

Circuits which require a high impedance input stage are more prone to crosstalk than low impedance circuits so if a high impedance input is necessary, the 'guard ring' approach may be useful. Here, the high impedance amplifier is configured as a non-inverting buffer amplifier (Fig. 8) in which the amplifier's output impedance is much lower than that of its input. The

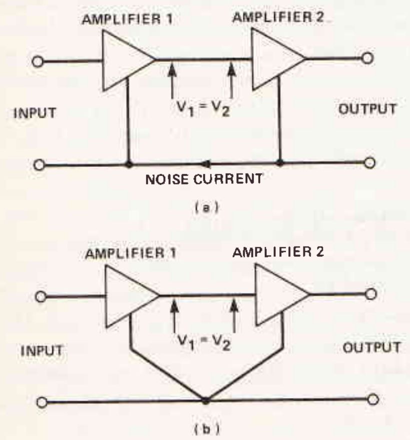


Fig.7 Earth loops can occur at PCB level (a) if separate earth points are used but (b) can be eliminated with a common earth

guard ring is linked to the amplifier's output, so that it forms a low resistance path to EMI signals.

On power supply PCBs, ripple and high frequency noise can be reduced if connections are made as large as possible, using copper planes rather than individual tracks. This has the added benefit of making the PCB slightly cheaper to make (less copper has to be removed at the etching stage).

Generally, particularly on signal boards, it is advisable also to leave copper on any unused areas of board. These can then be earthed.

Communicated EMI

Where EMI reaches the victim through cables, as opposed to being radiated, the only real solution is to filter out the interference signal. Generally, EMI will be in the form of voltage spikes and transients on AC power input leads, so the obvious course of action is to install a filter at the input to the equipment and various types exist. Neatest are the IEC-type chassis-mounted plug units, although many surface-mounted filters exist. EMI attenuation up to about 60dB is a feature.

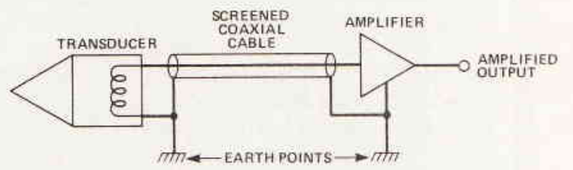


Fig.5 Earthing coaxial cable to both ends may cause an earth loop

Mains filters have the double benefit of attenuating noise produced *within* a system, attenuating the level of EMI going into the mains thus reducing the likelihood of EMI with other equipment. National regulations covering EMI produced by equipment may necessitate the use of such filters.

Transients, spikes and surges on the AC power lead may reach peaks much higher than equipment

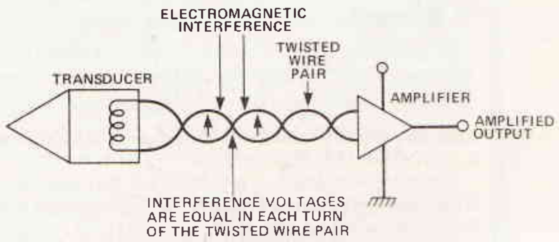


Fig.6 Principle of a twisted pair

can cope with and filters cannot dissipate the extra energy which occurs. Suppressors must be used if large over-voltages are expected. Two main types are available: 'gas discharge tube arrestors' and 'varistors'.

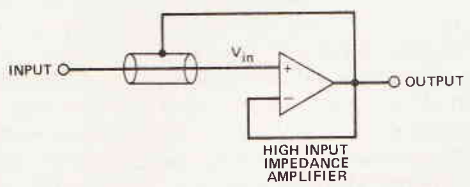


Fig.8 Guard rings reduce crosstalk to high impedance input stages

The former is connected across the input and under usual conditions remains open circuit. However, if the input voltage exceeds a sparkover voltage the gas inside the device becomes ionised and effectively short circuits the supply, until the surge ends.

The varistor clamps the AC power supply voltage to a preset value, rather like a zener diode does for DC supplies.

CONSTRUCTION SET COMPUTING

Mike Bedford finally gives up his Microtan for a new hardware man's computer — the IBM PC

The author's completed DIY PC/AT

Looking around today's home computer scene it seems that the true technically minded computer enthusiast is no more — that intrepid bunch of devotees to a number of systems which made their appearance in the early 1980s, typified by the Nascom and the Microtan. The Microtan in particular became widely accepted as 'the hardware man's computer' and has featured widely in the pages of ETI.

Although advocates of both these systems (and no doubt others) have battled on through the years expanding and modifying them and proving that contrary to the old saying it is possible to fit a quart into a pint pot, time waits for no man! Board based systems have been replaced by black boxes too numerous to mention. These plug-in-and-go machines were designed primarily for games players who perhaps wanted to dabble a bit in Basic programming.

In common with virtually all consumer booms, the appeal of this superficial infatuation with computers was short lived and the home computer boom is now history. The result of all this is that the home computer hobbyist is now considered a rare breed and most machines now on the market don't lend themselves too well to hardware tinkering.

Certainly, compared to the hoards of games players a few years ago, those computer enthusiasts with a hardware leaning are few. Nevertheless, few reading this magazine would suggest that our's is anything but a popular pastime. So what sort of computer available today is able to fill the same niche as that occupied by the Nascom and the Tangerine five years ago but will allow its owner to experience up to date technology such as 16/32-bit processors?

One way to tackle this question is to consider the features of these early machines that made them so appealing to hardware enthusiasts.

They were essentially modular systems, the individual cards connecting via a mother board. The advantages of this are numerous. A system can be built up gradually to cope with increasing demands and/or improving financial situation. Certain functional blocks (keyboards, power supplies, cases) need not be bought from the computer supplier but could be home made or reused from other equipment.

The modular approach encouraged third parties to offer plug-compatible cards hence increasing the options. For example, at least three different graphics cards were available for the Microtan, in addition to the offering from Tangerine. Magazines (especially ETI) published designs for compatible cards and owners experimented with their own designs.

The other point in favour of these systems (in common with their black box counterparts) is that they were supported by active user groups. On the reverse side of the coin, however, was the software availability situation — the one area where the Microtan and friends had to play second fiddle to the BBC micro, Spectrum, Dragon and so on.

PC To The Rescue

So, we are still left with the question of what machine, if any, fulfils the requirements outlined above and overcomes the one limitation given? I would like to suggest the answer is the IBM PC range and the numerous compatibles. At this point please don't switch off, dismissing it as a boring business black box but read on.

Black boxes most certainly are represented both from IBM and from the numerous clone manufacturers typified by Amstrad at the lower end of the price range. However, it will be the products of various Far Eastern manufacturers which will be of interest to the electronics enthusiast looking for a really low cost option. These companies are in the business of providing PC components such as motherboards, PSUs and keyboards to OEMs for incorporation into their

DIY PCs

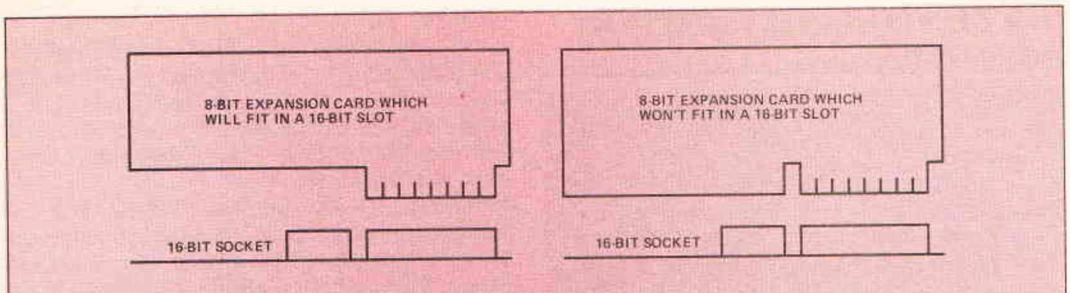


Fig.1 Eight into sixteen sometimes will and sometimes won't go

own 'badge engineered' clones. By purchasing these component parts, we can also assemble machines customised to our own requirements at an absolute minimum cost. The purpose of this article is to show just how to go about this process, giving names of suppliers together with typical pricings.

What about the concept held by many that even if we can build a PC ourselves, once complete it can only be used with word processors, spreadsheets, databases and accounting packages? This couldn't be further from the truth. Although all these types of package are available in abundance this is only the tip of the iceberg.

It is probably true to say that more software has been written to run under MS-DOS (the PC's operating system) than for any other machine. The following incomplete list is given just to whet the appetite. Languages: Basic in many flavours, Fortran, Algol, Cobol, C, Pascal, Forth, Lisp, Prolog, ADA and Assemblers both native and cross. Programming utilities: Libraries, Debuggers and so on. Applications: word processors, spreadsheets, databases, communications, business graphics, art packages, CAD/CAM. Games: Arcade type, adventures, strategy . . . and so the list goes on. Further more much is not sold commercially but is available as either public domain or user supported at very low cost.

EXPANSION CARDS

Actually a bit of a misnomer since with most mother boards a number of such cards are required to give even a base level system. This section should be read in conjunction with selecting the disk controllers, video and I/O cards described elsewhere in this article.

Expansion cards are of two main types, those with an 8-bit interface, and those with a 16-bit interface, and are intended for plugging into 8-bit expansion slots and 16-bit expansion slots respectively. There is, however, more flexibility than this statement would suggest. All cards have a 62-way edge connector whereas the 16-bit cards have an additional 36-way edge connector separated a short distance from the first.

An 8-bit card can be plugged into any type of expansion slot. If this is a 16-bit expansion slot on an AT then the transfer of data will be slower than if a true 16-bit card were to be used in the same slot. With inherently slow cards such as a serial I/O module this won't make any difference but use of an 8-bit memory card on an AT would give considerable degradation.

There is a physical constraint which gives an exception to this rule. Figure 1 shows a board which could be used and a board which couldn't and illustrates how some board shapes preclude their use in a 16-bit slot. Now considering the opposite situation, can a 16-bit card be plugged into an 8-bit slot? Well, the normal answer to this is no since it would leave a number of the signals on the card 'hanging' into free space!

There is one exception to this rule — cards which have sufficient intelligence on board to be able to recognise this situation and configure itself to either 8-bit or 16-bit operation as appropriate. An example of this is the generation of high performance add-on graphics cards which have on-board processors.

Building Blocks

So here is the nitty gritty, a roundup of all the constituent parts of a PC indicating all the options and the factors which will influence your choice.

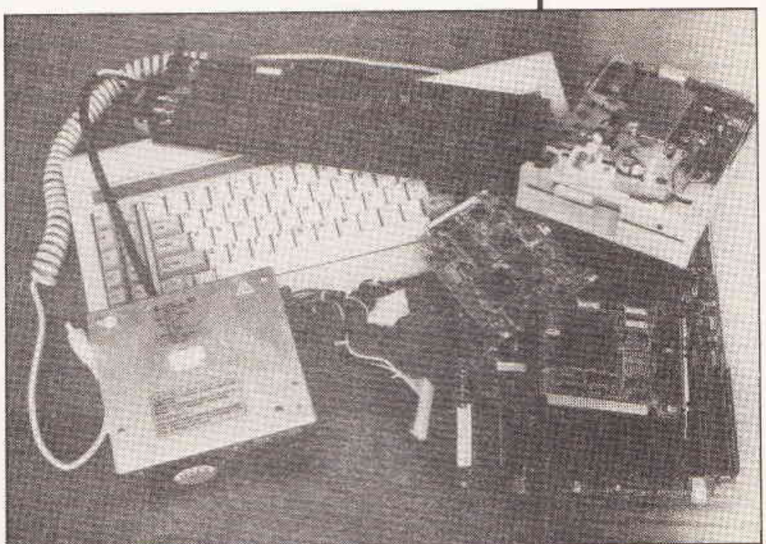
Motherboard

Otherwise called the mainboard, this is the heart of the PC and unlike some systems, the motherboard is not just a passive component allowing the active boards to be interconnected but actually includes all the basic circuitry. This includes the processor and its associated glue logic, a floating point co-processor (socketed option), RAM, the BIOS and sockets for expansion cards.

For PC or PC/XT compatible boards the processor will be the 8088 whereas for PC/ATs an 80286 is used. Although it wasn't a standard which IBM adopted, PC type boards which take an 80386 are also available but at much higher cost so probably won't be of much interest. Whereas the original PC had a 4.77MHz processor clock, many boards now have a so-called turbo facility allowing dual 4.77/8 or 4.77/10MHz and similarly turbo AT boards often give multiple speeds up to 12MHz or even 16MHz for more expensive versions.

Another variable feature of motherboards is the number of expansion slots — this will normally be six or eight. On an AT board these slots will be a mixture of 8-bit (PC compatible) and 16-bit (making full use of the 286 architecture) sockets.

The third main variable is the RAM capacity. RAM is usually configured in blocks of nine dynamic RAMs which each give a block of byte wide memory (the ninth chip is to provide parity). Depending on the board and the setting of DIL switches, these RAM slots may take 64K × 1 or 256K × 1 dynamic RAMs. Some motherboards have two such banks and therefore only allow up to 512K to be used. More often, four


The constituent parts of a DIY PC (less case)

Block 0 RAM to 64k
Block 1 RAM to 128k
Block 2 RAM to 192k
Block 3 RAM to 256k
Block 4 RAM to 320k
Block 5 RAM to 384k
Block 6 RAM to 448k
Block 7 RAM to 512k
Block 8 RAM to 576k
Block 9 RAM to 640k
Block A Extended video RAM
Block B Standard video RAM
Block C BIOS expansion (eg EGA)
Block D reserved
Block E reserved
Block F BIOS

Fig.2 The memory map of the standard IBM PC

EXTENDED/EXPANDED MEMORY

MS-DOS, written for the 8088 processor which has 20 address lines, considers its address map to be 1Mb in length. This memory map is shown in Fig.2.

It will be noticed that only 640K is officially designated as RAM space and this is the limit for most software. However there are two techniques for overcoming this limitation which give rise to memory standards with the confusingly similar names of extended memory and expanded memory. At one time memory beyond 640K was only found on expansion cards but since some motherboards now offer extended/expanded memory it is important to be aware of the implications from the start.

On an AT compatible machine the physical constraint of 20 address lines no longer exists and, in fact, the 80286 can address up to 16Mb linearly. Such memory above 1Mb is referred to as *Extended* memory. However, the operating system limitation still applies and MS-DOS actually uses the 80286 in its 'real' mode in which it emulates the constraints of the 8086. Some software does switch the processor from real mode into 'protected' mode thereby allowing extended memory to be used but this is rare as it demands a much greater degree of software sophistication.

The other possible way to use this memory is to utilise one of the BIOS routines which swaps a block of data between base and extended memory. This is the method used by MS-DOS to implement a RAM disk in extended memory and this will probably be the most likely application of it.

Expanded memory employs a technique which can be used with ATs and PCs. The memory map reveals two 64K blocks which are officially designated 'other use' and have been essentially unused except for ROM cartridges in the IBM PC Junior. Certainly RAM could be put here but this would only give a maximum 128K non-contiguous expansion. Instead, in expanded memory, an empty 64K block in the memory map is used as a window into a much larger area of paged memory. So, for example 1Mb would appear as 16 pages. The standard for page switching is the Lotus/Intel/Microsoft EMS standard. Memory adhering to this standard can either be used by specially written application software or by MS-DOS to create a RAM disk.

banks are available allowing configurations up to 640K or 1MB to be used even though memory beyond 640K is of less general use than so called base memory up to this level.

There are clearly a number of decisions to be made, most fundamentally the processor type and speed. The decision comes down to a trade off between power and price. If it is intended to experiment with true 16-bit interfacing or if a major requirement is say PCB CAD with auto-routing then a machine based on an 8088 must be discounted. The turbo version of a board will often be only a little more expensive than the single (low) speed version. It is worth bearing in mind the overheads of choosing a high clock speed though — namely more expensive lower access time RAMs and very much more expensive floating point co-processors (8087 or 80287) although it is unlikely that many will opt for adding this chip.

Putting it all together

The advantage of a large number of expansion slots is obvious. A lower number, on the other hand, results in a physically smaller board allowing use of a more compact cabinet and also gives the advantage of lower potential power consumption with PSU size and cost implications.

The choice of a board wih a 512K RAM limit is probably somewhat short-sighted as some software does require a full 640K to operate. This discussion refers to RAM capacity, the actual RAM fitted is nearly always zero on motherboards so there is always the possiblity of minimally populating initially and adding extra on-board memory at a later date.

It is also worth pointing out that the mother board may not include BIOS — if not it will have to be purchased separately so watch out for this. The BIOS is EPROM resident firmware Basic Input/Output System facilities which are used by MS-DOS. If the BIOS is bought separately it is important to recognise that the BIOS for a PC is different to that for an AT compatible.

As a final point before leaving the topic of motherboards, some will be found to include a floppy disk controller and/or serial/parallel interfaces. If this proves to be the case, then clearly cards offering these functions will not be required additionally. This must be considered the exception rather than the rule.

Power Supply

Power supplies intended for use in PCs have a number of factors in common, irrespective of the manufacturer. They have switched mode circuitry, are totally housed in a screened metal box with a fan and most importantly give outputs of +5V, +12V, −5V and −12V. The outputs are on flying leads terminated in the appropriate connectors for powering the motherboard and disk drives. The respect in which PSUs differ is their power output, 130W, 150W, 180W, 200W and 220W being common specifications.

The smaller supplies generally have outputs for two disk drives whereas those at the top of the range can often power four drives in addition to the motherboard. AT type motherboards generally draw more current than PC types and clearly the greater the number of expansion slots the larger is the potential power requirement. 150W is usually considered the maximum size necessary for an 8-slot PC with up to two disk drives. A 200W supply is the standard type for a full size AT whereas for those with just six expansion slots, 180W or less may be sufficient. The 220W PSUs are normally only required for 80386 based machines.

This is an area where there is the possibility of substituting a non-PC component if one can be found at the right price, however, PC PSUs are quite competitively priced. If substituting, the following typical output figures for a 130W supply will give some idea of the current consumption at the various voltages: +5V at 15A, +12V at 4A, −5V at 0.4A, −12V at 0.25A. Please also make sure the physical size of any substituted PSU is consistent with being fitted inside a standard PC case (if indeed you intend to use one).

Keyboards

The first thing to point out about keyboards is that a standard serial or parallel ASCII encoded type cannot be used. Instead one of the special PC compatible keyboards should be used. Although other variants can be found, the most common ones are the 84-key type and the 101/102-key types otherwise known as the enhanced AT keyboard. The main difference between the two is that the larger variant has a separate cursor control pad between the 'QWERTY' block and the numeric pad. The 84-key type has these cursor control functions (up, down, left, right, home, page-up and so on) as a shift of the numeric keyboard keys. As a rough convention, 84-key keyboards are used with PC compatibles and 101/102-key versions with ATs. There is actually no technical reason for this convention and if it is desired to have a more ergonomic keyboard on a PC or shave a little off the cost of an AT then this could be reversed.

We should also consider keyboard language. It will be noticed that the AT enhanced keyboard was described as having 101/102 keys. The fact is that the US version has 101 keys whereas the international versions (including the UK type) have 102 keys. It is probably fair to say that most people reading this article will not be interested in the European variants so the choice is between US and UK. Well, from a compatibility point of view it doesn't really matter, any flavour of PC keyboard will attach to any PC as the MS-DOS operating system provides drivers for all the variants. In addition, any character which does not have a corresponding key on the keyboard (such as £ on a US or Ü on a French) can be generated by use of the Alt key at the expense of extra key depressions. So, the decision comes down to personal preference.

Disk Drives And Controllers

Unlike most of the home computers where a disk drive was considered a luxury add-on, the floppy disk drive is an absolute essential on a PC or AT compatible and a hard disk is a highly desirable extra. As another of those conventions which have no technical reason behind them (other than the fact that disk drive technology had progressed between the introduction of the PC and the birth of the AT) PCs have 360K floppy drives whereas ATs have 1.2M drives. These types of drive are both of the 5¼in variety and although never part of IBM's PC range, we now also have the 3½in drives of the type found in the PS/2 to consider. 3½in disks have capacities of 720K or 1.44M. So long as the disk controllers match, any of these floppy disk drive may be used on any PC or AT compatible — it all depends on whether it is intended to stay with convention and/or inside a budget.

Usually a 1.2M drive can read and write 360K disks although this cannot be relied on. A 360K drive, of course, cannot read or write to 1.2M disks.

There is an operating system consideration too. The newer disk drive types are only supported on the more recent versions of MS-DOS. It is unlikely that DOS of an earlier version than 3.2 will be obtained but it should be borne in mind that V3.3 is required to support the 1.44M drive.

So if anything can plug into anything how do we decide on disk configurations? As always, a lot of this will come down to price. 360K drives are by far the cheapest and they also happen to use the least expensive media. 3½in disks are particularly expensive but in terms of pence per K there probably isn't too much difference. Of course it is possible to put a mixture of disk drives into a single machine if there is a good reason to do so and this is simplified by the fact that some controllers will support more than one standard. Use of a 1.44M 3½in drive may be particularly attractive on an AT compatible as it then gives the option of substituting OS/2 for MS-DOS and effectively upgrading to a PS/2 (almost).

Although for the purpose of this article I shall consider a hard disk drive as an add-on rather than part of the basic machine, considering it at this stage could save some money in the long run. It is possible to obtain controller cards which support both hard and floppy disk drives, so if it is intended to add a hard disk at a later stage it may be worthwhile investing in a combined controller at the start. The circumstance in which this wouldn't make sense is if one of the increasingly popular hard cards is eventually added. These cards combine the function of a hard disk controller and the hard disk in the single unit hence obviating the need for a separate hard disk controller.

Although it is probably true to say that virtually anybody can manufacture something like a mother board which is totally electronic, disk drives from an unknown manufacturer can be more suspect. This being the case, when selecting disk drives and more particularly hard disks, unless there is a very significant price saving and you're prepared to accept a possibly more unreliable product then stay with the big names (Teak, Suggart, Seagate and so on).

Video Card

This is the last system component which has to be considered as absolutely essential and once again a bewildering array of choices faces us. Fig.3 gives a run down on the screen modes provided by the various cards and should be used as a basis for coming to a decision. Some standards (such as the PGA) are virtually obsolete and most people will restrict their

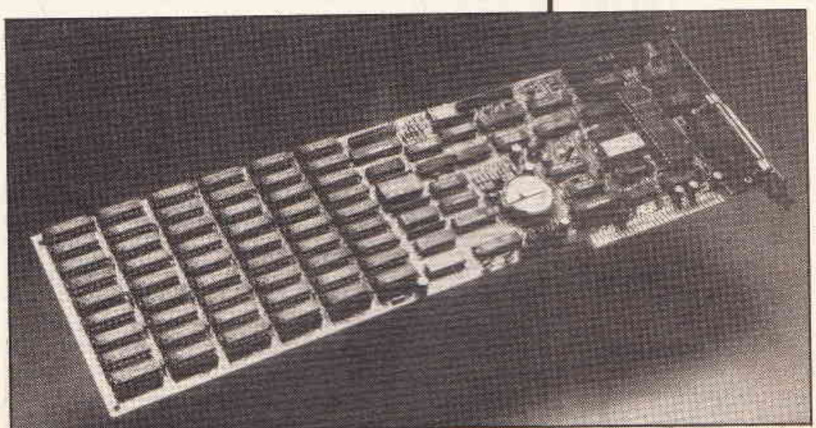
PROCESSOR TYPES

8086 This is the base level Intel 16-bit processor. It is not commonly found in PC compatibles although the Amstrad PC1512 and PC1640 are notable exceptions to this rule. The processor has a 20-bit address bus and is therefore able to address 1MB of memory.

8088 The original IBM PC processor and still the one most widely encountered in clones. It is essentially an 8086 internally but with an 8-bit external data bus. The purpose of this restriction was to allow it to be used with cheaper 8-bit peripherals and to reduce the chip package size. However, having effectively to do two memory accesses to read or write a 16-bit word causes it to be inherently slower than the 8086.

80286 An 8086 with on-chip memory management and protection and hardware support for multitasking (a feature only used by the OS/2 operating system of the PS/2 range). This is the processor found in the PC/AT and compatibles. Its pipelined architecture, high speed bus and interrupt response times give a base level (8MHz) chip about six times the power of a base level (4.77MHz) 8086. Its 24 address lines allow 16MBs to be addressed. The instruction set is upwards compatible with the 8086/8088.

80386 A 32-bit processor offering the advanced features of the 80286. Further improved instruction pipelining and on-chip address translation ensures very high speed operation and figures of 4-6 MIPS are claimed. As the current top of the range, 4Gb of memory can be addressed but once again compatibility with the lower end processors at an object code level is maintained.



AST's Sixpack Plus memory expansion board

Mode	Text Format	Graphics Resolution	Colours	Display adapter
0	40x25		2	MDA
1	40x25		16	CGA
2	80x25		2	MDA
3	80x25		16	CGA
4		320x200	4	CGA
5		320x200	2	CGA
6		640x200	2	CGA
13		320x200	16	EGA
14		640x200	16	EGA
15		640x350	2	EGA
16		640x350	16	EGA
17		640x480	2	VGA
18		640x480	16	VGA
19		320x200	256	VGA
—	80x25		2	Hercules
—		720x348	2	Hercules

Fig.3 The IBM 'official' screen modes

VIDEO STANDARDS

The choice of video cards is extensive. Figure 3 lists the more common of IBM's official screen modes indicating which modes are provided by which cards. In fact the last mode is not an offical IBM one but the Hercules card has nevertheless become an industry standard.
It should be borne in mind that the lower resolution modes are not lost in going to a higher performance card. In other words all the CGA modes are provided by the EGA card and all the EGA (and hence CGA) modes are available on the VGA card.

There are also enhanced EGA cards provided by a number of manufacturers. In addition to the official EGA modes these provide those VGA modes which do not require more than 64 colours (modes 17 and 18) and very often go beyond even this level giving resolutions of say 752x410 and 800x600. Furthermore, enhanced VGA cards are now starting to hit the market (at a not insignificant price), providing these higher resolution modes in a greater number of colours.

choice to Hercules, CGA and EGA or possibly also the VGA if upwards compatibility with the PS/2 is being considered.

The Hercules gives the lowest cost graphics product, especially since it enables a monochrome monitor to be used. The CGA card is generally available for about the same sort of price as the Hercules but of course a colour monitor is now necessary increasing the overall system cost and CGA text is pretty appalling. It is probably fair to say that anyone who is serious about colour graphics will opt for EGA. The EGA card supports the CGA modes as a subset but a result of supporting both 200 and 350 line formats is that a special EGA dual standard monitor is required. As an alternative, however, most EGA cards now available solve this problem by repeating each line in the CGA modes twice to give 400 lines and implementing the EGA modes as a 350 line window within the 400 display lines, obviating the need for a dual standard monitor. However, these cards often provide graphics performance in excess of EGA but to make use of these modes in addition to CGA/EGA a multi-synch type monitor is required. It is therefore important to make sure whether a particular card is a clone of a basic EGA or one of the so called enhanced EGAs.

I/O Cards

Although perhaps not absolutely essential, most people would consider a Centronics printer port and at least one serial RS232 port to be standard equipment. The options here are more limited than in most of the areas so far considered and the most likely configuration will be a combined serial/parallel I/O card which will provide both functions. Of course if it was desired to have, say, only Centronics or only RS232 then such a card could be obtained but it wouldn't be much less expensive than a combined card. On the other hand, many video cards include a parallel printer port and in this case then clearly a serial I/O card will be obtained separately. A myriad of other types of I/O card are available but this would take us into the realm of add-ons.

The Case For The Third Party

Once again, the case is a component which we could at a pinch do without or perhaps built out of chipboard but I suspect most people will be prepared to spend that extra £40 to smarten the machine up and give it that truly professional image. PC or AT cases differ in size depending mainly on the size of the motherboard and power supply. The larger cases also allow up to four disk drives to be fitted whereas the smaller ones limit this to two (excluding any hardcards which fit vertically in the expansion slots).

The other point to note about cases is the front panel controls and indicators. Some have a keyswitch to lock the keyboard, push button switches for switching clock speeds and reset and indicator lamps to show 'Turbo', 'Power' or 'Hard Disk Access'. It is important to ensure that any switches or indicators required by the motherboard are available or can be fitted. However, some switches appear to be necessary but in fact are not. For example although many motherboards provide the facility to switch clock speeds by use of a push button, there is often an alternative method provided by the BIOS in the form of keyboard key combinations (Ctrl Alt –).

Putting It All Together

There really isn't too much to be said about this. Most people will find it fairly obvious how to plug the various component parts together. What goes where doesn't vary much from one clone to another. The one area which may be less obvious is the configuring of links and DIL switches. As this varies from manufacturer to manufacturer this cannot be covered here but on buying any PC system component, check a manual is provided (even though the English may be translated in a quaint manner!).

Spending Money

The following is a list of some British companies known to sell constituent parts of PC compatble systems.

AAA Trading Ltd.,
10, Greycoat Place,
London SW1P 1SB.
Tel: 01-222 8866

Atomstyle Ltd.,
Millmead Business Centre,
London N17 1QU.
Tel: 01-801 1838

DRAM Electronics Ltd.,
Unit 12,
Kingston Mill,
Chestergate,
Stockport SK3 0AL
Tel: 061-429 0626

This is by no means a complete list, nor are they *necessarily* the cheapest, so check price lists from them, look for other suppliers and shop around. Don't assume that because a particular supplier is competitive on motherboards, it is the place for the cheapest disk drives.

Building up a system this way usually gives a significant price advantage over the big name low cost clones and will be slightly cheaper than the anonymous clones also available from many of these companies. Table 1 quantifies this by giving typical costings for a

PS/2

What about the PS/2? Does it really make sense to start down the path of PC compatible computing more than a year after IBM have replaced this range of computers by its new PS/2 range? The answer to this question is 'Yes' but it's appropriate to give the reasons for this to assure readers this route won't lead to obsolescence in a short period of time.

The PS/2 range as available in the UK currently consists of models 30, 50, 60 and 80. The top three models are truly what people consider as the new generation, having Microchannel Architecture (the new bus specification and corresponding add-on card format) and allowing use of the new multitasking OS/2 operating system as an alternative to MS-DOS. The models 50 and 60 have 80286 processors whereas the model 80 has an 80386, the 80286 being the base level processor for use of OS/2. The model 30, on the other hand is a totally different machine. It has the superficial features of the PS/2 range in terms of styling and use of 3½in disk drives but can only run the MS-DOS operating system and has the same bus specification as the original PC. To all intents and purposes, the de facto standard for base level personal computing has not changed. By putting a 3½in disk and VGA card into a PC we virtually have a PS/2 30. True PS/2 clones are slow to take off and although IBM no longer make a PC or PC/AT compatible, the third parties are still very strong in this area. Furthermore there is nothing inherent in the AT architecture to prevent the running of the OS/2 operating system and thereby give PS/2 50 or 60 functionality. The only difference, of course, would be the lack of the Microchannel Architecture (MCA) bus. Even this needn't be a problem. Certainly it means that any true PS/2 cards couldn't be plugged in but it has to be said that the PC bus has been a standard for so long that virtually every imaginable add-on board is available in this format.

New moves by PC manufacturers made recently make the future of original PC compatibles and cards even more secure. A consortium including such big names as Compaq, AST, Wyse and Tandy (nine companies in all) are developing a competing architecture to the MCA which will support the 32-bit data bus of the 80386.

Called the Extended Industry Standard Architecture (EISA) the AT bus (and hence also the PC bus) is a subset, hence allowing cards designed for these earlier machines to be used on the new bus.

bottom end PC compatible and a bottom end AT compatible.

It should be borne in mind that these prices do not include a monitor or the MS-DOS operating system nor do they include RAM since at the time of writing the price of RAMs is (hopefully, temporarily) extremely high and would therefore give a false impression.

These prices may look attractive but if we're prepared to be that bit more adventurous, top end systems can be built up even more cheaply. The secret is to buy from the far east, probably Taiwan. To give an example, let's consider an 80386 based machine.

This is Intel's true 32-bit processor and we haven't really considered them so far in this article because the pricing would normally be prohibitive (almost £1000 for the motherboard). A recent advertisement for a Taiwanese 20MHz 80386 motherboard (excluding RAM and processor) gave a price of $345 (at today's exchange rate, less than £200).

Admittedly this is really a high volume price and such companies are not really in the business of providing one-offs to end users. Nevertheless, it will probably be possible to obtain a 'sample' for a slight extra handling charge. The example given is a high value, low weight product and is therefore the type of product which is particularly efficient to import. Because of freight charges, low value, heavy items such as power supplies and cases won't be too attractive to buy from overseas.

