EVERYDAY WITH PRACTICAL ELECTRONICS

APRIL 1994

INCORPORATING ELECTRONICS MONTHLY

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LET YOUR PC ASTOUND WITH SOUND

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MOSFET VARIABLE BENCH POWER SUPPLY

0 TO 25V AT UP TO 2·5A

BEST OF BRITISH

NEW SERIES LOOKING AT BRITISH COMPANIES

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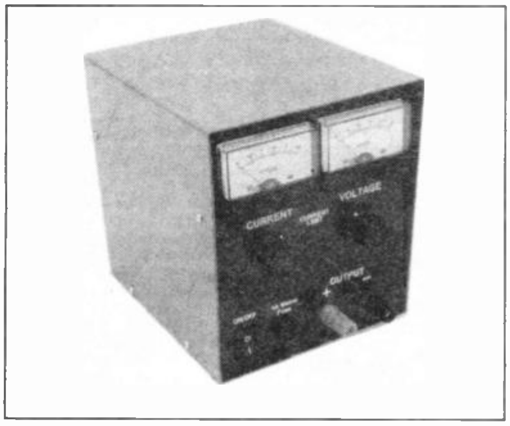
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

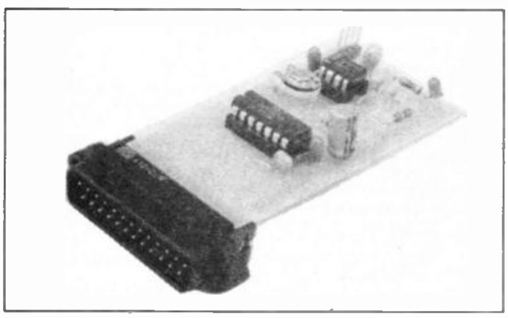
VOL. 23 No. 4 APRIL 1994

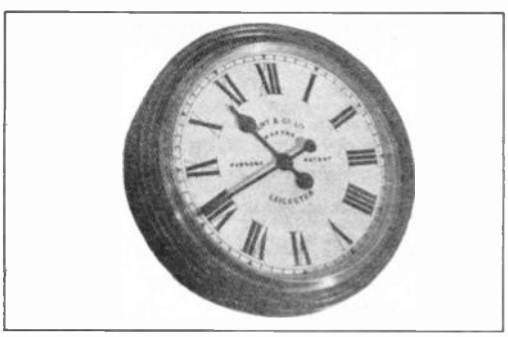
EVERYDAY WITH PRACTICAL ELECTRONICS

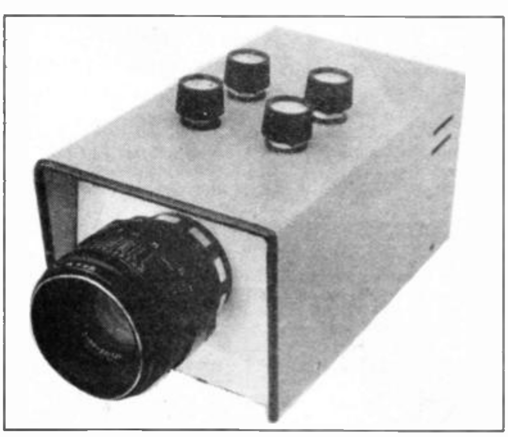
INCORPORATING ELECTRONICS MONTHLY

The No. 1 Independent Magazine for Electronics, Technology and Computer Projects









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Enhance the sound output of your PC with this simple plug-in unit

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Our May '94 issue will be published on Thursday, 31 March 1994. See page 251 for details.

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NEXT MONTH

TENS UNIT

Now widely used in the Health Service, TENS units help with the relief of a wide range of pain. They are also commercially available for around £80. Our project can be built for a fraction of that price, is pocket sized and has switching for continuous or pulsed operation plus amplitude control. In a later issue we will also describe a more complex design with additional controls for pulse-width, frequency etc.

L.E.D. MATRIX MESSAGE DISPLAY

A versatile display unit with moving messages and graphics. A host of features include manually keyed or library messages.

Message displays are in widespread use and are a very effective medium for attracting attention. This unit can be used for a variety of applications including use in a shop window for retail advertising, at discos, parties and weddings for entertainment purposes, and for warning or security messages. The ability to design your own messages is included, and graphics characters enhance the visual effect.

This is a low cost project with performance comparable to commercial units, it has the following features:

- Large bright l.e.d. display
- Long range visibility
- Self-contained unit with built-in Z80A CPU
- Single 8V to 12V power supply required
- Easy to use five-key keypad for message input and control
- Four built-in message libraries, each containing about 50 messages
- Manual keying of user messages
- Quick library message access
- Message search facility using a "string" of characters
- Many message display style options
- Message sequencing
- Four fonts (type styles)
- Eight animation styles
- Graphics characters and punctuation in each font
- One-shot or continuous message display facility
- Long message handling (word breaking or whole message scrolling)
- Piezo sounder to assist with key operation and error reporting

STEREO NOISE GATE

If you are into any kind of music electronics, perhaps recording or using effects units with a guitar or synthesiser, you'll be very familiar with the problems of unwanted noise, be it mains hum picked up on a mic. lead, or background hiss rushing in to ruin quiet parts of a performance.

This unit can go a long way towards cleaning up unwanted noise and will find a home in small recording set-ups as well as on stage.

EVERYDAY WITH PRACTICAL ELECTRONICS

OUR MAY ISSUE WILL BE PUBLISHED ON THURSDAY MARCH 31ST

MAILTECH

ELECTRONIC COMPONENTS

PROJECT BOXES A range of high quality boxes moulded in black high impact ABS, easily drilled or punched to produce a professional looking end product

TYPE	W	L	H	PRICE
T2	75	56	25	£0.77
T4	111	57	22	£0.92
MB1	79	61	40	£1.35
MB2	100	76	41	£1.47
MB3	118	98	45	£1.71
MB4	216	130	85	£5.19
MB5	150	100	60	£2.35
MB6	220	150	64	£3.95
MB7	177	120	83	£3.42
MB8	150	80	50	£2.22

All sizes are in millimetres

CRYSTAL OSCILLATORS

4.0 mhz	ALL
7.5 mhz	£1.50 each
12.0 mhz	OR
18.432 mhz	4 FOR
33.33 mhz	£5.00

MICRO SWITCH roller arm operation spdt 40p each

MINIATURE TOGGLE SWITCHES

spdt	60p each	spdt 3 position c/off	70p each
dpdt	70p each	dpdt 3 position c/off	80p each
spdt biased	60p each	spdt 3 position c/off biased both ways	70p each
		dpdt 3 position c/off biased one way	80p each

MINIATURE PUSH TO MAKE SWITCH 50p each

DIL RELAYS 5 volt dp/changeover 60p 10 for £5.00
12 volt dp/changeover 80p 10 for £6.00

RELAY 10 amp contacts sp/changeover 12 volt coil £1.20 each

CAR HORN RELAY in metal can with fixing lug, s/pole on 10 amp contacts £1.00 each 6 for £5.00

20 AMP RELAY dp on 12 volt coil £1.50 each 4 for £5.00

REED RELAY 12 volt 50p each 10 for £4.00

240 VOLT AC RELAY. 3-pole c/o 10 amp contacts £1.50 each 4 for £5.00

'D' CONNECTORS

	plug	socket	cover
9 pin	30p	30p	35p
15 pin	40p	40p	35p
25 pin	50p	50p	40p

SEMICONDUCTORS – TRANSISTORS – ICS – DIODES – REGULATORS – ETC

VOLTAGE REGULATORS
1 amp 7805/7812/7815 all 33p each. 7905/7912/7915 all 39p each
2 amp 78505/785212 54p each
100mA 78L05/78412/78L15 all 26p each. 79L05/79L12/79L15 all 29p each
Adjustable LM317T 47p each. LM723 29p each, L200 £1.28 each
Transistors TIP2955 70p each, TIP 3055 70p each
2N3053 29p each, 2N3055 70p each, 2N4403 28p each, 2N3819 40p each
MICRO IC'S –Z80A CPU £1.20; Z80A PIO £1.50; Z80B SIO-1 £4.00

SPECIAL OFFER PROJECT BOX
In white
high impact ABS
50 x 70 x 25mm
60p each 10 for £5.00

OPTO DEVICES – LEDS – ETC

5mm rnd red/yellow/green/amber 10p each 12 for £1.00 any mix
5mm rnd high brightness red/green 20p each 6 for £1.00 any mix
5mm rnd flashing red 60p each, yellow/green 70p each
5mm rnd bi-colour 35p each, tri-colour 45p each
LED mounted in chrome bezel red, yellow or green 30p each, 4 for £1
LED mounted in a black bezel red only 25p each, 5 for £1.00
PLASTIC BEZEL for 5mm rnd leds 10 for 40p
High brightness bi-colour l.e.d., rectangular, red/green, two leads 40p each

TEMPERATURE PROBE

High quality probe made for the medical profession. Consists of a resistive sensor mounted in a plastic covered probe with a 1 meter curled lead. Temp. range −40 to 150°C. Resistance at: 150°C 188.3 ohms; −40°C 336.5 kohm; 25°C 10.0 kohm ± 70 ohms. The original price of these probes was over £24.00. Full data supplied. **OUR PRICE £3.76**

RESET TIMER PCB

Gives a timed relay closure following a momentary input. Requires 12V d.c. supply SP c/o relay output LED indication. 19 different time intervals from 25sec to 35min 20sec. £5.98 each.

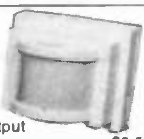
UNIVERSAL BELL TIMER

10 or 20 minute bell cut off +ve or −ve trigger' timed relay contacts. £4.96

ALARM CONTROL UNIT

Single zone alarm control unit built into a domestic light switch box. Ideal for home, caravan, boat, garage, shed etc.
Facilities: – Normally closed loop for pir sensors, door/window contacts etc. Normally open loop for pressure mats. 24-hour loop for personal attack button Visual indication that the system is operational. Automatic entry/exit delay. Automatic system reset. Alarm output cmos logic level.
PRICE COMPLETE WITH FULL INSTRUCTIONS £8.95

SIREN
12 volt dc for external use 115db £8.95



SUB-MINIATURE PASSIVE INFRA-RED SENSOR ONLY £7.95
Brand new passive infra-red sensor, measures only 33mmW x 24mmH x 29mmD. Logic level output. Full data and application notes supplied.

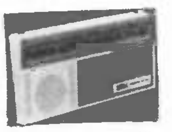
EX INSTALLATION SENSORS tested working.
Type 1. Measures 180 x 112 x 70mm with walk test led, relay output and tamper protection. 12 volt dc supply required £8.50 each
Type 2. As above but a smaller unit 123 x 62 x 50mm £11.75 each
Type 3. Ceiling mounting passive, infra red sensor 360° detection, 12V d.c. supply relay output, tamper circuit and pulse count option. Data supplied. £15.70 each

Please note: There may be variations in the size of the above passive infra red sensors depending on stock at the time of ordering. But the unit will certainly be within the stated sizes.

DOOR/WINDOW CONTACTS
Surface or flush mounting, white £1.10 each
JUNCTION BOX
white 6 way 60p

DUAL TECH SENSOR Microwave and passive infra-red combined. Separate led indication for each function. Measures 120 x 75 x 50mm. 12 volt d.c. supply, Relay output. Tamper protection. £29.95 each

ALARM CONTROL PANEL ST3000



'Wire free alarm control panel, detectors communicate with the panel by means of radio transmitters'. Speech synthesis for programming and general operating guidance'. Built in user programmable telephone dialler'. Up to 32 transmitters can be be used'. Programmable exit/entry and bell timers'. Programmable user codes.' Full installation data supplied, the only thing that has to be handwired is the output to the siren/bell unit (not supplied)'. These control panels cost over £300.00. Yours for only £59.95.
Suitable **PASSIVE INFRA SENSOR/TX £25.85**
Battery operated, available in 8m range, 10m range or 25m range.

UNIVERSAL TX

For connection of normally open or closed contacts e.g. door/window switches, pressure mats etc. £17.63

BREADBOARDS – CAPACITORS – SOLAR CELLS – HEATSHRINK – ETC

SOLAR CELL 2 volt 150mA max, size 60 x 100mm £1.35 each 5 for £6
BNC SOCKETS 50 ohm single hole fixing 50p each 10 for £4.00

MERCURY TILT SWITCH
Standard on/off £1.00 each
4 Contact (Directional) £1.50 each
PIEZO VIBRATION SENSOR
with data sheet £1.00 each

BREADBOARD
173 X 65mm 840TP £5.25 each
TEXTOOL ZIF SOCKET
28 pin zero insertion socket £5.95 each

6 VOLT NI-CAD PACK 5AA NI-CADS, fast charge type £3.95
CAPACITOR 10,000 mfd 25 volt with fixing clip 60p each
EPROMS 27C256 – 30 27C512 – 25. Once programmed but never used eprom. Mounted on a plastic carrier, can easily be removed from the carrier or used with a low insertion force socket.
27C256 £1.00 each 6 for £5.00 **27C512** £1.20 each 5 for £5.00
Suitable low insertion force socket 28 pin 40p each 3 for £1.00
MULTITURN PRESETS 20mm RECT, 500R, 1K, 5K, 10K, 20K, 50K, 100K 1MO. 40p each, 3 for £1.00

CAR CIGAR LIGHTER ADAPTER (DUAL SIZE)
mounted on two metres of cable £2.00 each
100db PIEZO SOUNDER
2KHz note, 3-12V d.c. 40Ma, 45mm dia. x 26mm £1.76 each
VIBRATION SENSITIVE ALARM BOARD WITH PIEZO SOUNDER
Originally a bike alarm. There is a short delay after activation then the piezo sounder operates for a preset period. £3.76 each
or the above alarm board with custom designed case, fixing clip and keyswitch £9.95
INFRA-RED BREAK BEAM Transmitter and receiver p.c.b. with 2 lens assemblies. 12V d.c. supply. These are ex-installation units and are not guaranteed to be working. £4.96 pair

RECHARGEABLE BATTERIES £7.64 each

AA (HP7) 600 mAH	£1.02 each	C (HP11) 1200 mAH	£2.29 each
D (HP2) 1200 mAH	£2.40 each	PP3 8.4V 100 mAH	£4.77 each

FLOURESCENT LIGHT INVERTOR. Drives an 8 watt tube directly from 6V d.c. Data supplied £4.50 each

£1.00 BARGAIN PACKS

SUB-MINIATURE TOGGLE SWITCHES
P.C.B. Mounting

BO1 S.P. on 4 for £1.00
BO2 D.P. on 3 for £1.00
BO3 3 x D.P. 3 pos, centre off
BOO4 **DIL SWITCHES** 4-way S.P. on 3 for £1.00
BOO5 **DIL SWITCHES** 8-way S.P. on 2 for £1.00
BOO6 **DIL SWITCHES** 12-way 90° sp on 2 for £1.00
BOO7 **12 x PP3 BATTERY SNAPS**
BOO8 **1 x CAPACITOR 1 FARAD 5.5 VOLT** 20mm dia. x 7mm high
BOO9 **INSTRUMENT KNOBS (0.25" SHAFT)** High quality grey plastic knob, collet fixing 15mm dia, 5 for £1.00
BO10 as above but 29mm dia, 3 for £1.00
BO11 **4 x MAGNETIC EARPIECE** 8 ohm with 3.5mm plug
BO12 **4 x 28-WAY TURNED PIN DIL SOCKET**
BO13 **15 x 12 VOLT WIRE-ENDED LAMPS**
BO14 **8 x 2 PIN DIN PLUGS** screw terminal connection
BO15 **2 x LIGHT DEPENDENT RESISTOR** Less than 200 ohms in daylight, greater than 10 megohms in darkness
BO16 **1 x KEYPAD** 20-key in 5 x 4 matrix bubble type switch contacts
BO17 **2 x PIEZO BUZZERS** approx 3 to 20 volt d.c.
BO18 **5 x 78M12 VOLTAGE REGULATORS** positive 12V 500mA
BO19 **4 x TL082CP** bi-fet op-amps
BO20 **20 x ASSORTED LEDS** full spec. various shapes and sizes
BO21 **3 x INFRA-RED DIODE TX/RX PAIRS** made by Honeywell(no info)
BO22 **4 x CONSTANT CURRENT LED** 5mm round, red 2-18V d.c. or a.c. nominal 14mA
BO23 **50 x IN4148** diode
BO24 **2 x INFRA-RED TRANSISTOR FPT5133**
BO25 **5 x DIACS**
BO26 **3 BDX33C** 10 amp 100V npn transistor
BO27 **12 x 2N3702** Transistor
BO28 **12 x 2N3904** Transistor
BO29 **12 x BC337** Transistor
BO30 **4 x LM317T** Variable regulator mounted on a small heatsink
BO31 **2 x MAN6610** 2 digit 0.6" 7 segment display Com anode, amber
BO32 **3 x PHONO TO PHONO LEAD** 63cm long
BO33 **15 x RECTANGULAR RED LEDs** 6 x 6 x 2mm stackable
BO34 **1 x PHOTO SENSITIVE SCR** mounted on a PCB, data sheet supplied
BO35 **4 x IEC Panel Mounting Mains Plug** Snap fix
BO36 **5 x ASSORTED PIEZO TRANSDUCERS**
BO37 **5 LENGTHS OF HEATSHRINK SLEEVING** 8mm dia. 400mm long
BO38 **25 x CERAMIC DISC CAPACITORS** 0.1 mfd 63V
BO39 **15 x MONOLITHIC CERAMIC CAPACITORS** 0.1 mfd 63V, in a dil package
BO40 **25 x ASSORTED ELECTROLYTIC CAPACITORS** PCB mounting useful values
BO41 **25 ASSORTED PRE-SET RESISTORS**
BO42 **6 x 3·5mm LINE JACK SOCKETS** (mono)
BO43 **6 x 3·5mm JACK PLUG** (mono)
BO44 **8 x 3·5mm CHASSIS SOCKET** (mono)
BO45 **2 x TRIACS** 800 volt 8 amp
BO46 **12 x BC213L** Transistor
BO47 **12 x MIN SLIDE SWITCH dpdt**
BO48 **15 x MIN CERMET TRIMMER POTS** (good range of values)
BO49 **1 x PCB WITH TWO LARGE LEDS** 15mm square, one red and one green
BO50 **1 x 12V DC RELAY** 4-pole c/o with plug in base
BO51 **4 x LM324** quad op-amps
BO52 **4 x 555** Timer
BO53 **5 x 741** op-amp
BO54 **25 x IN4001** diode
BO55 **20 x IN4007** diode
BO56 **1 x SLOTTED OPTO**
BO57 **1 x DAC08** Digital to analogue convertor with data
BO58 **4 x OPTO ISOLATOR**
BO60 **3 x C106D** Thyristor
BO61 **5 x 78M05 VOLTAGE REGULATORS** positive 5 volt 500mA

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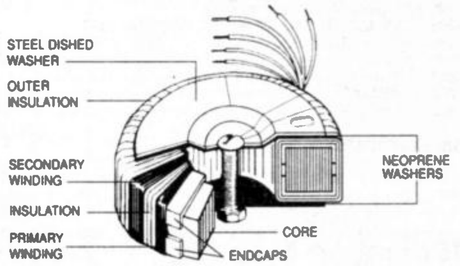

TYPE	SERIES NO.	SEC VOLTS	RMS CURRENT
15VA	03010	6+6	1.25
	03011	9+9	0.83
£10.68	03012	12+12	0.63
	03013	15+15	0.50
	03014	18+18	0.42
	03015	22+22	0.34
	03016	25+25	0.30
	03017	30+30	0.25
30VA	13010	6+6	2.50
£12.21	13011	9+9	1.66
	13012	12+12	1.25
	13013	15+15	1.00
	13014	18+18	0.83
	13015	22+22	0.68
	13016	25+25	0.60
	13017	30+30	0.50
50VA	23010	6+6	4.16
£13.84	23011	9+9	2.77
	23012	12+12	2.08
	23013	15+15	1.66
	23014	18+18	1.38
	23015	22+22	1.13
	23016	25+25	1.00
	23017	30+30	0.83
	23028	110	0.45
	23029	220	0.22
	23030	240	0.20
80VA	33010	6+6	6.66
£15.43	33011	9+9	4.44
	33012	12+12	3.33
	33013	15+15	2.66
	33014	18+18	2.22
	33015	22+22	1.81
	33016	25+25	1.60
	33017	30+30	1.33
	33028	110	0.72
	33029	220	0.36
	33030	240	0.33
120VA	43010	6+6	10.00
£16.45	43011	9+9	6.66
	43012	12+12	5.00
	43013	15+15	4.00
	43014	18+18	3.33
	43015	22+22	2.72
	43016	25+25	2.40
	43017	30+30	2.00
	43018	35+35	1.71
	43027	20+20	3.00
	43028	110	1.09
	43029	220	0.54
	43030	240	0.50
160VA	53011	9+9	8.89
£19.21	53012	12+12	6.66
	53013	15+15	5.33
	53014	18+18	4.44
	53015	22+22	3.63
	53016	25+25	3.20
	53017	30+30	2.66
	53018	35+35	2.28
	53026	40+40	2.00
	53028	110	1.45
	53029	220	0.72
	53030	240	0.66

TYPE	SERIES NO.	SEC VOLTS	RMS CURRENT
225VA	63012	12+12	9.38
	63013	15+15	7.50
£21.04	63014	18+18	6.25
	63015	22+22	5.11
	63016	25+25	4.50
	63017	30+30	3.75
	63018	35+35	3.21
	63026	40+40	2.81
	63025	45+45	2.50
	63033	50+50	2.25
	63028	110	2.04
	63029	220	1.02
	63030	240	0.93
300VA	73013	15+15	10.00
	73014	18+18	8.33
£22.94	73015	22+22	6.82
	73016	25+25	6.00
	73017	30+30	5.00
	73018	35+35	4.28
	73026	40+40	3.75
	73025	45+45	3.33
	73033	50+50	3.00
	73028	110	2.72
	73029	220	1.36
	73030	240	1.25
500VA	83016	25+25	10.00
£29.57	83017	30+30	8.33
	83018	35+35	7.14
	83026	40+40	6.25
	83025	45+45	5.55
	83033	50+50	5.00
	83042	55+55	4.54
	83028	110	4.54
	83029	220	2.27
	83030	240	2.08
625VA	93017	30+30	10.41
	93018	35+35	8.92
£32.64	93026	40+40	7.81
	93025	45+45	6.94
	93033	50+50	6.25
	93042	55+55	5.68
	93028	110	5.68
	93029	220	2.84
	93030	240	2.60

13.8V DC POWER SUPPLY TRANSFORMERS

8C267	500VA	18+18V	£32.64
9T845	675VA	16.1V	£38.06

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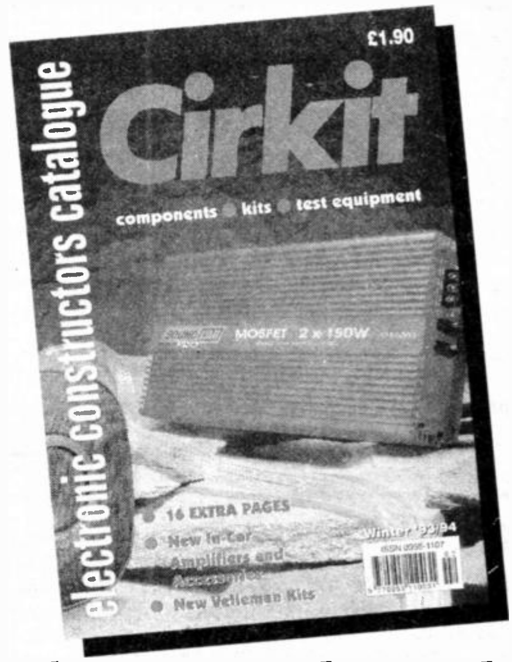
WINTER 1993/94 CATALOGUE



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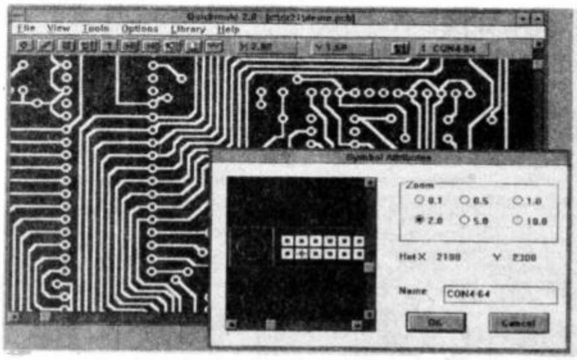

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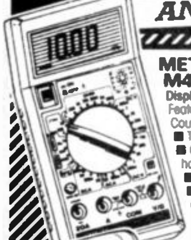

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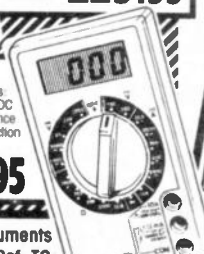

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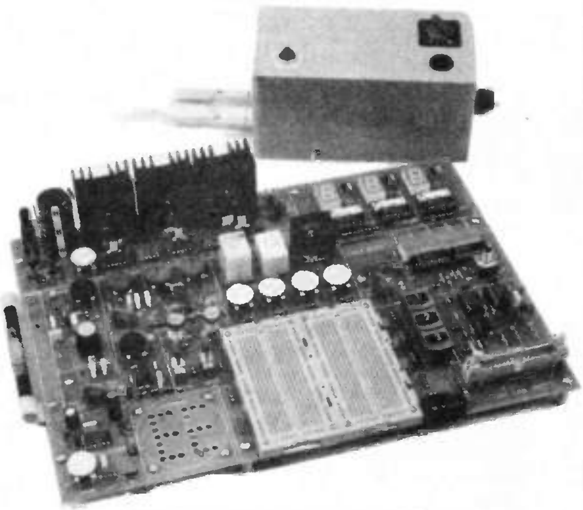

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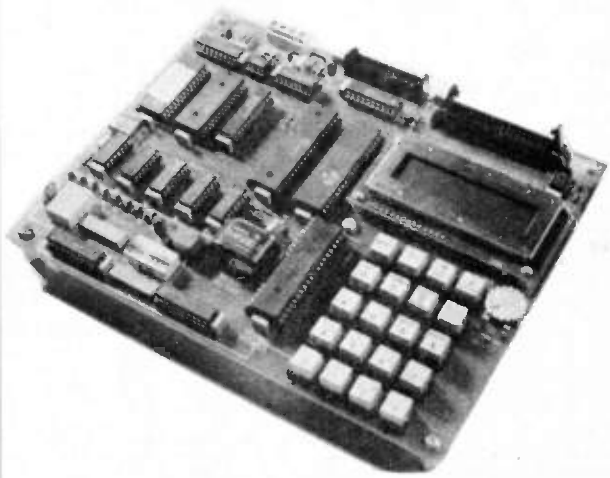

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47	£0.06	£0.06	£0.11	–	–
100	£0.06	£0.09	£0.11	–	–
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470	£0.15	£0.19	£0.57	–	–
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470	£0.21	£0.24	£0.69	–	–
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BEST OF BRITISH?