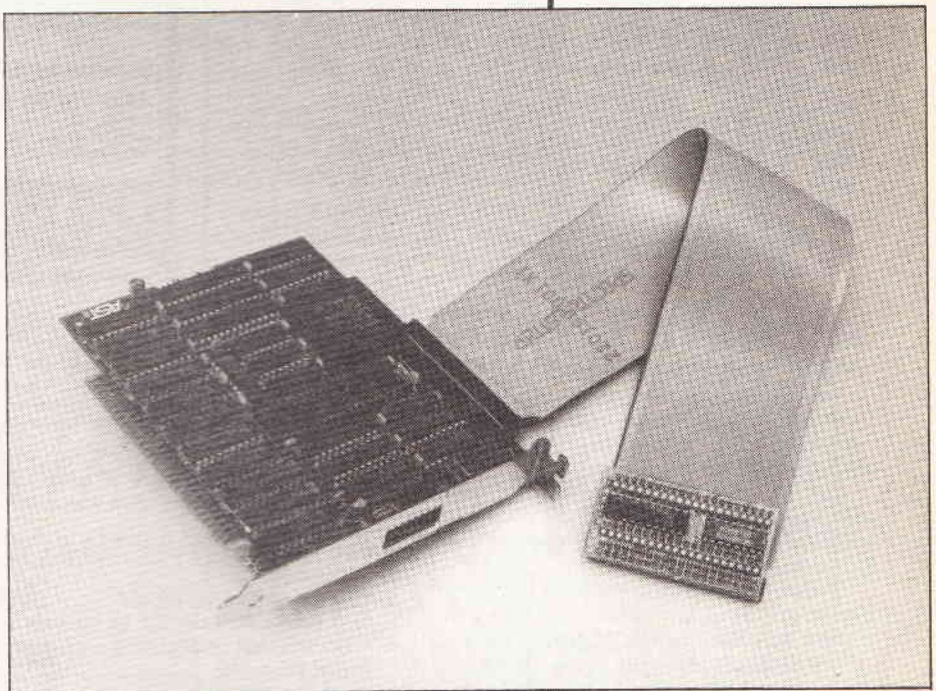
A few points should be made about buying from the far east. Firstly the prices quoted will be F.O.B. in US$. That is a price including nothing more than carriage onto an aircraft in Taipei (or wherever). It is the buyer's responsibility to pay for the air freight and once it's in the UK to pay import duty and VAT.

This can all get a bit complicated so if your're tempted to dabble in a bit of importing then contact a forwarding agent (listed under the classification Freight Forwarding Agents or Import Agents in the Yellow Pages) who for a small fee will be able to relieve you of all this and also, of course, advise as to how much all these extras will come to before ordering. We're not going to give any examples of far eastern suppliers essentially because there are so many of them and a small sample couldn't be representative but keep your eyes open in the PC related press. One very useful publication is *Asian Sources Computer Products*, it is not too generally available but you should be able to obtain a copy from the publishers at:

Trade Media Ltd.,
Grand Cayman,
Cayman Islands,
British West Indies.

The Future

Clearly we are predicting a rapid increase in the popularity of PC compatibles for home use. Furthermore we expect such machines to appeal to the more technically minded. Certainly the technology is not new nor has this trend just begun but at the sort of pricings we now see, this will surely mushroom. ETI



AST's Hotshot-286 processor substitution card

	PC		AT	
Motherboard	4.77/10MHz, 640k	49.00	6/12MHz, 1M	215.00
PSU	150W	40.00	200W	60.00
Video card	CGA/Printer	27.00	CGA/Printer	27.00
F. Disk controller	360k	15.00	360k/720k/1.2M	23.00
F. Disk drive	360k	59.00	1.2M	68.00
I/O card	Serial	14.00	Serial	14.00
Keyboard	84 keys	32.00	102 keys	43.00
Case	PC type	30.00	AT type	45.00
	TOTAL	£266.00	TOTAL	£495.00

Table 1 Typical 'shop-around' prices for a basic PC and AT

intends to support PC compatibles. A general article on PC interfacing is planned and it is also hoped to present designs for a number of add-on cards. However, this depends very much on the response and contributions we receive. Although we regularly make appeals for articles it is appropriate at this stage to say that we would be particularly interested in designs for PC add-ons.

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8085A-2	3.90
80C85A	4.50
80C86AL-2	18.90
CDP6805E2E	11.30
CDP6805E3E	12.19
D8748H	46.03
D80287-8	180.00
D80287-10	216.00
EF6809EP	4.42
HD6303RP	10.40
HD6305X2P	9.10
HD6305Y2P	10.40
HD63B03XCP	13.52
HD64180R1P10	19.50
HD64180R1P6	17.88
HD64180R1P8	19.50
HD68000-12	73.81
HD68000P-8	15.20
HD6800P	5.25
HD6802P	4.94
HD6803P	7.49
HD6809P	7.80
HD68B00P	5.23
HD68HC000CP8	21.45
HD68HC000P10	19.50
HD68HC000P12	27.30
HD68HC000P8	17.94
HD68P01M0	78.00
INS8035N-11	3.38
INS8035N-6	2.90
INS8039N-6	3.94
INS8040N-6	5.80
INS8060N	13.65
MAB8031AH-12P	5.79
MAB8039HL-11P	4.45
MC14500BCP	6.10
MC146805E2P	9.69
MC6800P	4.75
MC68000P8	9.25
MC68000P10	10.94
MC6800P12	15.73
MC68008P8	13.37
MC68010P10	29.38
MC68010P8	20.41
MC68701S	38.87
MC68B09P	11.44
MC68HC000P-10	18.15
MC68H000P8	15.90
MSM80C31FRS	10.50
MSM80C85A-2	8.90
MSM80C85ARS	5.07
MSM80C86RS	15.80
NS32008D6	37.96
NS32016D6	43.81
NS32032D6	58.50
NS87P50D-6	54.08
NSC800N	11.60

	£
NSC800N-1	7.09
NSC800N-4	15.66
P8031	9.60
P8052AH	26.04
P8085AH	5.88
P80C31BH	12.38
PCB80C31-12P	11.25
PCB80C39-11P	5.04
R6502	4.73
R6502AP	7.31
R6504	9.66
R65C02P2	6.97
R65C02P3	10.92
R65C102P2	9.21
R65F11P	32.77
TMPZ84C00AP-6	4.50
TMPZ84C00AP-8	5.40
TMPZ84C00P	4.90
TMS32010NL	28.35
TMS320C10NL	37.80
TMS320C10NL-2	47.25
TMS320C25GBL	99.07
TMS9900NL	33.15
TMS9995NL	20.30
UPB8284AD	3.32
UPB8288D	6.23
UPD70008C	3.47
UPD70108D8	12.05
UPD70116D-8	17.88
UPD780C-1	2.98
UPD780C-2	3.35
UPD8035HLC	2.95
UPD8039HLC	3.70
UPD8085AHC	2.65
UPD8085AHC-2	3.44
UPD8086D-2	12.22
UPD8088D	13.44
UPD8088D-2	13.44
UPD80C35C	4.44
UPD80C39HC	4.33
UPD80C40HC	5.33
UPD8741AD	13.17
UPD8748HC	10.11
UPD8748HD	12.78
UPD8749HC	11.62
UPD8749HD	13.26
Z80A CPU	1.70
Z80B CPU	3.40
Z80H CPU	8.07
Z80C00AB6	12.64
Z8671	8.94
Z8681AB1YN	8.38
Z8681B1YN	6.99
MICRO SUPPORT IC's	
1488P	0.60
1489P	0.60
14C88N	1.25
14C89AN	1.25
6520P	4.20
6522AP	5.40
6522P	3.30
6532P	6.75
6551P	6.40
6821P	1.40
6840P	3.10

	£
6845-1	9.70
6845P	6.40
68B21P	3.00
8251	2.90
8251A	3.40
8259	2.95
8259A	3.40
82C54	5.95
82C54P-8MHz	5.90
82C59A-2RS	4.50
AY-5-8136	6.45
AY-5-8136-006	7.80
AY3-1015D	4.65
CD82C86H-5	9.74
CDP6402CE	5.72
COM8116P	8.92
CP82C62	5.72
CRT-7004-001	9.90
D82C284-8	12.90
D82C288-10	11.60
DM86S126CQJN	24.57
DP8212N	2.77
DP8216N	2.57
DP8224N	3.33
DP8226N	2.57
DP8228N	5.97
DP8304BN	2.12
DP8304BWM	3.21
DP8409AN	20.80
DP8419N	30.16
DS1231	5.90
DS1231-20	6.10
DS1232	5.90
DS1287	26.64
DS14C89AN	1.25
HCPL-2630	5.86
HCPL-2730	3.75
HCPL-2731	4.25
HCPL-4100	5.82
HCPL-4200	5.82
HD146818AP	4.94
HD146818P	4.55
HD46508AP	10.11
HD6321P	3.90
HD6340P	8.06
HD6345SP	10.40
HD63484P-8	44.20
HD63484P-4	41.60
HD6350P	3.90
HD6821P	3.09
HD6840P	4.78
HD6845OU8	70.20
HD6845SP	8.45
HD6850P	2.47
HD6852P	3.81
HD68A50P	3.59
HD68B21P	4.29
ICM7170IPG	10.61
IM4702IPE	6.37
IM6402-1-IPL	5.53
IM6402AIPL	11.32
IM6402IPL	5.07
IM6403IPL	9.19
INS8154N	12.40
INS8243N	2.18
INS8250AN	8.95
INS8250AV	11.60
INS8250NB	7.09
INS82C50AN	12.25
INS82C50AV	13.52

	£
M82C88AS	16.36
M8719B1	3.69
MAX359CPE	7.60
MC14411P	11.17
MC146823P	5.54
MC3447P	6.24
MC3448AP	4.42
MC68488p	8.84
MC6854P	9.01
MC6875P	11.99
MCT-61	1.40
MM58167AN	11.78
MM58174AN	12.84
MM58274BN	8.70
MSM5832RS	3.64
MSM81C55Rs	5.07
MSM821C12RS	5.98
MSM8251ARS	4.65
MSM82C53-5RS	4.65
MSM82C55A5RS	4.97
MSM82C59A-2RS	8.55
MSM82C84A-2RS	6.90
MSM82C84ARS	5.95
MU08EP	7.40
NS16450N	11.60
NS16C450N	13.13
NS32081D6	58.50
NS32082D6	52.65
NS32201D6	11.66
NS32202D6	35.10
NS405A12N	23.01
NS455A12N	36.14
NSC810AN-4	15.86
NSC831N-1	8.06
P8185	30.55
P8256A	12.09
P8271	48.54
P8274	16.78
P8291A	34.01
P8292	28.99
P8293-10	21.33
P82050	8.85
P82510	14.95
PCF8573P	2.91
R6520	4.65
R6522	4.65
R6522AP	7.02
R6532	5.98
R6545-1	9.52
R6551	6.55
R65C21P	8.87
R65C21P2	5.23
R65C22P2	5.07
R65C51P2	11.18
SCB2675BC5N40	11.25
SCN2651CC1N28	6.46
SCN2671AC1N40	12.66
SCN2674BC4N40	9.52
SCN2681AC1N24	9.65
SCN2681AC1N28	9.41
SCN2681AC1N40	7.03

	£
SCN68681C1N40	6.34
TIM9902ANL	4.45
TIM9904ANL	5.92
TMPZ84C20P	3.12
TMPZ84C30P	4.36
TMS9129NL	15.15
TMS9901NL	4.64
TMS9914ANL	17.37
TMS9937NL	10.37
UPB8212C	2.46
UPB8282C	3.64
UPB8283C	3.71
UPB8286C	3.85
UPB8287C	4.37
UPD71051C	3.02
UPD7201C	6.50
UPD7219C	16.37
UPD7225G	2.77
UPD765AC	7.05
UPD8155HC	3.37
UPD8155HC2	4.47
UPD8156HC	3.71
UPD8237AC5	5.62
UPD8243HC	2.22
UPD8251AFC	2.67
UPD8253C2	2.33
UPD8255AC2	2.18
UPD8257C2	3.60
UPD8259AC2	2.85
UPD8279C2	2.74
UPD82C43C	3.78
Z80A-CTC	2.10
Z80A-DART	5.40
Z80A-DMA	6.05
Z80A-PIO	2.30
Z80A-SIO	4.75
Z80A-SIO/1	5.90
Z80A-SIO/2	5.90
Z80B-CTC	3.40
Z80B-DART	5.72
Z80B-PIO	3.40
Z80B-SIO	7.41
Z84C20AB6	10.89
Z84C30AB6	10.89
Z84C41AB6	22.43
Z84C42AB6	22.43
Z8530A	9.30
Z8536A	8.06
DYNAMIC RAM	
4164-15	POA
4416-15	POA
441464C-12	POA
41256C-15	POA
HM50464P-12	POA
TMS4464-12	7.60
TMS4464-15	7.60
MB8264A-12	2.40

STATIC RAM	£
6116LP-2	POA
6116LP-3	POA
6264LP-15	POA
CDM6116AE3	POA
CXK5864PN-15L	POA
CXK58256P-12L	17.80
HM4334P-3	3.40
HM62256LP-10	18.90
PCD5101P	2.75
TMS4016-15NL	POA
DUAL PORT RAM	
IDT71130L-100P	17.40
IDT71130S100	17.40
IDT7132LA-100P	15.50
E/EE/UVE PROMS	
27C64-15/12.5V	7.16
27C64-20/12.5V	5.85
27256-25	5.00
27C256-15	5.60
27C256-25	7.20
27C256-25/21V	7.20
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X2816AD	9.24
X2864AD-35	18.50
X2864AP-35	16.95
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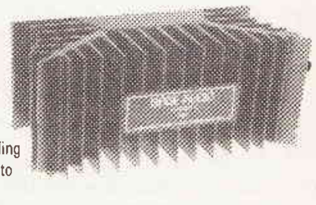

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Allow 28 days for delivery.

Please supply ...... Interspecs (RO ET5) at £29.95 plus £1.95 p&p per order.
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Name ....

Address ....

....

....

Please debit my ACCESS/VISA card No .... **to the sum of £** .... **Signed:** ....

INTERBEEB £49.95

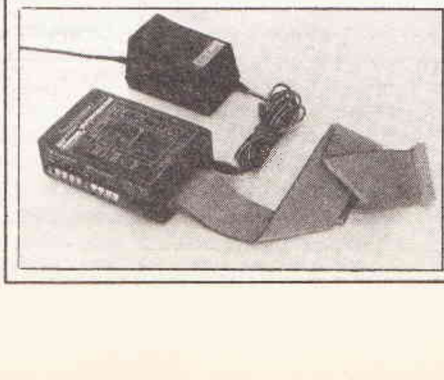
The Interbeeb unit connects to the BBC micro's 1MHz bus expansion connector and is supplied complete with its own power supply unit.

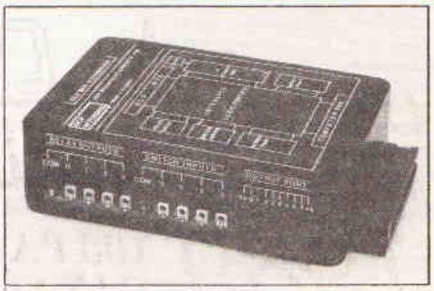
The interface unit is housed in a plastic case approx 4½x3x1in which contains the top quality double sided PCB and interface connectors.

- **8-bit input port**
- **8-bit output port**
- **four switch sensor inputs**
- **four relay-switched 12V 1A outputs**
- **eight channel multiplexed analogue to digital converter**
- **precision 2.5V reference**
- **external power supply**
- **15-way expansion bus**

All sections of the interface are memory mapped in the 1MHz expansion map for maximum ease of use and compatibility with existing peripherals.

The expansion bus provides all the data and address/control signals for the addition of further DCP modules or home-built devices. All the information required for using additional devices is included.





INTERSPEC £29.95

The Interspec unit plugs directly onto the expansion edge connector of the Spectrum to provide a full range of interfacing facilities.

The unit is housed in a plastic case approximately 4½x3x1in which contains the top quality double sided PCB and interface connections.

- **8-bit input port**
- **8-bit output port**
- **four switch sensor inputs**
- **four relay-switched 12V 1A outputs**
- **eight channel multiplexed analogue to digital converter**
- **15-way expansion bus**

All sections of the interface are I/O port mapped and designed for maximum compatibility with existing Spectrum peripherals. Power is supplied through the Spectrum edge connector.

The expansion bus provides all the data and address/control signals for the addition of further DCP modules or home-built devices. Connection is by multi-way PCB connector and all the information required for adding further devices is given.

COMPETITION & RESULTS

ETI has huddled together in a corner with Specialist Semiconductors to bring you the competition to end all others (well this one anyway). This is your chance to become the proud owner of a complete Variat-Ion ioniser with all the trimmings (though you'll have to make up the kit yourself, but then you are an ETI reader so that will be no problem). For two lucky runners-up we have Quest-Ion kits to give away.

All you have to do is to find the odd one out in the following lists of items. It's a dead cinch for intelligent ETI reader types so it shouldn't take you a trifle. When you've worked them out, write the odd one out for each list next to the list number on the back of a postcard or sealed envelope along with your name and address and send it to:

ETI Ion Competition
I Golden Square
London W1R 3AB

to arrive not later than February 28th.

1. Fortran Latin Pascal Forth
2. Transistor Tripod Diode Milking-stool
3. GaAs GaPs GaAsP GaP
4. Direction Question Variation Negotiation
5. Silicone Geranium Gallium Indian
6. BY127 OM335 1N4007 BAT42 1N4148

The Nite Sentry competition in the December 1988 issue flooded Golden Square with hopeful entries. Alas only two of these made it through the rigorous selection procedure (the Editor's now infamous Lithuanian Trilby): D. C. Horwood from Cheltenham and J. Ella from Wokingham.

In case you're still wondering what the answers were, the ingeniously cryptic addresses were:

84 Charing Cross Road (the book, film, clockwork toy, etc)
32 Windsor Gardens (Paddington Bear)
10 Rillington Place (the incident and film)
33 Railway Cuttings (Hancock's Half Hour)
50 Wimpole Street (The Barrett's residence)
1 Golden Square (oh, come on!)
77 Sunset Strip (US TV)
221b Baker Street (elementary, Watson)
100 Acre Wood (Winnie, Christopher Robin et al)
11 Downing Street (the Chancellor of the Exchequer)

In addition, the first 100 entries will soon be receiving a free copy of the Maplin Catalogue and if you think we are going to list all of them you can think again . . .

Thanks to all who entered. Keep reading the mag for more competitions.

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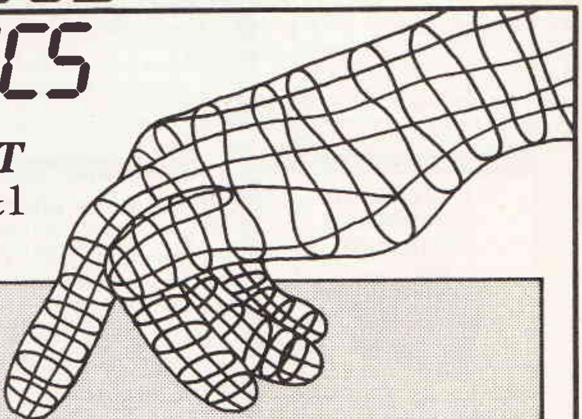

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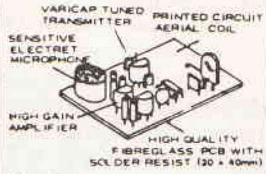

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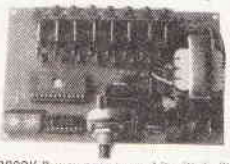

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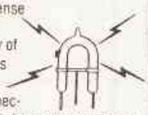

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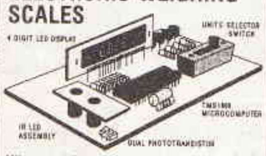

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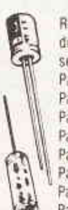

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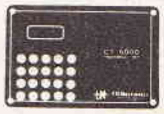

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SUN POWER

a-Si

Andrew Armstrong looks at amorphous silicon in general and photovoltaic cells in particular

The possibility of obtaining useful amounts of electricity from sunlight by photovoltaic generation has long been an intriguing possibility 'just around the corner'. It still seems to be around the corner but at least the corner is now perceptibly closer. Mass produced amorphous silicon solar cells open the door to many practical applications of solar generated electricity, though the national grid is not obsolete just yet.

The solar energy impinging on a square metre of ground at the equator on a clear day is approximately 800W. A reasonable conversion efficiency using low cost solar cells plus a reasonable storage method could permit the use of this energy, with a consequent reduction of electricity generating costs of environmental pollution.

In Britain, of course, the energy per square metre is much less but a high conversion efficiency can render its use practical.

Early satellites launched in the 1950s used solar cells costing around $1000 (£500-600) per watt. This cost was insignificant compared with the overall costs of putting a satellite into orbit but rendered solar cells uncompetitive for ground based applications.

The high cost of the solar cells arose from the fact that each cell uses a single crystal of silicon. The cost of producing monocrystalline silicon increases rapidly with size, so that solar cells were disproportionately more difficult to produce than transistors.

Costs of producing crystalline solar cells have been reduced from £550/W in the 1950s to just under £3/W. Both monocrystalline and polycrystalline cells fall into this category, each type having different strengths and weaknesses. Monocrystal cells achieve a conversion efficiency of 10-14%, while polycrystal ones manage 10-12%. Though their cost is similar at present, there is probably more scope for further cost reductions in the polycrystalline cells.

Amorphous Semiconductors

At these prices, solar cells are practical and economic for such applications as remote telecom repeaters, navigational aids and the like, as well as for such applications as small scale refrigeration in developing countries where no reliable electricity supply is available. Only recently, with the advent of a-Si (amorphous silicon) solar cells costing around £1/W, has photovoltaic power progressed beyond this level of application.

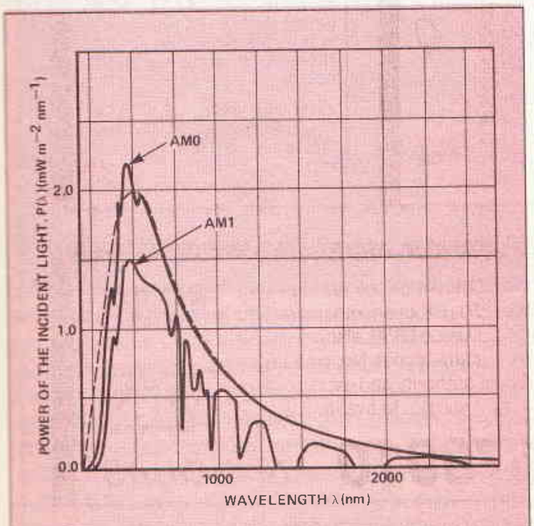
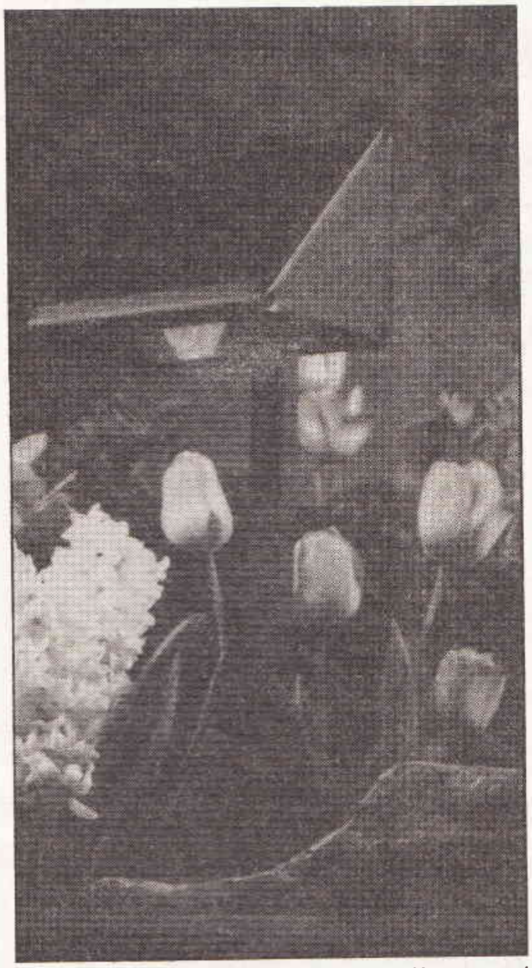


Fig.1 The spectrum of sunlight



Chronar's 'Walklite' path light with internal battery and solar cell

Amorphous semiconductor material is, as its name suggests, not in an ordered crystalline form but in a disordered glassy state. One might ask why this type of material (which is easier to produce and to work with) was not used from the start of solar cell development. The reason is the same as the reason why monocrystalline silicon is used for transistors and integrated circuits — amorphous silicon as it stands cannot be used to make semiconductor devices in the way that crystalline silicon can.

Most of the useful things which semiconductors can do arise from well defined differences in the energy levels of electrons in different states. A specific amount of energy is required to raise an electron from the valence band of energy levels (where it is participating in bonding atoms into the crystal lattice) to the conduction band in which it is free to move around. It is vital that the conduction electrons should have a reasonable lifetime before falling back to the valence band or no useful functioning can take place.

In crystalline silicon, the available bonds between the atoms are all used. Silicon has four available bonds — it is said to be four valent. When in a crystal in which there are atoms at the four positions needed to use these four bonds it is said to be four co-ordinated. The valent bonds between the atoms consist of pairs of shared electrons of opposite spin, which serve to

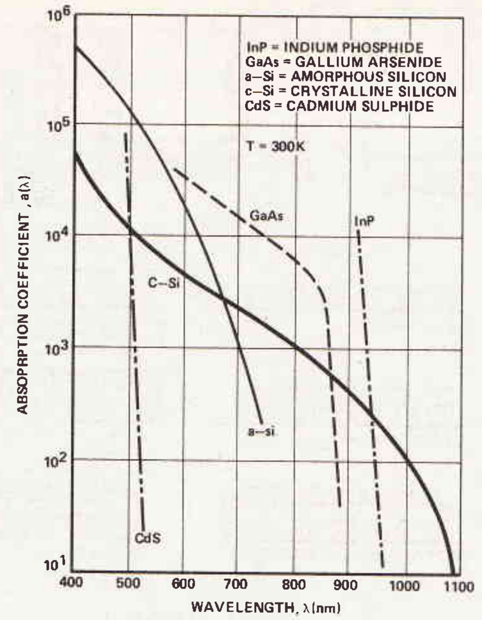


Fig.2 Energy absorption characteristics of various types of solar cell

complete the outer electron shells of the atoms involved.

This sort of bonding occurs in atoms where the outer shell has fewer electrons than the number to complete the ideal pattern for that shell. The atom can only have the number of electrons which balance the number of protons in the nucleus or else it will carry a net electrical charge.

Energy

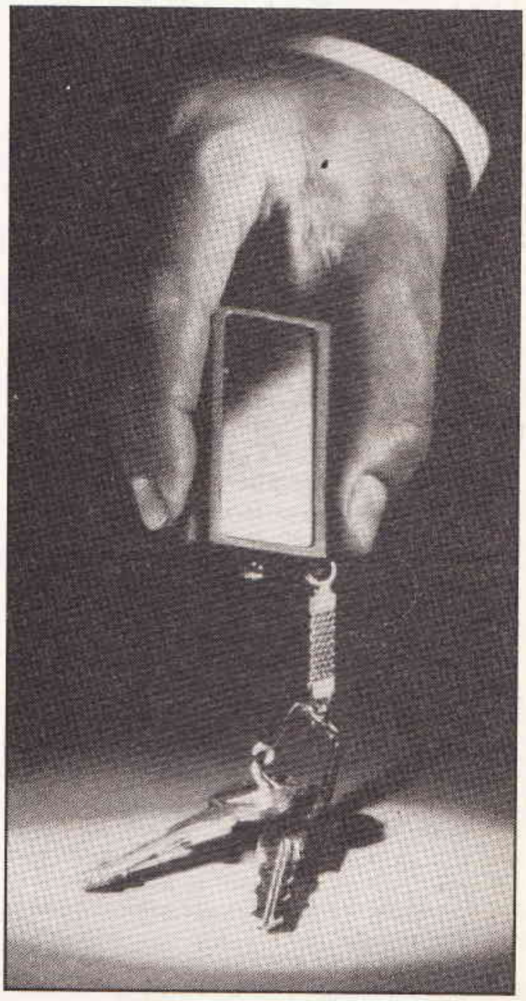
Just as water flows downhill so in general all systems tend towards the lowest energy state. Completion of all partial electron shells represents a lower energy state than non-completion but charge neutrality is a lower energy state still. Consequently an atom will not normally carry a charge to complete all shells but if it can share electrons with other atoms which also have incomplete shells, charge neutrality is maintained while the outer shells share electrons which complete their required patterns. This is a stable low energy state and such bonds are often very strong, resulting in chemically stable substances.

In an amorphous semiconductor like silicon, which is four co-ordinated in its crystalline form, many atoms are *not* four co-ordinated. They have dangling bonds which are ready to capture any passing electron of opposite spin. This completes the outer shell and charges the atom negatively. The dielectric constant of the material is sufficiently high that the fact the net electrical charge of the material is neutral overrides the effect of the localised excess of negative charge and the electron is bound firmly to the dangling bond rather than being repelled away electrostatically. This results in a very short life for electrons in the conduction band and the material is about as useful to make a semiconductor device as a piece of window glass.

Pioneering work on the electrical properties of amorphous solids by Sir Nevill Mott (then Cavendish Professor of physics at Cambridge) and P W Anderson, which earned them the Nobel prize for physics, opened the door to useable amorphous semiconductor devices. The actual process, discovered by Walter Spear of Dundee University, is to deposit silicon from Silane (SiH_4), by glow discharge (RF electron bombardment). At first he thought that it was the glow discharge which was making the important difference, by depositing the silicon differently. The physics of the situation showed that hydrogen from the silane occupies virtually all the dangling bonds, which permits electrons to remain in the conduction band for longer. It is the use of silane which is crucial.

Addition of phosgene (PH_3) to the deposition chamber dopes the amorphous silicon with phosphorous, which is five valent. In situations where the phosphorous is four co-ordinated (approximately 50% of phosphorous atoms settle this way) there is a vacancy for an electron to join with the spare bond from the phosphorous. This electron is weakly bound but while it is where the phosphorous atom is, a vacancy or hole exists elsewhere. Thus a P-type semiconductor is formed. N-type semiconductor material is made by doping with boron, which is three valent.

The conversion efficiency of a-Si (amorphous silicon) solar cells is around 7% but will probably exceed 10% by 1990 as it now does in laboratory specimens. Though more cell area is needed to give the same power output as crystalline cells, the reduced cost per unit of power output makes amorphous cells more attractive for most purposes.



The 'Keylite' solar powered keyring torch from Chronar

Figure 1 shows the spectral content of sunlight in space and after absorbtion by water vapour, ozone, carbon dioxide and nitrogen in the atmosphere. Figure 2 shows the energy absorbtion of the various types of solar cells and it can be seen that the amorphous cells are more efficient in the visible region (400-750mm). This gives rise to extended sensitivity under low light levels, where a-Si cells can be more effective than crystalline ones.

The high absorbtivity of a-Si in the visible range also means that a thinner layer of material will absorb the energy effectively. A-Si cells can be of the thin film variety, typically 1μm as compared with 0.25-0.5mm with crystalline cells.

Manufacture

One major advantage of a-Si solar cell modules is that the interconnection between cells is an integral part of the unit. The world's largest a-Si solar cell manufacturer, Chronar, uses the following processing steps: the P-I-N structure cells are fabricated by deposition of the required layers onto a glass sheet. As illustrated in Fig. 3. The first layer to be deposited is the front electrode, consisting of a layer of tin oxide which is laser scribed into strips. A-Si is then deposited and laser scribed. The final layer to be deposited is the back electrode, and this is also scribed to match with the strips of silicon. This rear electrode thus forms the contact between front and rear and is responsible for connecting the cell strips in series to give the required voltage.

Monolithic connection in this manner avoids the need to solder individual connections between cells, and is a significant factor in the competitive price of a-Si modules.

Crystalline cells are manufactured as wafers from cast ingots and by the time they have been scribed to shape, up to 50% of the base material may have been wasted. Considering the continued demand for silicon wafers from IC manufacturers (the increase in demand for RAM chips, for example, has contributed more than is generally realised to the well-publicised shortage while the production capacity catches up) the price of this base material is unlikely to fall dramatically. A-Si is cheaper and likely to remain so.

There appear to be two main companies involved in solar powered systems in the UK, Chronar and Solapak. Chronar is based in the USA, and is primarily a manufacturer of solar panels. Solapak, a UK based company, deals purely in applications, such as remote telemetry for the gas board. A sister company, Intersolar, deals with domestic products such as the Autovent. This is a ventilator which fits in the top of a car window, and leaves the car as secure as if the window were closed without the vent there. The more the sun shines, the hotter the car will tend to become, and the more efficiently the solar powered ventilator works to keep it cool.

Several other companies market cells or products in the UK. There is no indigenous British company manufacturing solar cells, and Chronar claims to be the only company manufacturing amorphous solar cells in Britain, with their substantial plant at Bridgend.

Solapak has a factory at High Wycombe to assemble systems and products. Interestingly, Solarpak is not so committed to a-Si, but prefers monocrystalline cells for industrial applications where performance is the main criterion.

Solapak was the main company involved in the Solar/Wind Energy Project at Milton Keynes. In this project, solar panels and a wind generator are used in conjunction with storage batteries to provide electricity for nine houses. A total generating capacity of 30kW is installed, with automatic switchover to mains electricity in the event that the batteries run too low. The combination of wind and solar power (80% solar, 20% wind) matches the seasonal demand for electricity and the houses are designed to use passive solar heating to minimise the electricity requirements for this most inefficient use of electricity.

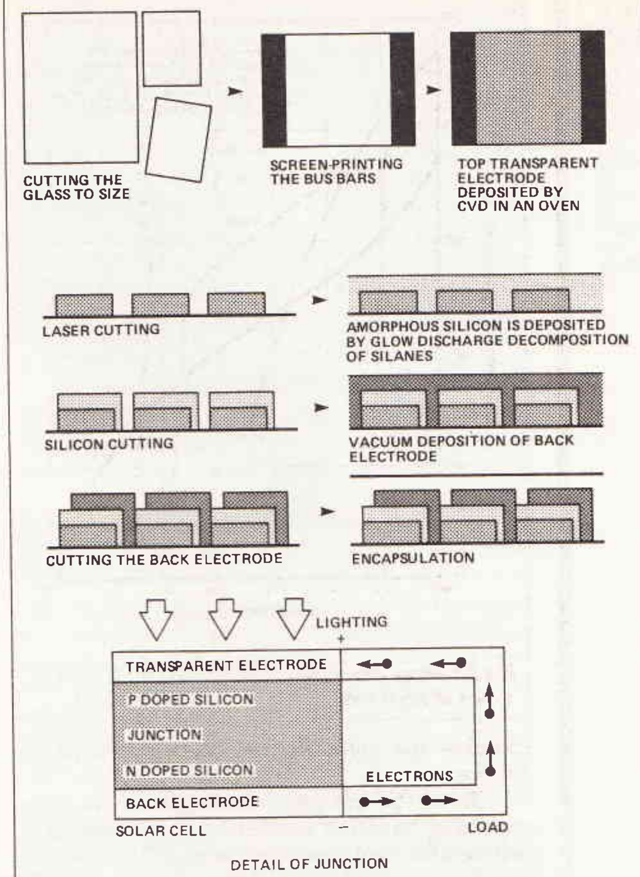


Fig.3 Fabrication of a-Si solar cells

Electrical Characteristics

A-Si cells produce approximately 0.8V off load, falling to 0.55V on load. Figure 4 shows the V-I characteristics of a typical cell. The characteristic is not linear and there is a well defined point at which maximum power is delivered to the load. An equivalent circuit giving a good representation of the characteristic is shown in Figure 5.

The precise V-I characteristic of the cells depends on the intensity of the incident light and the temperature. Both Chronar and Solapack (and probably others as well) have designed load tracking units which adjust the load applied to the photovoltaic panels to extract maximum power from them under the prevailing conditions. Such units are claimed to increase by 15% the average battery charging capability by making best use of morning and evening

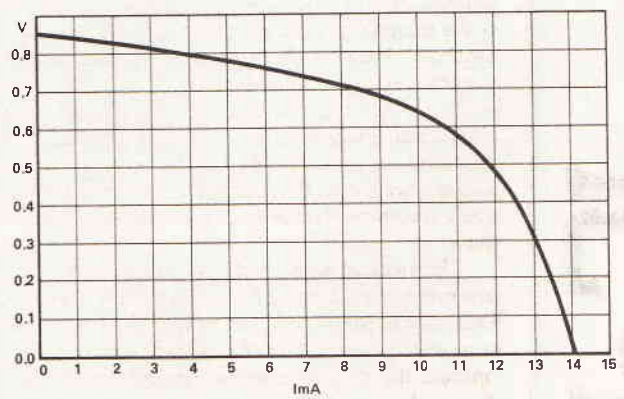


Fig.4 V-I characteristic of a typical a-Si solar cell

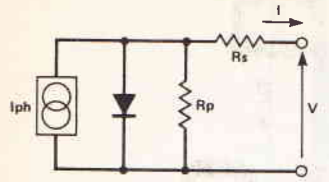


Fig.5 The equivalent circuit for a typical a-Si solar cell

light levels, as is shown in Figure 6.

Another advantage claimed for load optimising units is that if the solar cells are used to power, say, a pump directly, the amount of water pumped can be increased from 20 to 100%. This is because the pump starts earlier in the morning and works later in the evening. It can also run faster in the middle of the day when the total power is greatest (even though the cell voltage is the same). This is illustrated in Figure 7.

The load optimiser units work somewhat similarly to switched mode power supplies, using variable mark/space ratio switching to control the step up/down as shown in Figure 8.

Photovoltaic Applications

At present photovoltaic power is useful in Britain only for applications where it is not convenient to use mains power. If the price per watt were to drop further the applications could multiply.

To take a simple example, if solar cells were used in conjunction with rechargeable batteries in a radio, then the size of battery required would be less than that needed if it had to operate the radio with no top-up between charges. In this case, the batteries only have to retain enough charge to cope with periods when the light is not bright enough for the solar cells to run the set on their own. The same argument applies to other electronic products. Even if a separate or built-in charger is necessary, the addition of solar cells can extend battery life in normal use.

Already it is practical to use a-Si solar panels to charge batteries in caravans, small boats and the like to provide power for weekend use. With the increase in static 'key off' loads in cars, there may soon by an incentive to provide a solar battery charger, perhaps in the form of a sun roof. A-Si solar arrays are semi-transparent, rather like a dark tinted glass and could enhance the appearance of the car while preventing the increasing amount of continuously operating electronic equipment in the car from discharging the battery if the vehicle is left parked for a couple of weeks.

No doubt the availability of top-up charge from a solar panel would encourage the provision of more key-off loads, such as better security devices. One interesting possibility would be to power a ventilation fan to keep the internal temperature down to levels safe for pets who may have to remain in the car. Spare power along with an extra switch could solve that problem, as well as making the car more pleasant to get into after it has been parked for while in the sun.

Outland

Out in the outback solar power has been making an impact. Australian farmers living far from mains electricity supplies have for some time made use of diesel generators to provide electricity for the mod cons of contemporary civilisation. The drawback is that the efficiency is low. The diesel generator has to be able to supply the maximum load, which may be required for a short period each week but it has to be kept running all the time to maintain loads such as food freezers, radio communication equipment and so on.

If the diesel generator is run lightly loaded it is inefficient but still the fuel consumed is much less than at full load. Unfortunately a lightly loaded diesel engine is less reliable then a fully loaded one. For this reason, in many cases power is deliberately wasted, for example by using an air conditioner and a heater in the same room, to maintain the load at near maximum. This is costly but less inconvenient than arranging for repairs to a diesel generator set hundreds of miles from civilisation.

A possible answer would be to use the generator to charge batteries, and only start the engine when the batteries run low. This can help but once again unreliability becomes a problem. The solar solution diminishes the problems. At current prices it is not sensible to provide enough photovoltaic power and/or storage to cater for the maximum load but it is possible to provide for the base load at a cost which is quickly repaid in saved fuel costs.

Enough storage batteries are used to provide for the night-time operation of necessary loads and the diesel engine will be started automatically on the rare occasions when the stored energy is inadequate. Normally, however, the diesel engine would only be used when, for example, extra loads such as a washing machine, electric iron or whatever are used once or twice a week. The reliability of the diesel generator set is not seriously compromised by the limited stopping and starting required and if the generator fails the solar panels can keep essential loads supplied. The pay-back time for such schemes is claimed to be between one and two years.

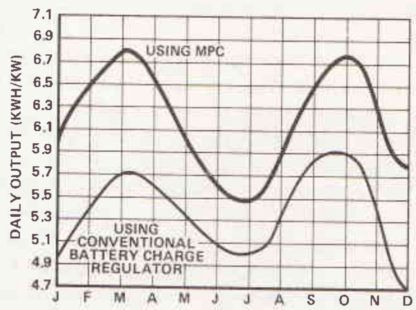
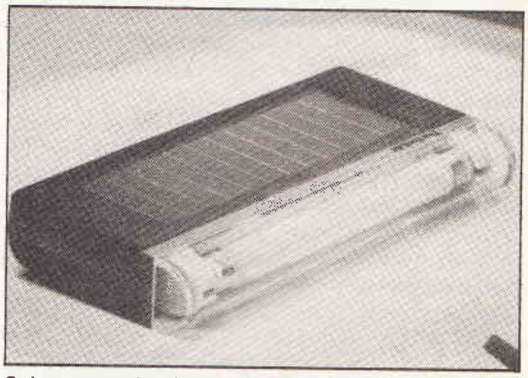


Fig.6 Annual output of a solar cell using a maximum power controller



Solar powered rechargeable hand lantern form Chronar

The farthest out application, geographically, is still in outer space. It is unlikely that a-Si will be suitable for satellite applications because efficiency is more important than price, and crystalline cells are likely to remain more efficient in the forseeable future. It is more likely that indium phosphide would replace crystalline silicon as the material for satellite solar cells.

The reason for this is that particle radiation gradually and irrevocably disrupts the crystalline structure of silicon, while the structure of indium phosphide reforms itself. So indium phosphide cells would not suffer the slow degradation which silicon cells suffer.

Amorphous Applications

The use of a-Si is not confined to solar cells. Researchers at Chronar have fabricated transistors and logic gates of up to 18 transistor functions per

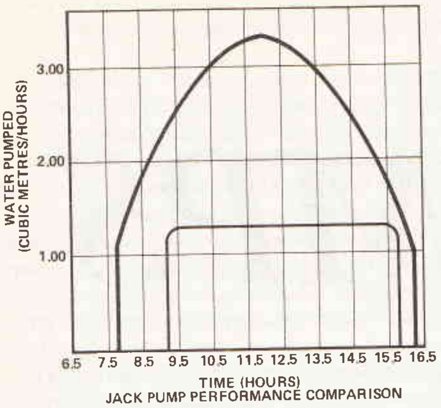


Fig.7 Load performance improvement using a maximum power controller

chip, and are currently developing more complex logic functions silicon logic circuits which can operate at up to 1MHz on supplies of 5V. This is hardly likely to outperform RISC processors in the near future but the performance is suitable to be incorporated into flat panel displays. For example, if driving electronics were to be incorporated into a liquid crystal display panel, then each pixel could be driven separately rather than being multiplexed.

The available contrast would then be the same as current digital LCDs provide — much greater than that available from multiplexed displays. Computer displays made in this way would be easy to read, unlike present supertwist LCDs which give limited contrast and a narrow viewing angle.

Another application of the technology is to produce non-volatile memories by an effect whereby a conduction path generated by a programming pulse remains in existence until an erase pulse is applied. The physics of this is still under investigation. The likely application is to produce memory modules as a substitute for diskettes in future generations of PCs. At last an end to BAD SECTOR ON DRIVE B.

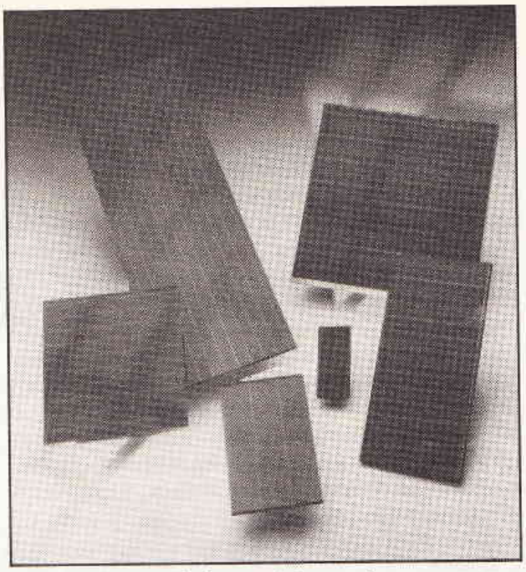
In the long run, a-Si logic would seem ideal for use in optical page readers and general image processing. Perhaps security cameras could be made with electronic motion detection built in to the faceplate, or page readers with character recognition built in, using parallel processing of the image.

The Future

Clearly the cost of photovoltaic power and specially a-Si solar panels, will decrease during the next few years as manufacturing processes are improved and volumes increased. Chronar says its new manufacturing plant at Bridgend will produce solar panels at a cost of approximately 50p per watt when it opens in 1989 and that this will be reduced to around 35p during 1991. This plant will be able to produce 10MW of a-Si solar panels per year, making it the largest such plant.

Such a reduction in costs, if achieved, will certainly open up many new applications. Most predictions turn out wrong or at least to have a wrong timescale, so I will suggest a few developments which I would *like* to see.

First of all, for reasons of sheer convenience, I would like to see more products incorporating solar cells and rechargeable batteries. This should reduce the tendency for batteries to run flat at an inconvenient moment. Of far more significance, though, would be the generation of useful amounts of electricity to reduce the need to burn coal and oil. The burning of coal, in particular, would appear to be one of the most



Chronar's range of photovoltaic panels

environmentally dangerous means of producing electricity, so even a modest reduction in the need to do so would be desirable.

It does not seem to me that in Britain, with our dim weather, centralised photovoltaic power generation would be attractive unless astounding conversion efficiencies were achieved. The land taken up with the solar panels could better be used to plant trees, which could in due time be cut down and burnt to produce electricity. However, if house roofs were made from solar panel tiles, and the power converted electronically to 50Hz, the overall effect could be quite beneficial — although an electrician would then be needed to repair a leak in the roof!

Power would only be generated during the day, of course but it is during the day that overall power demand is greatest because of industrial use. If the net domestic load could be reduced or even made into a net supply, the resultant load levelling should increase the efficiency of power generation as well as reducing the total requirement.

Photovoltaic power could also make a contribution to road transport. Though I cannot imagine long range electrically powered vehicles becoming practical or indeed possible in the foreseeable future, there would seem to be an application for shorter range vehicles to be used around town for shopping, taking the children to school and the like. No doubt mains recharging would be needed for all but the lightest use but the use of solar cells covering all the suitable surfaces on an electrically powered car could extend its usefulness and help to make it practical.

A short range vehicle like this could make a disproportionate reduction in total fuel consumption because it is short range town driving which is least efficient for normal cars and it is in the mile or two after starting that the poorest fuel economy (and the greatest engine wear) occurs. The major barrier in the way of this development in the medium term would appear to be the difficulty of taxing it.

Finally, to permit these and other beneficial developments, I would hope and expect that the efficiency of photovoltaic panels could be improved. Chronar has a research grant to improve efficiency and expects to achieve 10% in the near future, mainly by improving the quality of the junctions and the packing density. Improvements in the spectral absorption should in theory be possible, and it may be possible to achieve efficiencies in excess of 20% in the next decade.

ETI

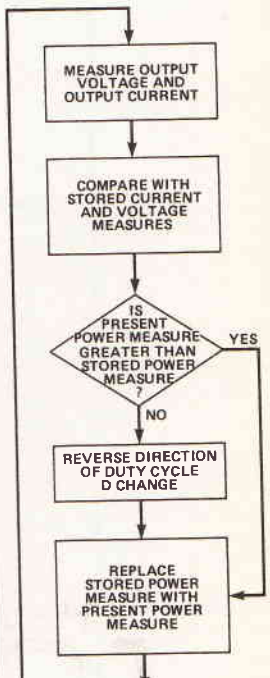


Fig.8 Operation of a switched mode optimum power controller

OP-AMPS

Paul Chappell returns to the relative sanity of real op-amps for a discourse on transfer functions, loop gain, return difference and the like

Still on the trail of frequency response, negative feedback and stability in op-amp circuits, I'm going to try stalking the subject from a different direction. In the last few articles I've been concerned with some of the practical aspects of designing a heating controller and one or two of the problems you might come across. This time we'll see what a more abstract approach can do for us.

Stripped to the bare essentials, a single loop feedback system can be summed up by the diagram of Fig.1a. There's an input of some kind, a forward path A, a feedback path β and a device which combines the signal emerging from the feedback path with the input signal. In a simple negative feedback loop the combination process is nothing more than the subtraction of the feedback signal from the input.

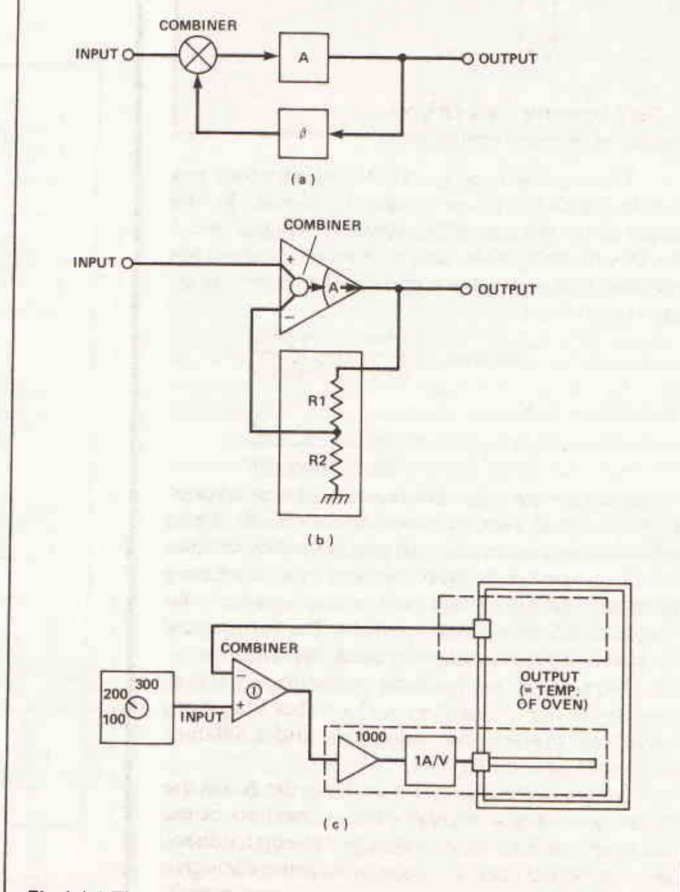


Fig.1 (a) The stripped bare diagram of the single loop feedback system (b) A practical version (c) Another

Figure 1b shows one practical form of the system and Fig.1c shows another. The diagram of Fig.1a is so stripped of any kind of personality that it could represent a wide range of systems, and not necessarily electronic ones either. It might be a mechanical fuel injection system in a car, for example, or a gas pressure regulator. Anything which takes account of the results of its actions and compares them with the input to see if it's doing the thing right has the same essential parts.

So if we can draw any conclusions from such unpromising material as the diagram of Fig.1a, they will hold good for an enormous number of apparently unrelated (but in essence very similar) devices.

Having said all that, I'm not really aiming for complete generality here — apart from anything else I'd have to keep stopping to show how the terms, conditions and results apply to various other systems, or to resort to heavy mathematics, neither of which I want to do. It's op-amps we're interested in, so that's what I'll concentrate on.

Having settled that, we can now say that A is the vo'age gain of the op-amp, β is the factor by which R1 and R2 (Fig.1b) reduce the output signal

$$(\beta = \frac{R_2}{R_1 + R_2})$$

and that the combining block represents the subtraction of the −input signal from the +input signal that happens in the input stage of the op-amp.

OK, if I'm not aiming for generality, why not stick to drawing proper op-amp circuits instead of boxes with odd names? The answer is that a slight shift in viewpoint often shows up all kinds of relationships that

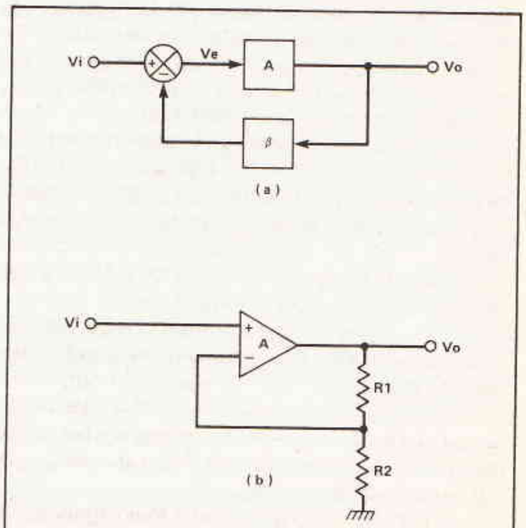


Fig.2 Putting formulae to (a) the stripped-bare version (b) Real op-amps

were not at all obvious before. Translating to the frequency domain, for instance, can make it impossible to miss things that were all but invisible in the time domain.

The shift we're making here is to see things in terms of what they *do* rather than what they *are*. We are no longer interested to know that the subtraction of the feedback signal from the input takes place inside the op-amp or that the division of the output is achieved with a pair of resistors. All we care about is that somehow or other it happens — irrelevant information is cast aside. The markings on the boxes represent their *transfer functions* — the way they process a signal on its way through. For the moment, function is all!

Let's begin by working out what the voltage gain of the network of Fig.2a will be. By inspection we can write down:

$$v_e = v_i - \beta v_o \text{ and } v_e = v_o/A$$

so, combining the two equations and losing v_e, which we're not interested in, we get:

$$v_i - \beta v_o = v_o/A$$

which, after a bit of fiddling around, gives:

$$v_o/v_i = A/\ (1 + A\beta).$$

Now, if the value of $A\beta$ happened to be much greater than one, there would be not much error in saying that the network gain v_o/v_i is $1/\beta$. If $A\beta$, on the other hand, turned out to be very much smaller than one, the gain would be pretty close to A, the gain of the forward path. Which is exactly what you'd expect from your experience with op-amps, isn't it? You sound doubtful.

Orientation exercises coming up. In the circuit of Fig.2b, you'd have no hesitation in telling me that the gain was $(R_1 + R_2)/R_2$. If pressed, you'd also admit that this was an approximate formula but one that gave an answer near-as-makes-no-odds correct as long as the demand gain was a good deal smaller than the open-loop gain A of the amplifier.

Translating this into As and βs, you are telling me that the gain is $1/\beta$ as long as $1/\beta$ is much less than A, which is the same as saying that $A\beta$ must be much greater than one. Which is exactly what I said before!

So what happens if the demanded gain gets close to the open-loop gain of the amplifier? Or equal to or greater than it? If you remember way back to the earliest articles in this series, I produced some figures showing exactly what the resulting gain would be. It would get closer and closer to A, the amplifier's own gain, and would no longer bear any relation to the values of the feedback resistors.

Once again, the translation into As and βs: you now tell me that as demanded gain $1/\beta$ approaches A it becomes a less and less reliable formula for the circuit's gain. If it goes way beyond A (which is to say that $A\beta$ becomes much less than 1) then the gain of the circuit gets closer and closer to A.

All clear now? Without hesitation then, if I replace R1 and R2 with a pot and turn the pot in the direction to increase the circuit's gain, am I increasing or decreasing β? If I set the pot so that the demanded gain $(R_1 + R_2)/R_2$ is equal to the op-amp's gain A, what will be the value of $A\beta$? And what will be the gain of the circuit? OK, you've passed!

Have a look at Fig.3a. For reasons best known to my psychiatrist, I've grounded the input of the network and broken the loop between the output and the β box. Not content with this, I'm also injecting an input straight into the β box and looking at what comes out of the other side of the cut. You can easily work out what it will be: $-A\beta v_{in}$.

In Fig.3b I've done the same thing again but in a different part of the loop. Once again the signal that comes out will be $-A\beta v_{in}$, and so would it be if I cut it yet again just before the A box. The term $-A\beta$ is known as the network's *loop gain* — it's the gain you get if you send a signal once around the loop, no matter where it starts and finishes.

Another quick test: there are two op-amps circuits on your bench, each using the circuit of Fig.2b. One is connected for a gain of 10 and the other for a gain of 1000. Assuming both use ICs with more or less the same open-loop gain, which circuit has the higher loop gain? (and which has the nicer coloured resistors?).

There's another relationship to be spotted here. The higher the demanded gain from the circuit, the lower the loop gain (strictly speaking, the lower the magnitude of the loop gain but you know what I mean). At the point where the demanded gain is equal to the open-loop gain (that is, if you have an op-amp with a gain of 10^6 and try to set a gain of 10^6 with the resistors) the loop gain will be one and the actual circuit gain will be almost exactly half the value you expect. If you apply lots of feedback and to select a gain much less than the open-loop gain, the loop gain will be high. Have just a little feedback and the loop gain will be low.

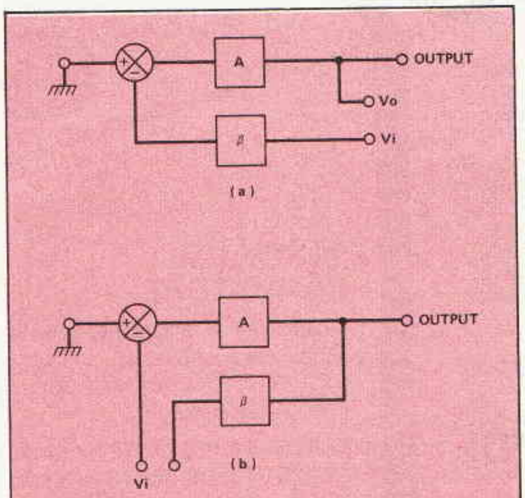


Fig.3 Locating the loop gain

There's one more term I should introduce this month, and that's the *return difference*. In the equation for the gain of the network of Fig.2a, the $1 + A\beta$ term is called the return difference — don't ask me why. Calling the various parts of the gain formula by name, it becomes:

$$\text{closed loop gain} = \frac{\text{open loop gain}}{\text{return difference}}$$

so it follows that:

$$\text{return difference} = \frac{\text{open loop gain}}{\text{closed loop gain}}$$

It's given a special name because, like pi, it keeps popping up all over the place, although why it isn't called something sensible like *gain ratio* is beyond me.

One of the main problems with feedback theory in general is that no two people ever agree on the names of definitions of any part of it. The theory grew up almost independently in several different areas — amplifiers, servo-mechanisms, control theory and so on. By the time everyone realised that they were essentially studying the same thing under different names, it was too late.

Some call the signal which feeds the A box the error signal, others insist that it is the correction. Some like to refer to loop gain, others prefer loop feedback factor or return ratio. So if you're browsing through a book on feedback and find that they use entirely different names and definitions, don't worry — just choose whichever you like the best!

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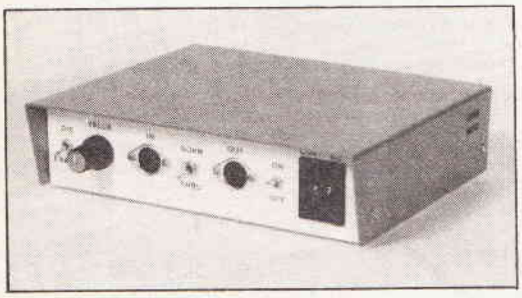
MIDI PROGRAMMER

PROJECT

Robert Penfold concocts control codes with his MIDI parameter programmer

In the early days of synthesisers, instruments had impressive rows of rotary controls and any desired parameter could be almost instantly selected and adjusted. Progress resulted in polyphonic and multi-timbral instruments which required too many controls for this approach to be viable, and so the numeric keypad plus single control was born. The keypad was used to select the required function and then the control knob was adjusted to obtain the required sound.



Finally, things were streamlined still further, with the control knob disappearing altogether and the push buttons being used to select and adjust everything. While all this was happening, the complexities of setting up a new sound were growing, with ever more parameters to set. The result of this has been that sound creation has become so complicated that most users of electronic instruments now simply settle for the factory preset sounds or sounds bought on cartridges (or whatever).

Matters have improved somewhat recently, with MIDI providing the possibility of easier access to the controls of an instrument. There are two basic approaches and the best of these is to have a sophisticated computer controller having an on screen control panel that gives the same ease of access to the controls as the analogue synthesisers of many years ago. Unfortunately, this tends to be a relatively expensive solution to the problem, even if suitable equipment and software can be tracked down.

Method number two is to go back one step, and to have something analogous to the keypad selector and single control knob. This is somewhat slower than the full control panel approach but it is still much quicker and more convenient than total push-button control. It is also something that can be achieved using a reasonably simple piece of hardware, with no need to resort to a full-blown microprocessor based system.

The MIDI controller described here is of this basic type but it has thumbwheel switches rather than a keypad to permit selection of the required control function. It will operate on any MIDI channel, and should function with any instrument that implements MIDI controllers.

A lot of instruments fall into this category but it is only fair to point out that some recent instruments, rather unhelpfully, provide access to many parts of the sound generator circuit only via system exclusive messages. The only MIDI controllers then implemented are (usually) modulation depth, master volume, and sustain on/off. With these instruments full control is only really possible using a dedicated microprocessor based system, or a home computer with custom software. This controller will not produce the system exclusive protocols and cannot be used for programming such instruments as the Roland MT-32 for example.

As always with MIDI equipment, check the specifications of your instruments before deciding on a course of action, and do not jump to conclusions. There are about as many MIDI different implementations as there are different pieces of MIDI equipment.

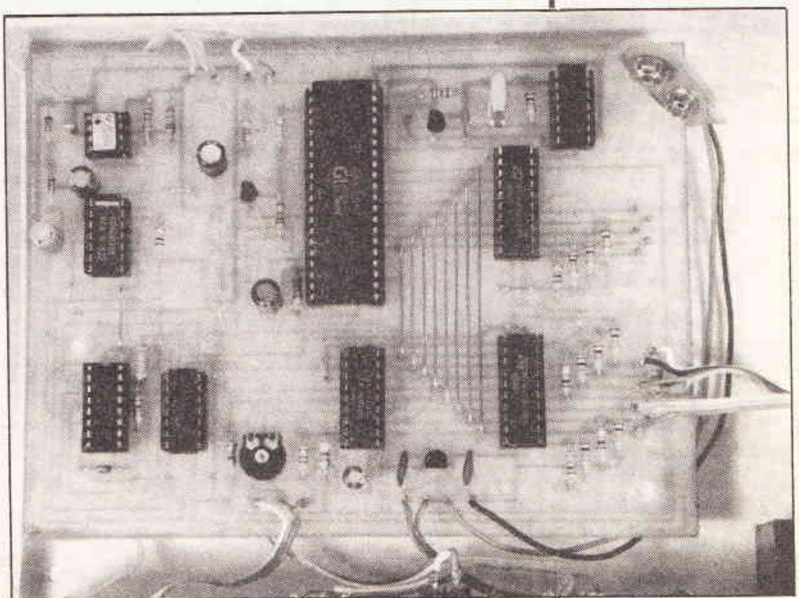
In Control

A MIDI message consists of a header byte which is usually followed by one or more bytes of data. The header byte consists of two nibbles, and for channel mode messages the most significant nibble indicates the type of message (note-on, note-off, and so on) while the least significant nibble carries the channel number. There are also system common messages, where the most significant nibble is the system common code, and the least significant nibble indicates the precise nature of the message (mostly forms of clock and synchronisation signal).

In this case it is a form of channel mode message that we are interested in. The MIDI controller header nibble is 1011 in binary and as this is a channel mode message, the least significant nibble is the channel value. Values from 0 to 15 are used in the MIDI message, but MIDI channels are conventionally numbered from 1 to 16. The value used here is therefore equal to one less than the number from the channel on which the message must be sent.

The header byte is followed by two data bytes. The first of these is the number of the control to be altered, and the second is the new control setting.

MIDI data bytes always have the most significant bit set to 0 (it is always set to 1 in header bytes), and the valid range for both of these bytes is therefore 0 to 127. Things are a little more complicated than this would suggest as some controls are grouped in pairs and the two bytes are combined as single 14-bit value. (Control numbers 0 to 31 are paired with controls 32 to 63 respectively. The control having the lower number is the one which takes the most significant byte.)