Perhaps some UK companies still have plenty to learn about publicity and P.R. One of the companies we approached for photos to go in the Best of British series (not a company that is mentioned in Part One I hasten to add) took nearly two months to respond to the request. Maybe there is still some element of inefficiency around but we feel that this is not the norm now. In fact, UK companies in the technology sector are often among the best in the world. The recent years of recession have ensured they are highly competitive and well motivated, something which does not now appear to be the case in all other industrialised countries.

Obviously we have been unable to look at a vast range of UK operations; those mentioned are directly connected with our hobby or the teaching of electronics in some general way. The series does illustrate the wide range of specialist areas there are and how UK industry is at the forefront in many of them.

OUR OWN INVOLVEMENT

One software company that has not been mentioned in the series is EPT Educational Software, the source of the software we market through our Direct Book Service. EPT is a UK company set up by one man about two years ago when he was made redundant. All the software, which is getting rave notices within education, has been written by him and is now selling through Direct Book Service all over the world. A marketing arrangement in Australia is presently under discussion and alternative versions of various packages are being developed. It looks like the start of a major player in specialist software supply.

Perhaps we should also blow our own trumpet a little! Wimborne Publishing Ltd. was formed by myself just over eight years ago when I.P.C. made me redundant and sold various titles. Since then the company, although small, has grown gradually and now has an annual turnover of about one million pounds. We publish *Everyday with Practical Electronics*, *The Modern Electronics Manual* and various *Teach-In* books. We also sell a wide range of other publishers' books, videos and software by mail order and we are presently working on the development of a further manual for the maintenance and servicing of electronic equipment.

We export to over 100 countries around the world and have special distribution/publishing rights agreements into Italy, Greece and Norway. With the exception of videos, all our material is generated and produced within the UK. Our Typesetting Bureau offers a full range of typesetting services and produces books, magazines and various literature for dozens of other companies.

Mike Kenward

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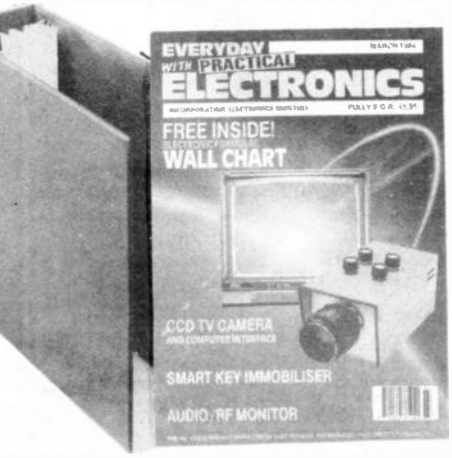

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We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply must be accompanied by a **stamped self-addressed envelope** or a **self addressed envelope and international reply coupons.** Due to the high cost **we cannot reply to overseas readers queries by Fax.**

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MOSFET VARIABLE BENCH POWER SUPPLY

MARK STUART

An unusual and highly efficient design developed from a previous EE project. Can supply 0 to 25V at up to 2·5 amps.

THIS project has been under consideration for some time. The original *Variable Bench Power Supply* was published in February 1988 and has been very popular. The question was, how do we improve it? The answer is the design presented here, which has all of the original features:

A high output voltage of 0 to 25 volts, and a maximum output current capability of 2·5 amps – far better than the more usual 12 volt and 1 amp supplies. An output voltage that can be reduced right down to zero (unlike most i.c. regulators which stop at a minimum of around 1·5 volts) and a "Current Limit" control which allows the maximum output current to be set anywhere between zero and maximum. Two panel meters monitor output Voltage and Current.

An effective Current Limit control is a very important feature. It allows circuits to be tested without fear of damage due to construction errors or accidental short circuits – a real delight for electronics experimenters. It is also extremely useful for battery charging. It can easily be set to provide constant current charging of NiCad batteries, or to control the maximum charge current of lead acid batteries.

Such a supply has a multitude of uses in the school science lab. Electrolysis, electroplating, polystyrene cutting, and as a power source for model motors, computer interfaces, and robotics. The two panel meters, make it easy to see exactly what is happening in a circuit. Ripple and noise in the output are very low, and the output voltage change in response to load current changes and mains voltage fluctuations is very small.

IMPROVEMENTS

The central part of the circuit is almost unchanged, in fact, by omitting some components, changing the type of MOSFET and adding a heatsink it is a simple matter to build the original circuit on the new board. The improvements are in three parts.

The first and most important change is that a circuit has been added which dramatically reduces the power lost in the MOSFET. This is achieved by a "low frequency switching pre-regulator" which reduces the voltage across the main smoothing capacitor so that it is never more than 5 volts above the output voltage setting. This type of pre-regulator is called a "tracking pre-regulator" because it "follows" the output voltage at a fixed distance.

The dramatic improvement is demonstrated by considering the power supply delivering 1·5 amps at 5 volts. In its original form, the voltage across the main smoothing capacitor C4 would be approximately 45 volts. The job of the MOSFET would be to reduce this to 5 volts and so it would have 40 volts across it and a current of 1·5 amps through it. This represents a power loss of 60 watts. Think of the heat from a 60 watt lamp and this gives a good idea of the heat that must be dissipated, and accounts for the large heatsink that was used.

In the new form, the voltage across the capacitor has been reduced by the pre-regulator to 10 volts leaving the MOSFET with just 5 volts and 1·5 amps and a power loss of 7·5 watts! The pre-regulator is not perfect, and so there is some additional power loss, but as it operates in a switch mode, the pre-regulator transistors being either ON or OFF it is efficient, and preserves most of the power saving.

LAYOUT

The second improvement is the printed circuit board which now holds the smoothing capacitor, the rectifier, the secondary fuse, and the MOSFET, as well as the new pre-regulator parts and all of the original components. Because of the shape of the case it is impractical to mount the two control potentiometers on the board as well as the output devices (without making the board big enough to span the case from front to rear), however, spaces on the board are provided for the controls so that alternative cases, and component layouts can be used if required.

For example, if the board is built to the old design, the controls can be board mounted and wires taken to the MOSFET which would be mounted on a heatsink at the rear. It is also a possibility to mount the controls on the board and use spindle extenders to the front. For the prototype the simple option was to mount the controls on the front panel and take wires to their connection points on the board. The three power devices could then be board mounted and screwed to the rear of the case for heatsinking.

The third improvement is the provision with the kit, of a punched, sprayed, and printed case. Metalwork is not always easy, even with soft aluminium, and a project like this where large holes are required for the meters is particularly difficult to make presentable. For those constructors who enjoy the metalwork, and craft training establishments (where the original design has been used extensively), a plain case is available.

CIRCUIT DESIGN

As in the original design, a high power device controls the output, and is driven from a low power regulator circuit designed around the four op-amps in an LM324 i.c. Dedicated voltage regulator i.c.s are widely available, but this tried and tested design is versatile and effective. It also has the advantage of using common parts, and being reliable – it is almost impossible to damage any of the low power regulator components even under severe overloads that damage the MOSFET.

Using a MOSFET for the output device aids reliability because MOSFETS are rugged, and can withstand considerable power surges. Another advantage is that the drive circuitry is simple because the MOSFET requires practically zero gate drive current. A small transistor with a high collector load resistor is all that is needed to provide the necessary drive.

The switching pre-regulator adds only a few extra components and works extremely well. Two *pnp* Darlington transistors are used to handle the power. The use of a single MOSFET was considered for this position, but it would have needed to be an expensive *p*-channel type if the circuit was not to become too complicated. As this is the new part of the circuit its operation will be described first.

SWITCHING PRE-REGULATOR

The function of the switching pre-regulator circuit is to limit the voltage that the MOSET has to drop. It achieves this by switching off the output from the bridge rectifier when the voltage across the main smoothing capacitor exceeds the regulated output voltage by 5 volts. Fig. 1 shows the circuit. Diodes D1 to D4 are the main bridge rectifier diodes which supply the load current. Two additional diodes D5 and D6 have been added to provide an unsmoothed full-wave rectified supply to R4 and thyristor CSR1.

At the beginning of a mains half cycle the voltage across CSR1 will be zero, and it will therefore be turned OFF. Early in the half cycle the voltage across CSR1 increases and TR3 is turned ON. Current through TR3 flows via the base-emitter junctions of TR1/TR2 and turns them ON so that current from the bridge rectifier passes into the smoothing capacitor C4. This state continues throughout the mains half cycle as long as the gate of CSR1 is not triggered. C4 therefore charges to the peak transformer voltage via D1 to D4 and TR1/TR2.

The operation changes when the voltage sensing circuit comes into operation. The base of TR4 is driven via a potential divider consisting of R14 and R12. This potential divider is connected across TR6 with one end at the capacitor voltage, and the other end at the regulated output voltage. To turn on TR4 requires 0·6 volts between its base and emitter. The potential divider has a ratio of (R12 × R14) / R12 which is 11 to 1, and so TR4 will turn on if the voltage across TR6 exceeds 6·6 volts.

When TR4 turns ON, current flows to the gate of CSR1 via R13. CSR1 is then turned ON, shorting the base of TR3 to negative and turning it OFF. This stops the base drive to TR1/TR2 which also turn OFF and so disconnects C4 from the bridge rectifier.

The voltage on C4 is limited in this way by disconnecting the supply from the transformer once the necessary level has been reached. The value of C4 is high enough to allow it to supply the maximum output current throughout the remaining part of the half cycle without the voltage dropping more than 2 volts. This ensures that there is always at least 4·6 volts (6·6 – 2) across TR6 so that it can work correctly.

Once triggered, CSR1 remains turned on as long as current flows between its anode (a) and cathode (k). At the end of the half cycle, the voltage across, and current through, CSR1 fall to zero so that it turns off ready to repeat the whole process through the next half cycle.

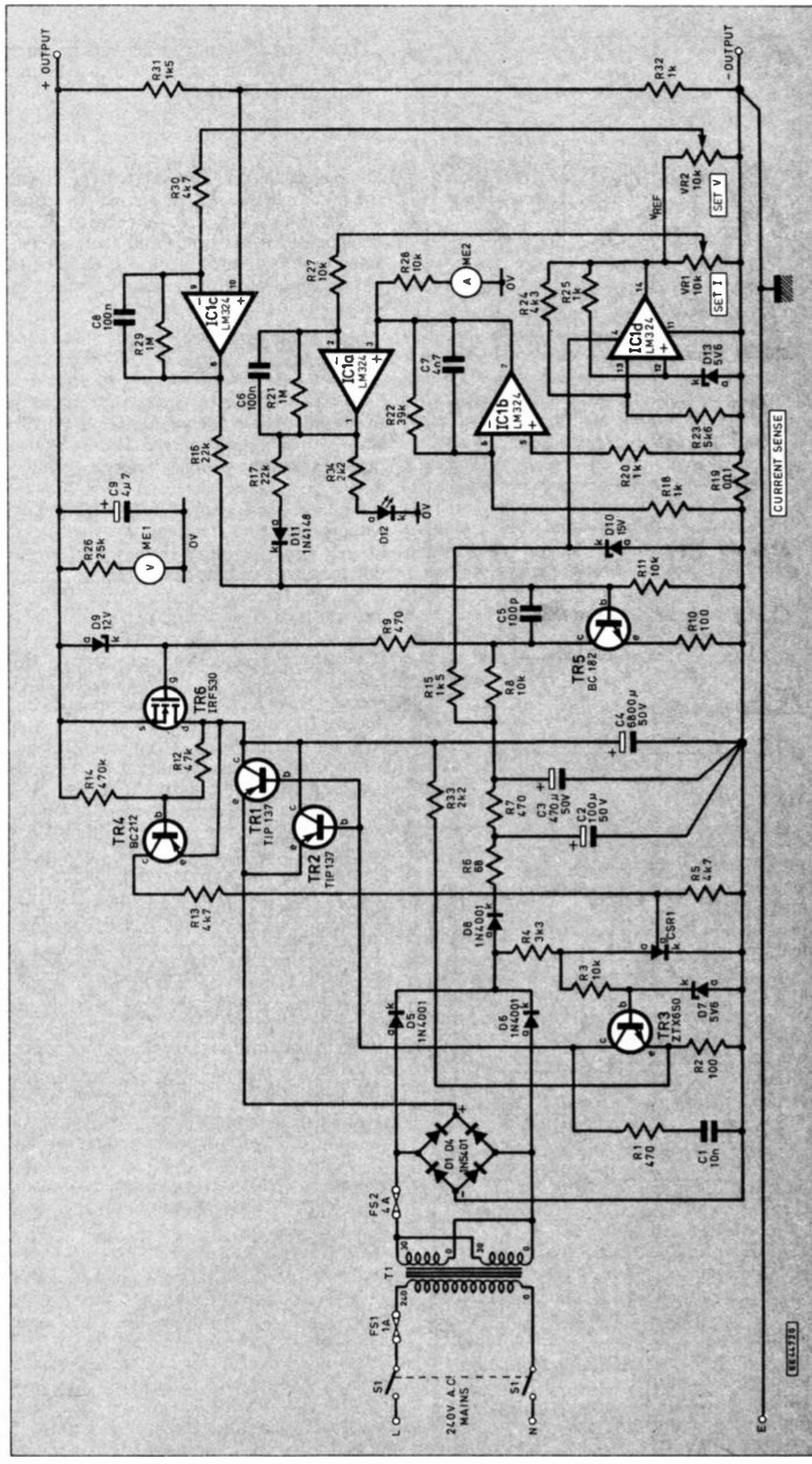


Fig. 1. Complete circuit diagram of the MOSFET Variable Bench Power Supply. Transistors TR1 to TR3 are Darlington types.

ADDITIONAL COMPONENTS

There are a number of additional components. Resistor R5 defines the gate sensitivity of CSR1 and prevents spurious triggering. R3 and D7 provide a constant base bias for TR3 throughout the half cycle so that TR3 delivers a constant current drive to TR1/TR2. C1 and R1 control the turn off time of TR1/TR2 to minimise voltage spikes that would otherwise occur as the high current flowing from the transformer is interrupted.

Resistor R33 provides feedback to the emitter of TR3 which reduces the drive current to TR1/TR2 when the voltage across C4 is higher. It also reduces the dissipation in TR3 at higher output voltage settings.

The circuit will revert to the original design if a link is inserted in place of TR1/TR2 emitter-collector. The other components will then have no effect and could be removed (D5 and D6 must stay, as they supply power to the low level regulator circuitry via D8 etc.). The option of reverting to the original design could be useful in testing and fault finding if the pre-regulator is suspected of being faulty – but *do not use high output currents,* unless TR6 is fitted with a good heatsink.

OUTPUT CONTROL CIRCUITS

The output from the power supply is controlled by a power N-Channel MOSFET (TR6). This device has at its input (Drain) the relatively unregulated supply from the switching pre-regulator, and must produce at its output (Source) the smooth regulated voltage demanded by the load. To achieve this the MOSFET gate is driven by an "error" signal which turns it on or off to a greater or lesser extent so that the output is always correct.

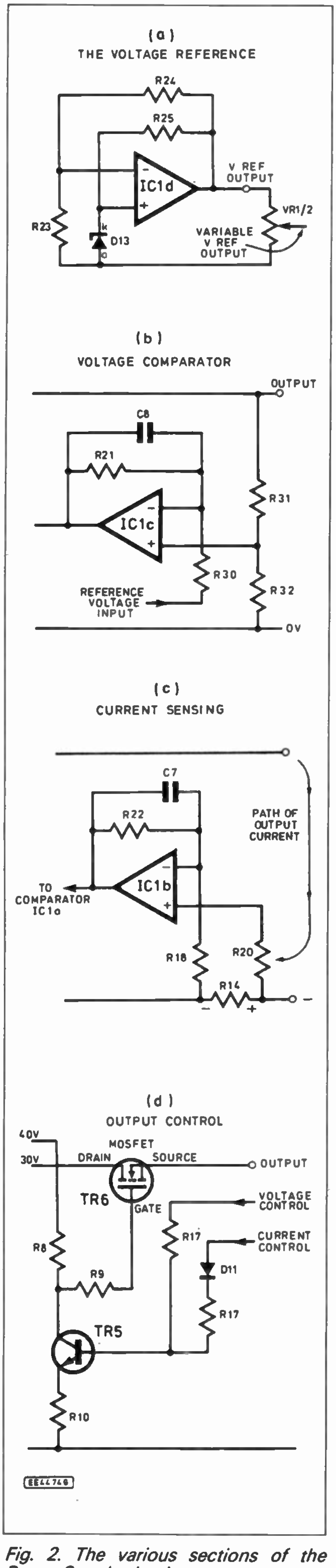


Fig. 2. The various sections of the Power Supply circuit.

This "error" signal is derived by comparing the output voltage with a reference voltage. Any difference between the two is amplified and used to drive the MOSFET gate so that the error is corrected. This is the same principle as negative feedback in an audio amplifier, the output is compared with the input and the difference used to reduce the distortion. Although the circuit looks complicated it is readily simplified by considering it as a series of blocks. Each block has a simple function and are described individually in the following sections.

REFERENCE VOLTAGE

A stable smooth voltage reference is produced at the output of IC1d. Fig. 2a shows this section of the circuit. Zener diode D13 is the primary reference source. A 5·6 volt Zener has been used because these have the lowest variation of voltage with temperature (temperature coefficient) of all Zener values. Higher and lower voltage devices are not as stable.

To get the best performance from a Zener diode a constant drive current is necessary. This is achieved very simply by IC1d and the associated resistors as follows. Upon switch on there is a low voltage across D13 which therefore does not conduct and acts like a very high value resistor. R25 and D13 form a potential divider around IC1d from the output to the non-inverting input. Similarly, R24 and R23 form another potential divider to the inverting input. At low voltage, with D13 not conducting, there is a greater amount of feedback to the non inverting input (+) than to the inverting (−) input. The net effect is positive feedback which drives the output voltage high.

As the output voltage rises, the voltage across D13 rises (via R25) until it begins to conduct and holds the non-inverting input of IC1d at 5·6 volts. The output continues to rise until the inverting input which is fed from the output via R24 and R23 also reaches 5·6 volts. When this happens, the circuit stabilises with the output voltage set by the Zener diode voltage and the ratio of (R23 + R24)/R24. The values chosen give an output of 10 volts from IC1d. The current through D13 is fixed by the output which is at 10 volts and the Zener diode at 5.6 volts, which leaves 4·4 volts across R25 giving a current of 4·4mA.

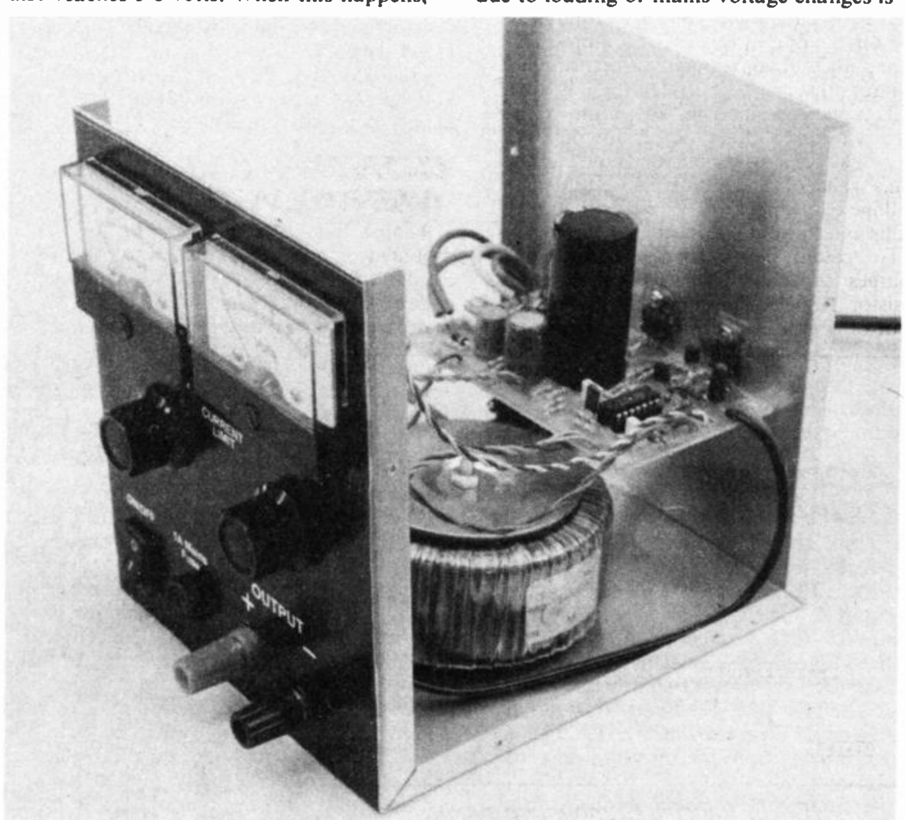
The important thing is that these values are set up by D13 and the resistor values only. The rest of the circuit has no effect whatsoever. The stable reference voltage from IC1d is fed to the two control potentiometers VR1 and VR2. The output from these is a voltage which varies smoothly from zero to 10 volts as they are turned clockwise.

VOLTAGE COMPARATOR

The voltage comparator stage compares the output from the supply with that from the "set voltage" control VR2. The result is an error signal that is used to drive the MOSFET. Fig. 2b shows the circuit. A proportion of the output voltage is tapped off via R31 and R32 and fed to the non-inverting input of IC1c.

The inverting input of IC1c is fed via R30 from the moving contact of VR2. The values of resistors R31 and R32 are chosen to give 10 volts at their junction when the output is 25 volts. IC1c operates as a high gain amplifier, amplifying the difference between its two inputs by over 100. If the voltage from the junction of R31 and R32 exceeds that from VR2, the output of IC1c is driven positive. This positive voltage is applied via R16 to the base of TR5 which turns on, pulls down the gate of TR6 and reduces the output voltage.

If the output voltage falls so that the voltage from the junction of R31 and R32 drops below that from VR2, the opposite things happen and the output voltage rises. In this way the circuit stabilises itself so that the two inputs of IC1c are kept equal. Any tendency of the output voltage to vary due to loading or mains voltage changes is



instantly corrected as IC1c rebalances its inputs and sends a signal to the output control circuits.

CURRENT SENSING

Output current control is carried out by IC1b in the part of the circuit shown in Fig. 2c. Resistor R19 is connected in the circuit negative line. All of the output current flows through it and so it develops a voltage drop accordingly. This voltage drop is connected via R18 and R20 to the inputs of IC1b and amplified so that currents from 0 to 2·5 amps produce an output voltage from IC1b of 0 to 10 volts. The output current meter is driven by this voltage via R28 (set to give full scale deflection for 10 volts).

The voltage from IC1b is also used to drive a second voltage comparator circuit IC1a. This works in the same way as IC1c but takes its reference input from VR1 the "set current" control. If the output current exceeds the setting of VR1 the output of IC1a rises and turns on TR5 via D11 and R17. This reduces the output voltage so that the output current falls. The circuit regulates itself in the same way as the voltage control so that the inputs to IC1a balance.

Whenever the output current attempts to exceed the setting of VR1 the output of IC1a rises and the l.e.d. D12 is lit indicating that the circuit is "current limiting". Varying VR1 from zero to maximum allows the current limit to be set anywhere from 0 to 2·5 amps.

OUTPUT CONTROL

The control of the output of the power supply is done by TR6 the power MOSFET. This is driven in turn by TR5. The MOSFET used is an *n*-channel enhancement type. This means that it is turned on when its gate is at a voltage more positive than its source.

For most devices of this type, gate voltages between 3 and 9 volts are required to support an output current of 3 amps. This means that at maximum output the gate voltage must be able to rise to 25 + 9 volts. This is may seem to be above the transformer output voltage range, however, the 30 volts transformer rating refers to the r.m.s. value of the voltage. The actual peak voltage of each cycle is 1·4 times the r.m.s. value and so would be more than enough.

To "catch" the peak voltage, diode D8 charges capacitor C2 via surge limiting resistor R6. As the current drain of the control circuit is small, the voltage across C2 "holds up" between cycles so that a steady high voltage is available. This voltage is smoothed by R7 and C3 and supplies the MOSFET drive via R8. A proportion of the voltage across C3 is also used to supply the rest of the control circuits after being reduced to 15 volts via R15 and Zener diode D10.

When TR5 is turned off, the voltage on its collector is pulled up via R8 and therefore TR6 is turned on. As TR5 is turned on, by drive from either the current or voltage control circuits IC1a and IC1c, its collector draws current through R8 and the voltage at the gate of TR6 falls. In this way the output voltage is reduced by the control circuits as required. Zener diode D9 and resistor R9 protect the MOSFET from overdrive and voltage surges by limiting the maximum gate to source voltage.

OTHER COMPONENTS

All of the details of the circuit have already been described individually. The main circuit diagram includes a number of other (essential) components such as fuses, switches, and the mains transformer. Incoming mains is switched by a two-pole switch before passing to the mains transformer primary, via a one amp fuse.

Most standard transformers are wound with two equal voltage secondary windings which can be connected in series or parallel to give a choice of outputs. Transformers with two 15V or two 30V secondary windings can be used. In the first case with the windings connected in series, and in the second with the windings connected in parallel.

Output voltage and current are indicated by separate meters fed via series resistors R26, and R28. Many types of meter can be used, the resistor values being varied as necessary to give the required full scale deflections. Meters scaled 0-25 and 0-2·5 are not readily available and so it is necessary to fit new scales. If 1mA meters are used, the values of R26 and R28 would be 25k and 10k respectively. Sometimes two resistors will be needed, connected in series to get the correct value, 10k and 15k make up the 25k if a 1mA meter is used for voltage. The meters supplied with the kit have a set of self-adhesive scales.

CONSTRUCTION METALWORK

Almost all of the components are mounted on a single printed circuit board available from the *EPE PCB Service*, order code 869 or with the kit – see *Shoptalk*. If a blank case is being used it is recommended that all cutting is done before any electronic construction. The printed circuit board can be used as a template for the three holes used to mount the power devices. It is important that these holes are drilled accurately and deburred, and that the rear panel around them remains flat. Any irregularities here will impair the heat transfer from the devices to the rear panel and so reduce the reliability.

The larger holes can be cut by drilling pilot holes and sawing with an "Abrafile" in a junior hacksaw frame. A file smooths the edges to complete the job. Metalwork of this type is not easy, a pre-punched case is supplied with the kit and should make construction a whole lot easier. The case is also sprayed and printed to give an excellent finish to the project.

Once the metalwork is done, the larger components should be mounted into the case. Start by fitting the self-adhesive feet to the case bottom. This prevents the unit from rocking and sliding all over the place and protects the working area. The toroidal transformer should be fitted between two rubber discs as shown in Fig. 3 with the dished steel washer at the top. As the mounting bolt is tightened the case bottom will deflect inwards, so take care not to overdo it.

P.C.B. ASSEMBLY

Begin the board assembly by fitting the resistors, diodes, and other low lying components. Follow the layout diagram Fig. 4 and take great care to get everything in the correct position. Time spent checking through the early stages can save hours later. Fit a socket for IC1 and fit the three wire links in the positions shown.

Fit diodes D5 and D6 before the main rectifier diodes D1 to D4. The rectifier leads are quite stiff and will need bending carefully to fit without stressing them. A pair of pointed nose pliers are best for this.

Fit the two fuse clips onto a fuse before soldering them into the board. This simple trick helps them to align properly. The smaller transistors and the thyristor should be identified and fitted the correct way round in their places as marked. All capacitors except the main smoothing capacitor should be fitted next. Note the polarity markings and make sure that they are fitted in the correct places.

The main smoothing capacitor should be left out as it gets in the way when aligning the power devices with their holes in the back panel. IC1 can be fitted at any time, it is not static sensitive, but do put it the right way round in the socket!

As the three power devices must align with their holes on the rear panel, it is a

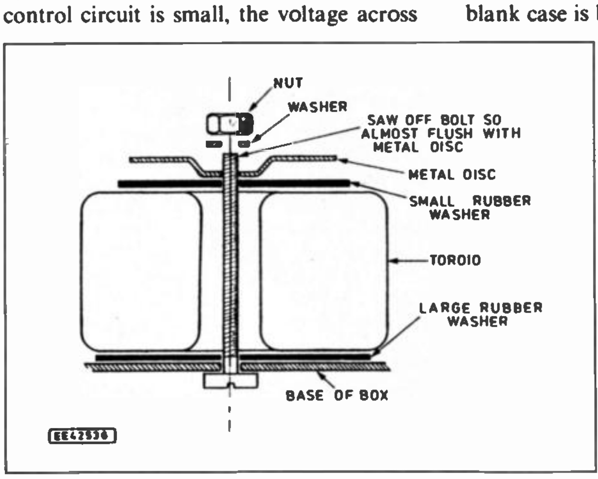
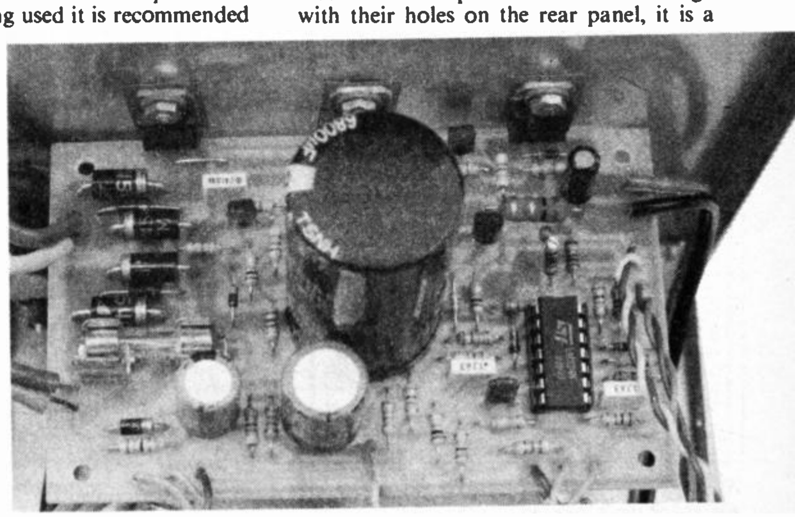


Fig. 3. Transformer mounting details.



COMPONENTS

Resistors

R1, R7, R9	470 (3 off)
R2, R10	100 (2 off)
R3, R8, R11, R27	10k (4 off)
R4	3k3
R5, R13, R30	4k7 (3 off)
R6	68
R12	47k
R14	470k
R15, R31	1k5 (2 off)
R16, R17	22k (2 off)
R18, R20, R25, R32	1k (4 off)
R19	0Ω1 wirewound 2·5W
R21, R29	1M (2 off)
R22	39k
R23	5k6
R24	4k3 } Metal film 1% 0·25W
R26	25k } Metal film 1% 0·25W
R28	10k } Metal film 1% 0·25W
R33, R34	2k2 (2 off)

All carbon film 5%, 0·25W except where stated

See SHOP TALK Page

Potentiometers

VR1, VR2	10k lin. carbon (2 off)

Capacitors

C1	10n 50V ceramic multilayer 10%
C2	100µ 50V radial elect
C3	470µ 50V radial elect
C4	6800µ 50V p.c.b. mounting
C5	100pF 50V ceramic
C6, C8	100nF 50V polyester box (2 off)
C7	4n7 50V mylar
C9	4µ7 30V radial elect

Semiconductors

D1 to D4	1N5401 (4 off)
D5, D6, D8	1N4001 (3 off)
D7, D13	5V6 400mW zener diode (2 off)
D9	12V 400mW Zener diode
D10	15V 400mW Zener diode
D11	1N4148 signal diode
D12	3mm red low current l.e.d.
TR1, TR2	TIP137 *pnp* Darlington transistor (2 off)
TR3	ZTX650 *npn* Darlington transistor
TR4	BC212 *pnp* transistor
TR5	BC182 *npn* transistor
TR6	IRF530 *n*-channel MOSFET
IC1	LM324 quad op-amp

Hardware

S1	DPST mains rocker switch
FS1	1A 20mm mains fuse
FS2	4A 20mm secondary fuse
ME1, ME2	Panel meters – see text
T1	Mains toroidal transformer 0-30, 0-30 volts 120 VA

Case; p.c.b. available from *EPE P.C.B. Service*, order code 869; 14-pin i.c. socket; insulating bushes, washers, screws, and nuts (3 sets); screw terminals, 1 – red, 1 – black; fuseholder for mains fuse; fuse clips for secondary fuse; Earthing stud: M4 screw, 2 – solder tags, 2 – nuts, 1 locking washer; mains cable 3 amp; connecting wire; mains cable entry clamp; cable ties (6 off); sleeving for mains connections; knobs (2 off).

Approx cost guidance only **£65**

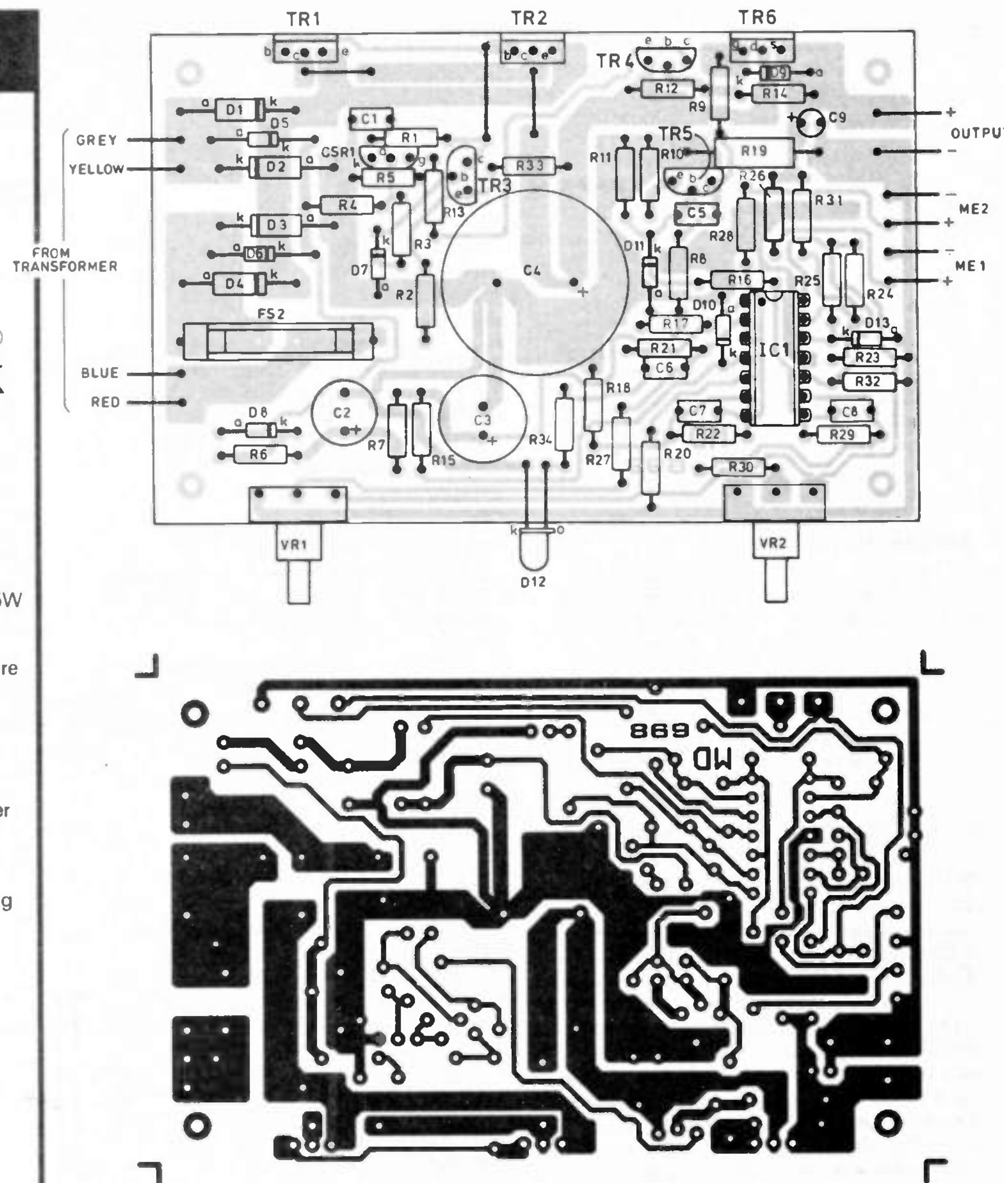


Fig. 4. P.C.B. layout and wiring diagram, VR1, VR2 and D12 can be fitted to the front panel (see text).

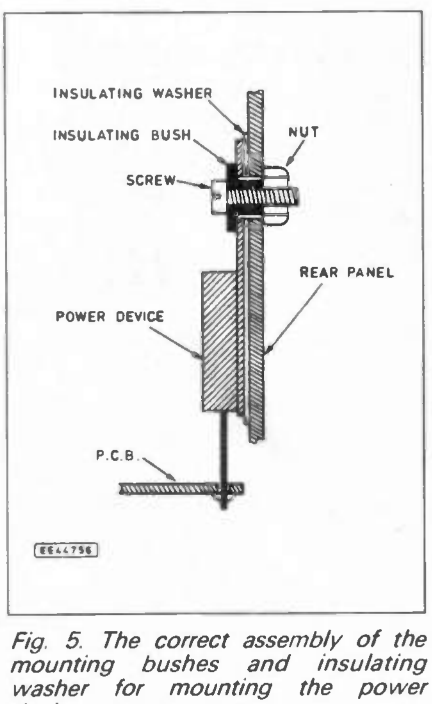
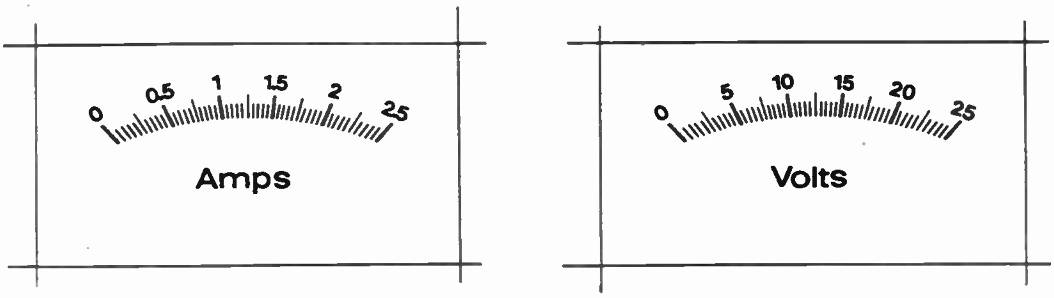


Fig. 5. The correct assembly of the mounting bushes and insulating washer for mounting the power devices.

good idea to screw them to the back panel and then slide the board over the leads so that they are soldered in the exact position required. To do this correctly needs a bit of three dimensional thinking. The best way is as follows: First fit the devices to the *outside* of the rear panel so that the leads are pointing *upwards*. Make sure the MOSFET is on the *left* when viewed from the outside rear of the case. Use the mounting bushes and washers assembled correctly as shown in Fig. 5 but do not overtighten them.

Next fit the board over the device pins so that the copper track side is uppermost and solder the centre lead of each one. Check that the devices are in the right places and that they are all the same distance from the board surface and that the board surface is at right angles to the case. Once everything has been aligned correctly, solder the remaining pins. Unscrew the power device mounting screws and remove the insulating bushes and washers.

The final component to be fitted to the board is the main smoothing capacitor. Take care to fit it with the correct polarity, and make very good soldered joints. The capacitor current as it charges is very high and poor joints here will soon overheat and cause problems.



Full size scale markings for the Current and Voltage meters.

Fit leads to the board for the meters, the output, the l.e.d. and the controls VR1 and VR2. The length should be left on the long side so that the wiring can be tidied up later when assembly is nearly complete.

WIRING

The mains wiring must be done carefully in order to be safe. Follow the wiring diagram Fig. 6 and make all of the joints "mechanically sound" before soldering. This way, even if a soldered joint is not 100 per cent the wires cannot come adrift and contact other parts. Insulated sleeving should be threaded onto the wires before the joints are made and then pushed forward to insulate them fully.

Use cable ties to keep the sleeving and wiring in place. When this is done properly all of the wires support one another so that should any one of them come adrift it cannot move out of position and make contact with anything else. This principle of "safety in numbers" can be applied to most types of wiring. The likelihood of more than one wire becoming detached is rare indeed.

The earthing point on the case bottom should be scraped clear of paint, and fitted with an M4 screw, two solder tags, a locking washer, and two nuts. The earth lead from the mains should be threaded through one of the solder tags, wrapped round and soldered to make sure the connection cannot come adrift. The other tag must be connected to the negative output terminal.

Having an earth on the negative side of the output is sometimes a problem because of ground loops, however, the level of safety gained by making the connection is important, *and it must be done*. If ground loops become a problem when connecting two pieces of equipment, fitting a low value resistor where the two grounds join is usually effective. Values between 10 ohms and 1k are normally used.

TRANSFORMER WIRING

The transformer wires should be left at their full length to avoid having to scrape off the insulating varnish and risk pulling them from the inside of the transformer. Four wires from the secondary are colour coded and should be connected to the printed circuit board as shown. The meters, potentiometers, l.e.d. and output terminals should next be fitted and connected loosely to their wires.

Do not tidy up the wiring until the board has been checked and tested. For testing, the board does not need to be in position, and fault finding is much easier with access to both sides. Take care though that nothing is accidentally short circuited by contact with the case. A carefully positioned piece of card makes a useful insulating barrier.

TESTING

Before applying the mains, check and re-check the wiring to be sure that it is correctly connected and insulated, and that the case earth connection is properly made. A resistance check between live and neutral should read approximately 20 ohms if the transformer primary is connected correctly (and the mains fuse has been fitted!).

Check also for continuity between the mains plug earth pin and the case. Do not fit the secondary fuse to the board yet, as a quick check can be made that the transformer is working on its own. Once everything has been checked connect the mains, and switch on. Using a multimeter set to the a.c. volts range, check across the transformer connections on the board for approximately 30 volts. If the mains fuse

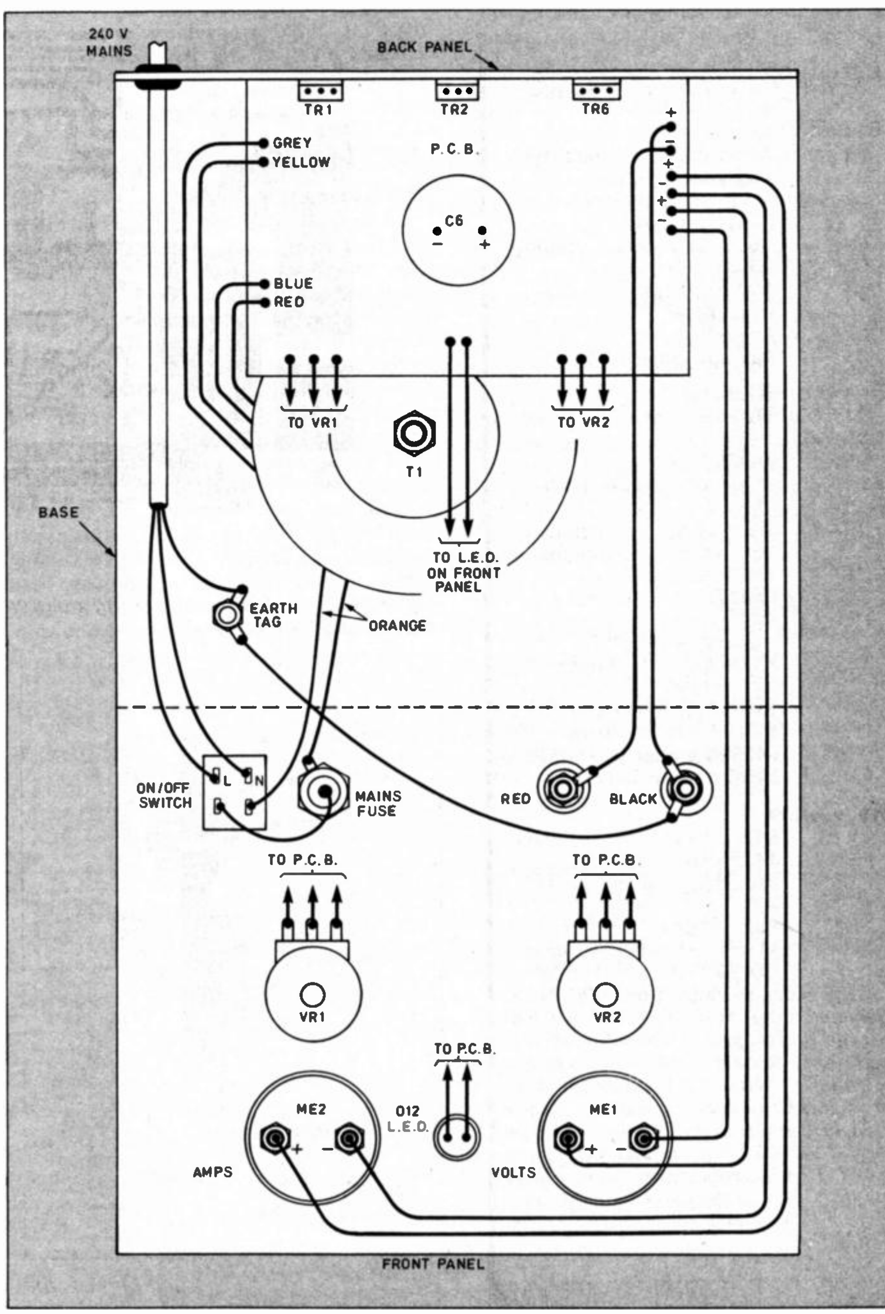
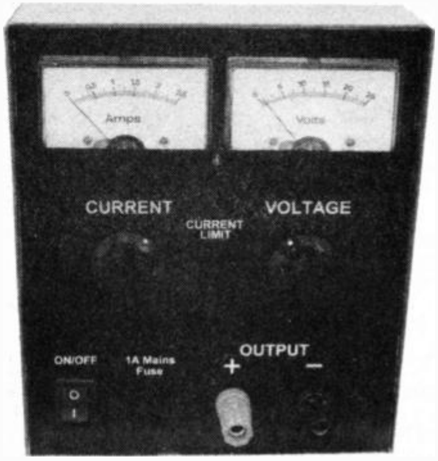


Fig. 6. Final wiring of the MOSFET Variable Bench Power Supply



Front panel lettering.

blows, the windings may have been incorrectly connected, placing a short circuit on the transformer secondary.