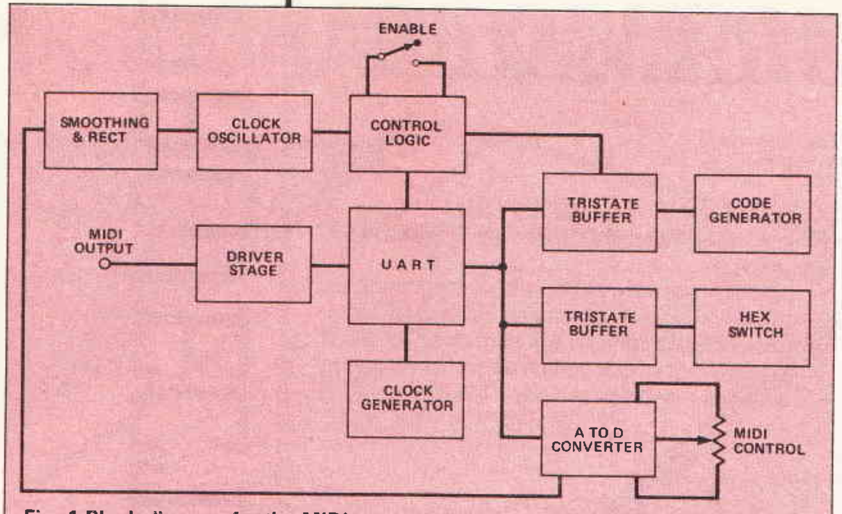


Fig. 1 Block diagram for the MIDI programmer

It is quite feasible to use our MIDI controller to adjust one byte of a control and then click the most significant digit of the hex switch through a couple of digits so that the other byte of a control can be adjusted. In practice this will not normally be necessary as it seems to be rare for the full 14-bit resolution to be implemented. Most controls have straightforward 7-bit resolution, and in some cases the least significant bit or bits are ignored so that only 5 or 6-bit resolution is obtained.

The manuals for your MIDI equipment should state the resolution of each control. Note that if only one byte is used it will be the most significant byte (the lower control number will be used and the higher one will simply be ignored).

Control numbers 64 to 95 are used for switches. The data byte is either 0 (off) of 127 (on), and other values will have no effect. Control numbers from 96 to 127 are either as yet unassigned, or are used for mode change messages.

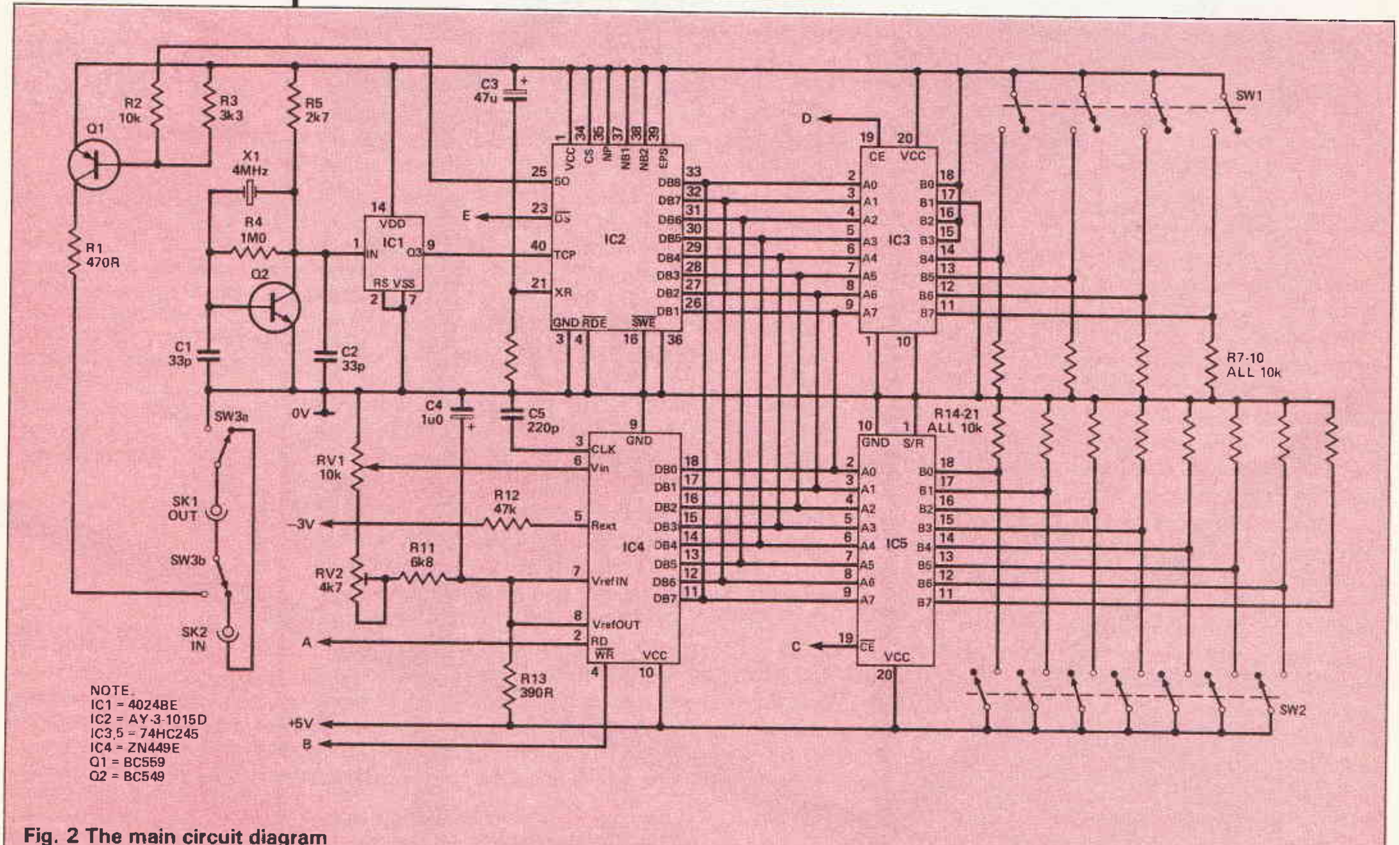


Fig. 2 The main circuit diagram

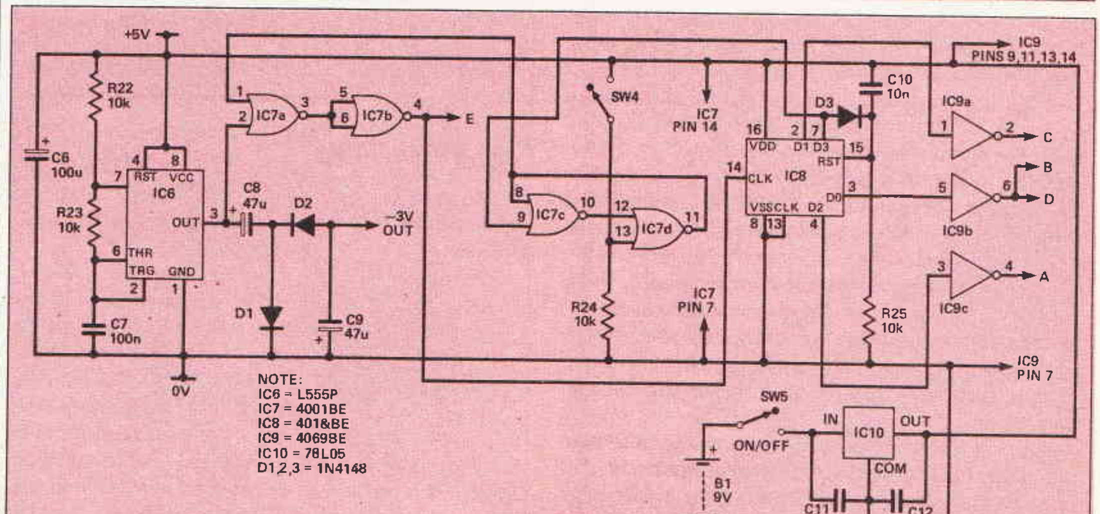


Fig. 3 The control and power supply circuit diagram

HOW IT WORKS

The general arrangement used in this unit is shown in Fig. 1. Generating the basic MIDI signal represents no real difficulty as MIDI uses what is virtually a standard RS232C serial signal as used in computer interfacing.

It differs from the RS232C standard in that the baud rate is non-standard (31250 baud), and the output signal is in the form of a 5mA current loop (which drives an opto-isolator at a MIDI input to guard against differences in chassis potential).

The baud rate can be accommodated using standard crystals, and the 5mA current loop merely requires a simple open collector output stage. A UART (Universal Asynchronous Receiver/Transmitter) plus suitable clock and output circuits will provide the necessary parallel to serial conversion.

The UART must be fed with three bytes in the correct sequence (header/channel byte, control number, and control value). The header/channel number byte is produced by a simple binary code generator circuit, and it is fed through to the UART via a buffer which has three state outputs.

A similar arrangement is used for the control number byte, with a double hex switch feeding into the tristate buffer.

The control value is generated by an ADC fed from a potentiometer. This value could be generated more simply using a hex switch, but adjustment using a potentiometer is much quicker and easier. It is probably cheaper as well. No separate tristate buffer is needed for the ADC as it has tristate outputs.

A control circuit is needed to activate the tristate outputs in sequence, and also to provide the *start conversion* pulses to the converter. The basic course of events is for the first tristate buffer to be activated and for a start conversion pulse to be supplied to the converter. Then the second tristate buffer is activated, and finally the outputs of the converter are activated. This train of events is repeated indefinitely.

The control logic circuit that provides these pulses is driven by a clock oscillator that produces about 160 complete messages per second. This ensures that any changes in the setting of the potentiometer are quickly transmitted, and there is no discernable lag between adjustments being made and the instrument responding to them.

The control logic circuit includes a disable function. Remember that the unit should not be left transmitting while changes in the control number are made. As the hex switch is adjusted from one control to another, this would result in any control numbers passed through on route being set to the current potentiometer value. A lot of work could be very rapidly undone in this way! The enable/disable switch allows the flow of data to be halted, and the circuit ensures that each three byte message is completed before the output signal is cut off.

A negative supply is required for the 'tail' resistor in the ADC, and this is derived by rectifying and smoothing some of the output from the control circuit's clock oscillator.

The main circuit diagram is shown in Fig. 2, with the control logic circuit shown separately in Fig. 3.

A standard 6402 UART (IC2) forms the basis of the circuit — the almost identical (but slightly cheaper) AY-3-1015D can be used.

The clock signal must be at sixteen times the required baud rate, which works out at 500kHz in this case. This is obtained from a 4MHz crystal oscillator based on Q2, and a three stage binary divider (IC1). Q1 is a common emitter switch which provides the nominal 5mA output pulses.

MIDI IN and OUT sockets are provided so that the unit can be connected in-line with another MIDI control device. SW5 enables the unit to be switched into circuit or bypassed, as required. IC2 requires a long reset pulse at switch-on, and this is provided by C3 and R6.

IC3 and IC5 are the tristate buffers, and are actually transceivers held permanently in the 'receive' mode. The most significant nibble of IC3 is wired to give the correct header code, and the least significant nibble is provided by a hex switch SW1. In most cases, operation only on MIDI channel 1 will be sufficient, and the hex switch can be omitted.

Both nibbles for IC5 are provided by a two digit hex switch SW2. The most significant bit of the switch is not connected, and is held permanently low by R21. Control numbers of more than 127 are not valid and this prevents illegal values from being transmitted.

The ADC (IC4) is a successive approximation type and has a built-in clock oscillator which requires discrete timing capacitor C5, giving a conversion time of about 20µs. Conversions are therefore completed comfortably within the 2ms or so between the 'start conversion' pulse being issued and the converter being read. The potentiometer is fed from the built-in 2.55V reference source of IC4, and RV2 is adjusted to give a maximum reading of 127.

A one-of-ten decoder (IC8) provides the basis of the control circuit. In this case only the first three outputs are required, and so output 3 resets the device.

C10 and R25 provide IC8 with an initial reset pulse at switch-on. This ensures that the unit starts by transmitting the header byte and not one of the data bytes. The outputs of IC8 provide positive pulses inverted for the buffers and converter by three stages of hex inverter IC9. The other three stages of IC9 are left unused but their inputs are tied to the positive supply rail in order to prevent spurious operations.

IC6 provides the clock signal for the control circuit, and apart from the fact IC6 is a low power device, this is a standard 555 astable circuit. The clock signal is supplied to IC8 by way of a gate circuit which uses two of the 2-input NOR gates of IC7.

The other two gates form a simple bistable circuit, and when SW4 is closed the bistable permanently enables the gate. The unit then provides a continuous stream of data. When SW4 is opened, the bistable is reset when IC8 completes its next cycle, and the clock signal is cut off. The output signal then ceases until SW4 is closed again.

The UART must be supplied with a pulse in order to initiate transmission of each byte. This signal is provided by the gated clock signal and not from IC8.

D1, D2, and C9 rectify and smooth some of the output from IC6 to generate the negative supply for IC4 (about 3V).

The main circuit requires 5V and has a current consumption of about 50mA . This is obtained from B1 via monolithic voltage regulator IC10.

It is important to realise that there is no true standardisation of the control functions. The MIDI specification assigns control 1 to the modulation amount, but apart from this there is a free-for-all and the equipment manufacturers can please themselves. It is not necessarily the case that parameters such as filter resonance and cutoff frequency will be assigned to separate control numbers. They may be assigned to a single control number with the front panel buttons of the instrument being used to select the current parameter.

With some equipment it is possible to assign functions to any desired control number of the appropriate type. Once again, it is a matter of reading the MIDI implementation sheets for your equipment to determine exactly how it handles MIDI controllers.

Construction

The component overlay is shown in Fig. 4. The use of IC sockets is strongly recommended for the nine DIL ICs.

A number of link-wires are required (22 swg tinned copper wire). Where several links run side-by-side they must be kept quite taut, or be insulated. At this stage, only fit pins to the board at the points where connections to off-board components will eventually be made. The case dimensions in *Buylines* represent about the smallest case that will comfortably accommodate everything. The PCB is mounted on stand-offs as far to the rear and left hand side of the unit as possible, with the battery to the right of the board.

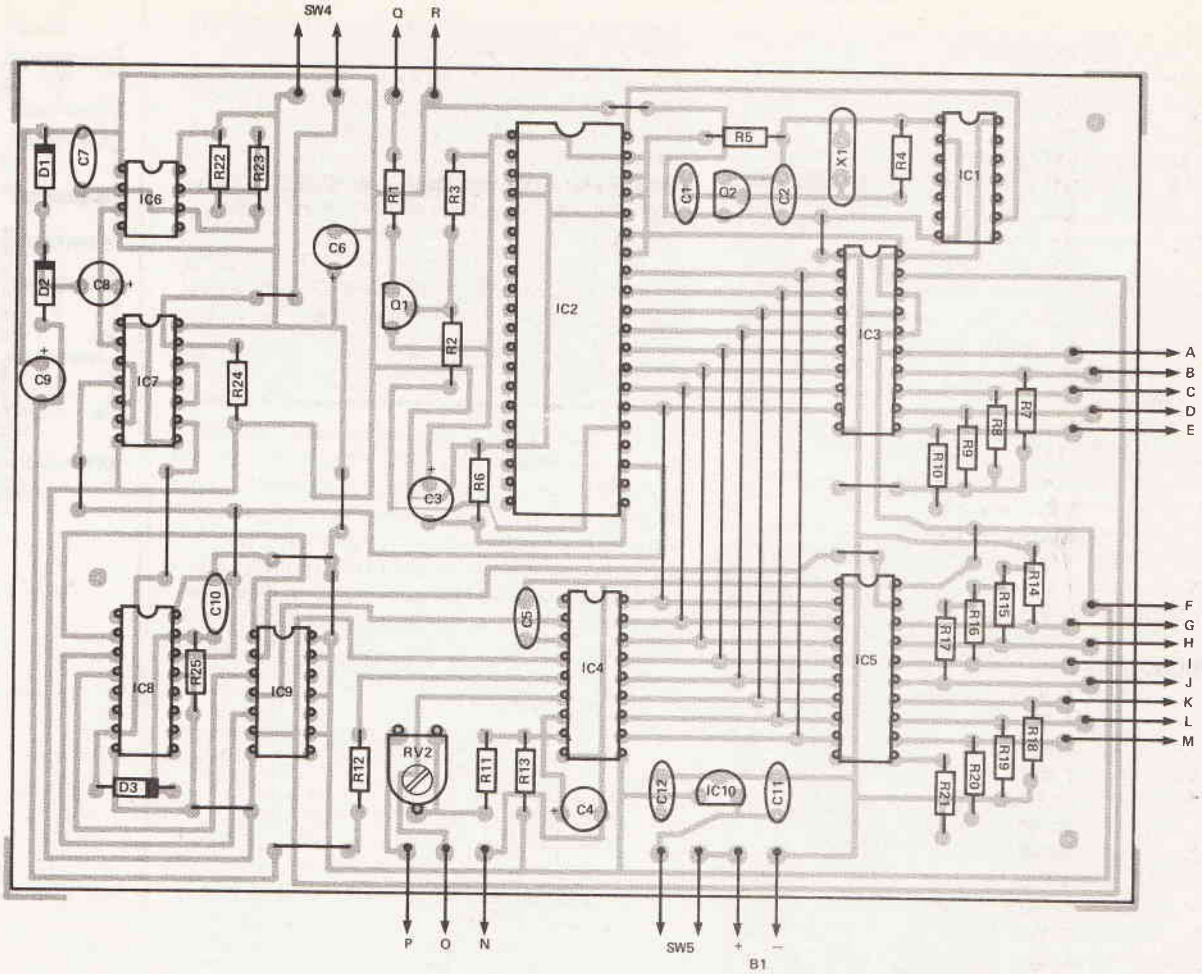
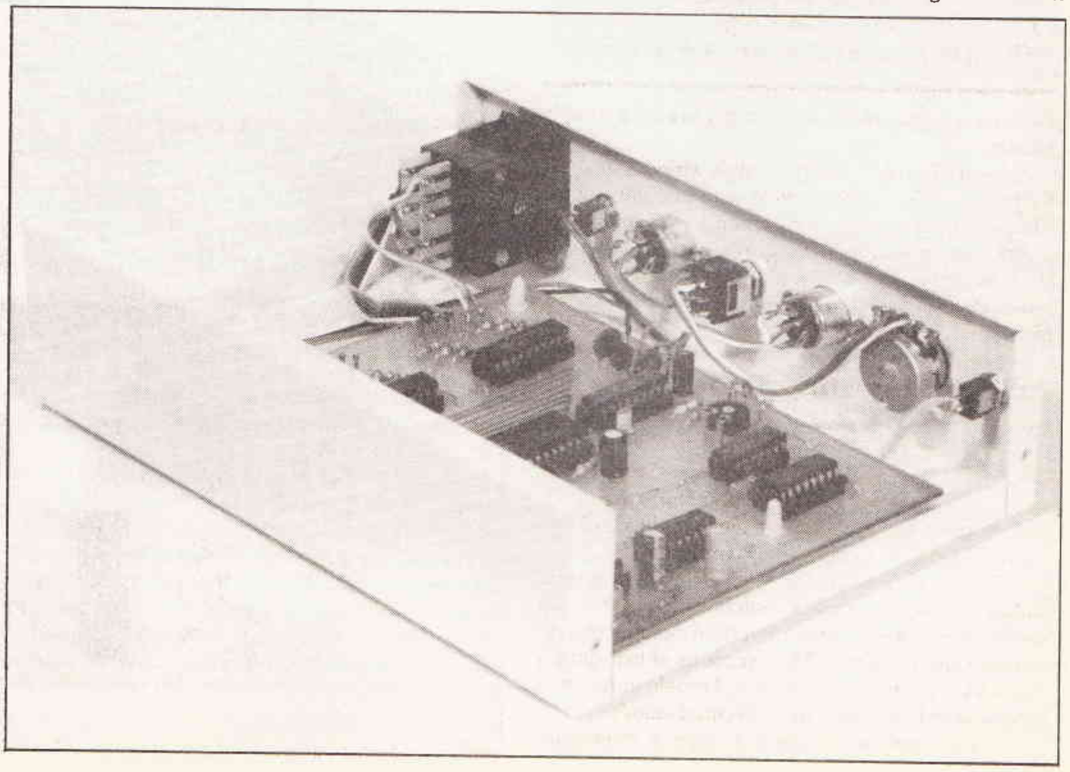


Fig. 4 Component overlay for the MIDI programmer

The precise front panel is not too critical, but SW2 must be mounted at the extreme right hand to avoid the PCB. I omitted the SW1, as operation on MIDI channel 1 was all that I required and a wider case must be used to accommodate SW1 unless it is relegated to the rear panel.

When fitting the end cheeks to SW1 and SW2 (see *Buylines*), beware the threaded rods that fix them together. If you cut them too short you can't fit the nuts, too long and it will not fit in the panel cutout. Cut them slightly too long and file them back. The cutout must be accurate and is 31mm high and 17mm



PARTS LIST

RESISTORS (all ¼W 5%)	
R1	470R
R2,7-10, 14-25	10k
R3	3k3
R4	1M0
R5	2k7
R8	1k8
R11	6k6
R12	47k
R13	390R
RV1	10k lin
RV2	4k7 sub-min horiz preset
CAPACITORS	
C1, 2	33p ceramic plate
C3, 8, 9	47µ 10V radial electrolytic
C4	1µ 50V radial electrolytic
C5	220p ceramic plate
C6	100µ radial electrolytic
C7	100n polyester
C10	10n polyester
C11, 12	100n ceramic
SEMICONDUCTORS	
IC1	4024BE
IC2	6402 or AY-3-1015D
IC3, 5	74HC245
IC4	ZN449E
IC6	TLC555P
IC7	4001BE
IC8	4017BE
IC9	4069BE
IC10	µA78L05
Q1	BC559
Q2	BC549
D1, 2, 3	1N4148
MISCELLANEOUS	
B1	9V battery (6×HP7 or PP9)
SK1, 2	5-way, 180° DIN socket
SW1	hex switch
SW2	double hex switch
SW3	DPDT miniature toggle switch
SW4, 5	SPST miniature toggle switch
X1	4MHz wire-ended crystal
PCB. Case. Knob. IC sockets. Battery connector. Separator. IC pins.	

wide for a single switch, or 24mm wide for a double switch.

Most of the point-to-point style wiring is straightforward but Fig. 5 should help with any difficulties. This assumes that the recommended thumbwheel switches are used for the two hex switches. Provided SK1 and SK2 are 5-way 180 degree DIN sockets connected as shown in Fig. 5, the unit can be fitted into the MIDI system using standard MIDI leads.

Adjustment And Use

Most instruments implement the modulation amount as controller 1, and this is a good one for initially testing the unit. With '01' selected on the twin hex switch, SW3 set to connect the output through to SK2, and the unit switched on and enabled, adjusting RV1 should control the modulation amount.

The unit can then be tried with other control values set on the twin hex switch. The fact that this switch is calibrated in hex rather than decimal should not give any problems. MIDI sections of instrument manuals seem to deal almost exclusively in hex and binary, with little mention of decimal values.

RV2 must be adjusted to give a maximum control value of 127. The ideal aid for adjusting this preset is a computer that will display values received at its MIDI port. In the absence of such equipment probably the best solution is to use any switch control of the instrument to indicate when a value of 127 has been reached. Remember that switch controls turn on at 127, and switch off at 0, ignoring values inbetween. Start with RV1 set at maximum, and RV2 set fully counter clockwise. Advance RV2 slowly, just far enough to switch on the selected control function. The unit is then ready for use.

BUYLINES

Crystal X1 must be a miniature wire-ended type (HC-18/U or HC-49/U) if it is to fit on the PCB as shown.

Most hex switches (SW1 and SW2) are intended for on-board mounting so are unsuitable for this project. A thumbwheel switch is best – these are obtained as single switches plus optional end cheeks. A double switch is simply two single switches sandwiched between a pair of end cheeks. These are available from Electromail (Tel: (0536) 20455). Switches are parts 337-093, end cheeks (pair) part 338-406.

IC4 is Ferranti's ZN449E available from STC (Tel: (0279) 626777). The higher quality ZN448E and ZN447E are also suitable and more commonly available, but are much more expensive and unnecessarily accurate.

The PCB is available from the PCB Service.

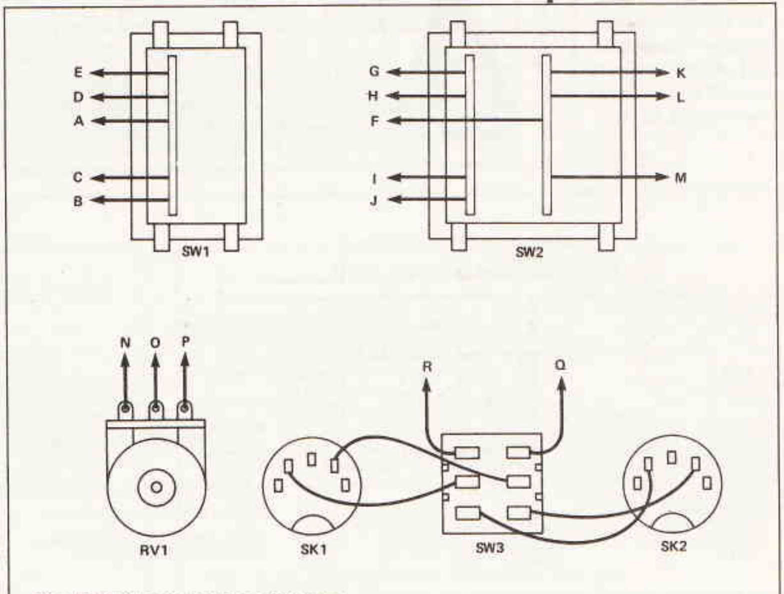
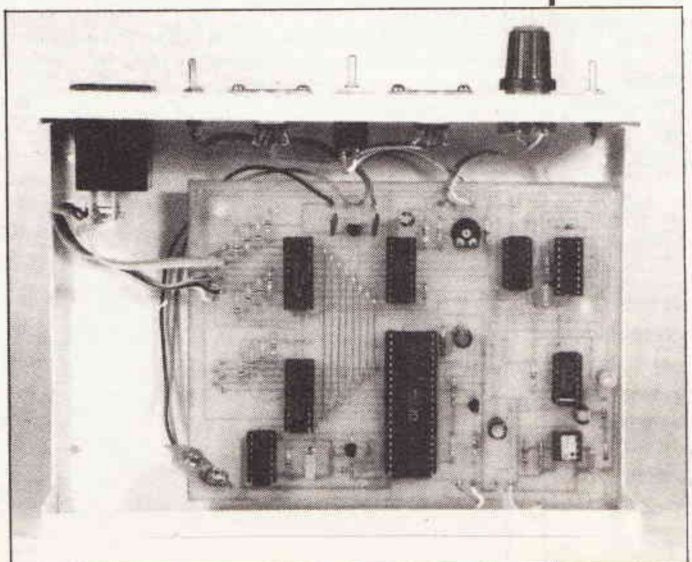
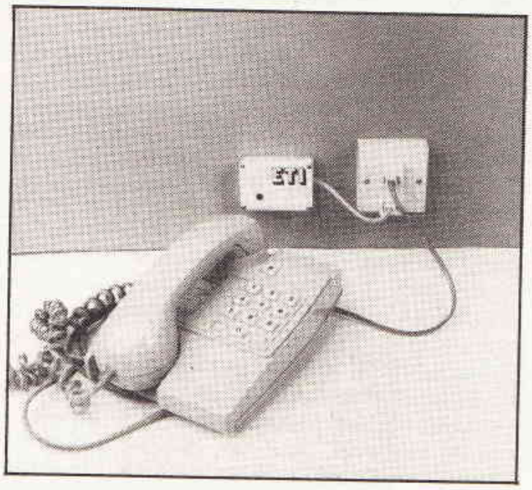


Fig. 5 Off-board wiring diagram



TELEPHONE INDICATOR

Ali Taalf keeps track of his extensions with this simple in-use signal for telephone circuits



This equipment is not approved by the British Approval Board for Telecommunications (BART) and so cannot legally be connected to a BT telephone line. However, if properly constructed the Telephone Indicator will not harm either the BT line or other equipment connected to it.

A regular modem user living in a three-storey house once had a problem. While he was online to his favourite bulletin board he would sometimes suffer such severe data corruption that the computer logged him off. He soon found the cause.

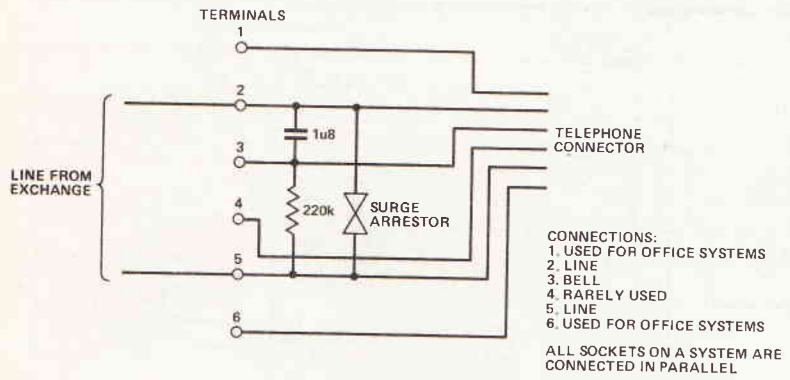


Fig. 1 The connections to a BT master socket

1st CLASS

His wife, two stories below him, did not know that the phone line was in use and picked up the extension phone to make a call. Sometimes even the click of picking it up, let alone trying to dial, could cause problems. He asked me how he could indicate when a line was in use, in such a way that the indication would be automatic and could be used at any extension socket.

I ascertained that his telephone system uses the modern rectangular BT sockets and I made some measurements on my own telephone socket. Figure 1 shows the circuit of a standard master socket, of which there is one per line. The function of the surge arrestor is obvious, the resistor is there to load the line and permit line tests even if all the telephones are unplugged and the capacitor is to provide ringing current to the sounders in the telephones.

Ringing current is AC and the capacitor is chosen to provide little impedance to the frequency used. When any handset is picked up, the ringing current output is loaded so that dialling pulses do not cause the telephones to tweet.

Clearly, in order to maintain indication of line operation without injecting any foreign signal into the system, the detector should measure across terminals 2 and 5.

When none of the phones are in use, there is about 50V across terminals 2 and 5. When you pick up a phone this reduces to about 10V, which changes still further if the number you are dialling answers. A simple means of measuring this voltage would detect line use and such a device with low off-state current consumption would be ideal.

The Answer

The need for the battery to last for a long time rules out the quiescent consumption of most ICs. However, an ordinary junction FET (field effect transistor) can be switched by the signal available and can have a very low quiescent consumption.

To make a tidy and movable indicator, it should be connected to a telephone plug and the telephone extension socket should be changed for a double socket. These are available with screw terminals so that the insulation displacement tool is not needed for installation.

The method of installation is simple. Note which wire(s) connect to which terminal number, disconnect them, reconnect to the same terminal numbers in the new socket. Be sure to make good connections or else there could be crackling on the line.

As an easier alternative to replacing the telephone socket, a 2-way telephone adaptor could be used or you could wire it permanently onto a socket (naughty) or even build the whole project into a socket (very naughty).

PARTS LIST

RESISTORS

R1,2	4M7
R3	3M3
R4	2k2

SEMICONDUCTORS

Q1	BF244 (or 2N3819 etc)
LED1	High efficiency red LED

MISCELLANEOUS

B1	9V PP3 battery

Stripboard. Battery clip. Phone plug on cable. Dual phone socket or 2-way adapter.

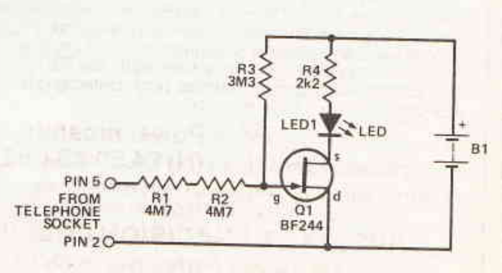


Fig. 2 The Telephone Indicator circuit

The circuit of the line indicator is shown in Figure 2. The N-channel junction FET is biased off by the 50V, which is connected so as to put about −5V on the gate via the potential divider action of R1, R2 and R3. With only 10V present (when the line is in use) the gate of the FET is biased slightly positive and the FET conducts and switches on the LED. R4 sets the LED current and I have chosen a value which will give enough brightness to see it clearly except in bright sunlight, while keeping the current low enough to make the battery last. Typical on operating current is 3.3mA and typical off leakage current is 5μA.

Two resistors in series are used in the input to protect against damage to the phone system if one should be short circuited. Telecom disapprove of modifications or additions which may damage or adversely affect the system. Actually I think they object to anything at all, no matter how carefully done but if you make sure that there is no significant loading on the line and that no significant extraneous signal is injected there can be little genuine cause for complaint.

Construction

No PCB design is given for this circuit because it is so simple as to make the expense a little silly. Instead a stripboard layout for the project is given in Figure 3.

This should pose no real problems. Just be careful to solder in the FET (Q1) the right way round and watch out for 'bridges' of solder between adjacent tracks.

When you first build the circuit, connect up the battery while the input is unconnected. The LED should light. Then connect the wires to the socket and it should go out. If not, try reversing the wires. If this does not work then the pinch off voltage of the FET may be so different from that of the prototype that different biasing resistor (R4) values are called for.

If the LED never extinguished, then increase the value of R3. If it never switched on, first check that it is connected the right way round, and does light if the source and drain of the FET are shorted together, then decrease the value of R3. Few units are likely to need this however.

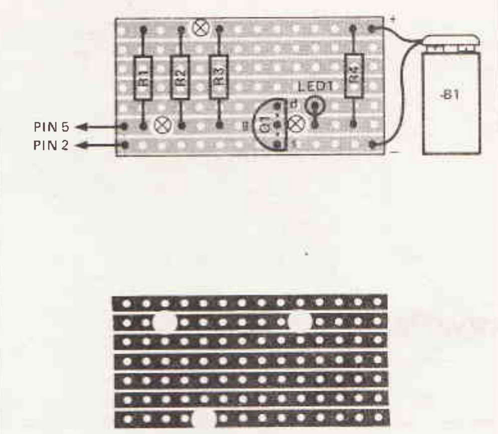


Fig. 3 The track cuts and component layout for the Telephone Indicator

BUYLINES

All the parts used in this project are easy to obtain. The BF244 is available from Maplin as are the phone socket and adapter.

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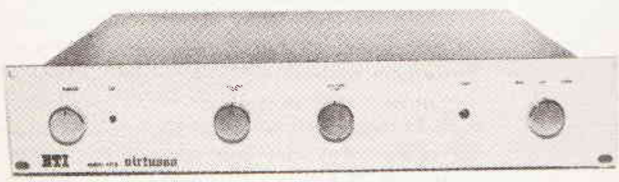

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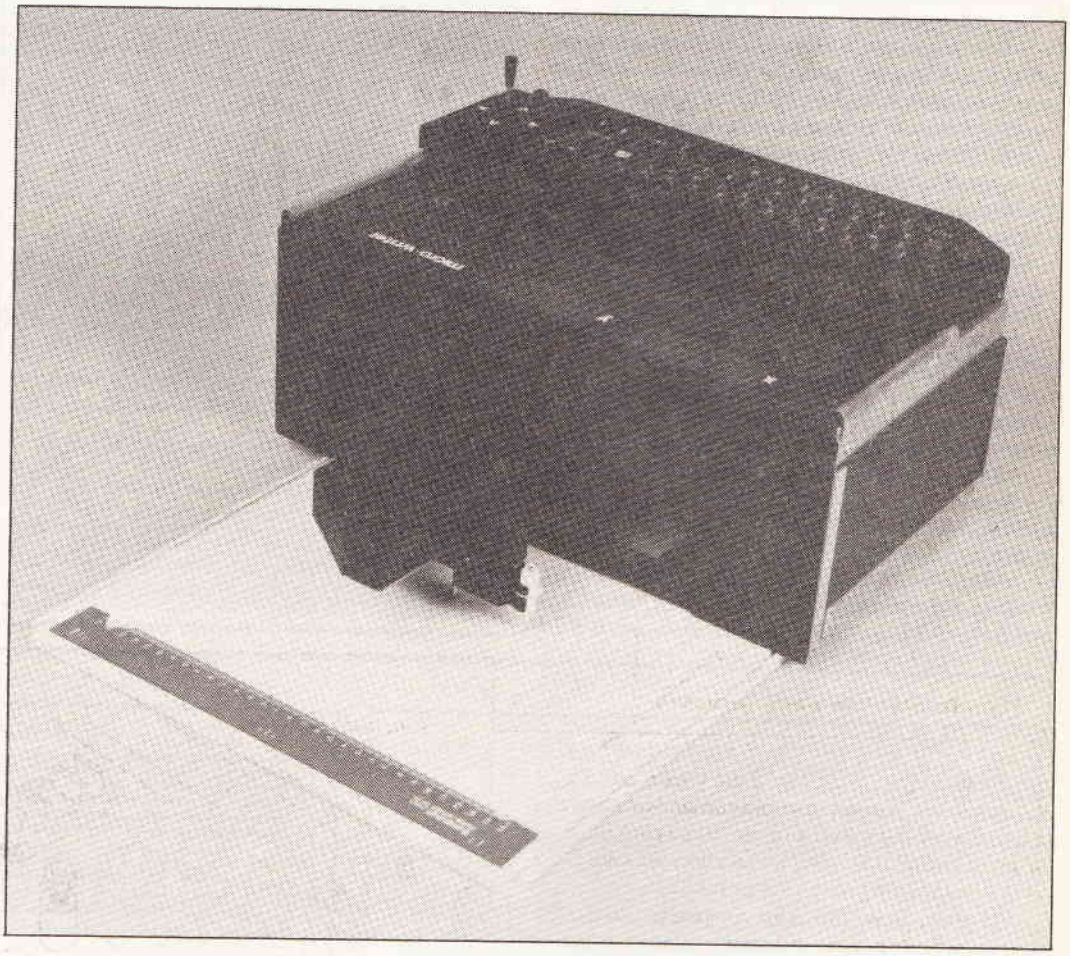
INTELLIGENT PLOTTER

The plot thickens as Bob Joyce shows his metal for the mechanics of his microprocessor controlled plotter

PROJECT



This month we turn to the mechanics of the intelligent plotter. The design is given in exploded arrangements of the various elements with greater detail where necessary.

For those of you who are fortunate enough to own a BBC micro there is a ROM available which allows the mechanics to be driven from the user port using ★ commands. The rest of you will have to wait until next month for the microprocessor controller board and keyboard.

Design Considerations

The construction provides ease of manufacture without unduly compromising the overall accuracy. In some instances alternative forms of construction are given so that those of you without access to machine tools can build the mechanics with the minimum of tools and without the need to resort to outside manufacturers.

The motors specified produce 400 steps per revolution with an increment of 0.1mm for each motor step. The resolution of the software and the hardware is thus 0.1mm so it is important to ensure that the moving parts are able to repeat their position to this accuracy.

The Metal Bits

The frame of the mechanics comprises extended aluminium sections and shaft holders of twin 8mm pipe clip plastic mouldings (see *Buylines*). Screws were used to fix the motor and shaft holders and 'pop' rivets to secure the frame sections. The designs given are a rough guide only. You can make the x or y axes dimensions as long as you like (software limit 1m) provided that you increase the shaft and aluminium sections to cater for the increased weight and corresponding bending moment.

The shafts should be 8mm round ground bar, tool steel rod (silver steel) or brass. If you really want to save money you could make them out of 2-off 8mm x 1m long chromed gas fire pipe fitting.

The nylon coated wire deserves a special mention. Several types and diameters of cable were tried and the nylon coated trace wire satisfied all the requirements and is available at large fishing tackle shops (the type used on the prototype was *cardylon* nylon covered stainless steel trace wire rated at 40kg breaking strain available in 7.5m lengths). Fig. 1 shows

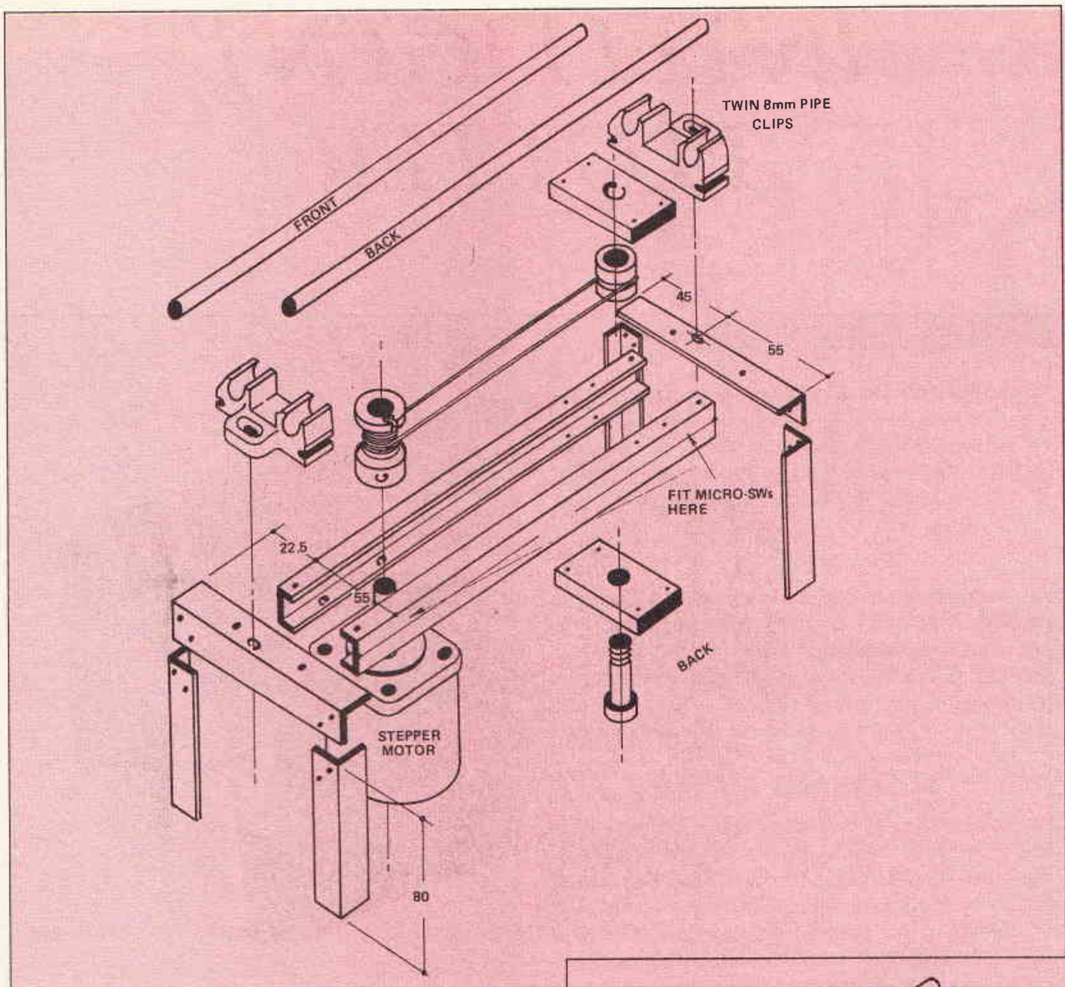


Fig. 1 Details of the x-axis mechanics

the details of the x-axis, Fig. 2 the y-axis, and Fig. 3 the details of the open solenoid carrier. Note that the x-axis carries the y-axis and motor, so care must be taken to ensure that adequate section sizes are used to prevent sagging of the support rails.

I hope that my efforts may inspire you to design your own version using my drawings as a basis. It is often possible to obtain old dot matrix printers or electric typewriters cheaply and use the slideways and bearings from them.

Motor Pulley Drives

The pulleys can be made from aluminium brass or steel, simply cylindrical or contoured. The pulley diameter determines the movement per revolution of the motor and must be calculated by dividing 40 (movement per revolution of the motor shaft) by π to give the pitch circle diameter of the centre of the cable. Hence a pulley diameter of around 12mm will be required.

To obtain an exact value the diameter of the stretched cable will need to be measured so that this can be subtracted from the calculated pitch circle diameter above to give the pulley outside diameter. The cable must be wound on to the pulley carefully, starting by trying a knot at the loose end of the cable and fixing it into the hole and sawn slot at the bottom of the drive pulley. Slowly wind the cable anti-clockwise around the pulley (approx 4 turns depending on length of travel) then take the cable around the loose pulley at the other end of the slide and back. Wind on to the pulley a further 4 times anti-clockwise, finally fixing the end into the other sawn slot at the top of the pulley using a knot as before.

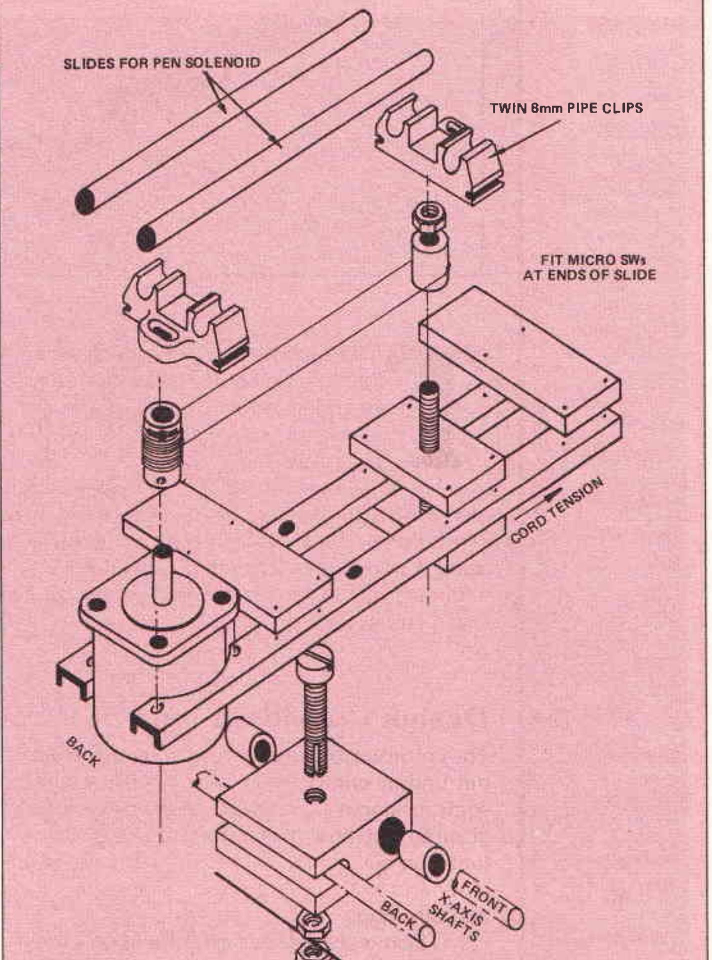


Fig. 2 Details of the y-axis mechanics

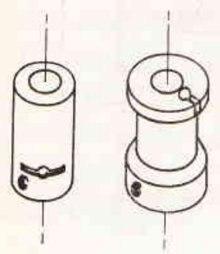


Fig. 4 Alternative designs for motor pulley drives

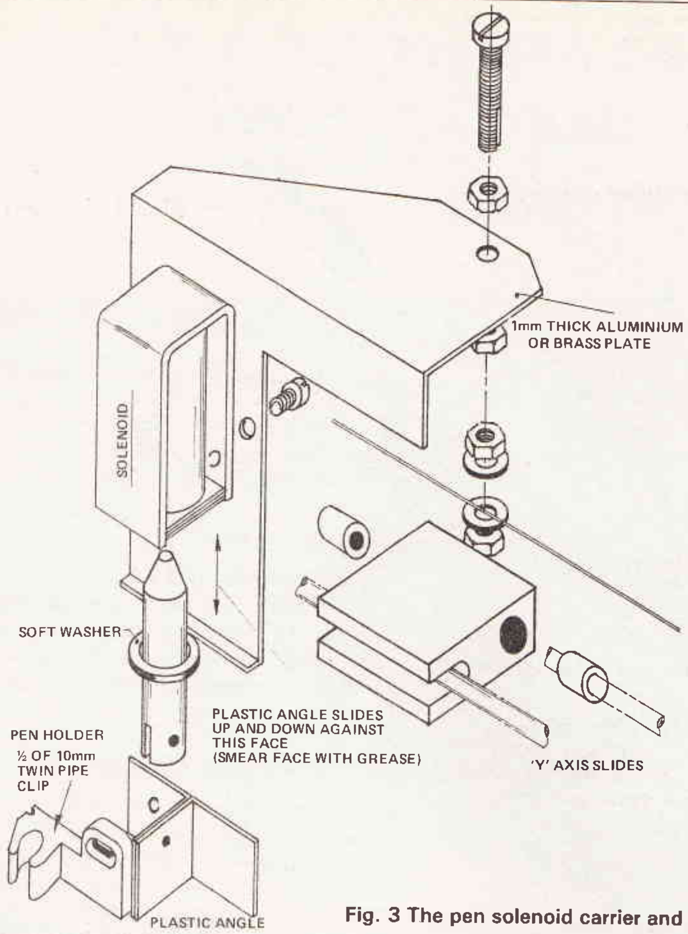
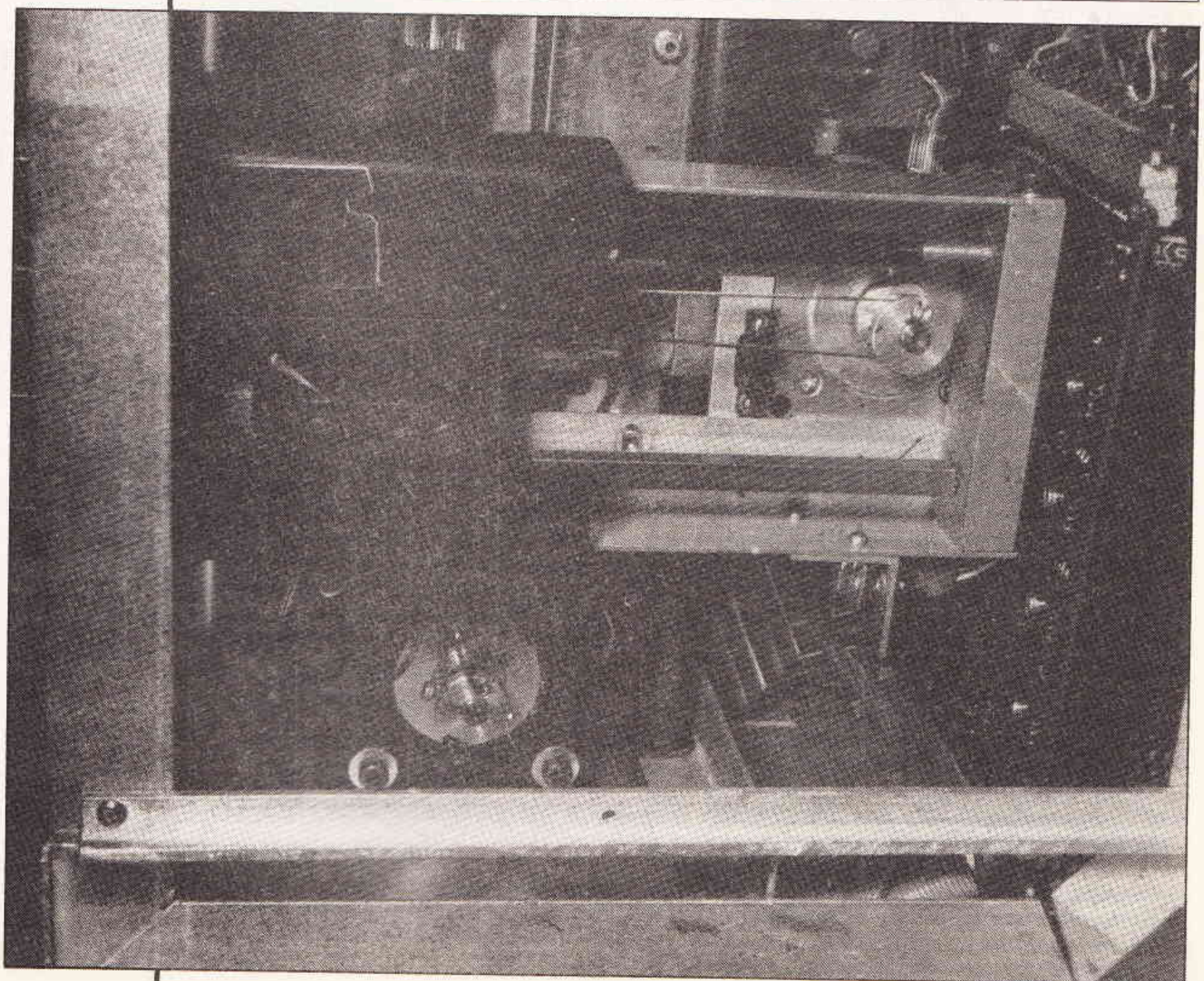


Fig. 3 The pen solenoid carrier and attachment to the y-axis



PARTS LIST

RESISTORS (¼W 5% unless specified)

R1-7	1k0 ⅛W (single 14-pin separate resistor network)
R8-14	10k ⅛W (single commoned resistor network)
R15-21	1k0 ⅛W (single commoned resistor network)
R22	330R

CAPACITORS

C1-4	10n polycarbonate
C5	1n0 polycarbonate
C6	100n sub miniature polyester
C7	1000µ 47V electrolytic

SEMICONDUCTORS

IC1	ULN 2003A
Q1	MJ3001
D1	UF4004
BR1	6A 200V bridge rectifier

MISCELLANEOUS

FS1	250mA anti-surge fuse
T1	50 VA transformer, primary mains, secondary 0-9

PCB. Heatsink (7°C/W approx). Solenoid (see *Buylines*).
The following items for the mechanics provide a general guide most constructors will probably use materials that they already have left over from other projects. Numbers in brackets are Electromial part numbers.
X and Y axis parts:
Aluminium sections various.
4-off twin 8mm pipe clips.
1-off twin 10mm pipe clips.
4-off limit switches V4 roller type.
2-off stepper motors 200 steps/revolution.
1-off trace wire (see text).
2-metres (approx) brass, silver steel or ground 8mm bar.
4-off bearings 8mm bore in plastic, brass or sintered bronze (alternatively for low cost 8mm brass plumbing olives).
1-off aluminium plate (solenoid support plate).

OUTER PANELS
The outer panels on the prototype are secured to the fixed aluminium sections and were made from perspex sheet, aluminium sheet and perforated sheet.

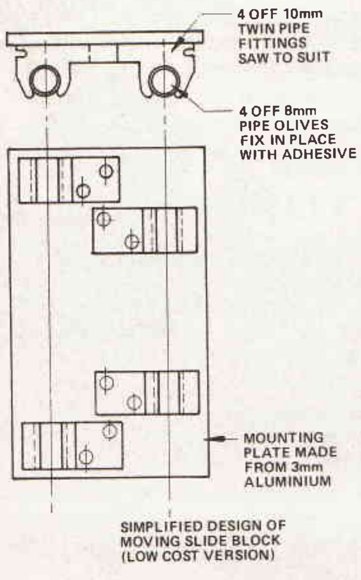


Fig. 5 Simplified low-cost moving slide block design

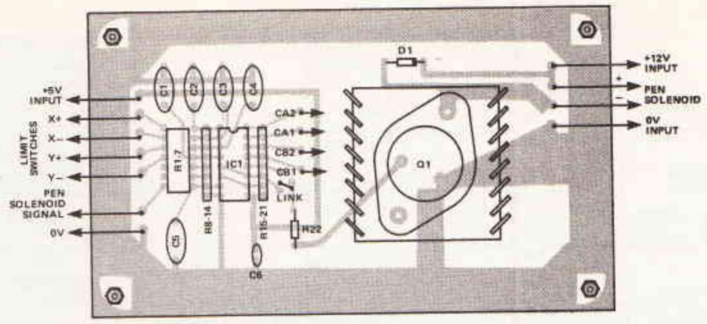


Fig. 6 Component overlay for the solenoid board

Tension the pulley by sliding the loose pulley and holder them rivet or screw into place, ensuring that the loose pulley is able to rotate freely.

Slides

Figure 4 illustrates one method of construction using a brass block and two oil pregnated (sintered) bearings. An alternative approach would be to use a plastic block without bearings. For a low cost design 8mm pipe olives could be used in conjuction with twin 10mm pipe clips as shown in Fig. 5.

The Solenoid Board

Construction of the solenoid PCB is straight forward using the overlay shown in Fig. 6. A fairly hefty heatsink is needed for Q1 (see *Buylines*) although if a smaller solenoid is used a correspondingly smaller transistor and heatsink would be sufficient. The interrupt wires labelled CA1, CA2, CB1 and CB2 will join to the Plotter processor board when it comes into existance next month.

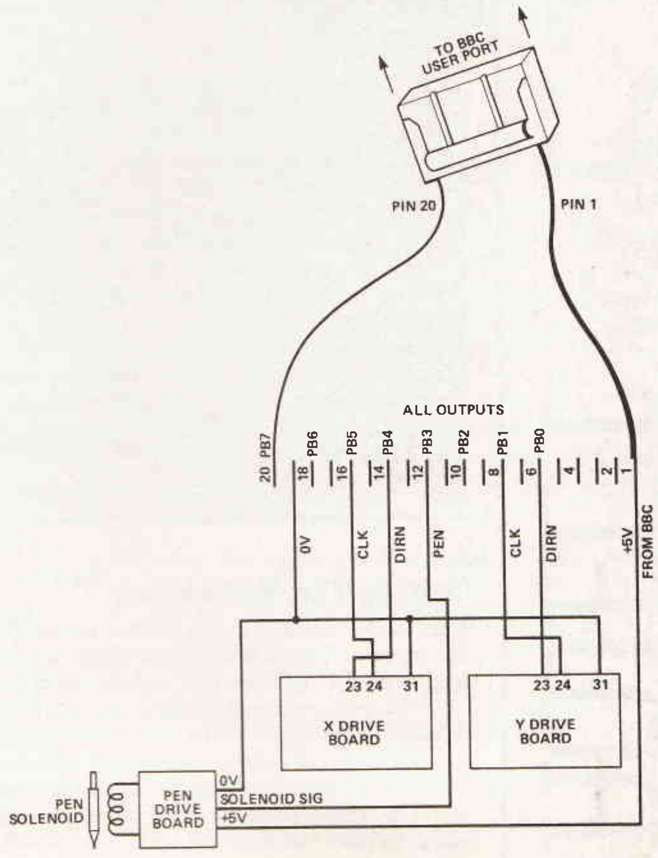


Fig. 7 Connections to a BBC computer

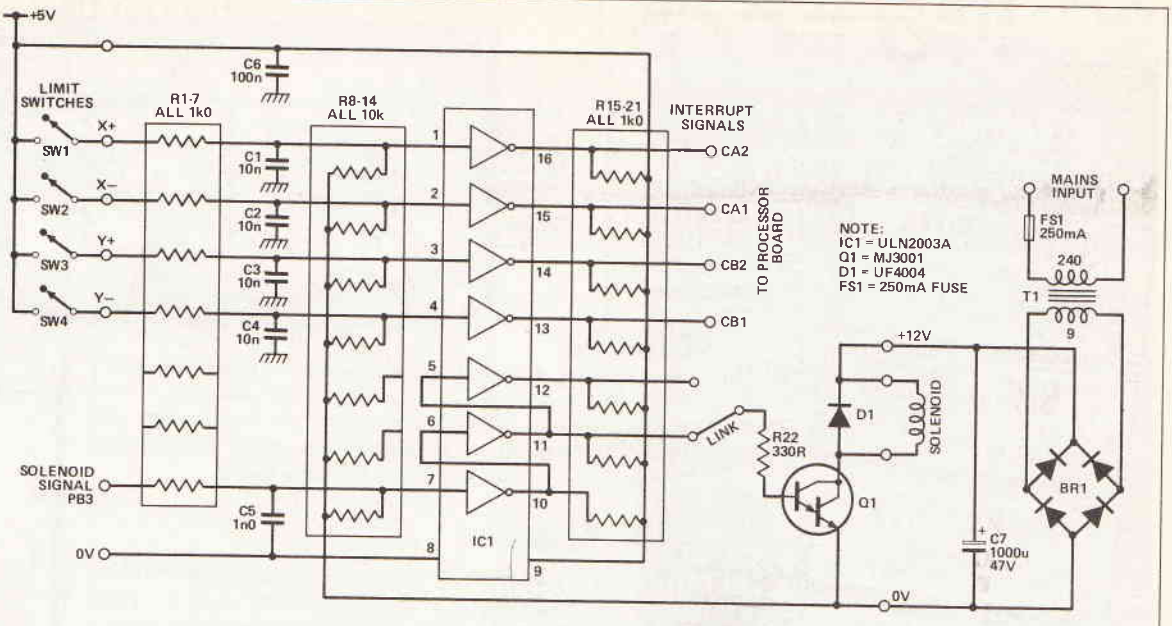


Fig. 8 Circuit diagram for the solenoid board

HOW IT WORKS

The circuit in Fig. 8 gives details of the pen drive electronics. The solenoid used has a 12V DC coil and is energised when pen lift is requested. When no power is given the pen releases under gravity thus allowing for varying thicknesses of drawing material an uneven working surfaces. On the prototype I used an A4 drawing board which clipped to the front of the Plotter.

The power darlington transistor Q1 could be replaced with a lower current darlington transistor if a smaller solenoid is used.

To operate the solenoid a 5V signal is applied to the voltage divider R1/R8 with C5 filtering the signal. IC1 inverts this signal twice switching on the darlington transistor driver Q1 thus operating the solenoid. D1 is used to prevent damage to Q1 during reverse voltage peaks from the solenoid.

A link is provided to change from a rising signal operating the solenoid to a falling signal.

The limit switches are held at 5V. When a limit switch is opened the voltage from the switch into IC1 will be 0V. IC1 inverts this signal sending a 5V signal onto the appropriate interrupt line to signal the processor that a limit has been broken.

Four limit switches are used to inform the Plotter processor board that the plotter had reached its end of travel. These limit switches are positioned at the extremities of the slides to prevent the mechanics reaching the end of their travel, and to facilitate datumming and repeatability of position.

The limit switch common terminals are wired to 5V (taken from the processor board). The normally closed contacts are connected to their respective terminals on the solenoid board. For speed of operation these signals are interrupt driven and consequently connected to the IRQ line through the 6522 VIA (Versatile Interface Adaptor) on the processor board.

The complete listing of the test ROM (see *Buylines*) is available from ETI, 1 Golden Square, London W1R 3AB. Enclose an A4 SAE plus 38p in stamps. Mark your envelope 'Plotter ROM'.

Testing The Mechanics

The Intelligent Plotter mechanics can be tested from the processor board, from a BBC computer or from a square wave oscillator (manual operation only).

The processor and keyboard interface will be described next month. In the meanwhile if you have a BBC computer or have built up the square wave oscillator the mechanics can be tested right away.

The square wave oscillator simply connects to each axis drive board clock input using two switches. The direction can be changed on the drive board or remotely as shown in last month's article. Build up the speed by increasing the oscillator frequency and try reversing the direction whilst running and check for play or backlash on the mechanics.

As mentioned earlier a ROM is available for the BBC which provides various 'star' commands from within a basic program or directly from the computer keyboard to move and draw.

Note that you do not need this ROM if you are building up the processor board as it contains its own ROMs which provide all the move, draw and test routines which are available directly from the Plotter's keyboard.

Connecting Up To A BBC

Attach the drive boards and mechanics to the BBC user port via a 20-way IDC connector as shown in Fig. 7.

Insert the EPROM into a vacant sideways ROM socket, connect the relevant power supplies for the solenoid and drive board, and enter the commands:

★PLOTI (return)

★PLOTT (return)

This will initiate the plotter (★PLOTI) followed by plotting the test program (★PLOTT) shown in the picture. Various other '★' commands are available to operate the mechanics directly from the computer keyboard or from within a basic program.

Next month we conclude with the central processing board, the keyboard and interface devices.

BUYLINES

All the components are available from Electromail (0536-204555) and other major suppliers.

The stepper motors used in the prototype were Electromail part 332-082, the limit switches part 331-405 and the solenoid part 349-709.

Pile clip mouldings are available from large DIY centres – those for the prototype came from Do-It-All.

Aluminium sheet is available from Maplin.

A ROM is available for a BBC micro which allows many of the Plotter commands to be made directly from the BBC micro keyboard using '★' commands. This ROM is available for £15 from the author Mr. R. Joyce, 104 Craythorne Avenue, Handsworth Wood, Birmingham B20 1LN.