If everything is correct, switch off, turn both controls to minimum, and fit the secondary 4 amp fuse. Switch on again, and watch for any sign of overheating. If there is none, it is possible that everything is correct! Check that the meters read zero, and turn the current control up one quarter of a turn. Next, turn up the voltage control and see if the voltmeter reading increases, if it does, the circuit is good so far, if not, it will be necessary to take some circuit voltage readings to find out what is wrong.

Check first that the voltage across C2 and C3 is around 40 volts, and then check for 15 volts across D10 and the power pins of IC1. Once these are correct, check around IC1d which should have 5·6 volts on its input (across D13) and 10 volts on its output which is also connected across the two controls. The voltage on the sliders of the controls should vary smoothly from 0 to 10 volts as they are turned from end to end. If all of these voltages are correct, the chances are that the power control circuitry is working.

FAULTS

Remember that a single solder whisker, a dry joint, or a reversed or incorrect component can cause all manner of faults. The best fault finding tool of all is eyesight! It is surprising how many faults, which have been found after hours of thought and measurements, could have been seen immediately if someone had just looked carefully.

The next voltage to check is across C4. If the switching pre-regulator is not working, C4 may have either the full supply across it or nothing. It is doubtful that it would have anything in between. To simplify fault finding here, the pre-regulator can be taken out of circuit by short circuiting the emitter and collector of TR1 or TR2. This will put the full supply voltage onto C4 and will make the supply function exactly as the original MOSFET design. With 40 volts across C4, and reasonable voltage readings around IC1, the likely problem area is around TR5 and TR6. Check that D9 and TR5 are the correct types, and that the correct resistors are fitted around them. If the problem is zero output, try short circuiting the base and emitter of TR5 and check its collector voltage which should become high, making the output high in turn. If this happens, TR5 and TR6 are working and the chances are that there is a fault around IC1a, b, or c.

Once the circuit is working correctly, the operation of the switching pre-regulator should be checked. Disconnect the short circuit from TR1 or TR2 (if it has been fitted), and connect a light load across the output. A 100 ohm resistor is appropriate. Turn the voltage control up and down and make sure that the voltage varies correctly as shown on the voltmeter. Measure the voltage across C4 and check that this voltage also rises and falls and is always around 5 volts above the output. If this is happening correctly, connect a lower load resistor and repeat the test. Do not take too long however as the power devices will need a heatsink if a substantial current is taken for more than a few seconds.

The current limit control can also be checked at this point. Set the output voltage to maximum, and check that the load current can be varied down to zero by the current limit control. The current limit l.e.d. should light to indicate whenever the output is being controlled by the current limit control. A little experimentation with the two controls should make their operation easier to understand. Faults in the switching pre-regulator should be easy to trace as there are relatively few components involved. As before inspect carefully, and check component types and values.

POWER DEVICE MOUNTING

At this point, if the circuit is working correctly, switch off, unplug, and mount the power devices to the case. The flexible mounting washers supplied with the kit do not need thermal compound and are much easier to fit (and a lot less messy).

The board is held in position by the nine connections to the power devices. If extra heavy duty is planned, with lots of moving around, the board could be supported by extra fixings using the holes provided. For average bench use this is not necessary.

Once they are mounted, check that the power device tabs are definitely insulated properly, and tidy up all of the remaining wiring. Fit the case top, making sure that the screws do not pierce any of the internal wiring, and the job is complete. A one amp fuse fitted in the mains plug is a good idea as a back-up to the front panel fuse.

USE

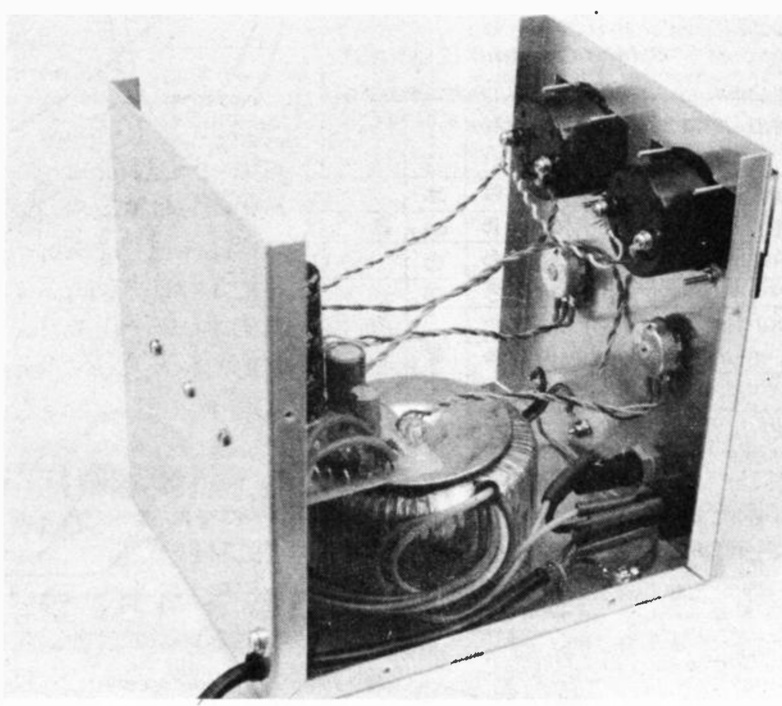
One of the main features of the supply is the current limit control. When testing a suspect or newly built circuit, correct use of the voltage and current controls will prevent excess power in being drawn and damaging components. Start with both controls set to minimum and gradually increase them little by little, checking the meter readings at the same time. Once the correct circuit working voltage has been reached, advance the current limit control. If there is no further rise in current, all is well. If the current continues to rise, the circuit probably has a fault.

NiCad batteries can be charged from the supply by setting the voltage control to somewhere above the maximum full charge voltage, and setting the current using the current limit control. This will give constant current charging which should be set at a level to suit the batteries. TAKE CARE NOT TO OVERCHARGE NiCad BATTERIES.

The average NiCad battery will continue to accept charge even though it is fully charged, and will eventually overheat and be damaged. If high charging currents are to be used then the charge MUST be stopped manually after a set time. At lower current levels, NiCads can be trickle charged continuously without difficulty.

When using high output currents and low output voltages, the supply components are under maximum stress. Even though the output devices do not get excessively hot, the transformer and rectifier diodes are working very hard. It is recommended that the supply is used only briefly under these conditions.

To have made the design capable of delivering 2·5 amps continuously at 0·5 volts would be "over engineering", and would have raised the cost considerably. In practice such applications are rare, and the supply will stay cool and work perfectly supplying all "normal" loads. If there is a need for high current low voltage operation, then a resistor in series with the load will be a great help as it raises the output voltage and reduces the burden on the transformer and rectifiers. □



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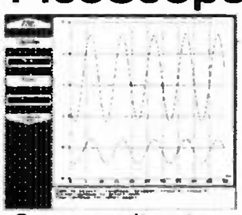
Each device comes with a comprehensive manual. C, Pascal and Basic drivers are included for users who wish to write their own software Software supplied on 3.5" disk.

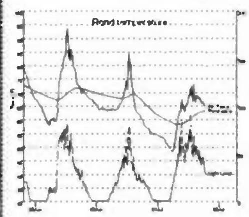
PicoScope



'Virtual instrument' software package. Storage oscilloscope with trigger, timebase, rulers and offset functions. Realtime spectrum analysis with mi/max frequency options and signal averaging. Multiple meters on screen (digital and bargraph). Printer and file handling support

Scope, voltmeter, spectrum analyser

PicoLog



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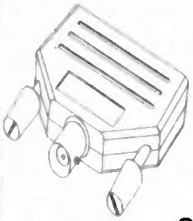
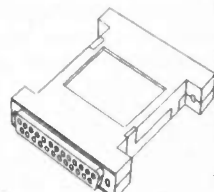
ADC-10



- Up to 24kHz sampling rate from a 386/33MHz machine
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection
- Includes PicoScope software

Single Channel 8 bit ADC

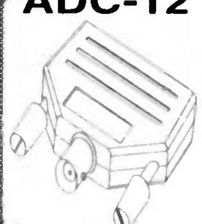
ADC-11



- 15K samples per second
- 0-2.5V Input range
- Digital output
- D25 input connector
- 30V overload protection
- Parallel port connection

11 Channel 10 bit ADC

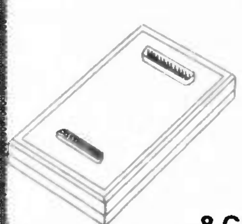
ADC-12



- Up to 18kHz sampling rate
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection

Single Channel 12 bit ADC

ADC-16



- Software selectable single ended or differential inputs
- Resolution programmable between 8 and 16 bits + sign
- ±2.5V input range
- 5V reference output
- Connects to serial port
- Includes PicoLog software

8 Channel 16 bit + sign ADC

Typical application	ADC -10	ADC -11	ADC -12	ADC -16
Oscilloscope	●	●	●	
Voltmeter	●	●	●	●
Spectrum analyser	●	●	●	
Audio sampling	●	●	●	
Chart recorder emulation		●		●
Temperature measurement	●	●	●	●
Pressure measurement	●	●	●	●
Automotive monitoring		●		●
Medical research		●	●	●
Education	●	●	●	●

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ADC-10 with PicoScope	£49
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ADC-12 with PicoScope	£85
ADC-12 with PicoScope and PicoLog	£95
ADC-16 with PicoLog	£109
PicoLog (for ADC-10/11/12)	£25
Oscilloscope probes (x1,x10)	£10

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Startling Revelations of Mazda's Collision Avoidance System

Will the British Driver Accept It?

by Hazel Cavendish

MAZDA'S much-heralded Collision Avoidance System – briefly reported in the national press at the end of last year – is a further development of their Safe Driving System exhibited at the Tokyo Motor Show back in 1991. The company has proved remarkably coy over releasing any useful electronic details of their latest brainchild, talking vaguely about a planned release of information next summer, but finally their European agents have come up with further details. Meanwhile, our DTI scouts tell us that most of the big Japanese car companies are working flat out on collision avoidance and there is something of a race to produce the most viable system ahead of the competition in this field.

Much of the philosophy behind this new concept will seem at odds with the British driver's temperament. Mazda's Advanced Safety Vehicle (ASV) is claimed to offer a way of creating "a safe and pleasant vehicle-orientated society". (Try that on frustrated drivers on the M25 on a Friday night).

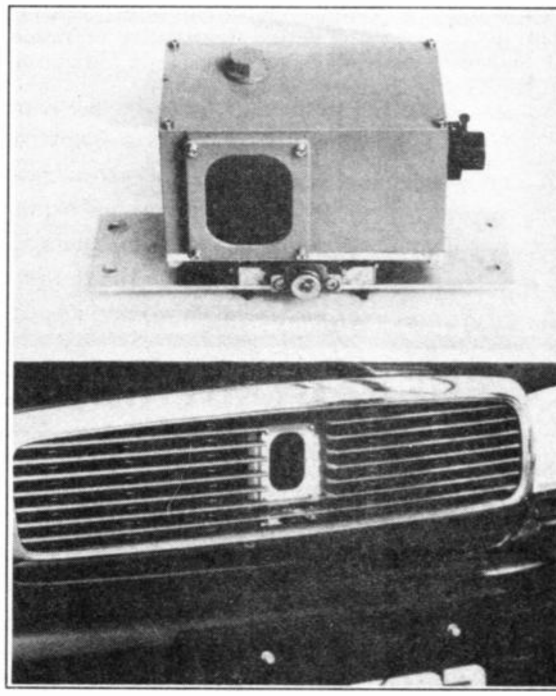
Its concept includes the establishment of accompanying road traffic infrastructures. The latter are calculated to raise some eyebrows in County Council finance departments, as they involve road markers fitted with magnetic plates at *all major cross-roads* as well as other road devices.

The use of electronics in the system is quite extensive. The on-board system supports the driver with navigation advice which includes traffic flow information, driving environment monitoring and danger assessment, hazard warnings – and emergency car operation if all those warnings fail to produce driver reaction.

Somewhat alarmingly, to most drivers, the back-up operation actually brakes the car for you. One can only imagine the indignation of the driver who considered he had the situation well in hand!

Driving conditions are monitored by a camera and a sensor mounted in the car, and the system incorporates laser radar, a communication antenna, a control computer, throttle and brake actuators, as well as driver interface display screen.

Because the system has been developed in a country whose cities and towns are even more congested than those of Britain, much importance is placed in the detection of pedestrians, as well as other vehicles on the road ahead, and claims proudly that it is able to detect people and impediments far ahead "even on a curved road". (Were they thinking of our winding country lanes?) The Car Communication Detection Camera (CCD) views the road ahead and the scanning laser measures the proximity of an object on the road. Meanwhile an alarm warns of the potential danger of a collision when the car gets too close to a pedestrian or a vehicle ahead.

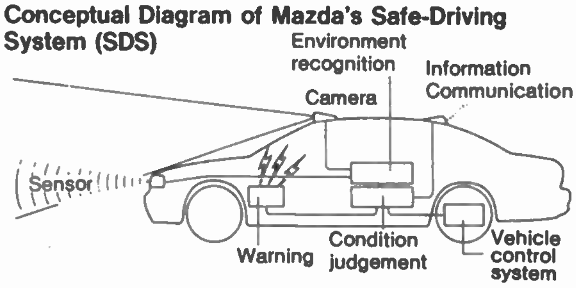


If the driver does not decelerate the system automatically operates the brakes. "This system is effective in preventing accidents with pedestrians crossing the road or vehicle collisions" adds the report somewhat smugly.

A strong possibility of causing driver irritation, if not apoplexy, is suggested by their lane-keeping system which *automatically* steers a vehicle from crossing a lane-dividing line. The system recognises the white line on the road with the CCD camera and sounds an alarm when the vehicle starts to drift beyond its lane without the driver operating the turn signal. *If the driver does not return the vehicle to its present lane the system automatically steers the vehicle to stay in its lane.*

Possibly this works with a docile and highly disciplined Japanese driver, but would it be acceptable to Britain's ruggedly independent driver with a mind of his own?

Conceptual Diagram of Mazda's Safe-Driving System (SDS)



In another example of "Nanny Knows Best" the system prevents a vehicle from proceeding through an intersection without a traffic signal. It recognises the distance between a road marker and a stop line with its magnetic sensor, and if the driver continues towards the intersection without stopping the system sounds an alarm. If he fails to stop the system operates the brakes, claimed to prevent "blind-side collisions between vehicles as they simultaneously enter an intersection". Well, yes . . .

Nanny takes over again in controlling cornering. "When a vehicle is approaching a corner the system estimates a speed safe enough to negotiate a turn and the distance to the starting point of the curve, based on information from a road marker" says the report. (Council traffic department's had better start saving NOW for even more traffic markers.)

If the vehicle speed sensor detects a speed greater than the estimated safe speed, that alarm is going to sound off in the driver's ear once again. The inevitable braking response if he takes no notice could be nasty if the road happens to be wet or icy as he goes into the bend, but Nanny is busy saying he has escaped a nasty collision with another vehicle, or even one with "a road structure". She thinks of everything, does Nanny.

Supersonic sensors installed on the sides of the car body detect a vehicle or even a scooter approaching from the rear, and once again the alarm shrills if the driver signals a turn or attempts to change lanes. Likewise, supersonic sensors embedded in the front bumpers detect a pedestrian or a cyclist crossing in front of the car and will also activate the alarm.

With the true earnestness of the Japanese strive for perfection, the original safety paper says "Our safe driving support (will) correct for human errors, such as falling asleep behind the steering wheel . . ."

Sleep? With all those alarms shrilling?

Worthy of praise are some of the more straightforward safety features incorporated in the new models. These include an excellent four-wheel anti-lock brake system which is electronically controlled. This detects locking of braked wheels in an emergency and reduces a car's tendency to skid. The system gives the car firmer braking control in an emergency or on slippery or icy surfaces. Although such a system is not unique to the Mazda, it is not always found in cars in the lower price ranges. The Company has also increased the number of models to incorporate ventilated disc brakes.

Work has been done in designing a safer body structure. In 1991 Mazda acquired its second supercomputer for collision data analysis, and introduced a deceleration impact simulator capable of creating complex realistic collision situations. The Company recognises that efficient absorption of impact energy in a crash situation requires highly advanced structural design to achieve a body structure with ample crushable zones. The car absorbs impact energy by deforming at collision points.

Mazda is also making efforts to improve the protection of fuel tanks and pipes. Such practical consideration of the basics of driver and passenger safety will contribute more positively to the future of this innovative motor car.

HIGH-TECH TV TEDDY

Tomy is a brand which, in an impromptu *EPE* straw-poll amongst mothers, received a firm thumbs-up for their imaginiative and high quality children's toys. "TV Teddy" is the latest Tomy product which uses electronics technology to create a bear-faced friend with a difference. TV Teddy is a cute and loveable bear which Tomy claims is the first truly "interactive" children's toy. The furry fun character works in conjunction with specially programmed video cassettes and a remote transmitter which is connected to the home video cassette recorder.

TV Teddy is intended to work with custom-made educational videos which are encoded with synchronising information. This data is sent by a special transmitter to the bear which runs on batteries and can sing and laugh as well as moving his eyes when talking. Each VCR cassette lasts some thirty minutes and it is hoped that standard TV programmes can also be broadcast eventually which contain TV Teddy-encrypted information, so that the bear will join in watching the television, helping youngsters to learn from the TV. It remains to be seen whether Tomy can enlist the support of TV schedulers though.

Revealed in January at London's *1994 Toy Fair*, over half a million TV Teddies were sold in the US in just a few weeks when it was launched last October. At a time when the UK video games market is being investigated by the Monopolies Commission, perhaps TV Teddy will prove that electronics really can have a proper place in constructive video entertainment; mums should certainly approve. – *A.R.W.*

Digital I.C. Tester

A portable i.c. tester capable of functionally testing the vast majority of logic devices in general purpose use, as well as numerous common memory devices has been introduced by Polar Instruments Ltd. Designated the D320, the tester costs just £180 and comes in a handheld package (see photo above) weighing 285g, powered by a 9V PP3 battery.

A comprehensive built-in library for over 350 popular standard devices allows test engineers to quickly and easily verify the functionality of suspect digital i.c.s. Following a possible location of the cause of failure the tester can be employed to functionally verify the diagnosis, giving an instant and clear test result.

The D320 tests digital components with up to 20 pins, and has a built-in library of truth table tests for 74/74LS/74HC TTL and 4000 series CMOS logic, plus checks for 41/44 series dynamic RAMs. If the component being tested does not have markings, or has a manufacturer's proprietary coding, the D320 can be switched into a search mode which will compare its logic function against the library to identify the generic type.

I.C.s are tested out of circuit, by placing them in a ZIF (zero insertion force) socket. Using the tester's six control keys and on-line l.c.d., the user can select a standard test by scrolling through the library, or switch the instrument into search mode. Once the identity is set, a functional i.c. test takes only a few seconds.

Priced at £180 the D320 is available from Polar Instruments Ltd, Dept EPE, Garenne Park, St Sampson's, Guernsey, Channel Islands GY2 4AF. Tel 0481 53081; Fax: 0481 52476.

AMATEUR RADIO RALLY

The *37th Longleat Amateur Radio Rally* takes place on Sunday, 26th June from 10am at Longleat Park near Warminster in Wiltshire. (Follow signposts to "Longleat House" not the Safari Park). The event is much more than just a radio/electronics gathering. It is the largest single annual event to take place at Longleat. Last year the attendance was 5,189 paying adults.

In addition to all types of communications equipment being sold, this year the organisers will be encouraging an even greater number of exhibitors/traders selling and showing all aspects of computers and associated peripherals. Seven large marquees will house a total of around 200 different traders.

A major factor of the rally will be the Bring and Buy section; last year this had a turnover of nearly £40,000. For those not interested in computers or electronics one marquee is devoted to a major Craft Fair exhibition and another to refreshments.

Admission to the grounds and rally are frozen at last years prices £2.50 for adults, £1.50 for pensioners and 50p for children.

Further details of the rally or information on table bookings please contact the organisers The Bristol Radio Group (Dept EPE), c/o Shaun O'Sullivan, 15 Witney Close, Saltford, Bristol BS18 3DX. Tel 0272 860422, Fax 0272 869387

REMAP

We have been asked to make readers aware of REMAP the charity that provides technical help for disabled people. REMAP are interested in recruiting new members who could help to design and construct specialist aids for the disabled.

If any reader is interested in giving his or her time and expertise to this worthy charity then please contact the National Organiser, Eur.Ing J.J. Wright, Hazeldene, Ightham, Kent TN15 9AD. Tel 0732 883818. Incidentally they tell us EPE projects are sometimes helpful to them, the *Visual Doorbell* last month being a case in point.

New Technology Update

Ian Poole investigates the latest research developments in low power high speed i.c.s, printed circuit board materials and optical computers

IT HAS always been accepted that speed and power dissipation go hand in hand. High speed circuits including high speed dividers, fast processors, and general high frequency circuits are always power hungry. The old emitter coupled logic series of i.c.s was a prime example of this. Operating at speeds up to 1GHz and more they ran exceedingly hot.

Often i.c.s in a 14-pin dual in line package would dissipate as much as half a watt and they would become hot to touch even at room temperature. Today with speeds rising all the time, power dissipation is an ever more important criterion, and one which many manufacturers are spending vast sums of money to resolve.

This research is paying dividends in many areas. One example is demonstrated by a recent announcement from NEC. They have developed a new gallium arsenide technology which uses only a tenth of the power of existing products, whilst being able to operate at higher frequencies.

The new devices use an *n*-type AlGaAs/InGaAs heterojunction f.e.t. with a gate length of just 0.25μm. This gives a very high electron mobility, thereby reducing the source/drain resistance. Low resistance is also a key feature of the gate design.

A "Y" shaped structure is used in conjunction with a low resistance alloy to achieve this. In fact by using these and other measures a cut off frequency for the individual f.e.t.s of over 100GHz has been achieved. All of this has been done with operating voltages of less than a volt, which means that power consumption is drastically reduced.

NEC does not expect to market devices using the new technology for at least another four years. Even so some of the test results currently being achieved appear quite remarkable.

Gates are able to pass data at rates of 10Gbits/second with an operating voltage of only 0·8 volts and power dissipations of just under 20mW. In addition to this another test circuit configured as a frequency divider has successfully operated at 10GHz.

When the new devices become available they should prove to be very useful in an industry where increased speed devices are more in demand than ever.

RF Circuit Boards

Radio frequency circuits are affected by a wide variety of factors, and this is often what makes r.f. design seem a little like a black art. One of the items which has a large effect on the circuit is the material used in the printed circuit board itself. This is of particular importance where components including inductors and transmission lines are printed onto the board.

The use of printed components offers several advantages. In the first place it provides a very cost effective and convenient way of making a component.

It only costs a small amount of board space, whereas if it had to be manufactured it could become costly in view of the tight tolerances which might be required. In addition to this a printed component is accurately placed, giving a high level of repeatability.

Finally there is no cost associated with fitting it. Transmission lines, or coax leads can be very fiddly and time consuming to fit, making the printed option very attractive. To illustrate how widely this technique is used, printed coils are found in the tuner sections of most of today's televisions.

Printed Components

In most cases the use of printed components works very well. As the properties of the component are governed partly by the dimensions this factor can be easily controlled to a high degree of accuracy. However the board itself will alter the values of any component used. Board thickness and dielectric constant also have a major effect. In many instances this may not be a major problem. Within television tuners these variations can be accommodated by the overall circuit. However in very high performance applications this is not always the case.

Where optimum performance is of paramount importance, normal fibreglass board cannot be tolerated. Its dielectric constant cannot be held within the required tolerance. In addition to this it introduces losses into the circuit at the higher frequencies.

As a result other substances have to be used for the base of the circuit board. One of the most popular is p.t.f.e. In many respects it is ideal because it causes much less loss than ordinary fibreglass and the tolerance on the dielectric constant can be controlled much better.

Despite these advantages, the p.t.f.e. base still has some drawbacks when it is used in some of the most exacting circumstances. In response to this the Microwave and Circuit Materials Division of Rogers Corporation in Chandler, Arizona, have developed a new material which helps overcome some of the problems.

The first requirement of the material is that its dielectric constant must be very accurately known and maintained. If there is a variation in this parameter, the first the equipment manufacturer will know about it is when the circuits do not perform correctly. To ensure this is not a problem, the dielectric constant of the new material is 2.2, and it is maintained to an accuracy of ±0·015.

Dimensional Stability

Dimensional stability is also very important. However problems arise as a result of the temperatures used in the manufacture of the material. During the process, copper is bonded to the Teflon, at a temperature of just over 300 degrees C. As the materials cool they contract, but the differing coefficients of expansion mean that a stress is set up in the board.

This is relieved when the board is etched during the equipment manufacture and the dimensions change slightly. As a result the exacting tolerances required by the p.c.b. design cannot be achieved without extra stages being introduced into the p.c.b. manufacture. To overcome this Rogers have developed a new bonding process which involves a thermal conditioning stage.

The new material called RT Duroid 5880DS promises to offer the microwave designer significant advantages over previous materials. Although it is not likely to be seen in many pieces of consumer electronics, it does represent a significant improvement in the field of performance for professional RF equipment.

Optical Computers

Changing tack somewhat, news is just beginning to surface about a breakthrough in the field of optical computer technology. Up until now these computers have relied heavily on conventional electronics for their control. Now researchers at Colorado University have developed a machine consisting of optical fibres, arrays of lasers, and optical switches.

The machine uses lengths of optical fibre as it memory. Bits of data are sent into the three mile lengths emerging two millionths of a second later. For control, other lasers route light from the fibre to optical switches for processing. In this way it is currently possible to perform simple calculations.

Although optical computing is still very much in its infancy, it promises to give some very exciting developments. Offering the possibility of a quantum leap in terms of processing speed, it could well be the technology of the future.

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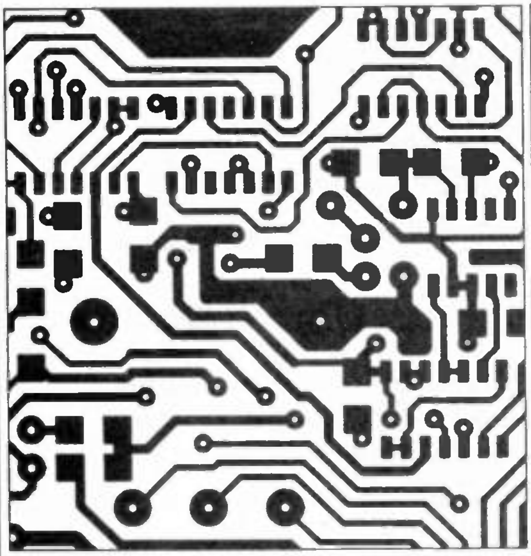

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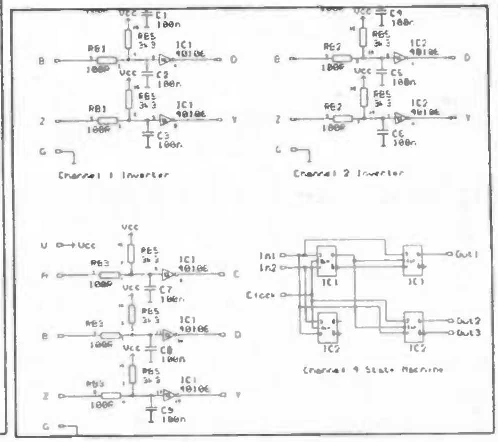

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Electronic Designs Right First Time?

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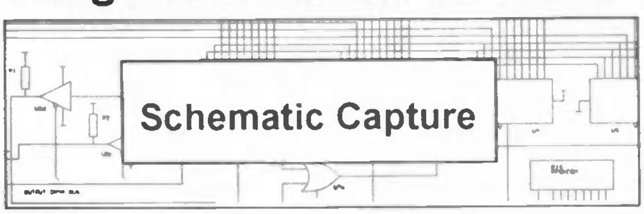
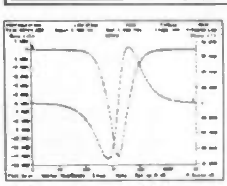
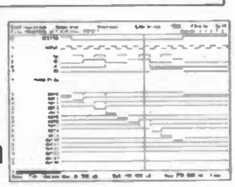
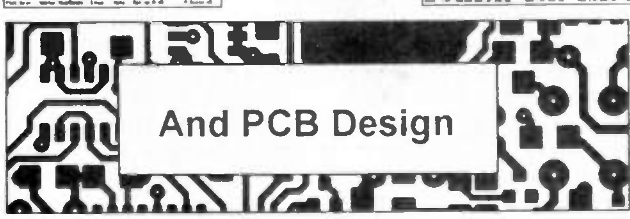




Analogue & Digital Simulation





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THE BEST OF BRITISH

TERRY de VAUX-BALBIRNIE

Where is Britain's place in the world scene?

This is the first in a four-part short series about the British electronics industry. Over the next few months we shall explore British manufacturing and find areas where the UK has particular importance.* The Best of British *is aimed at the hobby electronics constructor, consumer and those engaged in education and training. However, some specialised items will be introduced where they have special interest or relevance.

BRITISH innovation is not the same as badge-sticking. Here, we are not concerned with a British-sounding name attached to a product designed and manufactured in the Far East. In this series we are interested in goods where design, development, manufacture and marketing – practically everything apart from basic bought-in components – may be regarded as *British*.

In the final part, we shall look at component suppliers. Here we shall be concerned only with the company itself – not the sources of supply which will be bought in from a variety of manufacturers and agents world-wide.

We obviously cannot include every British manufacturer but only a small sample. Also, although all products mentioned are of a high quality, it is not our purpose to show bias or to express opinions about their relative merits. Those wishing to compare one product with another should approach companies or their agents direct – all will provide helpful literature on request.

This month we shall look at p.c.b. (printed circuit board) design software and robots suitable for instruction purposes. Over the following months we shall examine British audio equipment, test instruments and soldering materials and finally the electronics service industries – educational course organisers and component suppliers.

History isn't bunk

Britain has a long, proud history of electrical and electronic discovery, invention and innovation. In 1831 Michael Faraday made the first electrical generator and the transformer on which the large-scale generation and distribution of electrical power depends.

The discovery of the electron itself, the control of which constitutes the very subject *electronics*, was made by the British physicist Sir Joseph John Thomson in 1897 (for his work he was awarded the Nobel Prize in 1906). Sir John Ambrose Fleming (1849-1945) constructed the first *diode valve* in 1904 which led the way to the development of *radio* and the *amplifier* based on the *triode valve* which was invented by the American electrical engineer, Lee de Forest (1873 – 1961) two years later.

If you want to see what is going on in British electronics industry, you need to look in the right places. Not in the cut-throat high street market of cheap consumer goods. Here, a label on the back of the product will inform you that it has been made in Korea, Malaysia or the Philippines.

Low labour costs in the Far East make it very difficult for British manufacturers to compete at the *cheap and cheerful* end of the market. You are more likely to find the *"Best of British"* in specialist and high-quality products. Here we have some undoubted world leaders. Our audio equipment, for example, is second to none and exported to all parts of the world.

We British appear to have a particular aptitude for *thinking* and *designing*. Perhaps a consistent lack of funding has made us more resourceful than most. It also seems true that we have less ability at assessing the mass market and turning an idea into profitability.

Our lack of giving people what they want rather than what we think they *might* want has often been the downfall of British invention. An example is the ill-fated Sinclair C5 electric car. Sometimes we become so engrossed in elegant design that we miss the real human need.

Software

Such expertise in thinking and designing is perhaps why we have made such a large contribution in the field of "software writing". Another likely reason is that it is possible to design sophisticated programs with only a modest financial outlay. It may also be due in part to our development of inexpensive portable computers in the early 80's.

Largely due to the efforts of Sir Clive Sinclair, the computer was put within the reach of all. By taking it out of the computer room and putting it into the living room, children learnt to see the computer as a friend while many parents saw it as a threat. Children learnt to control the computer possibly by playing games on it and some developed programming skills – the very children who are now writing the type of software which we shall be discussing presently.

It seems hard to believe that it was only 14 years ago that the *Sinclair ZX80* was advertised in the pages of *Everyday Electronics* at a ready-built price of £99.95 or in kit form, £79.95. This had 1 kilobyte of RAM compared with several megabytes in a modern desktop or laptop computer.

You CAD

In the UK we write computer-aided design (CAD) software for use all over the world. A good example of this, and one which will be of interest to the electronics hobbyist, is that used for printed circuit board (p.c.b.) design.

Most people are familiar with printed circuits. Many years ago, electronic equipment such as radios and TV's were built by "hard-wiring" the individual components together. However, this method does not lend itself well to mass production and was really only appropriate to relatively simple circuits. With a p.c.b, individual wires are replaced by copper tracks and pads formed on a flat board. Several such boards may exist inside a given piece of equipment. Many projects featured in *EPE* use a circuit based on a single-sided p.c.b.

The board used for a p.c.b. is made from insulating material bonded with a thin layer of copper *(copper clad board)*. The parts which will eventually make the tracks and pads are covered over to protect them from the chemical etchant which will remove the redundant material.

The simplest way of doing this is to draw the circuit on the copper using a special "etch resist" pen or to use tape which is stuck down on to the surface. When the board is placed in ferric chloride solution, the exposed copper is dissolved – or etched – away to leave the required tracks and pads.

If several identical boards need to be made, or where a complex layout is involved, this method is not appropriate. In such cases, a photographic technique is used. Here, special copper clad board having an ultra-violet sensitive (resist) coating is used.

The artwork is prepared on transparent film which is then laid in contact with the sensitive coating. The board is exposed to ultra-violet light through the transparency then placed in a developer bath. This removes the resist in the areas reached by the UV. The board is then immersed in etchant and the unprotected areas of copper dissolved away to leave the final circuit. Using only one master, any number of p.c.b's can therefore be made.

Cut and Stick

Those who make only the occasional simple p.c.b. may find that sticking down tracks and pads made from sticky tape is still the most appropriate method. However, there is much to be gained by designing the layout on a computer screen. The user may then produce master artwork on a printer. A transparent copy may be made from this using a photocopier or those having an ink-jet or laser printer can make one *direct* on transparent film.

One advantage of computer-aided design is that mistakes are easily corrected. Also, the design may be stored on disc so that it may be modified at a later date and used for other similar circuits.

As a rule, companies produce two levels of software. We shall be more concerned with the lower-level type (so-called *entry level*) because this will be of greater interest to the amateur. However, many companies offer 100 per cent buy-back if a customer wishes to upgrade. That is, the higher-level product is obtained by paying the difference in price.

Typically, this type of software runs on a PC and has two distinct uses – p.c.b. design and the drawing of circuit diagrams *(schematics)*. For either application the appropriate symbols such as resistors, capacitors and so on are drawn from a library. These are displayed on the screen and may be moved and rotated as required.

The copper tracks may be defined in a number of widths then added and routed to make the circuit diagram or layout required. For p.c.b's, pads may be generated in various shapes and sizes and having a range of hole diameters. A grid may be used to get component lead and pin spacing right and the layout may be magnified to enable small sections to fill the screen for close examination.

Where non-standard component symbols are required, these may be defined by the user and stored for future use. Using the *block* command, large areas of the diagram may be edited, moved, rotated, mirrored and copied as required. Generally text in various sizes and widths can be added to diagrams.

As a rule, the software may be driven using the computer keyboard or a mouse. Although a mouse makes it easy to use, *keyboard shortcuts* are faster and more convenient for frequent users. Note that the two functions – p.c.b. design and circuit diagrams are often completely separate. It is not usually possible to import parts taken from one into the other.

Matter of Opinion

Because much of the foregoing information is of a general nature, anyone contemplating buying this software should seek specific information from the supplier. It may be necessary to check that it will run correctly on the available equipment and that sufficient free memory is available.

When a facility is mentioned for one particular product, this does not imply that it is not available on others. Readers will need to check with the manufacturer for facilities which they are particularly interested in.

Often a *demonstration disc* will be sent if a serious request is made to the company. Obviously, these will not have all the facilities of the full software. However, by using it you can get a feel for the product and find which one suits your requirements and method of working best before making a commitment to buy. Teachers in schools and colleges will often find that an educational discount is available.

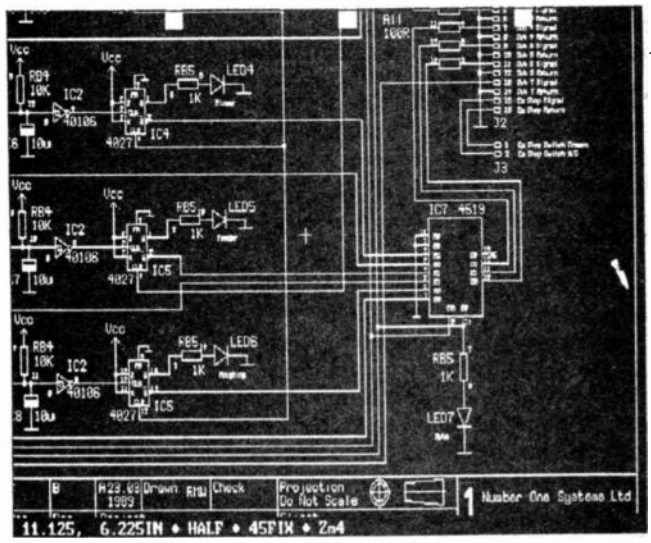
To illustrate all this, we shall examine four companies: Number One Systems Ltd (*EASY-PC*), Tsien (UK) Ltd (*BoardMaker*) Labcenter Electronics (*Isis* and *Ares*) and Niche Software (*PCB Designer*).

EASY-PC

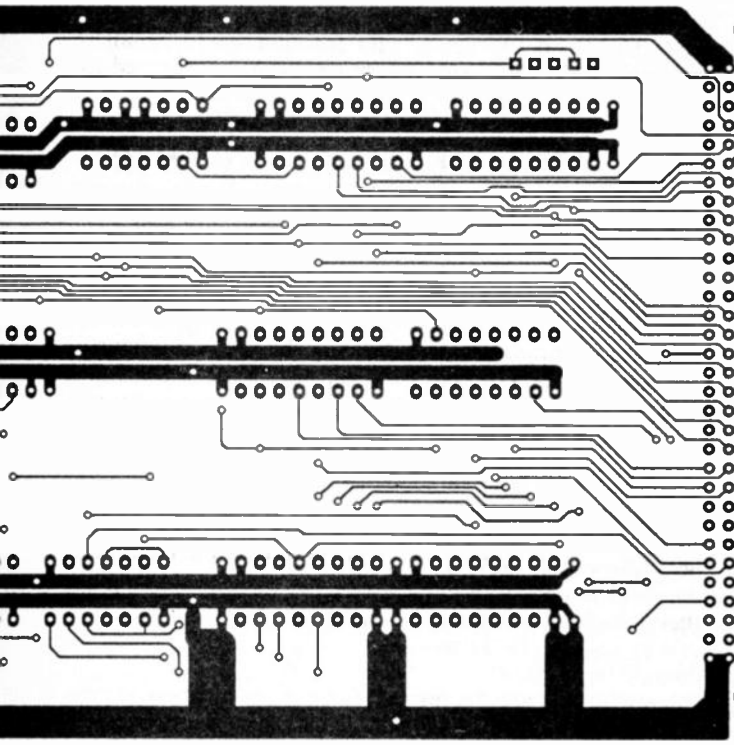
The company now called ***Number One Systems, Ltd.*** began in 1978 as *Number One Marine*. This specialised in the manufacture of products for sailing enthusiasts such as self-steering equipment. However, in 1983 and with the present company name, they entered the computer simulation market and over the following years gained valuable expertise in developing and marketing analogue – and subsequently digital – circuit simulation software. The line continues to this day with entry and professional versions of *Pulsar* (digital circuit simulator) and *Analyser III* (linear analogue circuit simulator).

In 1987, the first version of *EASY-PC* (the entry level p.c.b. design and schematic drawing software) was developed ready for sale. Note that the higher-level *EASY-PC Professional* links directly with Pulsar and Analyser providing the professional engineer and serious hobbyist with a complete integrated system for circuit development, testing and subsequently designing a p.c.b. layout without actually touching a component.

Number One Systems carry out all aspects of software development, sales and marketing on site with some 18



Circuit diagram on Easy PC.



P.C.B. design taken from Easy P.C

workers involved. The company has, at the time of writing, over 17,000 installations of *EASY-PC* and 25,000 installations in total world-wide. Some 40 per cent of production is exported – to 76 countries at the last count. EASY-PC is marketed in various foreign language versions and for the American market, the company have opened an office in the United States.

EASY-PC combines separate schematic drawing capability with p.c.b. design. Text may be added in various sizes and widths – it is even possible to use special characters such as "Ω" and "μ". To run EASY-PC you will need a PC XT/AT/286/386/486 (although you will find that it will run on the most basic of machines) and DOS 2.0 or later with a minimum of 512K memory. Installation on a hard disc is preferable but two floppy drives may be used instead.

The cost of *EASY-PC* is £98 and of *EASY-PC Professional*, £195 (plus VAT and postage/packing) and Number One Systems promise free support for life. Updates (that is, a later version of the same product) are supplied free for the first 6 months. After that, they cost £25 *maximum*.

Many amateurs begin with the entry level product but there are increasing numbers of hobbyists who go straight for EASY-PC Professional. Cautious users have nothing to lose by starting at entry level since a future upgrade is made by simply paying the difference in price. A demonstration disc is available on request for anyone contemplating buying either EASY-PC or EASY-PC Professional. Educational discounts are also available.

BoardMaker

Established in 1989, ***Tsien (UK) Ltd*** is a wholly British company and now has a turnover of £0·25 million. At the moment 40 per cent of production is sold on the domestic market and 60 per cent. exported world-wide.

Tsien's *BoardMaker* is made in two versions – the entry level product, *BoardMaker 1*, and the more technically advanced one, *BoardMaker 2*. They claim some 5000 users of BoardMaker world-wide – among them large corporations such as GEC and Rolls Royce as well as national government agencies and government establishments abroad.

BoardMaker 1 provides all the features needed to produce circuit diagrams and p.c.b. design artwork. However, an upgrade to BoardMaker 2 may be useful to those who require autorouting of tracks in a p.c.b. design – that is, the facility to route tracks around the board automatically.

Either BoardMaker version will run on virtually any PC. You will also need DOS 3.0 or later and 640K of available RAM. Installation on a hard disc is best – this will need 1Mb of free space. A less convenient alternative is to use two floppy drives.

It is possible to operate BoardMaker without a mouse by using the arrow keys and keyboard short-cuts. However, in practice, a mouse will be found almost essential. Tsien will provide three months of free telephone support to its users. At the time of writing *BoardMaker 1* costs £95 (plus VAT).

Supersketch

Labcenter Electronics produce the families – *Isis* (Intelligent Schematic Input System) and *Ares* (Advanced Routing and Editing Software). All products are developed in-house and sold around the world – to 30 countries at the last count with exports accounting for 30 per cent of turnover.

Isis *Supersketch* is the budget package which enables circuit diagrams to be drawn and *PCBII* is the matching p.c.b. design package. To run Supersketch and PCBII you will need a PC XT/AT/386/486 and at least 512K (640K for full capacity) of available RAM and a hard disc drive with 1Mb of free space. A mouse is also necessary.

Unusually at entry level, Supersketch features *Automatic Wire Routing*. This is invoked when the mouse is clicked on a component pin. It then assumes that you are going to route a wire from that point. When you click on a pin elsewhere, a wire is automatically drawn between the pins taking into account the positions of existing components and wires. It is also possible to route the wire manually if the automatic one is inappropriate.

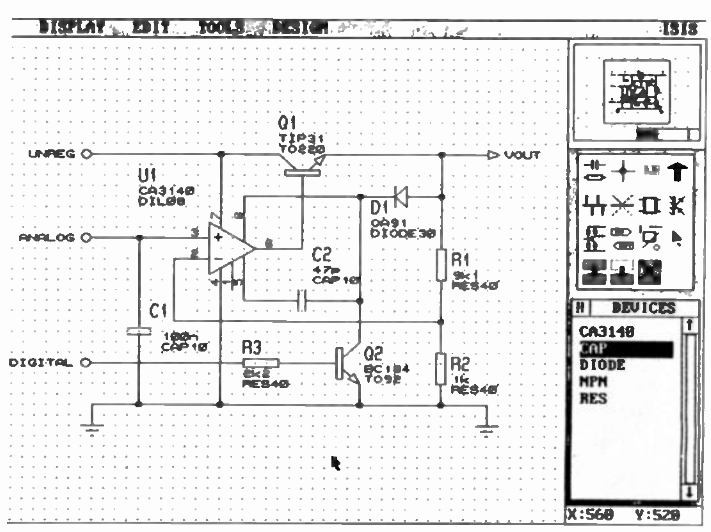
Automatic dot placement is another feature of Supersketch. This means that where three or more wires meet at a point, a dot is automatically placed at the junction.

Labcenter currently package *Supersketch* and *PCBII* together as a *Cadpak*. This has been updated recently with the addition of a surface-mount library. The all-in price is £79 (plus VAT) and it will be available at this price throughout 1994 and probably beyond. Telephone support of Labcenter products is provided without restriction.