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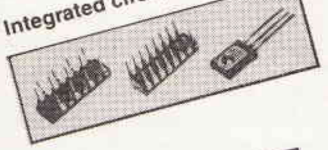

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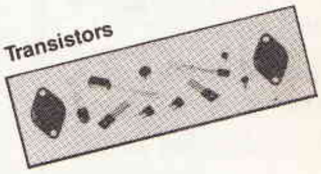

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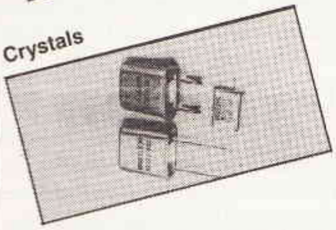

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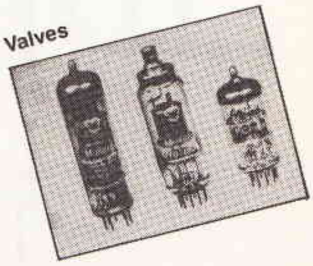

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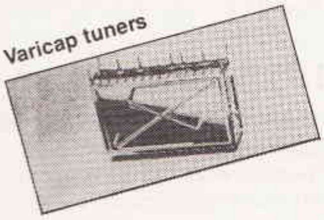

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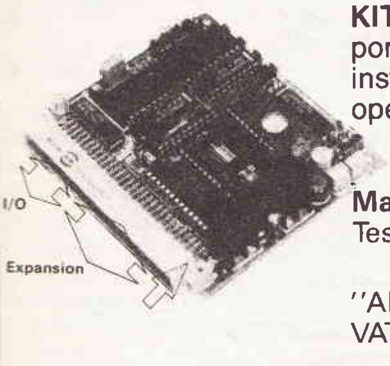

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MODULAR PRE-AMP DISC INPUT STAGE

Barry Porter revisits the disc input stage of his 1983 modular pre-amp with a conversion to high quality balanced input

UPDATE

Four years have elapsed since the publication of my Modular Pre-Amplifier design and if reports from satisfied builders are to be believed (I only believe the satisfied ones!), it has withstood the test of time pretty well.

However, recent development work has led to a few circuit improvements which, if implemented, should give the basic design a new lease of life.

Disc Amplifier Stage

The original disc stage was very successful — and was certainly good enough for at least one hi-fi manufacturer to 'borrow' the circuit! For the past year or so I have been experimenting with balanced input connections for pick-up cartridges and have concluded that the additional circuit complexity, not to mention expense, is well justified.

A pick-up cartridge, whether moving coil or moving magnet, is an electrical generator with anti-phase outputs which are floating with respect to earth. As such, it may be connected to a balanced input in the form of a transformer or a suitable differential input amplifier (Fig. 1). A comparison may be drawn between a pick-up cartridge and a moving coil microphone. They both have low impedance and floating outputs and both generate very low signal levels which means that until their output is amplified to a higher level, there is a great danger of hum and other unwanted noise being picked up by the interconnection cable.

No-one in their right mind plugs a moving coil microphone into an unbalanced input and I am now convinced that the same should apply to pick-up cartridges (even though they are not normally hung on the end of 100 metres of interconnect cable).

Due to their low output voltage, moving coil cartridges will benefit more from balancing than those of the moving magnet variety but the freedom from noise problems makes balancing the disc input stage a very worthwhile venture, regardless of cartridge type.

The circuit of Fig. 2 is not too far removed from the original disc stage (Page 56 of December 1983 ETI). One advantage of the new configuration is that the gains are now set by a single resistor (R8-R15) and, being DC coupled at this point, the value of this resistor may be reduced to a minimum at high gain settings in order to keep its noise contribution as small as possible. The original version suffered by having to have its gain setting resistor (R4) AC coupled by C2, which would have to be 4700µ for R4 to be reduced to 10R.

Gain Structure

With 15V supply rails, a NE5532 or 5534 will deliver an output of more than 9V RMS before clipping. If an overload margin of 33dB is to be achieved then an operating level of 200mV is necessary. (33dB below 9.0V = 9/44.668 = 201.5mV).

It would be nice to use the linear input buffer to amplify the input signal to 200mV but unfortunately we are dealing with a pre-emphasised signal. The RIAA characteristic fixes the 20kHz signal level at almost 20dB above the 1kHz level and this has to be taken into account when fixing the input stage gain.

The answer is to arrange things so that the output of the first stage at 1kHz, is 20dB below 200mV — namely 20mV — and this is what is obtained with the values shown in Fig. 2.

Having arrived at the output of IC4, the signal may now be subjected to de-emphasis at 75µs, obtained by the action of R26, R27, and C10, Note the move away from E96 value resistors, which are very difficult to obtain in small quantities. In fact, the parallel combination of R26 and R27 leads to increased accuacy — at 10kHz, the previous error of

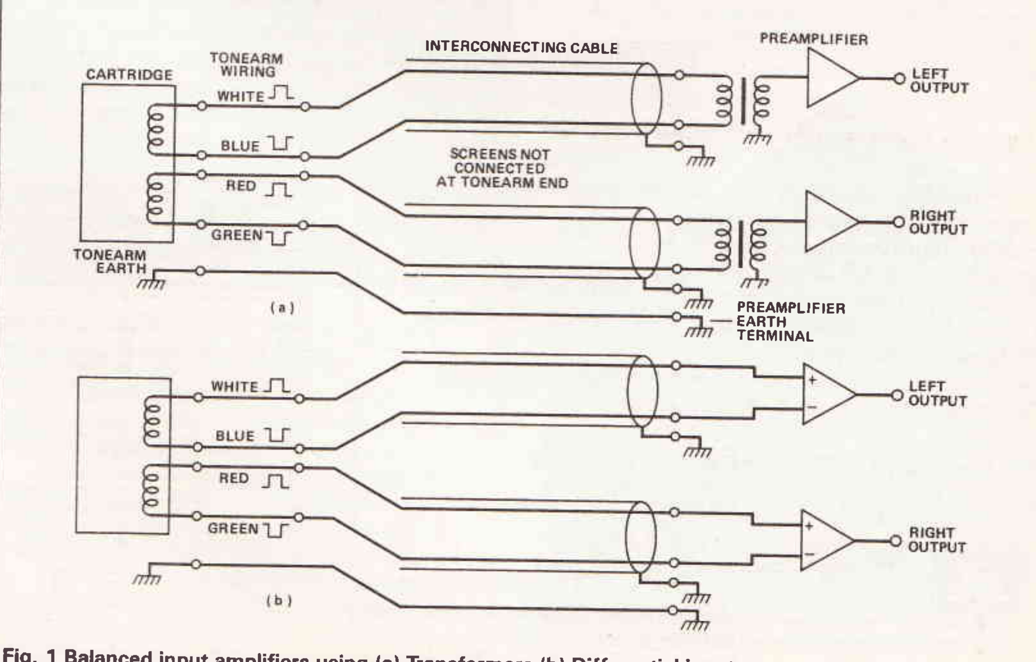


Fig. 1 Balanced input amplifiers using (a) Transformers (b) Differential input

0.022dB has been reduced to 0.0033dB (assuming R26, R27 and C10 to be zero tolerance components). The 318 and 3180μs time constants are provided by IC5 in a similar manner to the original circuit, again with the exception of the E96 resistors.

Input Loading

The original version had fixed input loading components, which made experimenting with alternative values somewhat difficult so a DIL switch is now used to simplify the process. The values given in Fig. 2 appear to be suitable for most cartridges, offering 47k in parallel with 220p for moving magnet types and a choice of 33.8, 51 or 100R in parallel with 10n, 22n or 32n for moving coils. Obviously the values of R1-R3 and C1-C3 may be changed to suit personal preferences.

The final PCB design is given in Fig. 3.

Common Mode Rejection

The single main advantage of balancing the disc input stage is that any hum and noise picked up by the interconnecting cable between cartridge and preamplifier is rejected by the differential action of IC4. In order to fine tune this rejection, RV1 and CV1 are adjusted at low and high frequencies respectively, until the common mode signal is at a minimum. With care, it is possible to reduce the output level of any common mode signal within the audio band by 70dB or more, usually taking it below the noise floor of the amplifier. The method of adjusting the common mode rejection is as follows:

- Using connection A of Fig.4, inject a 100Hz signal at a level that gives an output from the disc stage of +20dBm (7.75V)
- Change to connection B of Fig.4, and, while measuring the output voltage, adjust RV1 for minimum output.
- Repeat first step but using a 10kHz signal.
- Repeat second step but adjust CV1 for minimum output.

The easiest way to set the minimum output is to observe the waveform on a sensitive oscilloscope.

To give some idea of the effectiveness of a balanced disc input stage, during development the amplifier was connected to a Dynavector moving coil cartridge by 10 metres of unscreened twin core mains cable. This cable was routed close to three mains transformers, being wound three times around one of them. (The transformers were in pieces of equipment such as a cassette recorder and FM tuner and were powered during the test.) With the disc amplifier sensitivity set to 0.2mV at a pretty high listening level, no hum was detectable from a pair of sensitive speakers.

When the input was unbalanced, the bass unit cones almost parted company from their voice coils, Marmaduke, our tone deaf cat, did a fair impression of a Saturn V at T+20 and our five-year-old started phoning estate agents with a view to leaving home!

Other Circuit Changes

In spite of trying, I have still not found an alternative to the LM394 for moving coil input stages, although

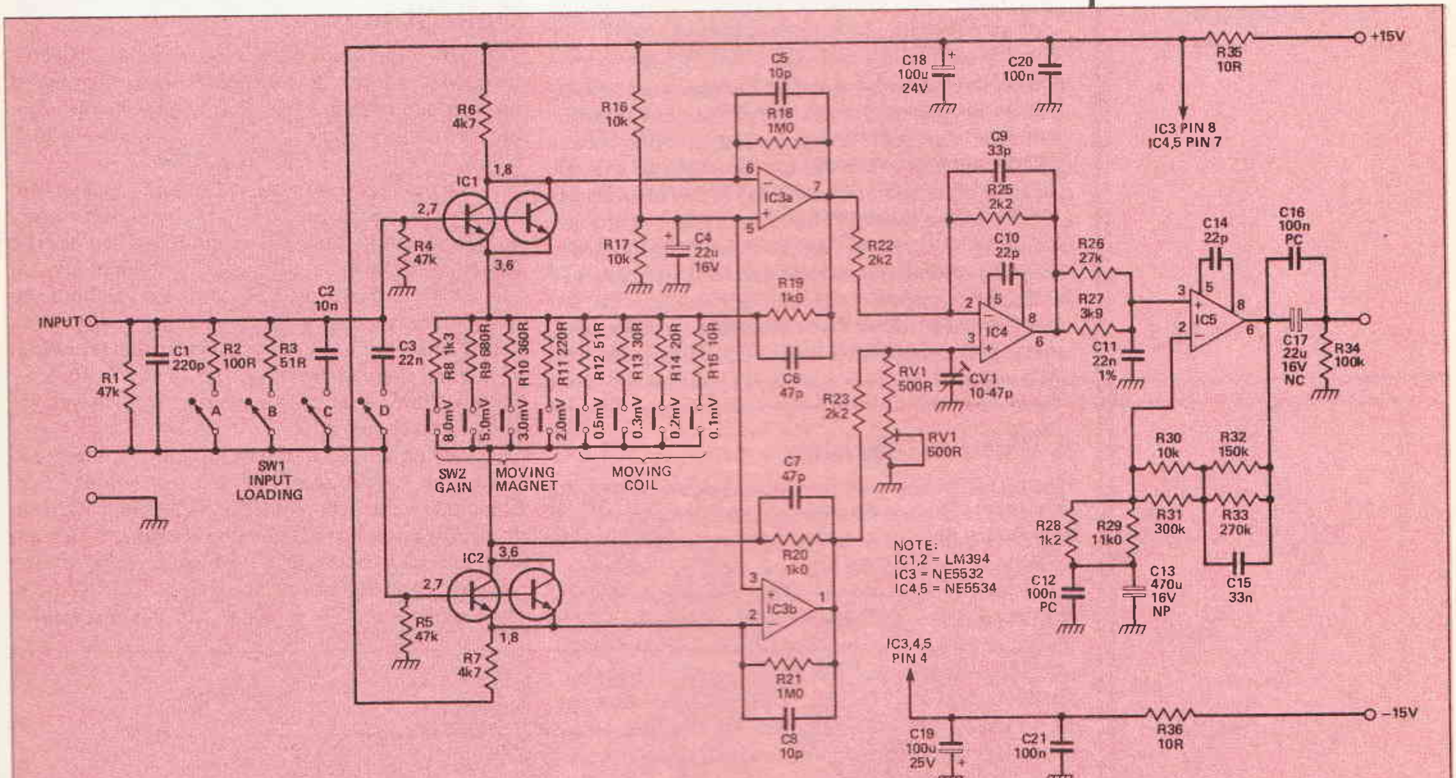


Fig. 2 The circuit diagram of the updated disc input stage

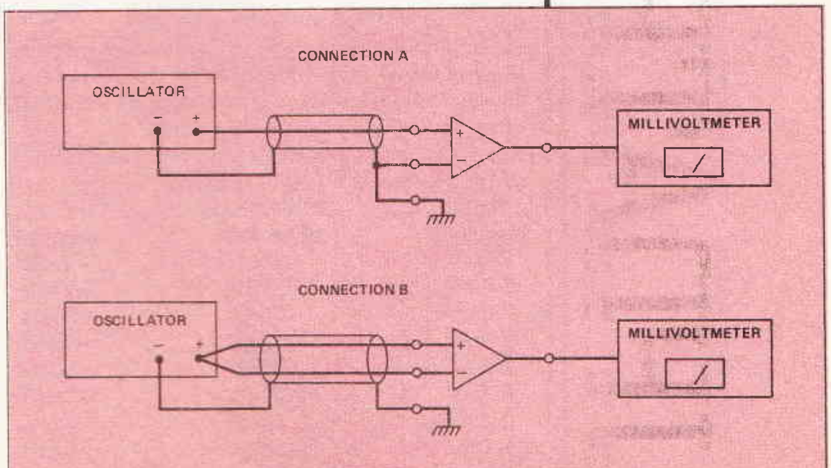


Fig. 4 Balancing the input stage to reduce the common mode rejection

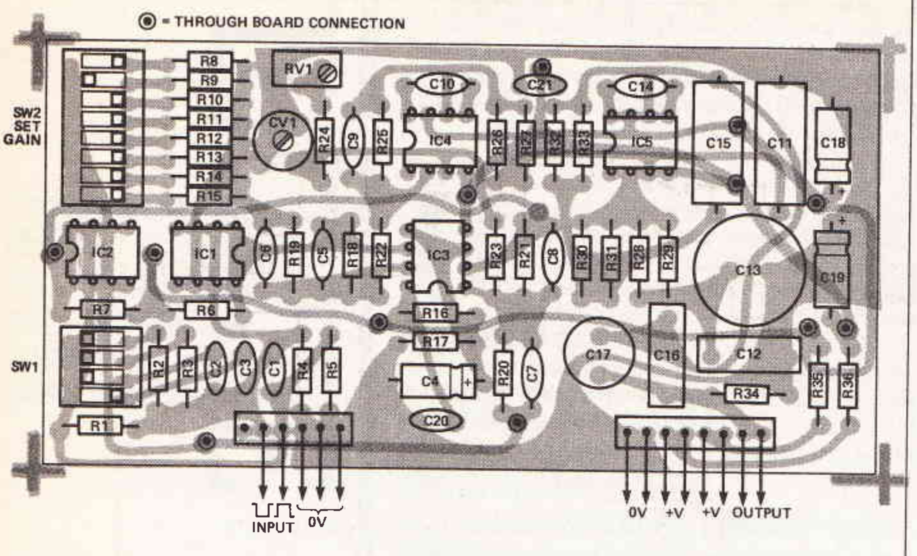


Fig. 3 The component overlay for the updated PCB

some of the low base resistance transistors now available are very attractive in view of their low cost. In particular, the 2SD7865 is almost as quiet as an LM394 and if you turn the circuit upside down and use PNP input devices, the 2SB7375 is only about 0.25dB noisier than a 394 but for some reason it introduces a harshness to the sound that becomes quite tiring with extended listening. I also tried replacing the NE5534 op-amps with Linear Technology LT1028 chips but could neither hear nor measure a difference. With a price differential of nearly 12:1, I'll stay with my 5534s.

A Word of Warning

Having switchable gain and input loading is great if you want to change things around to get the best performance from your cartridge but if you make changes while your pre-amplifier is in use, don't lay a finger on either switch until you have turned the volume down.

In particular, the gain setting switch briefly upsets the DC stability of the circuit and is capable of sending out high level 'thumps' that are guaranteed to see off anything short of a 15in JBL. You have been warned, so no claims will be entertained for new speakers, re-plastering the mansion or multiple visits to have your fillings renewed.

Performance

Although individual methods of construction will have some effect on the performance of a pre-amplifier, typical noise performance is likely to be similar to that measured with my development unit:

Noise: Disc input to main output, with Level control adusted to give 0.5V RMS output at 1kHz.

Input sensitivity	22Hz-22kHz bandwidth	IEC 'A' weighted
8.0mV	−84dB	−91dB
5.0mV	−80dB	−87dB
3.0mV	−75dB	−81dB
2.0mV	−72dB	−78dB
0.5mV	−75dB	−80dB
0.3mV	−71dB	−76dB
0.2mV	−68dB	−72dB
0.1mV	−63dB	−68dB

Distortion: THD at +20dBm (7.75V R.M.S.), any frequency 20Hz-20kHz.

Moving Magnet settings: <0.005% (Typically 0.001% at 1kHz.)

Moving Coil settings: <0.008% (Typically 0.0025% at 1kHz.)

At lower output level, distortion is below noise.

RIAA Equalisation Accuracy: 20Hz-20kHz: Within 0.2dB of reference curve. 10Hz-100kHz: Within 1.0dB of reference curve.

PARTS LIST

RESISTORS (all ¼W 1% metal film)

R1,4,5	47k
R2	100R
R3	51R
R6,7	4k7
R8	1k3
R9	680R
R10	360R
R11	220R
R12	51R
R13	30R
R14	20R
R15,35,36	10R
R16,17,30	10k
R18,21	1M0
R19,20	110
R22,23,25	2k2
R24	2k0
R26	27k
R27	3k9
R28	1k2
R29	11k
R31	300k
R32	150k
R33	270k
R34	100k
RV1	500R multi-turn preset

CAPACITORS

C1	220p ceramic
C2	10n ceramic
C3	22n ceramic
C4	22n 16V axial electrolytic
C5,8	10p ceramic
C6,7	47p ceramic
C9	33p ceramic
C10,14	22p ceramic
C11	22n Mullard 425 polystyrene 1%
C12,16	100n 100V Mullard 344 polycarbonate
C13	470µ 16V Roederstein EKU non-polarised
C15	33n Mullard 425 polystyrene 1%
C17	22µ 16V Roederstein EKU non-polarised
C18,19	100µ 25V axial electrolytic
C20,21	100n ceramic
CV1	10-47p preset

SEMICONDUCTORS

IC1,2	LM394
IC3	NE5532
IC4,5	NE5534

MISCELLANEOUS

SW1	4-way DIL SPST switch
SW2	8-way DIL SPST switch

PCB. Input connectors. Connecting wire.

UPDATE

Cartridge Connector

I have been in touch with the majority of tone-arm manufacturers and importers and it appears that most arms are suitable for balanced operation, with little or no modification required. Just ensure that with your system, it is possible to separately access the four cartridge outputs and that none of them connects to an Earth of any description.

Each channel input at the pre-amplifier should have a 3-pin connector (DIN is the natural choice, but LEMO multi-pin connectors are the best for a top quality system) and each plug should be connected to the tone-arm by a twin conductor, screened cable, with the screen only connected at the pre-amplifier end. Earth continuity from the tone-arm and, if necessary, the turntable, should be carried by a separate heavy wire to the pre-amplifier Earth terminal. The method of connection is illustrated in Fig. 1.

The updated disc amplifier stage circuit board layout (Fig. 4) is of identical dimensions to the original, so no problems should be encountered in replacing the original boards.

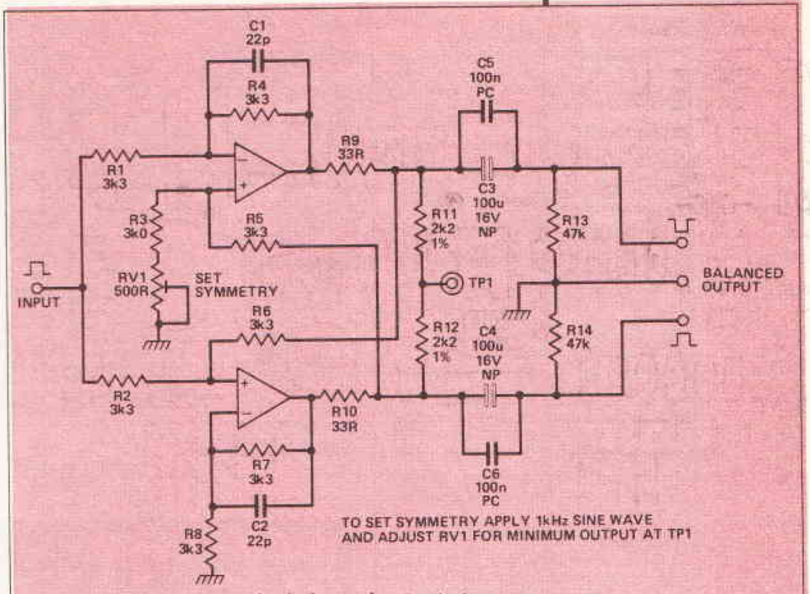


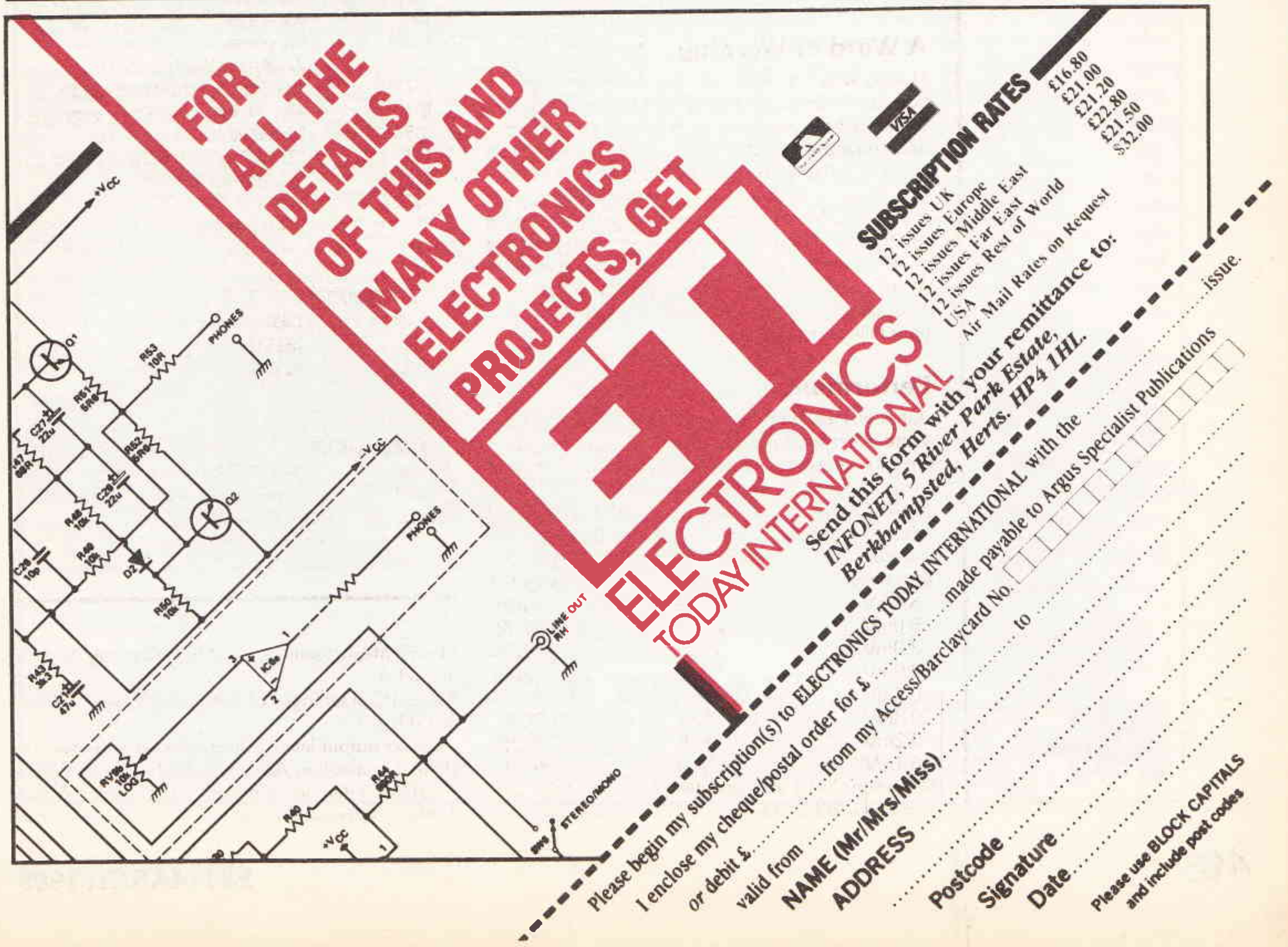
Fig. 5 Modification to the balanced output stage

Further Tweaks

The original balanced output amplifier (January 1984 ETI) had a rather crude method of setting the output symmetry, which requires an extremely steady hand to obtain the optimum balance. Fig. 5 shows a modification which, while being a more elegant solution to the method of symmetry adjustment, is quite easy to implement on the original circuit board. RV1 should be a multi-turn type and with a 1kHz tone applied to the amplifier, should be adjusted for minimum signal at TP1.

The final modification is concerned with the tone control stage. If you can obtain some 10k linear potentiometers with centre tapped tracks, these should be used for the amplitude controls, the centre taps being taken to Earth. This will give a small noise improvement to the stage, will ensure a flat response when the controls are centrally placed and will totally stop interaction between the two sections.

I am sure there are many other improvements that can be carried out to the design but as time is limited, and each change can take many months to implement and test, the above should be enough for the time being.



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BD22	2	25 watt loud speaker two unit cross-overs
BD29	1	B.O.A.C. stereo unit is wonderful value
BD30	2	nicad constant current chargers adapt to charge almost any nicad battery
BD32	2	humidity switches, as the air becomes damper the membrane stretches and oeprates a microswitch
BD34	48	2 meter length of connecting wire all colour coded
BD42	5	13A rocker switch three tag so on/ofi, or change over with centre off
BD45	1	24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day. Original cost £40 each
BD49	10	neon valves, with series resistors, these make good night lights
BD56	1	mini uniselector, one use is for an electric jigsaw puzzel, we give circuit diagram for this. One pulse into motor, moves switch through one pole
BD59	2	flat solenoids – you could make your multi-tester read AC amps with this
BD67	1	suck or blow operated pressure switch, or it can be operated by any low pressure variations such as water level in water tanks
BD91	2	mains operated motors with gearbox. Final speed 16rpm, 2 watt rated
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BD193	6	5 amp 3 pin flush mounting sockets makes a low cost disco panel
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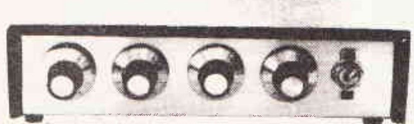

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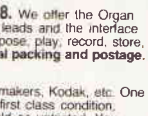
This is helium-neon and has a power rating of 1.6mW. Completely safe so long as you do not look directly into the beam when eye damage could result. Brand new, full spec, £30 plus £3 insured delivery. Mains operated power supply for this tube gives 8kv striking and 1.25kv at 5mA running. Complete kit with case £13. No extra for post if ordered with tube.

HIGH RESOLUTION MONITOR. 9in black and white, uses Philips tube M24/306W. Made up in a lacquered frame and has open sides. Made for use with OPD computer but suitable for most others. Brand new, **£16 plus £5 cost.** Our reference 16P1.

TANGENTIAL HEATERS. We again have good stocks of this quiet running, instant heat units. They require only a simple case or could be fitted into the bottom of a kitchen unit, etc. 1.2kw, which is a very compact little unit and also a 2.5kw, which is approximately 10in long plus motor. Price for either model **£5.** Being rather fragile needs special packing so add **£2** per heater for post and packing. Control switch for 2.5kw model giving full heat, half heat or cold blow. Price **50p.**



MINI MONO AMP on p.c.b. size 4" × 2" (app.) Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of **£1.15 each, or 13 for £12.00.**

FDD BARGAINS

3½in made by Chinon of Japan. Single sided, 80 track Shugart compatible interface. Interchangeable with most other 3½in and 5¼in drives. **£28.50 plus £3 post.** 3in Hitachi, reference 305SXA. Standard Shugart connection, works with most computers but particularly suitable and recommended for Amstrad 6128, etc. **£30 plus £3 post.**

Generous discounts for quantities

J & N BULL ELECTRICAL

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MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1.50 service charge. Monthly account orders accept from schools and public companies. Access & B/card orders are accepted – minimum £5. Brighton (0273) 734648 or 203500.

BARGAINS STILL AVAILABLE

SUB-MIN TOGGLE SWITCH. Body size 8mm × 4mm × 7mm SPDT with chrome dolly fixing nuts. 4 for £1.00. Order ref BD649.

VERY POWERFUL MAGNETS. Although only less than 1in long and not much thicker than a pencil these are very difficult to pull apart. Could be used to operate embedded reed switches, etc. Price 50p each, 2 for £1.00. Our ref BD642.

CLEAR LACQUER. Quick drying for the protection of transfers, markings, maps, etc. Also protects wood and metal. Exceptionally clear. Large can for £1.00. Order ref BD660.

PAPST AXIAL FAN. MANUFACTURERS REF NO TYP4580N. This is mains operated 15watt rating and in a metal frame with metal blades so OK in high temperatures. Body size approximately 4¾in square × 1⅝in thick. £6.00 each, plus £1.00 postage. Our re 6P6.

TRANSMITTER SURVEILLANCE (BUG) – tiny, easily hidden, but which will enable conversation to be picked up with FM radio. Can be housed in a matchbox. All electronic parts and circuit. Price £2. Ref 2P52.

ASTEC PSU. Mains operated switch mode so very compact (6½" × 4" × 2" approx.). Outputs: +5 Volts 3.5 amp. +12 Volts 1.5 amp. –5 Volt 1.5 amp. Brand new. Normal price £30+. Our price only £10. Ref. 10P34.

APPLIANCE THERMOSTATS – spindle adjust type suitable for convector heaters or similar. Price 2 for £1. Ref. BD582.

3 CORE FLEX BARGAIN No. 1 – Core size 5mm so ideal for long extension leads carrying up to 5 amps or short leads up to 10 amps. 15mm for £2. Order Ref. 2P189.

3 CORE FLEX BARGAIN No. 2 – Core size 1.25mm so suitable for long extension leads carrying up to 13 amps – or short leads up to 25A. 10m for £2. Order Ref. 2P190.

CASE WITH 13A PRONGS – to go into 13A socket, nice size and suitable for plenty of projects such as car battery trickle charger, speed controller, time switch, night light, noise suppressor, dimmers etc. Price – 2 for £1. Ref. BD565.

ALPHA-NUMERIC KEYBOARD – this keyboard has 73 keys with contactless capacitance switches giving long trouble free life and no contact bounce. The keys are arranged in two groups, the main area field is a QWERTY array and on the right is a 15 key number pad, board size is approx. 13" × 4" – brand new but offered at only a fraction of its cost namely £3, plus £1 post. Ref. 3P27.

TELEPHONE EXTENSIONS – it is now legal for you to undertake the wiring of telephone extensions. For this we can supply 4 core telephone cable, 100m coil £8.50. Extension BT sockets £2.95. Packet of 50 plastic headed staples £2. Dual adaptor for taking two appliances from one socket £3.95. Leads with BT plug for changing old phones 3 for £2.

WIRE BARGAIN – 500 metres 0.7mm solid copper tinned and p.v.c. covered. Only £3 + £1 post. Ref. 3P31 – that's well under 1p per metre, and this wire is ideal for push on connections.

INTERRUPTED BEAM KIT – this kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken. Main components – relay photo transistor, resistors and caps etc. Circuit diagram but no case. Price £2. Ref 2P15.

CAPACITOR BARGAIN – axial ended – 4700uf @ 25v Jap made. Normally 50p each, but you will get 4 for £1. Ref. 613.

SPRING LOADED TEST PRODS – heavy duty, made by the famous Bulgin company. Very good quality. Price four for £1. Ref. BD597.

SOLAR POWERED NI-CAD CHARGER 4 NI-CAD batteries AA (HP7) charged in eight hours or two in only 4 hours. It is complete, boxed ready to use unit. Price £6. Our Ref. 6P3.

50v 20A TRANSFORMER 'C' Core construction so quite easy to adapt for other outputs – tapped mains input, only £25, but very heavy so please add £5, if not collecting. Order Ref. 25P4.

FREE POWER! Can be yours if you use our solar cells – sturdily made modules with new system bubble magnifiers to concentrate the light and so eliminate the need for actual sunshine – they work just as well in bright light. Voltage input is .45 – you join in series to get desired voltage – and in parallel for more amps. **Module A** gives 100mA. Price £1. Our Ref. BD631. **Module C** gives 400mA. Price £2. Our ref 2P199. **Module D** gives 700mA. Price £3. Our Ref. 3P42.

SWITCH AC LOADS WITH YOUR COMPUTER. This is easy and reliable if you use our solid state relay. This has no moving parts, has high input resistance and acts as a noise barrier and provides 4kW isolation between logic terminals. The turn-on voltage is not critical, anything between 3 and 30V, internal resistance is about 1K ohm. AC loads up to 10A can be switched. Price is £2 each. Ref. 2P183.

METAL PROJECT BOX. Ideal size for battery charger, power supply etc; sprayed grey, size 8" × 4¼" × 4" high, ends are louvered for ventilation other sides are flat and undrilled. Order Ref. 2P191. Price £2.

BIG SMOOTHING CAPACITOR. Spraque powertytic 39,000uF at 50V. £3. Our Ref. 3P41.

4-CORE FLEX CABLE. Cores separately insulated and grey PVC covered overall. Each copper core sized 7/0.2mm. Ideal for long telephone runs or similar applications even at mains voltage. 20 metres £2. Our Ref. 2P196 or 100 metres coil £8. Order Ref. 8P19.

TWIN GANG TUNING CAPACITOR. Each section is .0005uF with trimmers and good length ¼in spindle. Unused but old and may be slightly soiled. Sleeved prong type. £1 each. Our Ref. BD630.

13A PLUGS. Good British make complete with fuse, parcel of 5 for £2. Order Ref. 2P186.

13A ADAPTERS – Takes 2 13A plugs, packet of 3 for £2. Order Ref. 2P187.

20v – 0 – 20v – Mains transformers 2½ amp (100 watt) loading, tapped primary. 200-245 upright mountings £4. Order Ref. 4P24.

POWERFUL 12V MOTOR was intended for Sinclair Electric Car, rating approx. ⅓ HP. Price £15 plus £2 post.

RE-CHARGEABLE NICADS 'D' SIZE these are tagged for easy joining together but tags can easily be removed, virtually unused, tested and gntd. £2.00 each. Ref. 2P141, 6 for £10. Ref. 10P47.

FLIP-OVER DIGITAL CLOCK – Quite an eyecatcher, this is mains operated. The figures flip-over per minute and per hour and give a larger than usual visual display. Supplied complete with front and perspex panels to glue together to make its case. £2.00 each. Our Ref. 2P205.

QUICK FIX MAINS CONNECTOR – A must for your workshop. Saves putting on plugs as you just push the wires under the spring clips. Automatically off when lid is up. Price £7.50. Our reference 7P5/1.

BT HANDSET with curly lead terminating at BT plug. Colour cream. Price £5.00. Our reference 5P123.

SINGLE SCREENED FLEX 7.02 copper conductors, pvc insulated then with copper screen, finally outer insulation. In fact quite normal screened flex. 10m for £1. Our ref BD668. Ditto, but solid conductor, 10m for £1. Our ref BD668A.

WHITE CEILING SWITCH 5 amp 2 way surface mounting with cord and tassle. Made by the famous Crabtree Company. Price £1 each. Our ref BD528.

13A SWITCH SOCKETS – Top quality made by Crabtree, fitted in metal box with cutouts so ideal for garage, workshop, cellar, etc. Price £2 each. Our ref 2P37.

EHT TRANSFORMERS – Normal primary, secondary 3.5v at 3mA continuous or 20mA intermittent. Ideal as a spark generator for boiler lighting, etc., or with a simple voltage doubler circuit would make a good ioniser. Price £7. Our ref 7P7. 8kv secondary 3mA. Price £10. Our ref 10P56.

DIGITALLY TUNED RADIO

PROJECT

Richard Grodzik counts on his radio to tune him to his favourite station

The humble radio has yet to be digitised at an affordable price. The world is increasingly crammed with digital electronics, populating boards from Shanghai to Sheffield, but the radio has stuck with its analogue roots.

This design reaches a compromise with old-fashioned analogue married to digital techniques. The block diagram is shown in Fig. 1. This radio has no tuning capacitors or condensors to rotate. Instead tuning is accomplished by means of a single push button. This increments a counter, the output of which is converted to an analogue voltage across the varicap diodes.

As the push button is kept depressed, the resonant frequency of the tuned circuit changes progressively, pulling in different stations. This would mean that on switch-off, the tuning is lost. Allowance can be made for this by winding the aerial coil on a tube such that the ferrite rod can slide. Your favourite station can be selected by 'permeability' tuning — fine adjustment of the ferrite rod. Once positioned as you wish, fix them with a blob of wax or hardening glue.

Construction

The component overlay for the digitally tuned radio is shown in Fig. 2. Construction is very straightforward

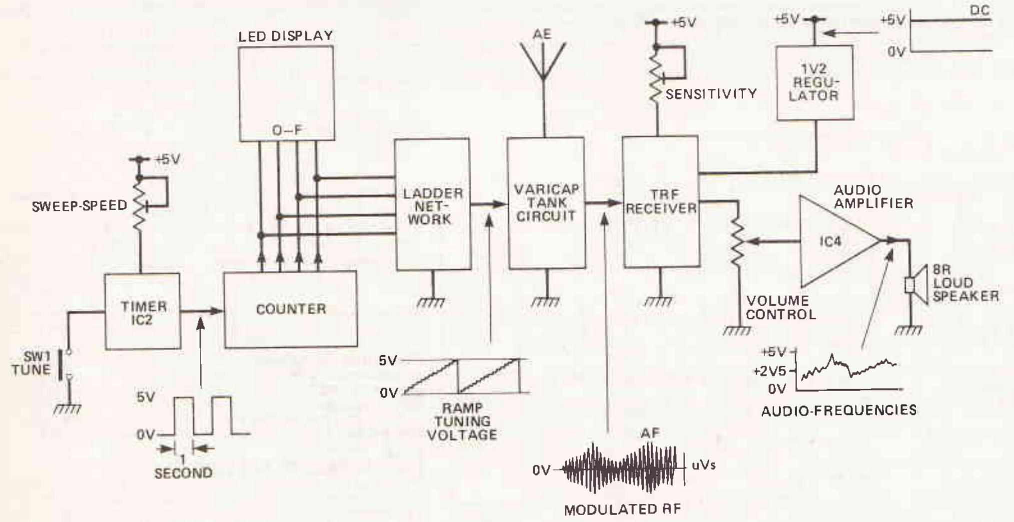
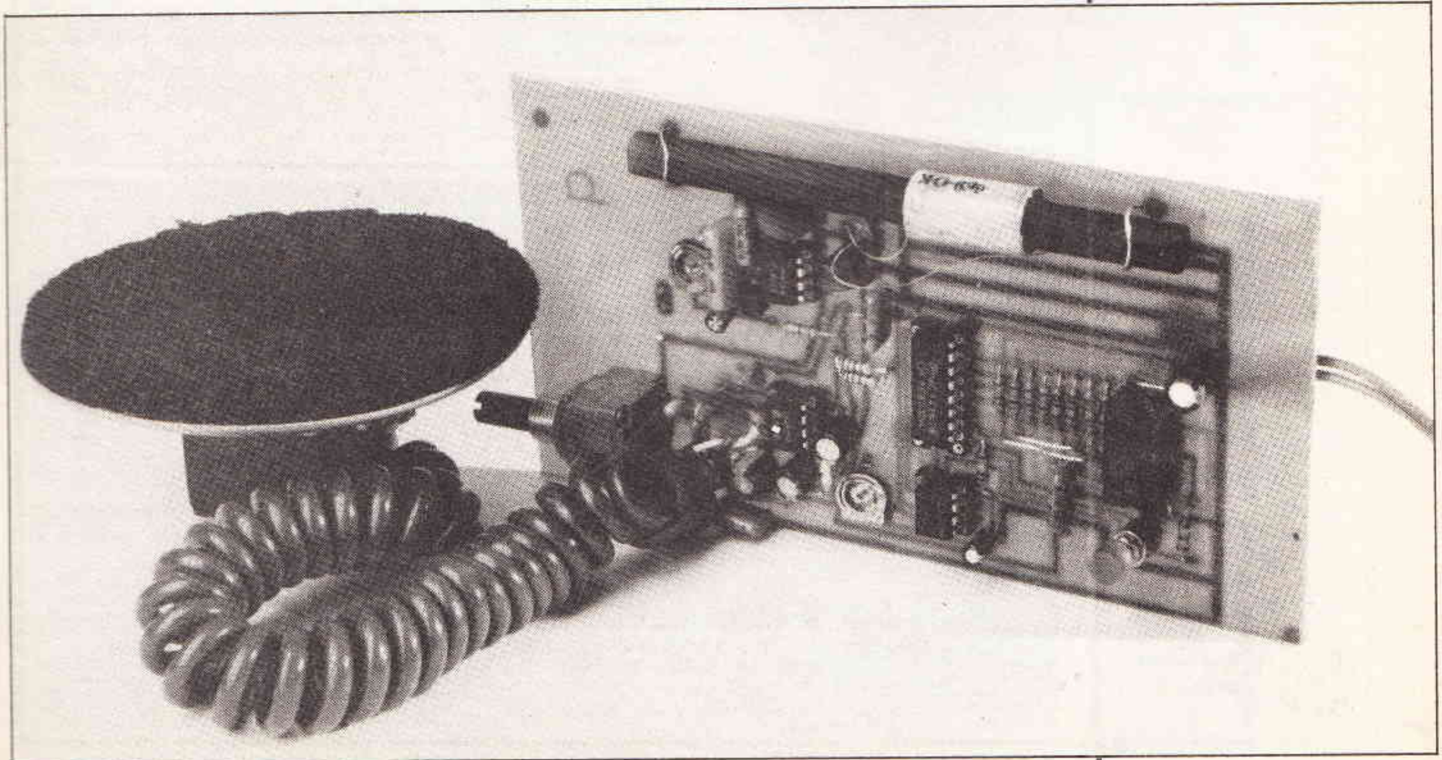


Fig. 1 Block diagram of the digitally tuned radio



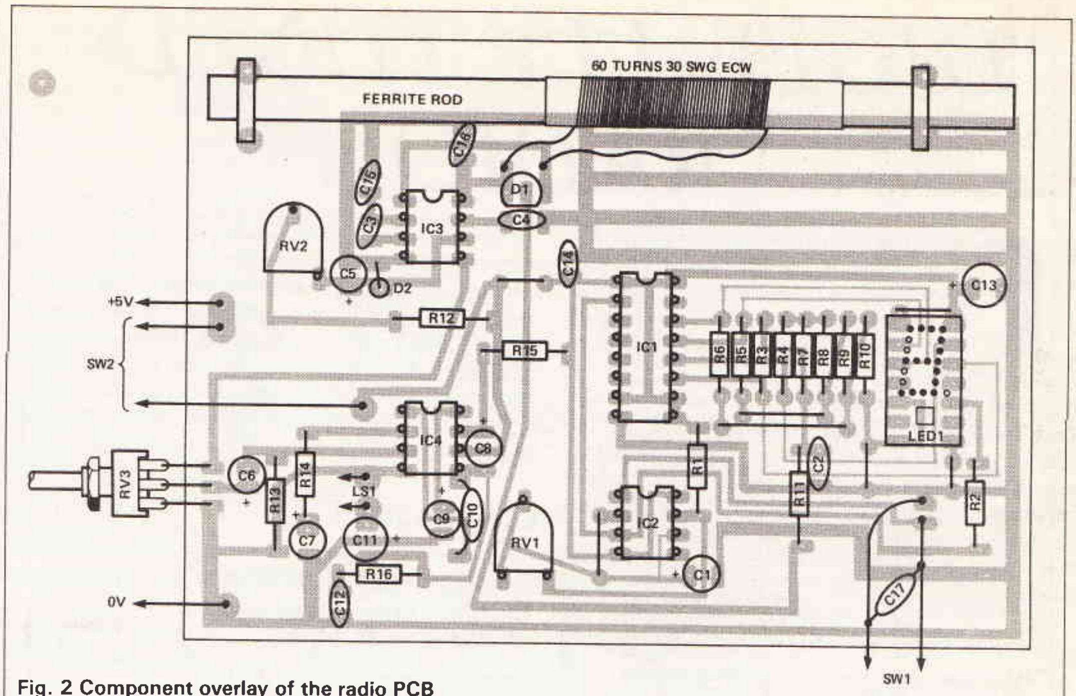


Fig. 2 Component overlay of the radio PCB

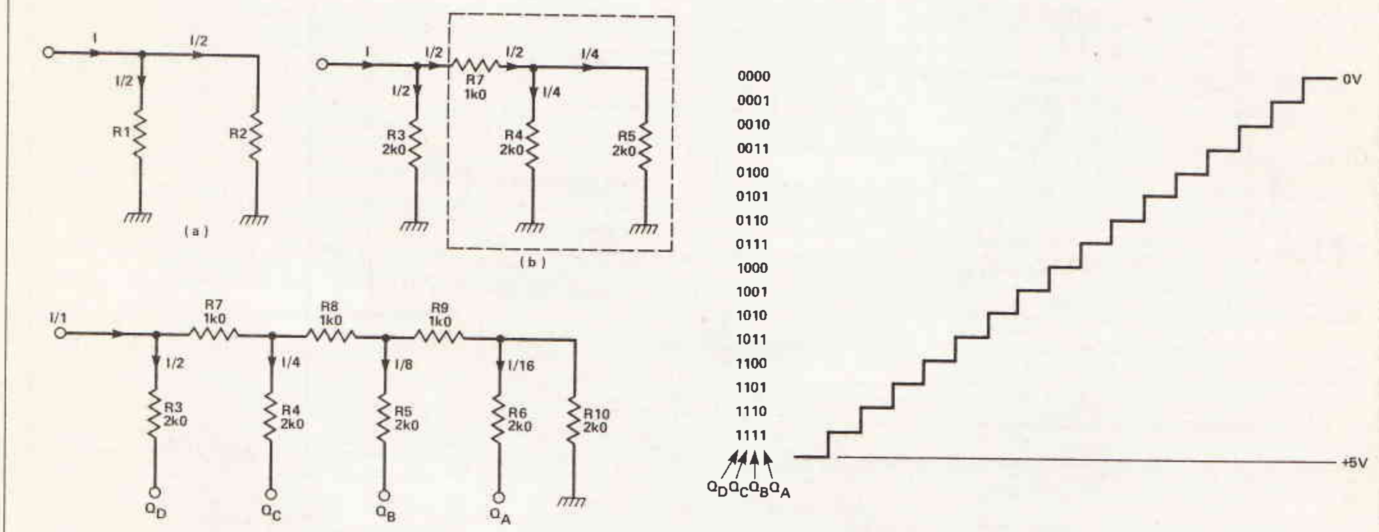


Fig. 3 Explanation of the R-2R tuning network

PARTS LIST

RESISTORS (all ¼W 5%)

R1	120k
R2	680R
R3-6	2k0
R7-10	1k0
R11	68k
R12	750R
R13	10k
R14	100R
R15	56R
R16	1R
R17	1k5
RV1,3	1k preset
RV2	470R preset
RV3	100k logarithmic

CAPACITORS

C1,5,6	10µ 16V radial electrolytic
C2,14,15	100n ceramic
C3	470n ceramic
C4,16,17	10n ceramic
C7,8,9,11,13	100µ 16V radial electrolytic
C10	220p polystyrene
C12	220n polyester

SEMICONDUCTORS

IC1	4161
IC2	ICM7555IPA
IC3	ZN416E
IC4	TBA820M
D1	BB212
D2	04BJ 1.26V ref.
LED1	0.27in Hex display
LED2	low current LED

MISCELLANEOUS

BAT1	4xC size NiCd batteries or 5V DC supply
L1	100mm ferrite rod + 60 turns 30swg on sliding tube
LS1	8R 2W loudspeaker
SW1	push-to-make
SW2	single pole toggle

HOW IT WORKS

The circuit diagram is shown in Fig. 4. The digital tuning is formed by IC1 and IC2, the analogue section by IC3 and IC4.

When SW1 is pressed it enables IC2 by grounding pin 1, producing very low frequency pulses. These pulses clock IC1, a 4-bit asynchronous counter with the output count on pins 11-14. This count is shown on the LED display, giving an indication of the tuning.

R3-10 translate the binary value of IC1 to a DC voltage using what is known as an R-2R configuration. Figure 3 shows how. The idea is that at each node, the input current is split in half for this to happen the resistance of each exit path must be the same.

So in Fig. 3a, the current I will split as required if R1=R2. In Fig. 3b, the combination of R4,5 and 7 must equal R3 (imagine the resistors inside the dotted line as a single component). At the second node, the incoming current is ½ and if R4=R5 this will split again to 2x¼. (Note that R4 and R5 in parallel give a resistance of 1k0 which together with R7 produces a 2k0 total resistance inside the dotted line, equalling that of R3 as desired).

Expanding to the full network in Fig. 3c, the division of current continues as you move along the ladder.

We then return the 'earth' ends of R3,4,5,6 to either ground or supply depending on the logic states of QD,QC,QB and QA of IC1 (the binary count). Thus the total amount of current supplied to the network varies with the binary count, altering the reverse voltage across D1 as in Fig. 3d.

The ramp tuning voltage increases as SW1 is depressed, and the capacitance of D1 alters accordingly. D1 in conjunction with L1 forms a tuned 'tank' circuit, with resonant frequency dependent on the capacitance value of D1. An incoming AM broadcast signal is selected by the tank circuit and fed to IC3 the heart of the analogue side is IC3, a tuned-radio-frequency circuit containing an RF amplifier, detector/demodulator, AGC circuits and a buffered output stage sufficient to drive a power amplifier IC4.

In order to provide a good signal to noise ratio, IC3 is designed to operate at a very low voltage, typically 1.3V. The gain and thus the overall sensitivity of the radio is adjusted by RV2 which varies the supply current to the chip.

The remainder of the circuitry is quite straightforward a single chip AF amplifier (IC4), delivering upto 2W to an 8R loudspeaker.

If fidelity is sought after, I strongly suggest the use of a large diameter loudspeaker. Of course, overall current consumption will increase but this will not present a problem to your battery finances if rechargable batteries are used.

Note that replacing R14 with a 470R pot will vary the overall gain to suit different speaker.

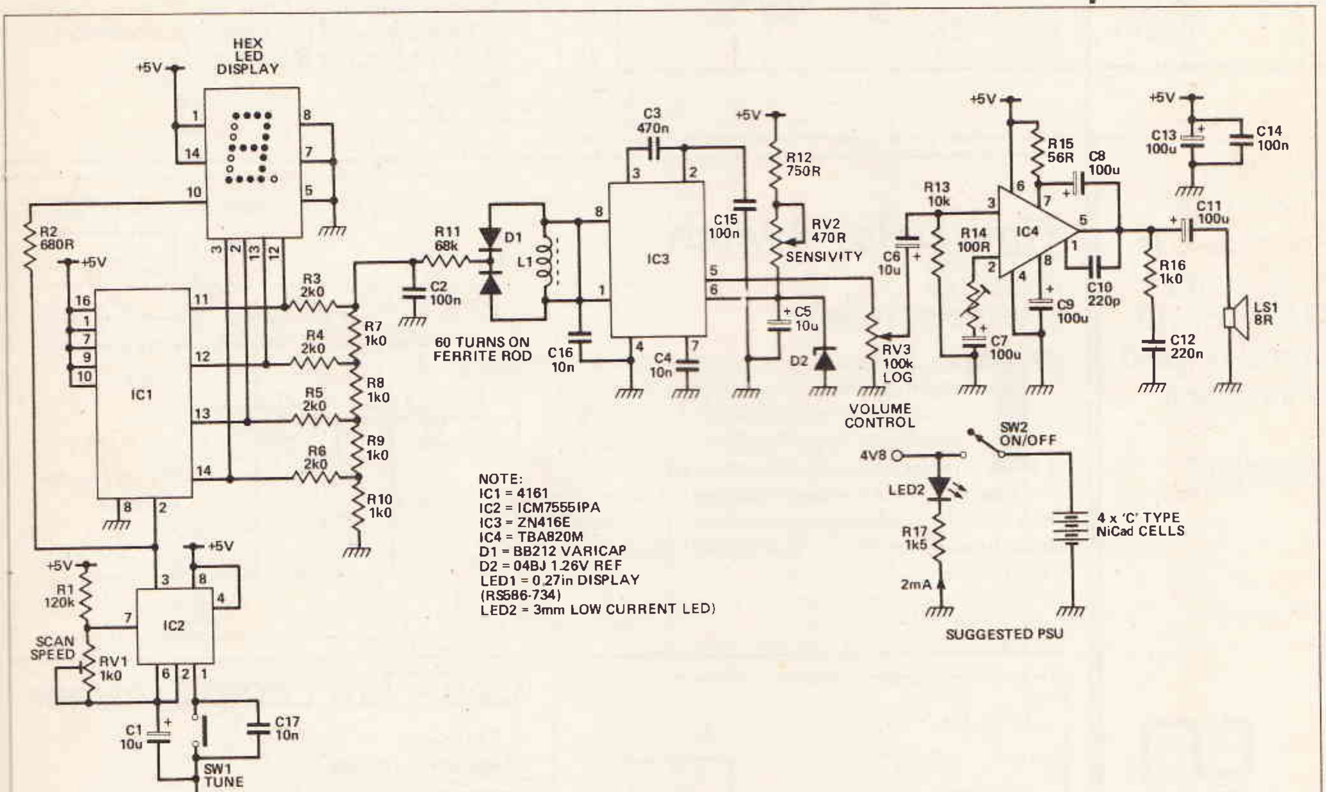


Fig. 4 The full circuit diagram for the radio

using the PCB. Build from the resistors up, sockets are recommended for ICs and for the display LED — the legs on this device are pretty fragile and it is also static sensitive so take the normal static precautions.

The push-to-make switch can be mounted either on the board or remotely, depending on how you intend to box the unit.

The connections to the loudspeaker on the prototype were secured with a dollup of glue, just in case a sharp pull broke through the solder.

Lastly, when you're fitting the rod into place, a couple of pairs of holes are on the board to take loops of wire towards each end of the rod. These should stop it sliding out of place too much during testing.

The simple power supply is all mounted off-board and uses four 'C' type batteries. These actually take up more room than the entire populated PCB but can be arranged two by two to form about the same shape. The whole unit can then be fitted quite neatly into a rectangular case.

BUYLINES

Most of the components are easily obtained. D1 is stocked by Maplin (order code YH83E). The display can be obtained from Electromail (Tel: (0536) 204555) as part 586-734.

The PCB is available from the ETI PCB Service listed at the back of the magazine.

TECH TIPS

Car Courtesy Delay

K. Wood
Ipswich

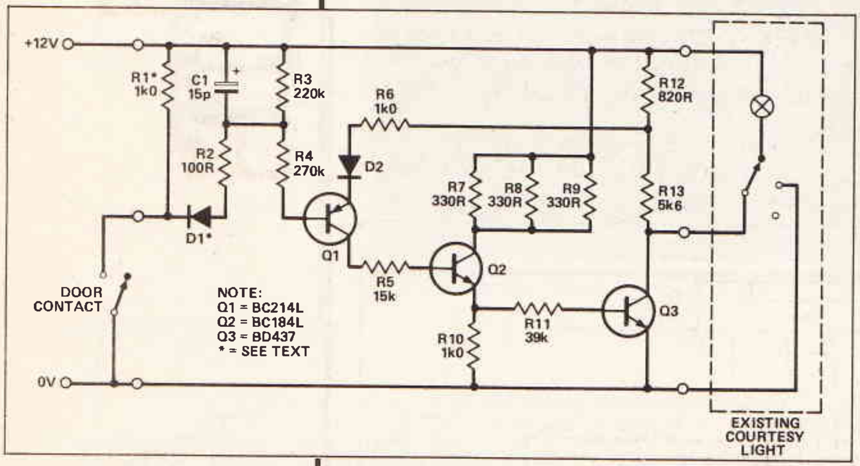
Car door lights are usually simple switches that plunge night drivers into darkness as soon as they close the door. This circuit is inserted between the door switches and the courtesy light in the car (negative earth) to keep the light on for a few seconds after the doors have been closed, then fade out gently.

Opening a door shorts point A to ground, charging C1, turning on Q1 and Q3 via Q2. Q3 drives the light (which should not be more than about 10W). The voltage at the junction between R12 and R13 is still not low enough to turn Q1 off, so the lamp is driven hard and Q3 does not get hot.

When the output voltage cannot rise any further (with Q1, Q2, and Q3 hard off) insignificant current flows from the supply, though the capacitor still has to finish discharging. Again there is no cause for Q3 to get hot.

The only time Q3 will get warm is during fade-out and this is quick enough not to matter. Q3 requires a lot of base drive supplied by Q2 with R7-R9 absorbing some of the power dissipation that would otherwise be concentrated in Q2.

R1 and D1 are optional to allow burglar alarms that monitor the door light circuit to function correctly. The actual value of R1 may need adjusting but watch out for the power if you make it much smaller than 1k0. Change C1 or R3 to alter the delay.



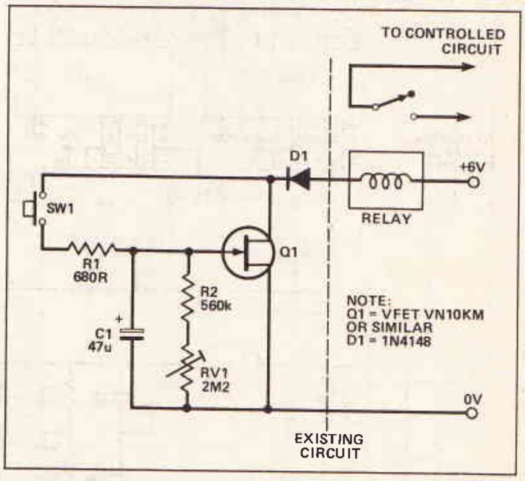
Circuits and other ideas for Tech Tips should be sent to ETI at 1 Golden Square, London W1R 3AB. All items used will be paid for. Please include a SAE for acknowledgement.

Time Delay Switch

D. Ian
East Molesey, Surrey

This design was produced to replace an expensive time delay switch for the light in a porch. No modification of the existing system is required, the circuit simply replaces the previous time-switch.

The push-to-make switch charges C1, switching on the VFET and closing the relay until C1 discharges through the preset RV1 — in this case variable from 1 to 10 minutes.



Capacitor Lamp Dimmer

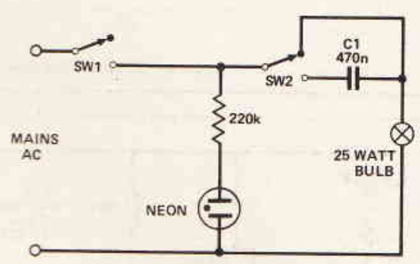
J. Quigley
Mapperley, Notts

Building a nightlight for a child's bedroom with a fully variable lamp dimmer is like using a guillotine to clear your dandruff. A capacitor in series with the lamp is a quick and cheap way of reducing power without interference. SW2 selects full power or reduced output.

The value of C1 depends on the wattage of the bulb and the brightness required (see table). You could fit a multiway switch with different capacitance values to give a variety of control.

Electrolytics must not be used, and simply shorting out C1 may damage both capacitor and switch. Use polyester, mixed or paper with at least a 300V rating. The neon will discharge C1 safely if the lamp is disconnected at the mains with the mains switch left closed.

Care must be taken when testing as the capacitors will hold a charge for some time.



	25 WATT	40 WATT	60 WATT
NIGHT LIGHT	470n	1u0	2u0
HALF POWER	1u0	1u5	3u0

READERS CIRCUITS

Opto Counter

S. S. Ahmed,
Karachi, Pakistan.

This circuit is a counter/timer with start and stop triggered by the breaking of optical links. The applications are wide, but the circuit was designed for use in classroom physics experiments such as the inclined plane experiment to calculate gravity.

There are three main sections — the timebase, the gate control and the counter stage.

The time base itself is not described here, as constructors will have different requirements. A 555 could be used for low precision work, or a crystal oscillator for high accuracy.

The time base is divided by a pair of 7490s to provide three time ranges 0.000 to 0.999s, 0.00 to 9,99s, and 00.0 to 99.9s. Further ranges could easily be added.

The light sources for the LDRs were 3V bulbs with built-in focussing lenses. A 2cm long barrel of card around both bulbs and LDRs works well even in bright lighting, even better with the inside of the card painted black.

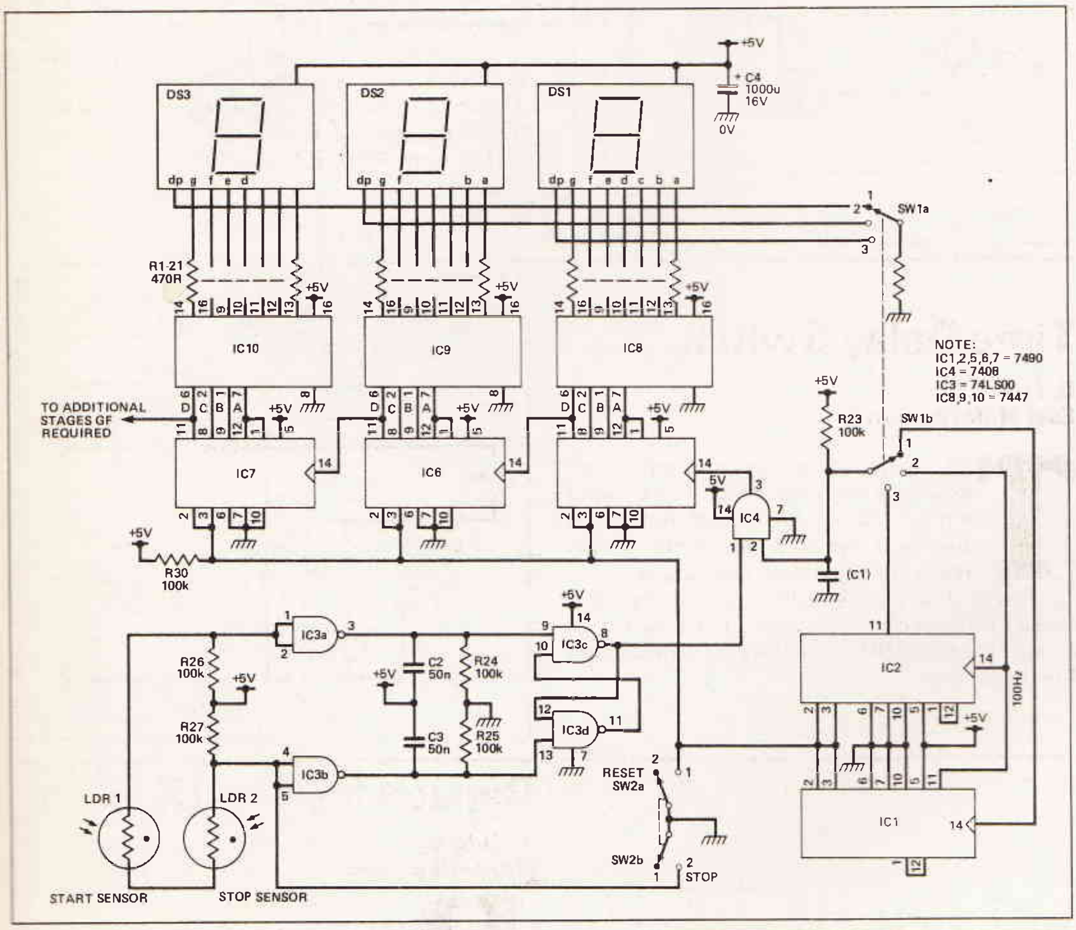
IC3 (quad NAND gate) controls the gating logic. The outputs of IC3a,b are normally low. The resistance of LDR1 falls when the light beam is cut and the output of IC1a goes high. This sets the R-S latch formed by IC3c,d and opens the input gate (IC4) enabling the timing pulses to be counted.