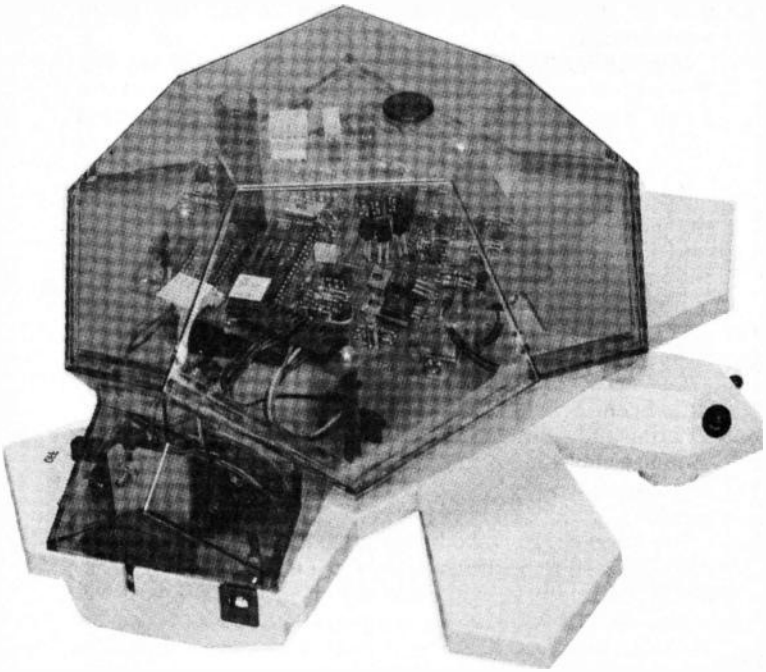
Filling a Niche

A relatively new company, ***Niche Software*** was formed in 1993. Stephen Hurcombe wrote *PCB Designer* on his own with the aim of producing an easy-to-use product using *Windows*. Plans for future software, not necessarily related to electronics, are in the low-volume "niche" market – the kind which is overlooked by the large companies.

PCB Designer is designed to run on a PC (minimum 286) with Windows 3.0 or 3.1, having 2MB RAM and a VGA



Circuit diagram on ISIS Supersketch.



The Valiant Turtle remote controlled turtle.

display. Its low cost – £49 inclusive of VAT and carriage – makes it a good proposition for those needing to produce simple p.c.b. design artwork.

PCB Designer will appeal to hobbyists. It could also be used as a good introduction to computer-aided design in schools and colleges. Its simplicity obviously means that there are limitations but these will be not be a problem within the target group. One unusual point is that it has been produced without a traditional instruction manual. Instead, it has an on-line tutorial which saves costs.

It took about nine months to develop PCB Designer. The next product will be the companion *Circuit Design* package. There have been enquiries for *Designer* from Europe and Syria. An order has been despatched recently to Sri Lanka so there is export potential.

Robotics

The word *Robot* comes from the play *R.U.R.* (Rossum's Universal Robots) written in 1920 by the Czech playwright Karel Capek. The old Science Fiction notion of robots appearing like human beings (*androids*) then grouping together, taking over the world and finally destroying humankind now seems very old-fashioned.

Although universal robots designed to look like humans seems fairly pointless they are often modelled on parts of the human anatomy – particularly the arm – and designed to do a specific type of job. This gives rise to a variety of industrial robots which can perform many of the routine tasks previously carried out by humans without fatigue, complaint or the need for pay.

The familiar *robot arm* with gripper looks much like a human arm and articulates in similar ways. However, its precision at placing parts and the speed at which it works far outstrips the ability of a human operator to perform the same task. Car manufacture and electronic assembly work are areas where robot arms are ideal.

Unlike previous generations of *dedicated* machines, the robot is *programmable*. It can thus be turned to new uses as the need arises. Thus, the large capital outlay can be justified.

One common method of programming is to lead the robot "by-the-nose" through the operations required. A human paint sprayer or welder, for example, can teach a robot arm to copy his movements. Other programming methods include the use of ready-written software or programming the device using a computer keyboard.

It is true that some countries use industrial robots more widely than we do. However, in one area we do very well. This is in the design and manufacture of small to medium-sized robot arms and buggy-type devices used for demonstration, educational and training purposes.

Roaming in the gloaming

Robots may be introduced to children with the *Roamer* and the *Turtle* manufactured by ***Valiant Technology Ltd.*** This company was set up in 1984 with the introduction of the Turtle. The Roamer followed in 1989.

Roamer is an entry-level robot which takes the form of a "smartie shaped" user-friendly buggy. Movement is controlled with single key-presses on a bright and colourful keyboard. A memory can store up to 70 instructions and by using *repeat* and *procedure* facilities, it can carry out hundreds of commands.

Roamer was developed after consultation with over 300 teachers to ensure that it matched the needs of the National Curriculum. It is suitable for very young children who find the Logo-like programming language easy to understand. Semi-disposable jackets, available in different colours, give the child an opportunity to personalize the robot and to use their imagination. Sounds are also possible (pitch, duration and tempo) so the device may be used to provide an introduction to music.

It can draw patterns on paper by means of a pen or pens attached using a special kit and although not as precise as the Turtle (see below), this does, nevertheless, give children an idea of simple graphics. By using the *Control Box* (available as an extra), which fits underneath, Roamer can interact with the environment using various motors sensors, lights, etc.

One interesting feature of Roamer is the ability to store a program using a computer interface. Different versions are available to run on a PC, BBC, Archimedes and other computers. Storing programs allows procedures to evolve over several lessons and a library of robot behaviour to be built up. Programs may also be merged so that groups of children can work independently on specific aspects of it.

Roamer costs £90 and a pack of four semi-disposable jackets, £17. The Control Box costs £47. These sample prices are approximate and exclude VAT and postage/packing. Light packs, sensor packs and motor packs (at about £30) are available from the company with a full price list available on request. Quantity discounts and discounts for prompt payment and for cash with order are available. The whole Roamer package is supplied with a User Guide and a book containing 16 activities. A wall poster and videos are also available.

Going Turtle

The Valiant *Turtle* is claimed to be the world's only remote-controlled (that is, wireless) floor turtle so it is free to move without encumbrance anywhere within a range of six metres of the host computer. The turtle is economical to run because it houses a set of rechargeable batteries (the eyes dim when it is time to re-charge!). The pen-carrying robot – said to be the most accurate on the market – can provide experience in a wide variety of topics ranging from computing, mathematics and geometry to pure artistic design.

The Turtle appears as an actual turtle (tortoise) with a transparent cover through which the inner workings may be seen – see photograph. It is programmed in *Logo* from the computer keyboard and this is easily understood by most children. It also acts as an introduction to more complex programming later.

Various computers may be used in conjunction with the appropriate software including the BBC B/Master, Archimedes, PC's and others. Complete Turtle systems cost around £250 with all computer interfaces, £36. Support is in the form of a technical manual, parent/teacher book and children's comic.

Annual turnover of Valiant is now £1 million and with agents having been appointed in the USA, New Zealand, and throughout Europe, the company anticipates exports to reach 40 per cent of production over the next few years. Valiant offer a free helpline with technical and educational support. They also produce a colourful User Group magazine *Go* which gives details of novel uses for the products, hints and tips as well as details of new materials being developed by the company.

TecQuipment

For more advanced robot training, ***TecQuipment Ltd*** produce a range of educational equipment and of particular interest are the MA2000 and MA3000 systems. The MA2000 is suitable for learning the principles of the industrial robot. It is, in fact, a small robot arm having a reach of 500mm and six axes of movement plus gripper. The three major axes are *waist*, *shoulder* and *elbow* plus three minor ones – *pitch*, *yaw* and *roll*.

All movements are driven by d.c. motors except the gripper which is pneumatic and needs a clean compressed air supply to work. This gripper can accept a variety of jaws and tools which enable "real" tasks to be carried out. The robot can be programmed by "lead-by-nose", taught from the keypad supplied or programmed from a computer keyboard. The package consists of the arm itself, controller interface, keypad and manual. Also available is supporting teaching material, student assignments, etc.

The larger MA3000 robot system has a reach of 750mm and, like its smaller brother, is supplied as the arm itself, interface, keypad and manual. It has the same major axis functions as the MA2000 but only two minor axes – pitch and roll.

Cybernetic Mentor

Cybernetic Applications produce a range of robotic training materials for education, training, research and industry. This company was established in 1984 following a series of articles about *Mentor* and *Neptune* robots by director Dick Becker in *Practical Electronics* (now incorporated in this magazine).

The *CyRo* Training System costs £495 and is a miniature training robot. Commands are provided from a host computer keyboard via a RS232 interface. It may also be programmed off-line with graphical simulation.

A complete work cell is available for £595. This consists of a "real" situation with 500mm conveyor, automatic parts dispenser, height and width gauges, infra-red component sensors, work pieces and so on. The system is secured to a 800mm × 600mm melamine faced board and included with it is a set of example programs and exercises.

Also of interest to the amateur and educationist is the Mentor Desk Top Robot (see photograph). This entry-level robot arm with a reach of 420mm is a small version of the familiar five-axis plus gripper human-arm type mentioned earlier. Mentor needs only a mains supply and a PC, BBC B or Master computer together with a suitable monitor.

Programming may be carried out from the computer keyboard or lead-by-nose. Another interesting method of programming is for the robot to copy the movements made by a small-scale handheld model of itself i.e. by *simulation*. The manual supplied with the arm suggests various experiments on accuracy, repeatability, etc. Cost of Mentor complete with control system is £1190 and the simulator, an extra £100.

More sophisticated systems produced by the same company have industrial capability and although more expensive may still fall within the budget of some larger educational establishments. The *Gryphon* 5-axis plus gripper precision robotic system having a reach of 640mm, for example, costs £3450 with gripper and simulator extra. Cybernetic Applications claim the world's largest range of low-cost robots. Presently 80 per cent of production is exported with half of that going to the EC.

That's all for this month. Next month we shall take a look at the British Audio industry with a particular emphasis on loudspeaker manufacture in which we excel.

Addresses

Computer-aided design:

Labcenter Electronics, Dept EPE, 14 Mariner's Drive, Bradford, BD9 4JT. Tel: 0274 542868

Niche Software, Dept EPE, The Bannut Tree, Kerrys Gate, Hereford. HR2 0AG. Tel: 0432 264800

Number One Systems Ltd., Dept EPE, Harding Way, Somersham Road, St. Ives, Huntingdon, Cambs. PE17 4WR. Tel: 0480 461778

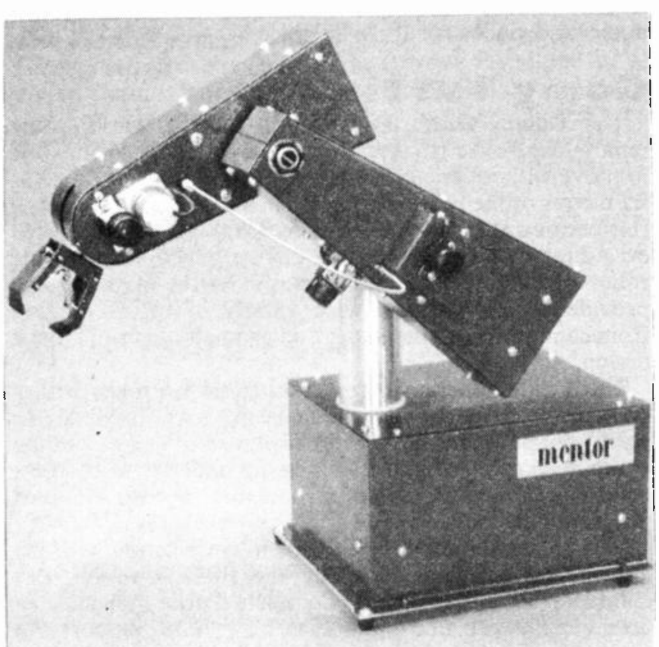
Tsien (UK) Ltd Aylesby House, Wenny Road, Chatteris, Cambs. PE16 6UT Tel: 0354 695959

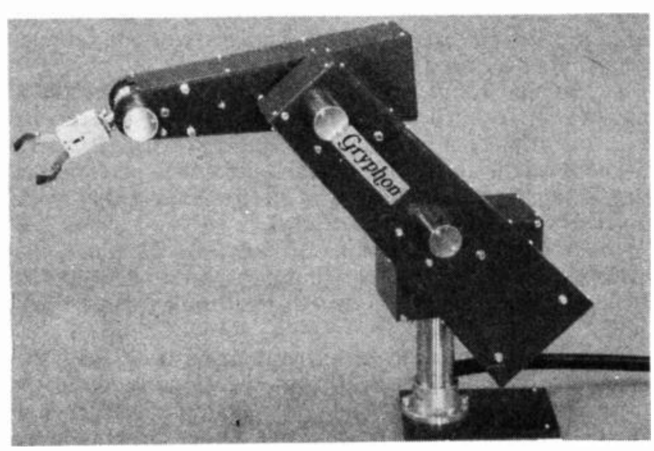
Robots:

Cybernetic Applications Ltd., Dept EPE, West Portway Industrial Estate, Andover, Hampshire, SP10 3LF. Tel: 0264 350093

TecQuipment Ltd, Dept EPE, Bonsall Street, Long Eaton, Nottingham. NG10 2AN. Tel: 0602 722611

Valiant Technology Ltd, Dept EPE, Myrtle House, 69 Salcott Road, London, SW11 6DQ. Tel: 071 924 2366





Cybernetic Applications robot arms Mentor (left) and Gryphon.

At last, a fully functional upgradeable PCB CAD system to suit any budget. Substantial trade-in discounts are available against other "professional" PCB design packages ...

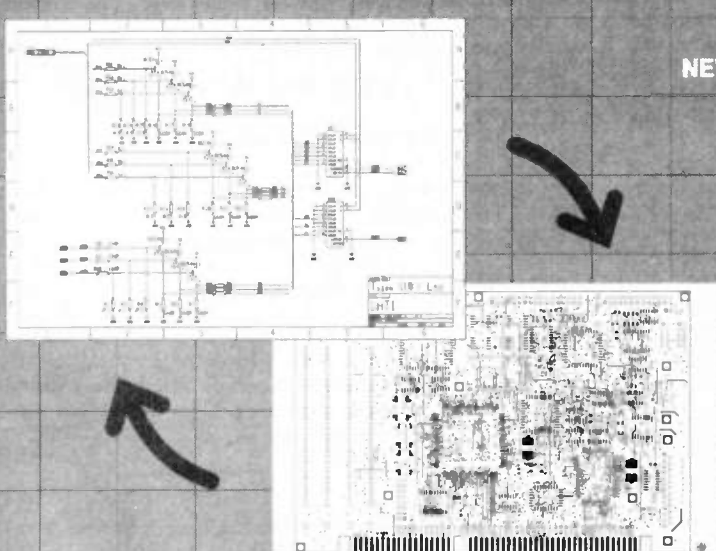
... call now for details.

BoardCapture

Schematic Capture Design Tool **£395**

- Direct netlist link to BoardMaker2
- Forward annotation with part values
- Full undo/redo facility (50 operations)
- Single-sheet, multi-paged and hierarchical designs
- Smooth scrolling
- Intelligent wires (automatic junctions)

- Dynamic connectivity information
- Automatic on-line annotation
- Integrated on-the-fly library editor
- Context sensitive editing
- Extensive component-based power control
- Back annotation from BoardMaker2



BoardMaker

BoardMaker1 - Entry level **£95**

- PCB and schematic drafting
- Easy and intuitive to use
- Surface mount and metric support
- 90, 45 and curved track corners
- Ground plane fill
- Copper highlight and clearance checking

BoardMaker2 - Advanced level **£295**

- All the features of BoardMaker1 +
- Full netlist support - BoardCapture, OrCad, Schema, Tango, CadStar and others
- Full Design Rule Checking both mechanical and electrical
- Top down modification from the schematic
- Component renumber with back annotation
- Report generator + Database ASCII, BOM
- **NEW** Thermal power plane support with full DRC

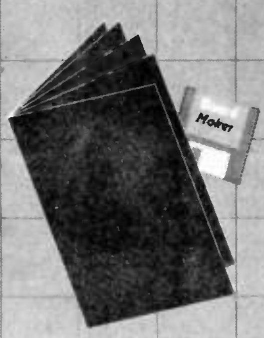
BoardRouter

Gridless re-entrant autorouter **£200**

- Simultaneous multi-layer routing
- SMD and analogue support
- Full interrupt, resume, pan and zoom while routing

Output drivers - Included as standard

- Printers - 9 & 24 pin Dot matrix, HPLaserjet and PostScript
- Penplotters - HP, Graphtec & Houston
- Photoplotters - All Gerber 3X00 and 4X00
- Excellon NC Drill and Annotated drill drawings (BM2)



Call, write or fax for more information
or a full evaluation kit

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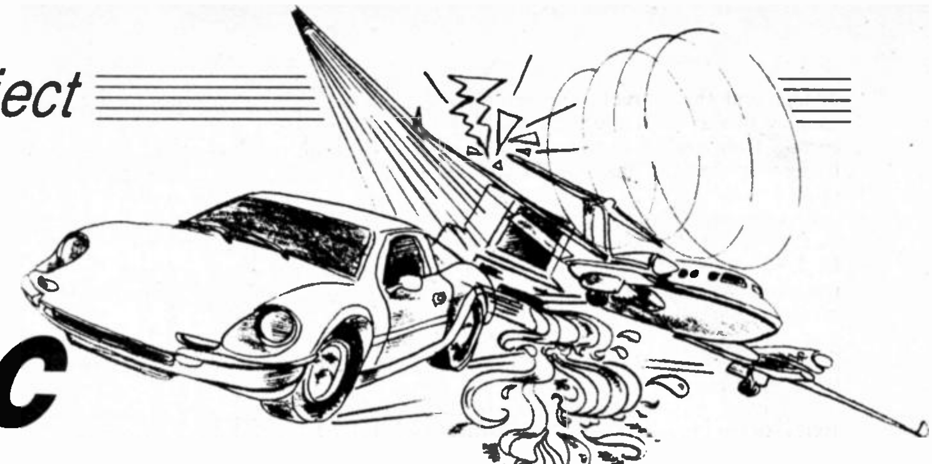
All trademarks acknowledged

Constructional Project



EPE SOUNDAC

ADD-ON PC SOUND CARD

PHIL GREEN

*The art of (cheap) noise! or...
Put your beep to sleep, and astound with sound!*

SINCE its introduction the IBM compatible PC has improved in so many ways – in terms of speed, ease of use, and smaller yet faster boxes.

One area that has been slow to develop is sound, and even now few PC's are capable of anything more than a "beep'. Commercial sound cards are now readily available, but are still fairly expensive. These fall into two categories – pure FM synthesis such as the Ad-Lib card, and those with digital to analogue conversion (DAC), for example the "Sound Blaster".

Microsoft Windows requires the latter type since it makes extensive use of digitally sampled sound files. These have the extension ".WAV" and consist basically of a short header indicating playback speed and length, followed by a stream of 8-bit sampled data. The most effective WAV files are unusual sound effects, such as breaking glass and explosions, or running water!

One disadvantage of a commercial board is that it isn't easily shared between two PC's – and what if you own a laptop which doesn't take expansion cards?

This project describes a simple, high quality unit which sounds just like a £100 commercial card, yet costs very little and simply plugs into the PC's printer port.

DIGITAL-to-ANALOGUE CONVERTER

The full circuit diagram for the EPE SounDAC is shown in Fig. 1. This circuit consists of just two integrated circuit devices; the ZN426E-8 digital-to-analogue converter (DAC), IC1, and a low voltage power amplifier, IC2, type LM386N-1.

Most of the "action" takes place inside the D/A converter chip, so the external component count is kept very low. The pinout details for the ZN426E-8 8-bit D/A converter is shown in Fig. 2.

So how does a DAC work? The ZN426E consists of a precision voltage reference, an array of switches, and a complex arrangement of resistors known as an "R-2R ladder network".

Since only two values of resistor are used, the values can be matched very accurately – far better than would be possible using discreet components. Let's take each stage in turn, starting with the simplest, the voltage reference.

The voltage reference section of the ZN426E, see Fig. 3, behaves like a very accurate 2·5V Zener diode, and has a very low internal impedance. This stage requires two additional components – a resistor which provides the reference current from the V_{cc} rail, and a capacitor to provide decoupling. The output from this stage can feed several DAC's in a more complex circuit, but in our case the voltage reference output is connected directly to the reference input.

STEP LADDERS

The ladder network is arranged as in Fig. 4, where each of the eight input bits controls one of eight "bit" switches. A logic zero ("low") equates to the switch effectively grounding its resistor, and a logic one ("high") switches that node to the reference voltage feed.

At each node, points 1 to 8, the resistance looking along the ladder is the same as the resistor value connected to ground. Since two 2R's in parallel equal R, each node supplies the next through a potential

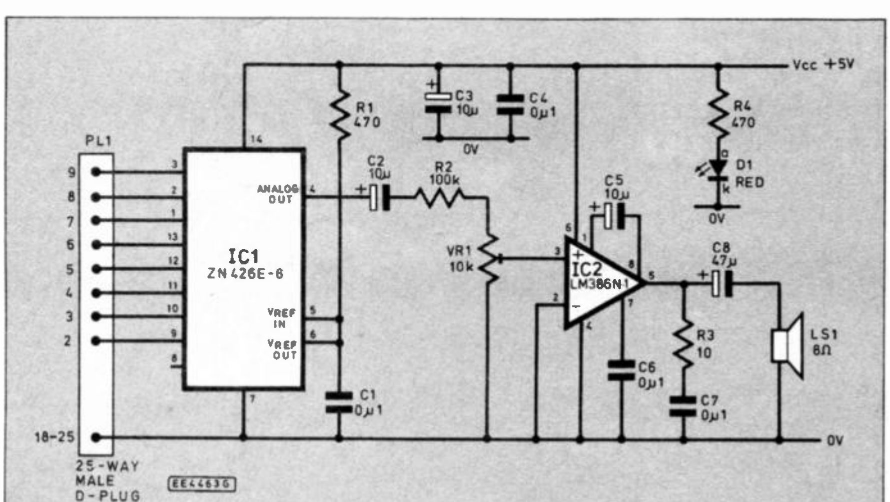


Fig. 1. Complete circuit diagram for the EPE SounDAC add-on sound card.

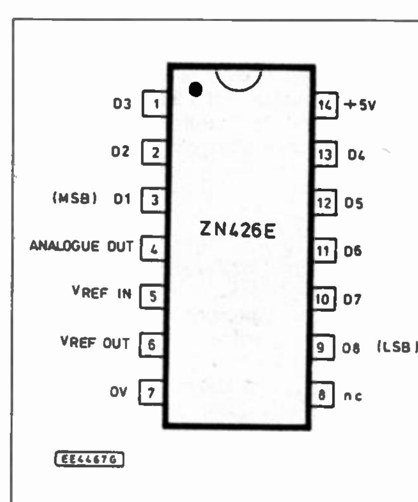


Fig. 2. Pinout details for the ZN426E 8-bit digital-to-analogue converter.

divider and the current is therefore divided by two at each node. The combined current from each active node is fed to a buffer amplifier, and finally to the analogue output.

Lets say, for example, that the reference current at node 8 is set to 128 microamps. Each successive node carries half the current from the preceding node, so node 7 takes 64 microamps, node 6 takes 32µA, node 5 takes 16µA, node 4 takes 8µA, node 3 takes 4µA, node 2 takes 2µA and node 1 takes 1 microamp.

A binary input to the DAC of say 10011101, or 9D in hex would, via switches 1, 3, 4, 5 and 8, take currents of 128µA + 16µA + 8µA + 4µA + 1µA, giving a combined output of 157 microamps. As you may have guessed, 9D in hex equals 157 in decimal, and the output stage would present 1·57V at the analogue output pin.

The analogue output from IC1 is fed, via capacitor C2 and "volume" control VR1, to the audio amplifier IC2. The capacitor across pins one and eight sets the gain of the amplifier.

If pins one and eight are left open circuit (unconnected) the gain is preset internally to about 20dB. Capacitor C6 connected to pin 7 sets the power supply rejection ratio.