When the second beam is broken, IC3b goes high, resetting the latch and stopping the counting.

The counter and display section of the circuit has nothing unusual — 7490s as decade counters, 7447s as decoders and display drivers, and any common anode LEDs for the display.

SW2 is a DPDT push switch. When pressed pins 2 and 3 of all 7490s go high, clearing all counters. It also stops the counting by pulling down the input of IC3b.

The LDRs used were from Tandy but any LDR that fall from 500k-1M0 to 100-300R when light is removed will work.

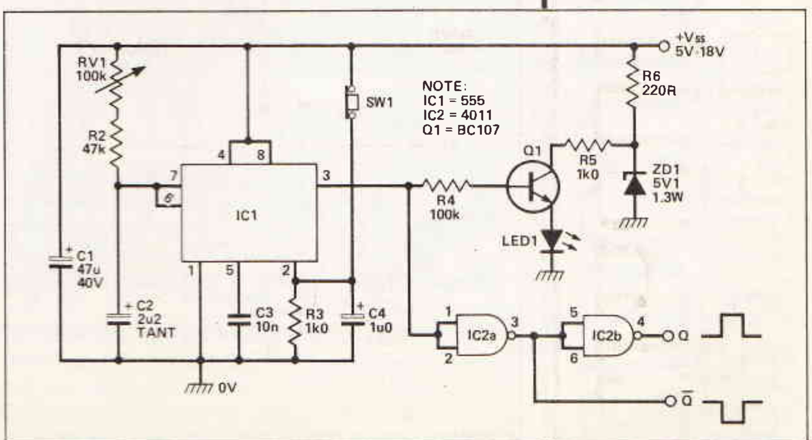


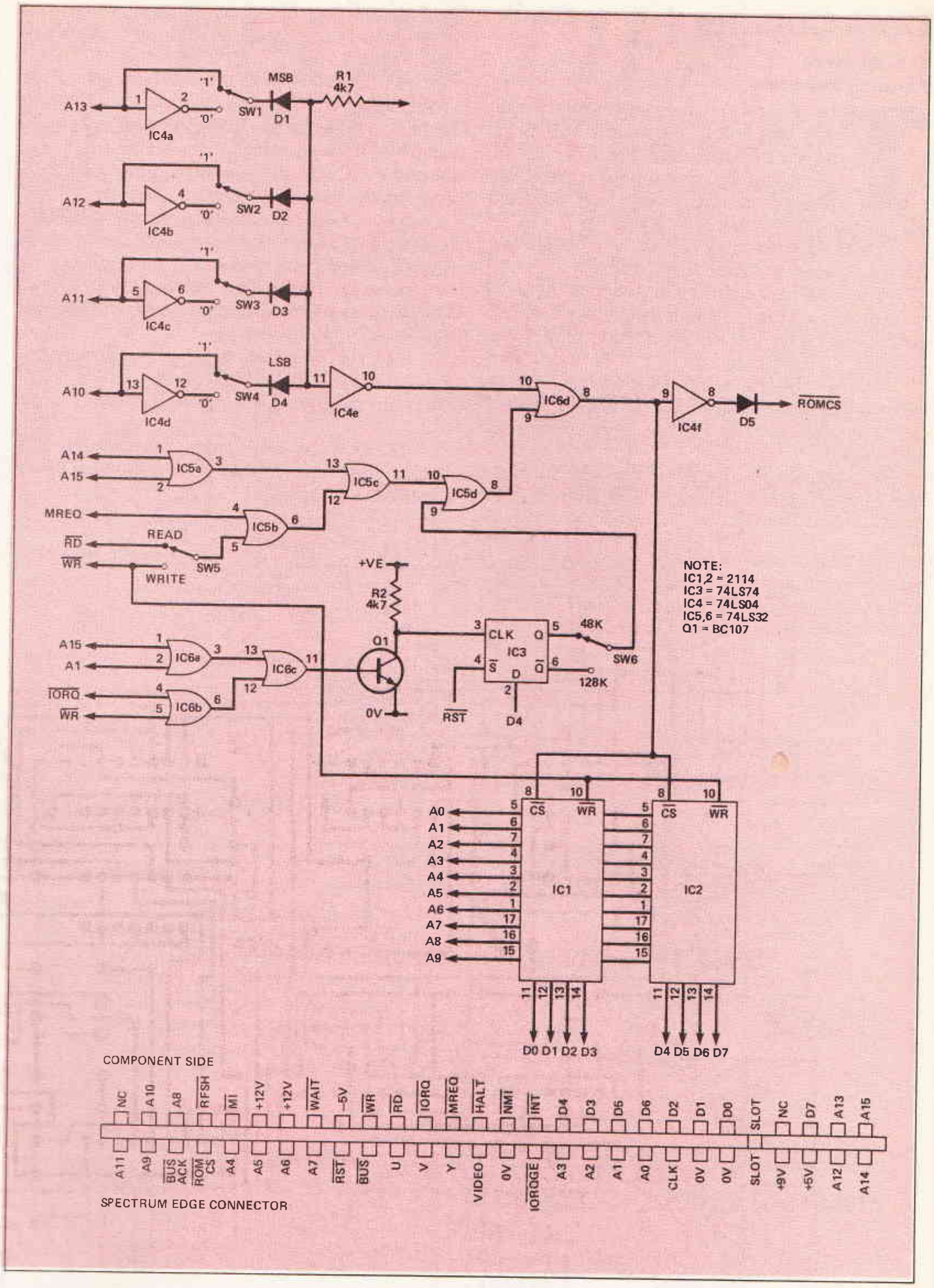
Single Pulse Generator

C. Carter
Falmouth

When designing counting circuits in either CMOS or TTL it can be difficult to decipher rapidly changing outputs. This circuit produces a single pulse of controllable width.

A 555 is used as a monostable with the trigger input (pin 2) decoupled to prevent false triggering. The LED pulse indicator is powered from a shunt regulator to allow any supply from 5-18V to be used. Note that SW1 must be a normally closed type. Outputs are buffered to ensure true logic level outputs.





Spectrum Programmable ROM

K.D. Hedger
Great Yarmouth

Spectrums are limited by the inability to add or change the commands resident in ROM. This circuit pages out the ROM, replacing it with RAM which will be write protected once it is switched in (and will survive even a system reset).

The RAM is a 1K block which can be switched in to replace areas in 1K steps selected by switches SW1-4 (SW1 as MSB). Thus with 0001 on the switches the RAM occupies &400 to &7FF, with 0010 the RAM occupies &800 to &BFF, and so on through the RAM map. Larger RAMs can be used. For example omitting SW4, D4 and IC4d would allow a 2K RAM to be switched in 2K blocks.

Any address line on A10-A13 not matching the relevant switch will send the output of IC4e and so IC6d high (disabling IC1 and 2). The output of IC4f goes low and is blocked by D5. Any address outside the range &0000-&3FFF will do the same via IC5.

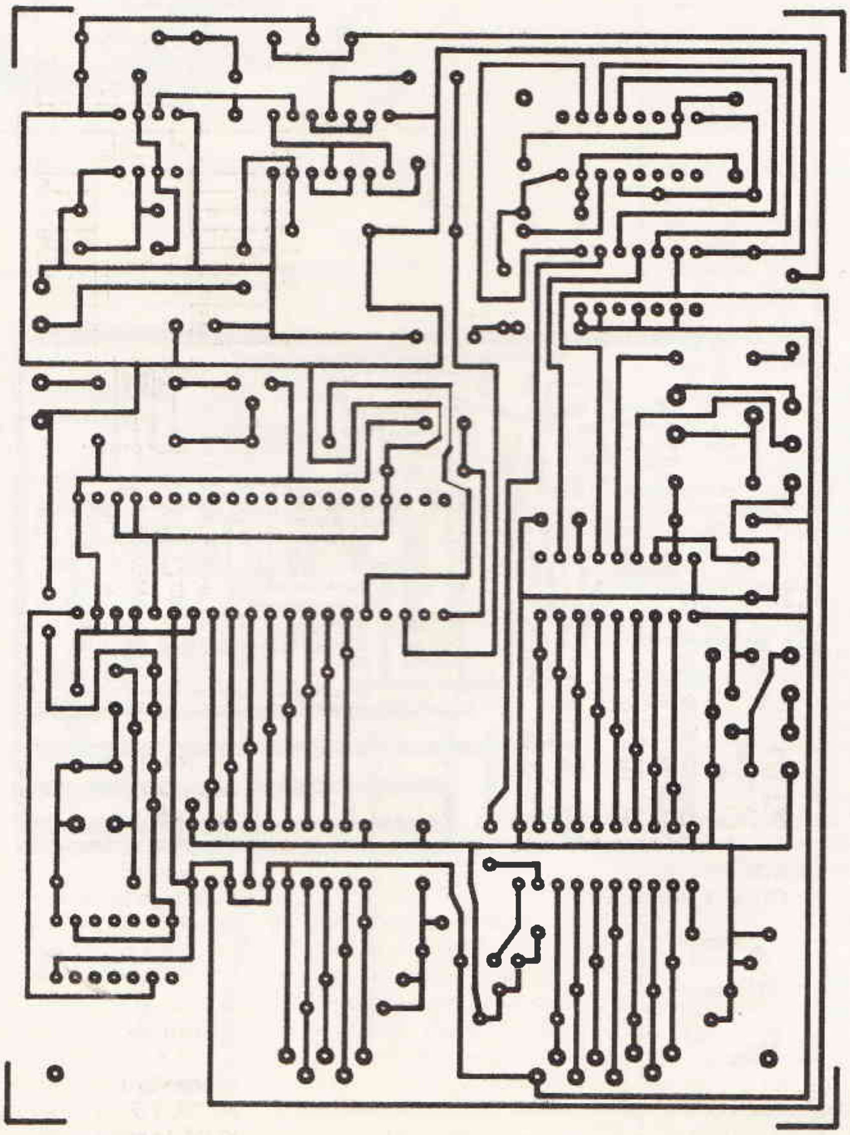
SW5 selects whether the RAM is to be read only or write only. In *write* position the normal ROM can be read and copied to RAM ready for alteration.

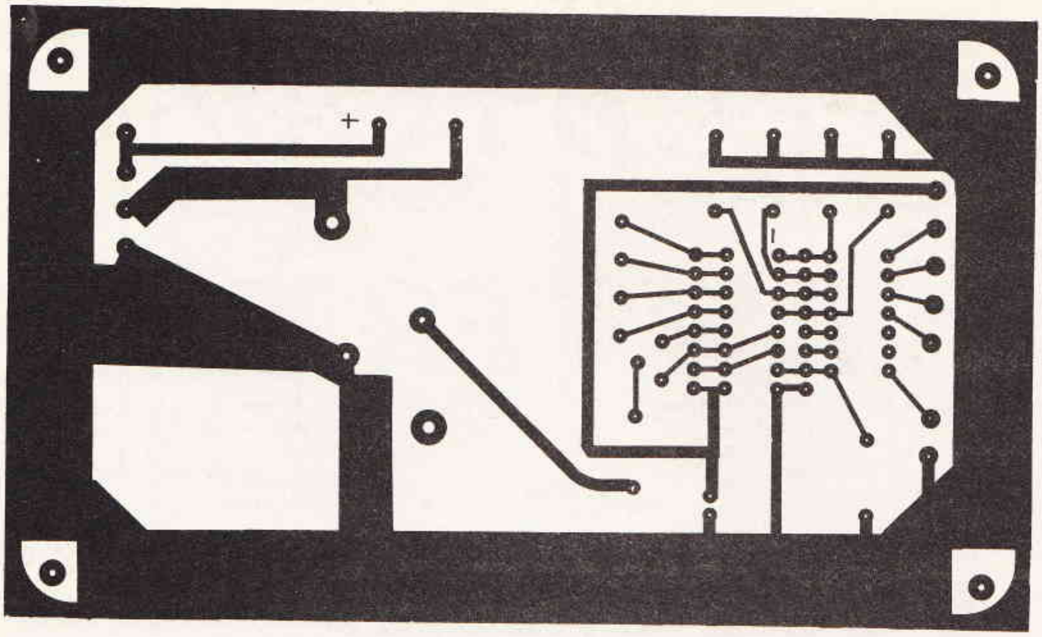
IC6, Q1, IC3 and SW6 make sure the RAM appears in the correct ROM as the 128 switches using an 'OUT 7FFD' instruction with bit 4 selecting the ROM. For 48K machines everything up to SW6 can be omitted and pin 9 of IC5d should be wired to 0V.

Note that on power up SW5 must be in write position.

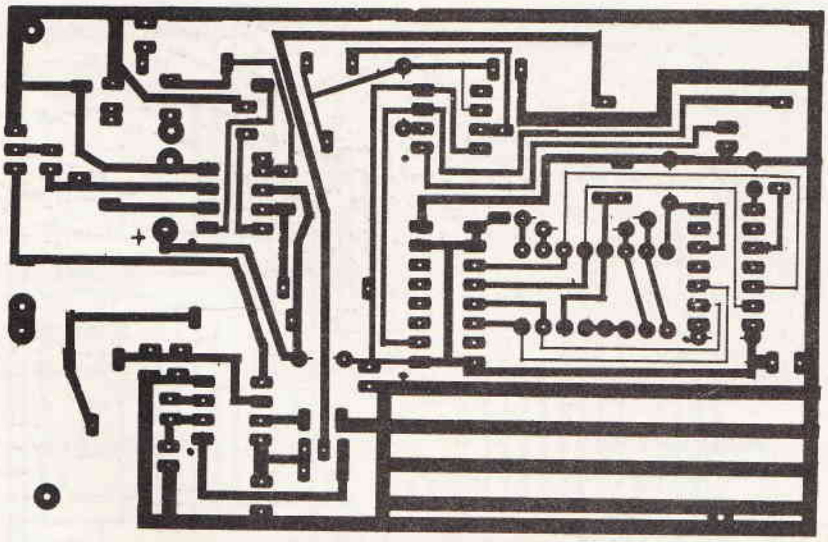
PCB FOIL PATTERNS

The MIDI Programmer foil pattern





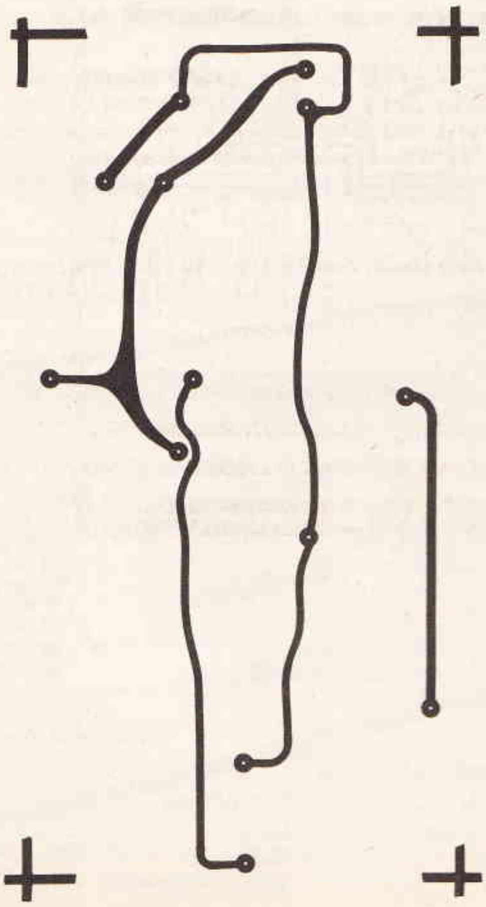
The intelligent plotter solenoid board

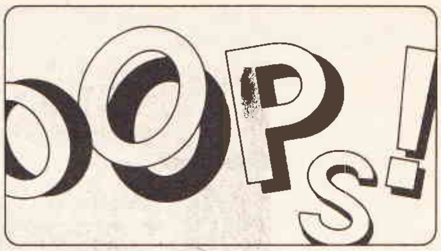


The digitally tuned radio PCB foil

The modular pre-amp input stage solderside foil

The modular pre-amp disc input stage topside foil





Dynamic Noise Reduction (May 1988)
The LM1894 is no longer available from the sources listed but it can be obtained from the author. Please address orders to Manu Mehra, 88 Gleneagle Road, Streatham, London SW16 6AF.

QL Output Port (Tech Tips May 1988)
Several problems with the diagram for this one. A5 should read AS — that is, address strobe. Pins 22 and 24 should be connected to +5V and the junction of the (only) resistor and diode connected to VPA on the QL.

Bicycle Battery Dynamo Backup (June 1988)
C1,2 are incorrectly given as 22μ in the Parts List. The value of 220μ given on the circuit diagram (Fig. 1) is correct.

QWL Loudspeakers (August 1988)
Some dimensions were missing from Fig. 7. The bass driver port centre should be $3\frac{3}{4}$in above the base of the baffle panel. The notches in the side of the tweeter cut-out are $\frac{1}{2}$in wide. The top plate is missing from the cutout diagram (Fig. 6). This is $7 \times 4\frac{5}{8}$in.

EEG Monitor (September 1987)
The wiring for the switch SW1 in Fig. 5 shows all the wires for selecting Alpha and Beta waves swapped. A_1 should read B_1. A_2 should read B_2 and so on. The easiest remedy is to swap the front panel labelling shown in Fig. 6 so that the switch labelling reads Theta, Beta, Alpha.

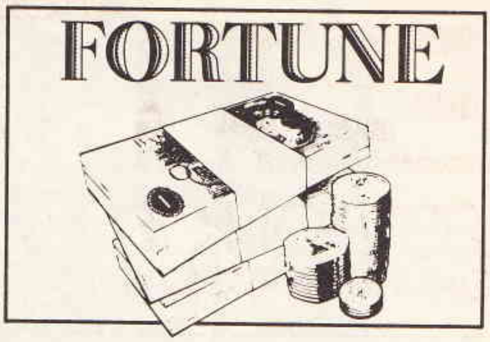
Chronoscope (November 1988)
In the overlay diagram for the counter PCB (Fig. 3) the polarity of C12 is shown the wrong way around. SW1a-d is shown as SW1-4. In Fig. 4 the cathodes of LED 8 and 9 are the righthand and lefthand pads respectively. The cathodes for LED 6,7 are marked as the wrong pin. In the text section on Battery Operation, Q1 should read T1. In Fig. 5 SW2 is incorrectly labelled SW5.

Doppler Speed Gun (December 1988)
In Fig. 2 the labelling of pins 7 and 4 of IC2 are transposed. IC10a Pin 1 and IC9c Pin 10 should connect together and not to the 5V rail. The positive terminal of C3 should connect to the junction of R2/R3. Pin 7 of IC2 should connect to the 12V rail and not to Pin 6/R1. So the pin labelling of CONN1 runs left-right on the overlay diagram, the corresponding labelling in Fig. 2 should be 3-1-2, reading downwards. Fig. 4 is correct in all respects except for the orientation of Q2 for which the c and e labels should be transposed. In addition the extra switch to be seen in the photograph of the prototype is a hangover from a previous incarnation. Just ignore it!

Burglar Buster (December 1988)
The foil part of the component overlay for the basic alarm (Fig. 1) was printed the wrong way around. It should be rotated through 180° as in Fig. 5.

Rev-Rider (January 1989)
In the parts list RV2 is incorrectly given at 33k. It should be 22k as in the circuit diagram. A 'blob' went missing from the circuit diagram. RV2, R7, R4, C1 and D3 should all be connected.

&



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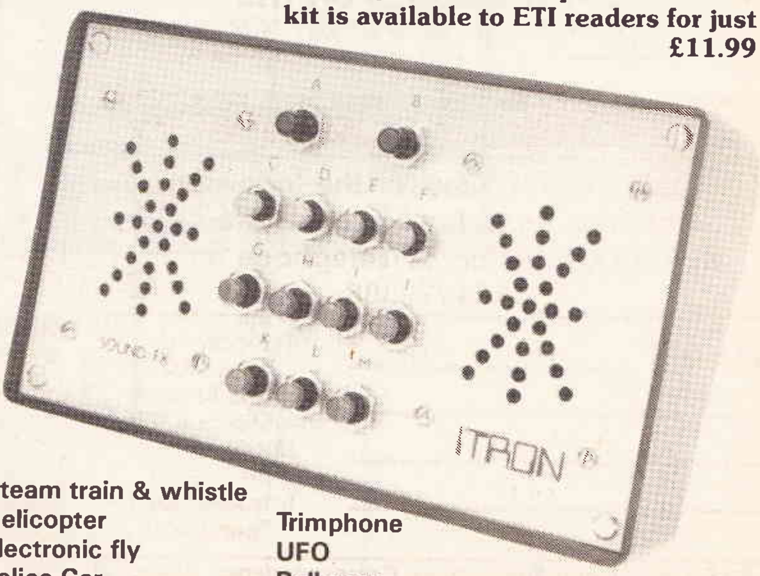

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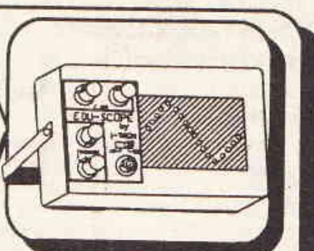

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This month's enquiry is from Adrian Moretti in Italy who has a problem with an old circuit from another mag (well it wouldn't be ETI, would it!)

This transistor assisted ignition project from the 1982 Australian edition of Electronic Projects For Cars *has me stumped. I have built it on the proper PCB, and it works fine on the bench. When I use it in my car, a model 316 BMW (1980 vintage) it invariably burns out the ignition coil after a few hundred kilometres. Can anything be done about it?*

It is difficult to solve problems at long distance but if I explain what the project does and how it works in more detail than the original article did, this may enable you to see what the problem is in your application.

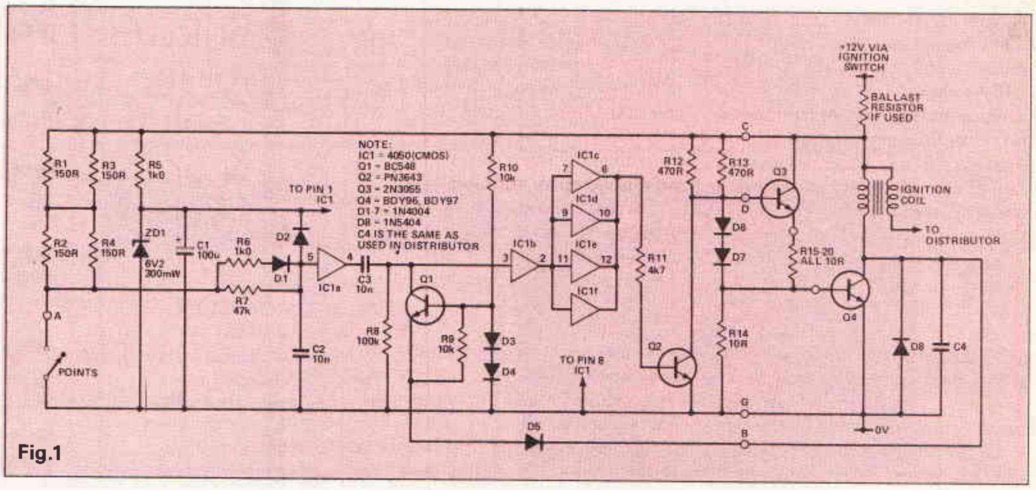

Fig.1

The reason for using a transistor assisted ignition is to provide a clean switching signal to the ignition coil, even though the point may not open absolutely cleanly. To see why this matters, we must first consider the principles of an ignition system.

A conventional ignition system stores energy in the magnetic field in the ignition coil while the points are open. When the points close, the current starts to rise following an exponential law, with a time constant of L/R where L is the inductance of the coil and R is the total circuit resistance.

Normally the current in the coil has time to get close to the maximum theoretical current, given by the voltage and the resistance alone, so that each time the contact opens there is a defined amount of energy available for the spark.

As the contact opens, it rapidly reaches the point where the voltage required to spark across the contacts is greater than that required to spark in the spark plugs, scaled by the turns of the coil. At this point, instead of the contacts arcing at perhaps 100V, the spark plug sparks over at several thousand volts. This simple system would work but would burn the contacts and fail after a short time. The addition of a capacitor in parallel with the contacts keeps the rate of rise of voltage across the contacts just below the rate at which the arc voltage rises as the contacts open.

If the opening of the contacts is not clean, which can be the case after wear has taken place, then some of the stored energy will be used in sparking and burning the contacts rather than in making a healthy spark at the spark plug. It is in this aspect of performance that a transistor assisted ignition can help. A transistor can be made to switch cleanly regardless of contact bounce on the points.

The circuit of the project in question, shown in Fig. 1, does just this. The contacts are debounced by the time constants of R6, R7, and C2. C2 charges rapidly as soon as the contacts open and discharges more slowly when they close. So brief contact bounces after the initial opening have no effect.

The voltage on C2 is fed to a CMOS buffer which will normally give saturated logic outputs despite the fact that it is not fed from logic levels because it has substantial voltage gain. The output logic level is fed to a further time constant which holds Q2 on for approximately 1ms.

Two logic gates in series are used to amplify the voltage change at the junction of C3 and R8 so that, although the voltage at this point changes relatively slowly, the base drive to Q2 switches rapidly over a small range of voltage on the time constant of C3 and R8.

While Q2 is switched on, Q4, which controls the coil current, is switched off. The rate of rise of voltage across Q4 when it switches off is limited by C4 to prevent damage to the transistor or to the ignition coil due to high voltage spikes.

There are two extra features of the circuit. Q3 which drives the output transistor is configured as a constant source (though it is temperature dependent). This maintains the correct drive current during starting, when the battery voltage may fall to 6V, without unnecessarily high dissipation when the battery is at 12V. Q1 is included to discharge C3 and thus switch on Q4 if the voltage across it rings negative. This is illustrated by Fig. 2.

Cause Of Failure

There would seem to be two general reasons why the coil might burn out when the ignition system is used. The first possibility is that the peak voltage across the coil is higher and that this is breaking down the insulation. The second possibility is that too much current is flowing, perhaps because a ballast resistor has been wired out of circuit and the coil is overheating. If the ballast resistor has been shorted, there will be too high a voltage as well, so there will be a double reason for the coil to break down.

These general reasons may be caused by a number of different problems but the first thing is to identify what the general problem is — whether or not it is one of the two possibilities suggested here. If an oscilloscope is available, display the waveform on the collector of Q4 when the ignition system is installed in the car and compare it with the waveform on the points when the conventional ignition is in use.

To protect the scope input (or probe) use potting down resistors of 100k and 1k0 to reduce the measured signal to 1% of its actual level.

This measurement will not indicate small differences in output voltage but if there is a substantial difference in secondary voltage this should be shown in the primary waveform. Look carefully to see whether the transistor sometimes switches when the points are closed. It is possible that noise in the wiring of the car could cause false triggering. If this did occur, it would be when the distributor arm was not in the correct position to route the output to one of the spark plugs. The lack of a proper discharge path for the energy would result in a higher than normal voltage.

The most likely place for noise pickup to occur would be on IC1 pin 3, and if this is where pickup occurs then a good way to try to cure the problem would be to incorporate a proper monostable to replace C3 and R8. Fig. 3 shows a possible circuit with less susceptibility to noise. The component values may require experiment.

The single most likely cause of the problem is a shorted ballast resistor. Before trying anything more complicated, double check whether there is a ballast resistor in your car and if so that it is in circuit when the transistor assisted ignition is in use.

Andrew Armstrong

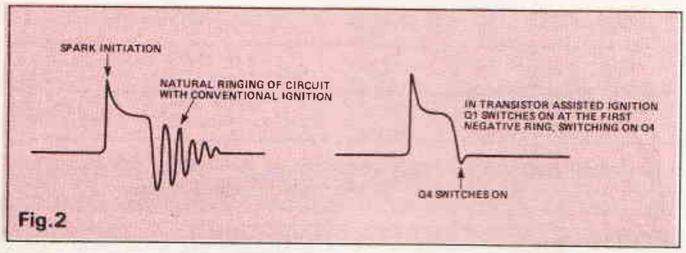

Fig.2

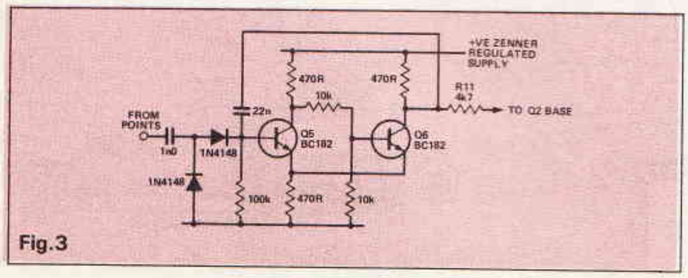

Fig.3

OPEN CHANNEL

America is slowly but surely coming to grips with the problems created by HDTV. To clarify, HDTV stands for *high-definition television* and it's the system proposed and currently being developed by the Japanese. It has around twice as many scan lines as the existing American television system NTSC (1125 lines, to be precise).

Sidestepping, *high*-definition television shouldn't be confused with *higher*-definition television, that is the sort of television we can expect with the MAC systems currently proposed for European satellite television. Even so, many media pundits do mistake the two terms. But that's by-the-by.

HDTV, which is currently undergoing a name change in the States to *advanced television* (ATV), is totally incompatible with existing systems. Its use would mean that NTSC would have to be scrapped. I'm sure that many readers will say that's about time, too — NTSC doesn't give the best of pictures. Nevertheless, it's taking some time for America to realise this.

MAC

In Europe, we've already gone through this realisation, many months ago, which is why we turned HDTV down at an early stage. We didn't want a totally new television system until it was on our terms and the time was right. That's why we opted for the MAC systems. MAC, although not capable of quite such high quality pictures as HDTV (oops sorry, ATV) is compatible with PAL.

Viewers, wanting the higher quality picture which MAC will provide, can opt to buy a new MAC television. Viewers with existing PAL receivers can still watch the MAC broadcasts, albeit only at PAL quality.

Even leaving compatibility aside, HDTV suffers from one particularly huge drawback that it requires significantly greater transmission bandwidth. No problem if the transmissions are to be received from satellite. There's always plenty of space in the spectrum there (pun intended). But this greater bandwidth requirement is very relevant for terrestrial television where only limited spectrum is available.

The Federal Communications Commission (FCC) in America recently took the bull by the horns at long last by announcing that no new frequencies will be made available for terrestrial television broadcasts and that all new broadcasts must be compatible with NTSC standards.

NTSC television channels are only 6MHz wide, whereas HDTV channels require at least 8.1MHz. So that rules out the use of HDTV (in existing form) for terrestrial television in the USA. What's the point of one system for terrestrial television, with another for satellite? None — two television receivers would be required to pick-up both television pictures and that's expensive, bulky and pointless.

To be fair, the reason why America has been wooing HDTV for so long is that the nation is particularly conscious that the consumer boom has been passing it by recently, with the Japanese taking centre stage. America sees ATV as a way of re-entering and eventually recapturing the consumer market, to improve the nation's economy.

Where does the FCC's recent announcement leave the American television industry now? Somewhere up the mucky creek without a paddle, I guess. Let me suggest an alternative approach to ATV for our Western allies. It's a wonderous television system that will give you a great improvement in picture and sound quality (after all, anything's better than NTSC).

Further, it's proven and we can even supply you with chips, shortly, with which to build your television receivers. It's totally compatible with terrestrial television system, it's totally compatible with satellite systems and, what's more, it only requires a transmission bandwidth the same size as terrestrial television.

It's called MAC.

Meanwhile back at the ranch, the American Electronics Association (AEA) has warned the country that unless ATV is quickly and properly developed, not only will the US consumer market continue to be dominated by the Japanese but its semiconductor, computer and automated manufacturing markets will go the same way.

So America is cornered. Having misled itself over the Japanese HDTV system for so long, it now lags considerably in the race to develop its own suitable ATV system. It will be very interesting to watch the overdue debate which is just starting over there.

Brits Hear It All

Finally, Logica has developed a voice-printing technique which appears to work. In fact, it works so well that soon over 10,000 users will have their voices analysed so that they may gain access to a computer system merely by talking to it. The system is to be incorporated into a US organisation (details, as yet unobtained), with a potential of up to 20,000 users. The burning question is, will it be able to detect heavy breathers, and bar them from access?

Keith Brindley

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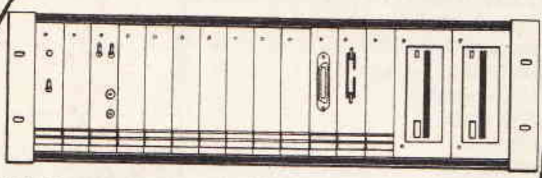

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