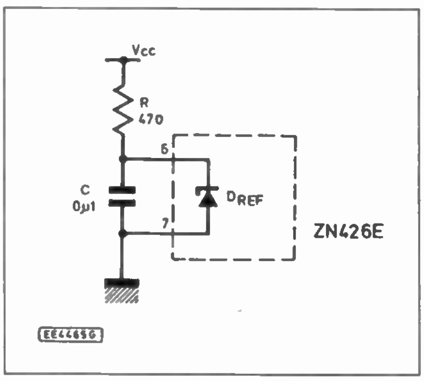


Fig. 3. Simplified voltage reference section of the ZN426E DAC.

CONVERSION THEORY

To store digitised sound, we must measure the incoming audio level at a rate which is at least twice that of the highest frequency we wish to reproduce. Since one byte can represent any of 256 values, (2 to the 8th power) each reading is approximated to one of 256 voltage levels and then stored in the .WAV file. Typically a sample frequency of 11kHz is used, giving an effective bandwidth of 5·5kHz.

A typical digital-to-analogue converter raises its output voltage by 0·01V for every increment at its binary inputs. Byte values of 0 to 255 at the inputs will therefore give outputs of 0 to 2·55 volts.

Since audio waveforms are a.c., i.e. they swing either side of a neutral point, we offset each byte value by 128, which leaves +/− 128 to represent values from 1·28 volts +/− 1·28 volts.

This is achieved at the recording phase, where the audio is biassed such that it centres on 1·28 volts, and amplified so that it peaks at 2·55 volts and 0 volts.

To produce a sound, the operating system or application takes data byte by byte from the relevant .WAV file, and passes this on to the EPE SounDAC software driver. Each byte is sequentially written out to either printer port, LPT1 at address 378 hex, or LPT2 at 278 hex.

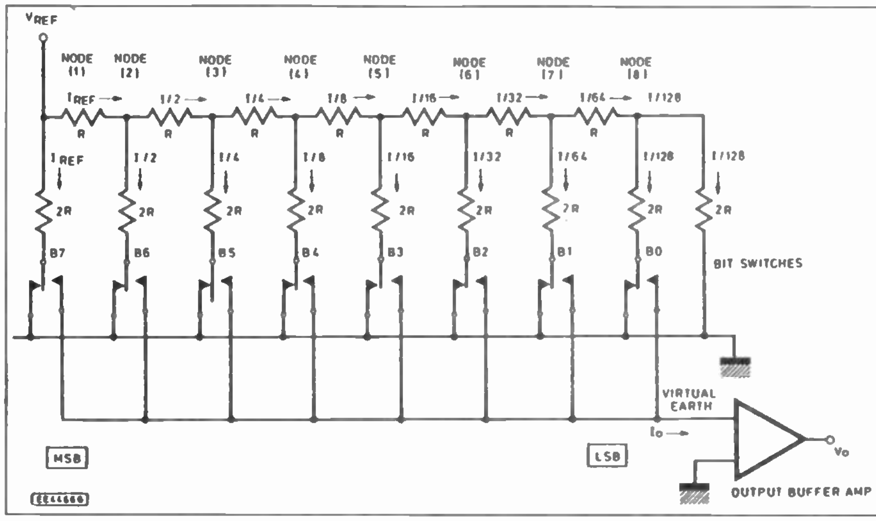


Fig. 4. The internal R-2R ladder network and binary switches of the ZN426E digital-to-analogue converter chip.

The digital-to-analogue converter is connected to the eight printer data lines and so its analogue output faithfully recreates the original audio signal. This in turn drives a loudspeaker LS1 via a small audio amplifier IC2. An l.e.d. D1 indicates that power is present.

CONSTRUCTION

The EPE SounDAC project is built on a small printed circuit board and the topside component layout and the full size underside copper foil master pattern are shown in Fig. 5. This board is available from the *EPE PCB Service*, code 868.

COMPONENTS

Approx cost guidance only **£17**

Resistors

R1, R4	470 (2 off)
R2	100k
R3	10

All 0·6W 5% carbon film

See SHOP TALK Page

Potentiometer

VR1	10k skeleton preset or rotary carbon (see text), log.

Capacitors

C1, C4, C6, C7	0µ1 polyester (4 off)
C2, C5	10µ tantalum bead, 16V
C3	100µ radial elect. 10V
C8	47µ tantslum bead 10V

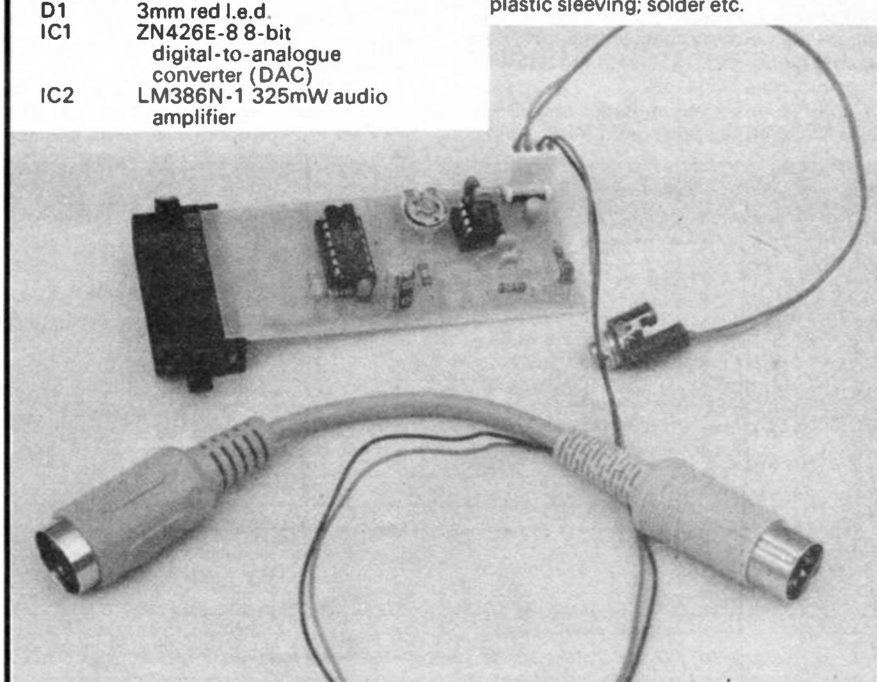
Semiconductors

D1	3mm red l.e.d.
IC1	ZN426E-8 8-bit digital-to-analogue converter (DAC)
IC2	LM386N-1 325mW audio amplifier

Miscellaneous

PL1	25-way male D-plug, either printed circuit board mounting or crimp-on (0·1 inch spacing).
LS1	8 ohm miniature loudspeaker or car speaker pod

Printed circuit board available from *EPE PCB Service*, code 868; 8-pin i.c. socket; 14-pin i.c. socket; 4-pin in-line "Molex" p.c.b. mounting header plug and socket; 3·5mm jack plug and switched socket for speaker; 5-pin DIN plug and socket (if required for keyboard power adaptor); 25-way ribbon cable (if required for remote p.c.b. connection); multistrand connecting wire; plastic sleeving; solder etc.



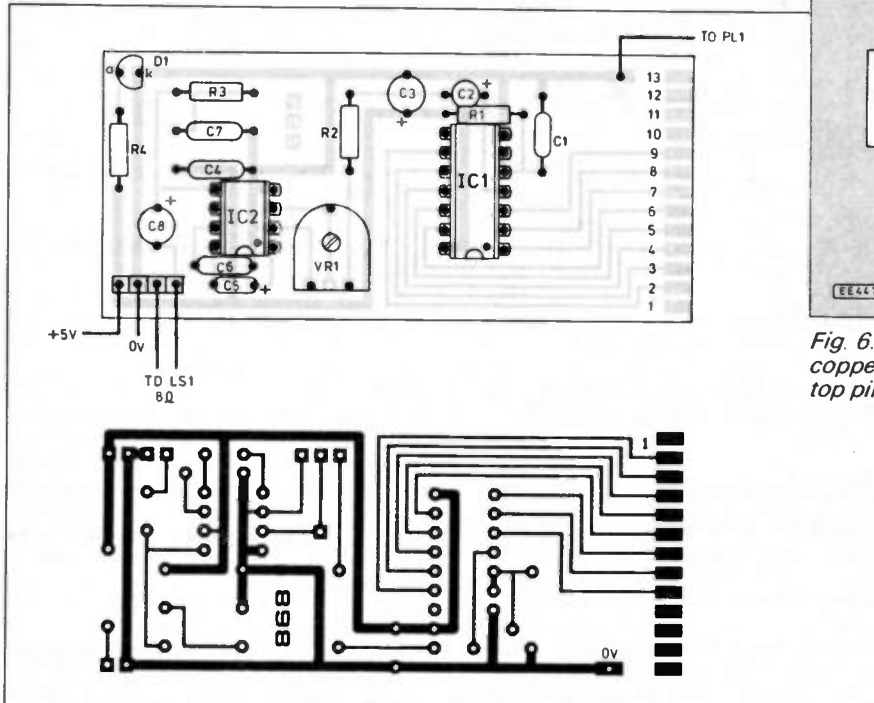


Fig. 5. Printed circuit board component layout and full size underside copper foil master pattern.

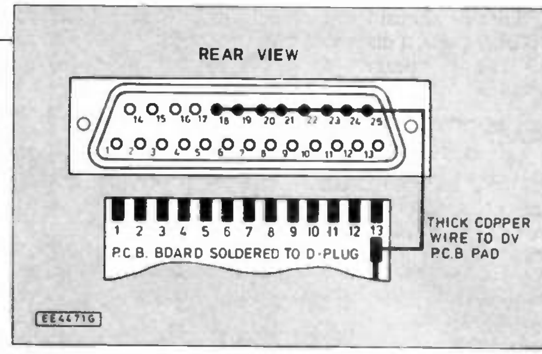


Fig. 6. Soldering the D-plug directly onto the p.c.b. copper pads using the lower pins 1 to 13, and the top pins (18-25) for the 0V line.

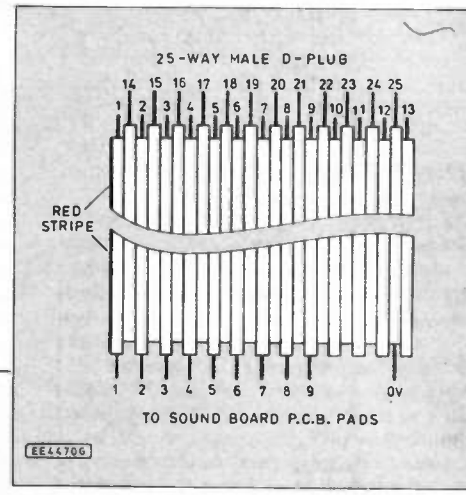
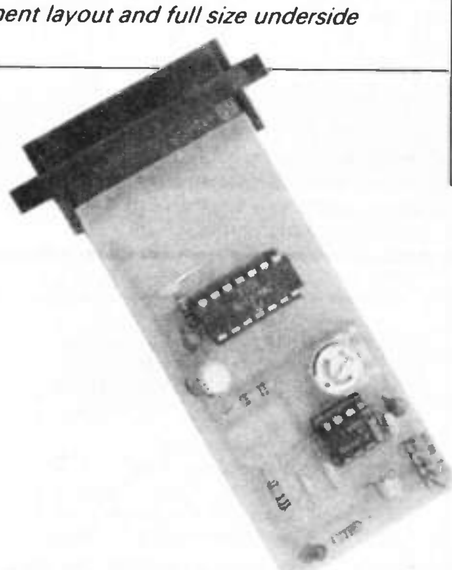
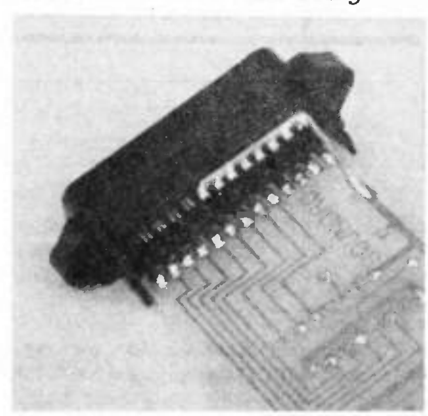


Fig. 7. Alternative ribbon cable wiring.





Choose whether to have your board mounted directly on its connector (as in the prototype model – see photograph and Fig. 6), so that it plugs directly onto the rear of the PC, or on a length of cable inside the speaker case. Note that the board is designed to take connectors with 0·1 inch spacing, such as the crimp-on ribbon types. You may also choose between a small, board mounting, preset potentiometer or a rotary spindle type mounted away from the main board.

Begin construction with the resistors, capacitors (noting the polarity of tantalum beads), the l.e.d. and i.c. sockets. If you choose to mount the connector directly onto the board, ensure that pins 2 to 9 are the ones which connect to the DAC, before soldering the plug to the board. Removing a wrongly-fitted plug will be quite difficult!

Use fairly heavy copper wire for the ground (0V) connection to the plug, as this will provide some mechanical support. Lay the wire across pins 18 to 25, then down to the ground pad below pin 25.

Carefully insert the amplifier and DAC i.c.'s. Make up the power and loudspeaker leads; a Molex-type header plug is ideal, but isn't essential – solder pins are cheaper, after all!

If you didn't use a board mounted connector, wire up the ribbon cable as per Fig. 7. We use only pins 2 to 9 for data, and any of pins 18 to 25 for "earth" (0V). Ribbon cable is the most convenient, but beware of the numbering scheme if you choose a crimp-on plug – taking the red stripe of the cable as pin 1, the line numbers should be as shown.

If you can find a male to male 25-way ribbon cable, simply snip it in the middle and make two!

POWER SUPPLY

Power can be taken from four pen cells, or preferably from the PC itself. Two options include a spare disk-drive power connector brought out through the rear of the PC, or by intercepting the keyboard lead which carries 5V. If you prefer to use a spare drive connector use only red and black; yellow carries 12V which will destroy the circuit!

A suitable keyboard adaptor can be made from a short length of 4-core cable (pin 3 is unused) and a 5-pin DIN plug and socket combination, see Fig. 8. Be especially careful that the connections are correct and that no shorts can occur between pins – sleeve each after soldering to be sure.

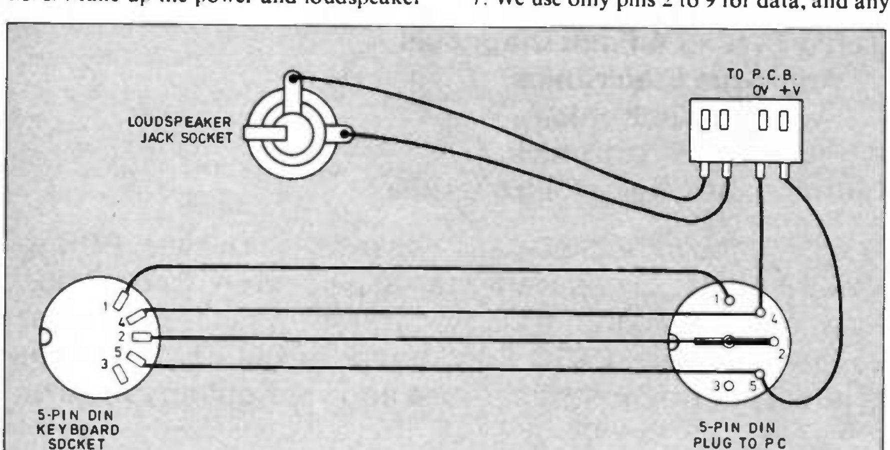


Fig. 8. Keyboard power interceptor wiring using 5-pin DIN plug and socket combination and a p.c.b. header plug.

Suitable housings include cheap car speaker pods, a discarded radio stripped of all but its speaker, or a CB extension speaker.

SETTING UP

The setting up procedure for Windows 3.1 is a little involved, so test the board using the DOS program 4PLAY.COM supplied on the driver disk (see under "Software Program Disk" heading). Connect up the power and speaker leads. Ensure that the l.e.d. lights, and expect a reassuring click as the loudspeaker is connected.

Carefully insert the board into your printer port. Insert the floppy disk, switch to drive A: and enter the line:

4PLAY VIDEO /S12 /P378 /R2

A simple circuit such as this should work first time. If not, check for pins bent under chips, tantalum bead polarities, and solder bridges. You did remember the ground connection to the plug, didn't you?

INSTALLING THE DRIVER SOFTWARE

Load up Windows 3.1 as usual, and double-click on Control Panel, which is usually in the Main group. The two relevant icons within control panel are Sound and Drivers. Double-click on Drivers, and select Add. A list of available drivers will be displayed, but select "unlisted driver".

Control Panel will ask for the driver disk to be inserted into drive A:. From the options "DAC on LPT1" and "DAC on LPT2" select your required driver.

Configure the speed to 266 (you may need to adjust this) and the volume all the way down to zero. Choose unlimited length of playback. Close down each window in turn, until you are back at the Control Panel. Select Sound, double click on any .WAV file, and... success!

Within Windows 3.1, sounds can be assigned to events such as startup, closedown, errors, and so on, using the Sound icon. Simply highlight an event, and the required .WAV file. Your Windows manual has details, and shareware packages are available to fully exploit sound within Windows.

Once tested, the completed circuit board can be mounted in a case, which can be drilled to take the optional volume control potentiometer and perhaps the power on indicator.

FURTHER DAC USE

The ZN426E is a general purpose DAC and is of course capable of more than audio reproduction. If the output of the DAC is taken to an oscilloscope, then sine waves, triangle waves and other functions can be generated and displayed.

Take a connection either from pin 4 of IC1, or from the positive terminal of capacitor C2, and set your scope to d.c., at a sensitivity of say one volt per centimetre. Using a simple program, numbers can be either calculated or taken from a table of values, and written out to the printer port. Careful examination of the scope trace will reveal the small steps between ideal values, similar in effect to a diagonal line drawn on a low-resolution graphics screen.

This short assembler program can be entered using Debug, and will display a ramp waveform until the PC is reset:

```
C:>debug
-a100
mov dx,378
out dx,al
inc al
jmp 103 <press return twice here...>
g=100
```

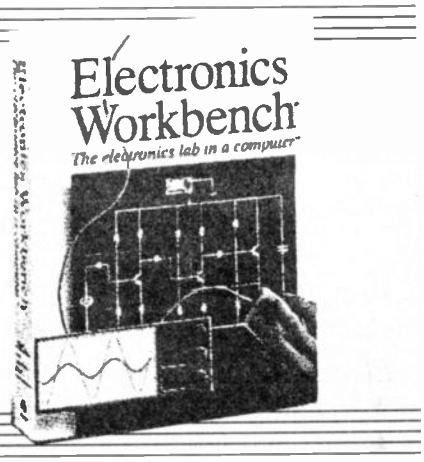
An equivalent BASIC program might read:

```
10 A=0
20 OUT &H378,A
30 A=A+1
40 IF A>255 THEN A=0
50 GOTO 20
```

Note that the frequency of the waveform in the second case is much lower, due to the use of an interpreted language. Decrementing the value to be output will reverse the slope of the ramp, but the calculation of SIN values to produce a sine wave is left for the keen experimenter and amateur mathematician!

SOFTWARE PROGRAM DISKS

Microsoft Windows sound driver programs: LPT1DAC.DRV and LPT2DAC.DRV DOS sample player program for DAC and PWM: 4PLAY.COM Available from the author Phil Green, at 6 Yews Close, Worrall, Sheffield S30 3BB. No charge will be made if you send a formatted disk in a re-usable mailer enclosing return postage and address label; otherwise please send a £5.00 cheque to cover costs. □



ELECTRONICS WORKBENCH

MIKE TOOLEY BA

Mike Tooley examines the "electronics lab in a computer" from Interactive Image Technologies.

IMAGINE being able to assemble an electronic circuit, connect it to a supply, and then check the performance of the circuit with a range of conventional items of test equipment, all without leaving the comfort of your office chair. Sounds impossible? Just read on!

Electronics Workbench is a remarkable new software package from Canadian-based company, Interactive Image Technologies and available here in the U.K. from Robinson Marshall. Electronics Workbench is available in seven languages and has been sold in over 20 countries.

The software allows you to build and test a wide range of analogue and digital circuits and it is ideal for designing and verifying circuits *before* you reach for the soldering iron or breadboard. In this respect, Electronics Workbench is hard to beat – you can plug and play to your heart's content without ever having to sacrifice a single component. If your circuit doesn't work first time, you can adjust the connections and component values until it does – without even having to make or break a soldered joint.

If you don't happen to have a logic analyser, 'scope, function generator or digital voltmeter handy, don't worry – Electronics Workbench has them all built in and ready for use at the touch of a button. Furthermore, the displays provided by the on-screen instruments are the same as those that you would get on real equipment.

As its name implies, Electronics Workbench simulates the work area in a real electronics lab. The large central workspace is like a breadboard, the parts bin runs along the right side, and the test instruments are stored in a shelf along the top. You build and test circuits entirely on the workbench using the mouse and menus. Everything you need, including a virtually limitless supply of reusable components of every conceivable type, is readily at hand.

THE SPICE OF LIFE...

Electronics Workbench has two modules, one for analogue circuits and one for digital. The modules are separate but similar and once you've become accustomed to one, you will quickly feel at home using the other.

Electronics Workbench is based on industry-standard SPICE models for components such as resistors, capacitors, inductors, diodes and transistors. You have complete control over the value of all parts in a circuit, as well as overall parameters of the models. Parameters are very easily changed and you can even develop component models to suit your own individual requirements.

Unlike some simulation packages, Electronics Workbench uses circuit diagrams rather than abstract netlists – the circuit diagrams look just the same as those you're already familiar with. With some other electronics simulators, you may have to type long lists of circuit nodes as text files. This is both tedious and error prone.

IN (AND OUT OF) THE LAB

Several different types of user will find Electronics Workbench invaluable. Students will be able to maximise their lab time by designing and testing circuits prior to real construction and testing. Investigations and assignments can first be tested on the computer, thus ensuring that real circuits work as expected. Even better, students will quickly find the software invaluable as a learning aid that allows them to build and test circuits without ever having to visit the laboratory!

Electronics Workbench can also be a valuable tool when preparing for practical exams. The software is also extremely handy for "what if" analysis. For example, consider a d.c. coupled multistage transistor amplifier. What will happen to the d.c. conditions and overall a.c. voltage gain if the current gain of all of the transistors increases by 20 per cent? A problem of this type will normally require several pages of error-prone calculations. Electronic Workbench will tell you what will happen in an instant – just by flicking the power switch to "on".

IN THE CLASSROOM

The trials and tribulations associated with giving classroom demonstrations of electronic circuits have to be experienced to be believed as breadboarded circuits have a happy knack of either not performing according to specification or even becoming totally unstable when you least want them to. This is another important application for Electronics Workbench.

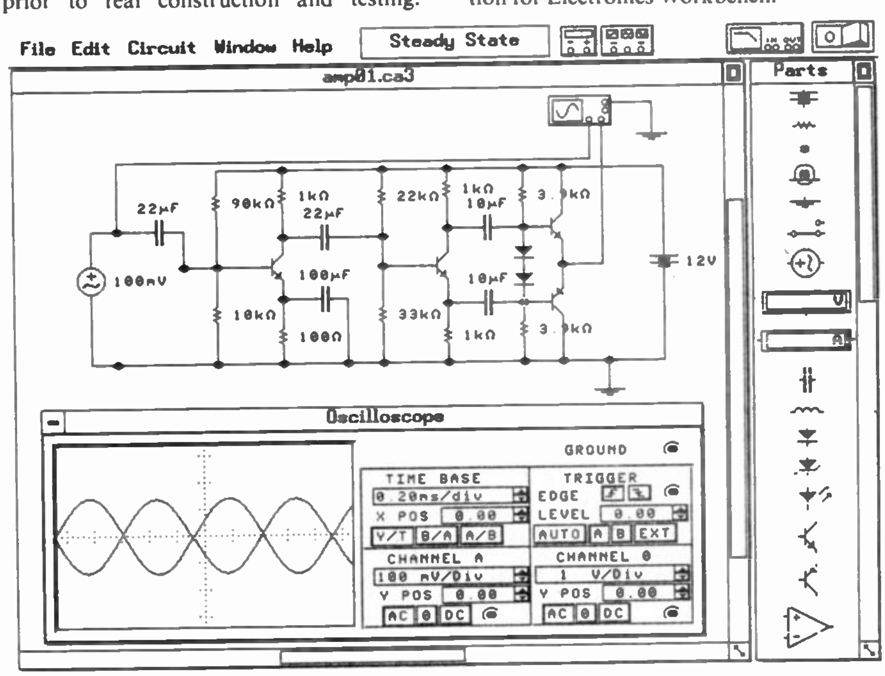


Fig. 1 Testing a simple multi-stage audio amplifier using Electronic Workbench's oscilloscope

Teachers and instructors will find that the basic principles of electronics can be quickly and easily demonstrated using Electronics Workbench. This process can be aided using one of several methods for displaying PC screen output in a classroom situation. Furthermore, trying to illustrate the dynamics of electronics using a static medium such as a chalkboard, flip chart or overhead projector can be difficult. Presentations can come to life when circuits can be put through their paces using Electronics Workbench.

Finally, the software can be useful as an aid to teaching electronic fault-finding. Faults can be very easily introduced into circuits by instructors and students can be set the task of locating the faults using the test equipment provided. All of this can be achieved safely and efficiently without the danger and expense associated with fault tracing on real circuits. That said, this is one area in which simulation *must* be augmented with real experience.

IN THE WORKSHOP

Troubleshooting real electronic systems can often be difficult. Electronics Workbench can aid this process in two ways. If you have problems getting a real circuit to work, you can construct it in software, test it, quickly make alterations and test it again. If the circuit works on the computer but not in real life you probably have a faulty part in the circuit.

Alternatively, to help you pinpoint a faulty part in a real circuit, you can simulate it in Electronics Workbench, then deliberately introduce faults in the circuit components. When you find one that gives you a set of matching readings, you've found the problem.

USER INTERFACE

Menus and mouse usage conform to emerging GUI standards (GUI, pronounced "gooey," means "graphic user interface"). The simulated instruments add realism. At your disposal in the analogue version are a digital multimeter, a function generator, an oscilloscope, and a "Bode plotter". For digital circuits you have a voltmeter, a digital word generator, a logic analyser and a "logic converter".

Everything you need is visible, handy and under your control. With other electronics simulators you may have to run three separate programs: one for building, another for simulating, and a third for graphing the results. But in Electronics Workbench you build and test directly on the workbench. You get immediate feedback and can quickly make revisions and test again. In fact, the instrument readings reflect changes *as you make them*.

SUPPORT AND GUIDANCE

Electronics Workbench comes with a range of support materials. Some are designed to get you started, some to use as a day-to-day reference, and some to help you get more out of the software. The excellent User's Guide includes tutorials, reference sections and troubleshooting information whilst the Quick Reference Card provides you with essential data for building and testing circuits. You can use it to get started, or keep it handy as a reference.

Interactive demonstrations (included on the disk) give you a quick overview of Electronics Workbench and show you how to build and test circuits. Sample circuits (also supplied on the disk) include approximately 20 typical analogue and digital circuits. You can examine, test and modify them or use them as building blocks for your own circuits.

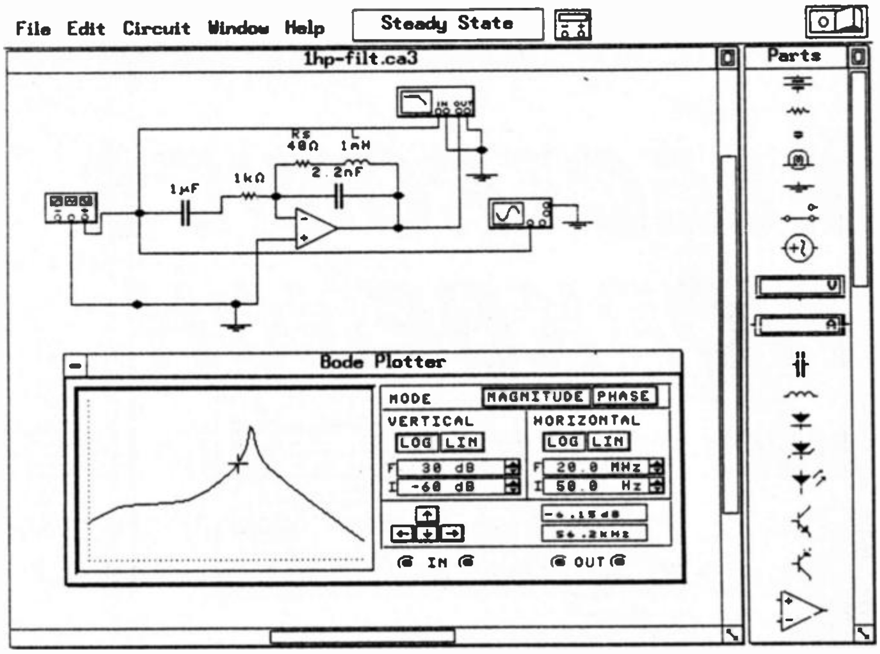


Fig. 2 Using Electronic Workbench's "Bode Plotter" to display the frequency response of a simple active filter

The tutorials included in chapters 3, 4 and 8 of the User's Guide are informative and worthwhile. They are designed for those with varying levels of computing and electronics experience, including those who may not have used a graphical interface before or who may be unfamiliar with building and testing electronic circuits.

Finally, if all else fails and you still have a problem that refuses to go away, you can contact the User Support "help-line". A Bulletin Board Service (BBS) is also available to provide the latest product information. It also allows users to leave questions and can be used as a means of uploading or downloading circuits.

START-UP OPTIONS

When you start Electronics Workbench you have a number of options available apart from selecting either the analogue or the digital environment. If your computer has at least 2MB of RAM, you can make the most of the extra memory by running Electronics Workbench in "protected" mode. Note, however, that if your computer's extra memory is in the form of an expansion card, Electronics Workbench may run slowly in protected mode. If so, you may prefer to force Electronics Workbench to use real mode.

Another start-up option allows you to specify which set of schematic symbols (either ANSI or DIN) to use with the package. This then becomes the default symbol set, used whenever you start Electronics Workbench.

POINT AND SHOOT

Electronic Workbench has a first class context-sensitive help system which, like most of today's GUI software packages, can be accessed using pull-down menus and windows. Even more useful, however, is the ability to move the mouse pointer over a component, click the left button (the selected component turns red), press F1 and, hey presto, a window will appear telling you about the component. As with the main help system, further options can be selected by simply clicking on the highlighted keywords. This simple yet elegant help system makes the software a joy to use and is perfect for the newcomer to electronics.

Having found out about the component, you might want to alter its parameters. You do this by double clicking the left mouse button. When you do this, a small window appears which allows you to set component values, voltages, frequencies, etc, as appropriate to the item concerned.

SPECIFICATION

Analogue module

- Resistors, capacitors, inductors, transformers, diodes, Zener diodes, light emitting diodes, bipolar junction transistors, bulbs, fuses, JFETs, MOSFETs and switches.
- Ideal and real-world libraries
- A.C. and d.c. voltage and current sources
- Function generator for square, triangular and sinusoidal waves
- Multimeter, ammeter and voltmeter
- Dual-trace oscilloscope
- Bode plotter
- SPICE simulation
- Transient and steady-state analysis

Digital module

- Simulation of ideal logic
- AND, OR, XOR, NOT, NAND and NOR gates
- RS, JK and D flip-flops, half-adder, seven-segment displays and voltmeter
- Binary word generator (16 eight-bit words)
- Eight-channel logic analyser (hexadecimal and graphical display)
- Logic conversion (gate, NAND gate, truth table and Boolean expression representations)
- Logic simplification (Quine-McCluskey method)

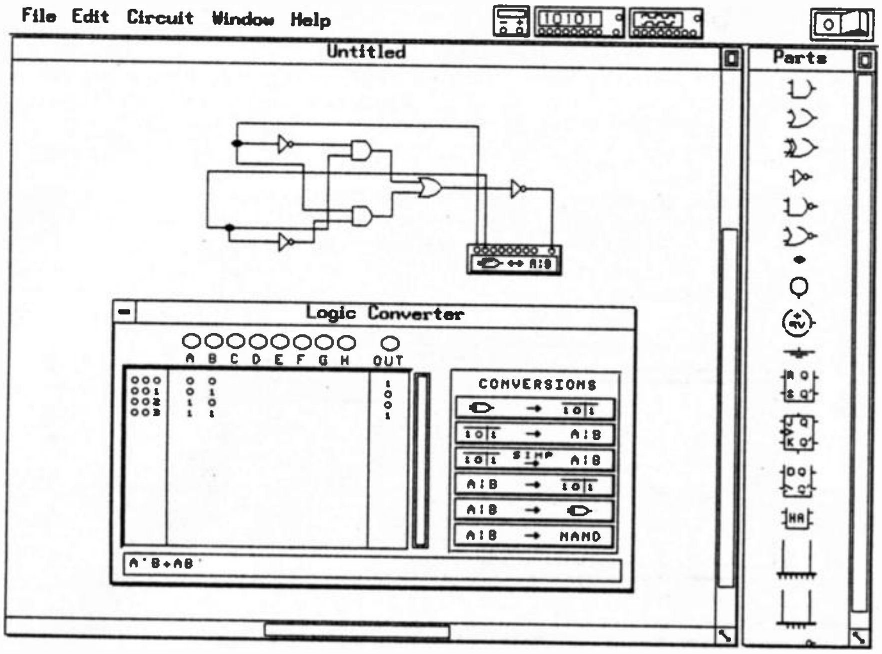


Fig. 3 Using Electronic Workbench's "Logic Converter" to check the truth table for a simple exclusive-NOR gate arrangement

GETTING INTO PRINT...

Electronics Workbench excels in one more respect – it offers a wide choice of printing facilities. Not only can you print the current display (exactly as it appears on your computer's screen) but you can also print out circuit descriptions, component lists, parameters associated with the component models, circuit diagrams, and test equipment displays.

For good measure, Electronic Workbench also allows you to convert your display into a PCX file for loading into one of many popular paint, graphics, CAD or DTP packages. This excellent print service is perfect for students (and others) who need to present their findings in written reports. Gone are the days of sketching waveforms and hand-drawing circuit diagrams...

IN USE

I tested Electronics Workbench with a variety of "everyday" circuits. Placing the components is easy. Connecting them together and aligning them neatly proved to be a little more fiddly! In fairness, Electronics Workbench does help in this process by automatically routing conductors with neat right angled bends. The package also lets you use the cursor keys to move selected components (very handy when you need to straighten things up!).

The circuits were all "up and running" within minutes. A simple four-transistor amplifier was "built" and checked for both d.c. and a.c. conditions (see Fig. 1). A filter based on an operational amplifier was put through its paces (see Fig. 2) and a simple exclusive-NOR gate arrangement (see Fig. 3) was checked using the digital version of Electronics Workbench. All of these circuits were assembled and checked in a matter of minutes.

LIMITATIONS AND WORK-AROUNDS

One small limitation of the package is that an a.c. circuit can have only one frequency. If a circuit contains more than one a.c. source (for example, a sine wave from the function generator as well as some a.c. voltage sources from the parts bin), setting the frequency of one source changes the frequency of all sources.

When using the software you may, at times, have to remember some of the limitations of real components such as internal resistance and stray capacitance. We often ignore these in practical circuits but Electronics Workbench requires precise models if it is to accurately simulate the behaviour of real circuitry.

As an example, Electronics Workbench cannot simulate batteries and switches in parallel since its ideal components have no series resistance. In the real world, batteries and switches sometimes can be put in parallel *because* they contain a small series resistance. If you need to simulate batteries or switches in parallel, you should add a small resistor in series with each one.

Finally, an "undelete" facility would be extremely useful. If you delete a component or node by mistake, you can only make good by dragging replacement parts from the "parts bin".

SUPPLEMENTARY TEXTS

Interactive Image Technologies has made two books available that serve to enhance the usefulness of Electronics Workbench

Electronics Workbench Practical Teaching Ideas (ISBN 0-921862-22-9) is designed as an aid for teachers using Electronics Workbench. The author, Allan D. Souder, Ph.D., shares his classroom experiences of using the software at Seneca College in Toronto.

His practical book contains:

- A teacher's perspective of the role Electronics Workbench can play in the classroom.
- Ten exercises to illustrate ways of teaching with Electronics Workbench.
- Ready-to-use sample student assignments.
- Examples of both group and individual student evaluation and testing techniques.

Electronics Workbench Practical Teaching Ideas comes complete with a floppy disk, containing the circuits shown in the book. These circuits can be loaded into Electronics Workbench and can then be used as the basis for further experimentation.

The second book, *Electronics Workbench 150 Circuits* (ISBN 0-921862-24-5) contains 150 of the most frequently-used standard circuits. Instead of spending time building circuits from scratch, you can select from this library of ready made circuits and go straight into modifying, experimentation and testing. The following types of circuit are included:

- RLC
- Diodes
- Transistors
- Filters
- Operational amplifiers
- Amplifiers

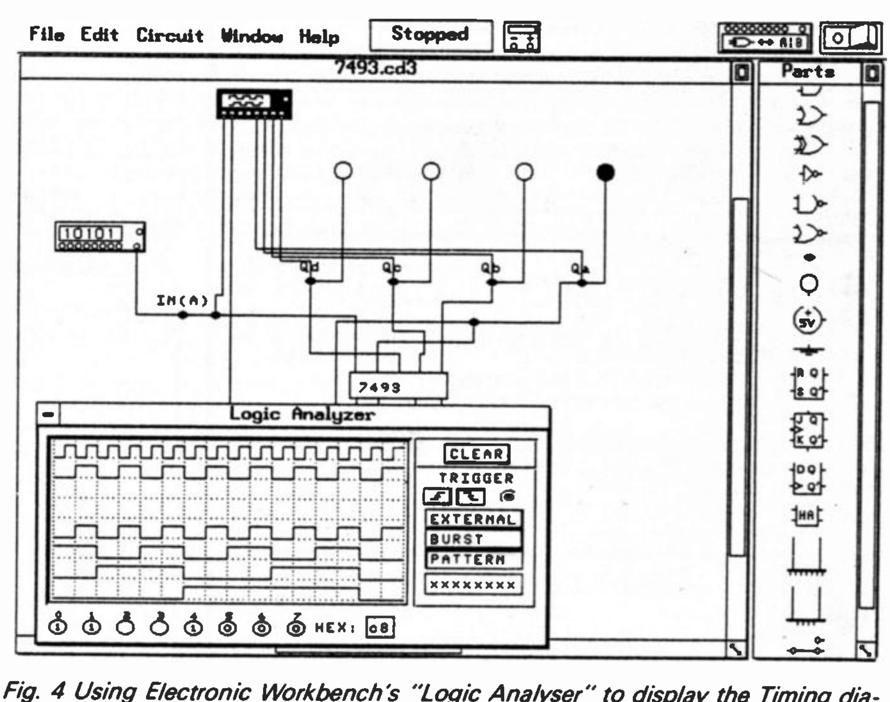


Fig. 4 Using Electronic Workbench's "Logic Analyser" to display the Timing diagram for a binary counter based on a 7493 TTL chip.

The book includes concise printed descriptions, schematics, and suggestions for experiments using the circuits provided. The circuits are, in fact, a selection of those found in most textbooks and laboratory manuals.

SYSTEM REQUIREMENTS

The MS-DOS version of Electronics Workbench requires an IBM PC-AT, PS/2 or true compatible with a 286 or higher processor. The system should have a hard disk, at least 1MB of RAM, a Microsoft compatible mouse, EGA or VGA display adapter and DOS 3.0 or greater. The software supports a maths coprocessor, if available.

The Windows version of Electronics Workbench requires a similar hardware configuration with MS-DOS 5, or higher, and Microsoft Windows 3.1 with a suitable pointing device. The Macintosh version runs on a Macintosh Plus or higher, 2MB RAM, system 6 or 7.

In order to install Electronics Workbench, your hard disk needs at least 4MB of available space. If your hard disk uses the MS-DOS 6.x double-space feature, make sure you have at least 6MB of available space. You will also need a minimum of 550K RAM to run the program and thus you may have to modify your configuration files (CONFIG.SYS and/or AUTOEXEC.BAT) to release more base memory.

IN CONCLUSION

Electronics Workbench can be very highly recommended. As an educational tool it is hard to beat. Indeed, if you will pardon the pun, it really is in a class of its own.

The package has been priced for the educational market and thus is probably out of the price range of many hobbyist working on a tight budget. This is unfortunate as the package is very effective as an individual learning aid and perhaps Interactive Image Technologies might consider a cut-down version for the enthusiast.

Electronics Workbench costs £199. *Electronics Workbench: 150 Circuits* costs £24.95 and *Electronics Workbench: Practical Teaching Ideas* costs £19.95.

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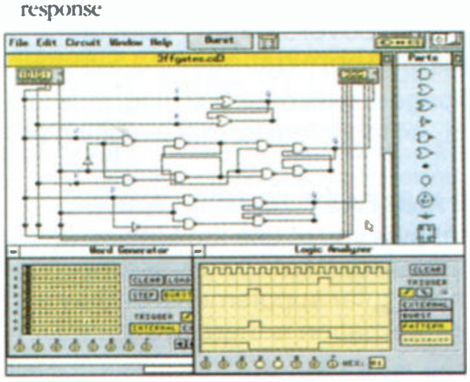

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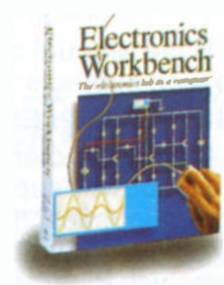

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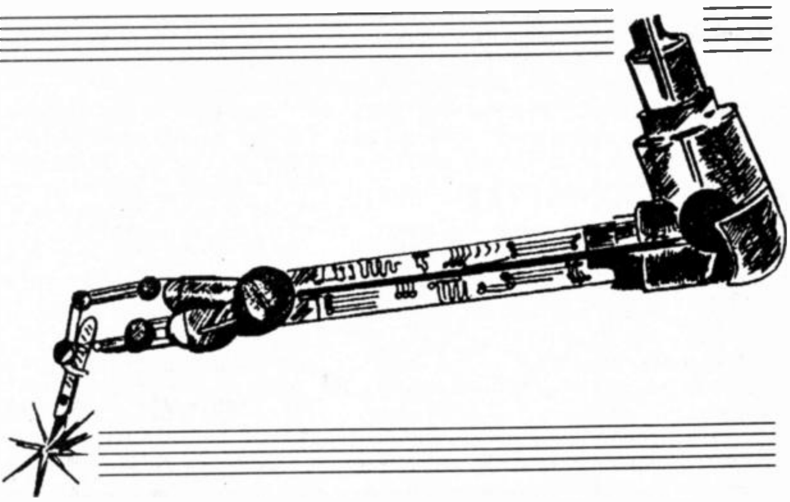


ALAN WINSTANLEY

***This is our two-way column which endeavours to enlighten readers who may have a particular problem in electronics. A wide variety of requests comes our way every month, so if you think you have a query or suggestion which might be of interest to your fellow readers, then why not drop Alan a line at* Circuit Surgery.**

A VARIETY of queries is received with every postbag and although I cannot promise to respond to each individual enquiry, I read every letter and any particularly appealing ideas are featured in *Circuit Surgery*. I hope I will at least manage to stimulate further ideas and point readers in the right direction. If you are involved in *teaching* electronics, see the news at the end of the column.

As regular readers probably know, I try to handle certain topics in reasonable depth – which is sometimes at the expense of those "quickie" letters for which a brief reply is fine. So now I want to hear from readers who might have any *brief* tips and ideas, perhaps discovered when building their latest project. I will try to feature all the best ideas in a future round-up of these quick one-offs. So if you've a great idea or hot tip to pass on, drop me a line!

Predictable Pulses

From ***Mr. Paul Spencer*** of Barkham, Wokingham comes a query concerning astable and monostable multivibrators assembled from logic gates.

What are the formulae for calculating pulse widths and frequencies when dealing with monostables and astables based around logic gates? Being a hoarder of the last 10 years of Everyday Electronics, *I can say with fair certainty that this information has not appeared before. There must be a way of accurately predicting the times involved?*

Firstly, a brief word of explanation concerning astables and monostables, for those who aren't too familiar. The word "stable" gives us a clue: a monostable (or "one shot") is a circuit which has **one** stable state. It generates a **single** pulse only (from microseconds to hours or longer if needed) when triggered and then returns to its steady, stable condition, when it snoozes until another trigger pulse comes along.

An astable actually has **no** stable state, so it generates a continuous stream of pulses. You might also come across a *bistable* (called a "flip-flop" in digital electronics) which as you would expect has **two** stable states – it changes over from one to the other every time a suitable triggering signal is received. It thus acts as a "memory" though there's no timing element involved.

Traditionally these pulse-generating circuits were assembled from transistor switches, or "multivibrators". With the advent of i.c. technology you have a wider choice of pulse generation techniques: for instance you could use a purpose-built integrated circuit such as the immortal 555 timer chip (or the ZN1034E or UA2240), or if you have a bountiful supply of spare logic gates, these can be assembled to form an astable or monostable pulse generator. Logic families also include several special multivibrator chips, such as the 4047 CMOS device which can be configured directly as either an astable or a monostable, within certain limits.

Unpredictable

Although simple and convenient, the problem with assembling multivibrators from logic gates is the fact that there is an element of unpredictability about them. This is principally due to the tolerances on the components used, plus the variations in logic threshold levels between individual logic gates.

Several sources state that monostables fabricated from individual gates should be avoided like the plague! Wherever possible, it's best to opt for a purpose-made chip instead for more consistent and predictable results.

Let's look at those formulae. Fig. 1 shows a monostable circuit which is constructed from a couple of NOR gates such as those contained in a CMOS 4001B; 74 series TTL (e.g. the 7402) could be used in a similar fashion. IC1a is used to detect a trigger signal (logic 1 will start the timing period) whilst IC1b is configured as an inverter. The formula you want for the timing period t is based on the exponential charging curve observed when the capacitor charges to a logic "1" level, once the circuit starts timing: it boils down to $t = 0{\cdot}7R.C$ where t is in seconds, R is in ohms and C is in farads. The formula isn't 100 per cent accurate but is near enough for practical use. A 220µF capacitor with a 22k resistor generated a delay of just over three seconds in a quick test.

Problems

There are several potential problems; the actual timing period depends on the tolerance of the RC network – which if an electrolytic is used for C implies that the tolerance will be very wide indeed. Leakage current through C, if electrolytic, will also contribute to inaccuracies. So straight away we could be looking at an accuracy of say 50 per cent or worse.

The gate trigger voltage (i.e. what input voltage IC1b deems to be a logic 1) determines the level which C needs to charge up to in order to make the monostable switch over. Typically this is half the supply voltage but any discrepancies between individual gates means that the threshold voltage may differ, so you may not observe consistent results between individual circuit samples.

As if that isn't enough, for fairly complex reasons this arrangement suffers from a significant over-voltage spike at pins 5/6 which is generated when the

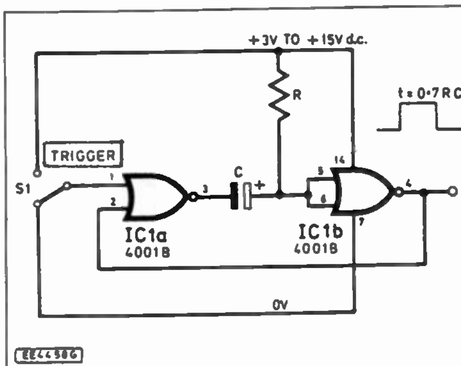


Fig. 1. Simple monostable using CMOS NOR gates.

monostable "times out". If the gate is operating at the maximum permissible supply voltage (say 15V to 18V) then the spike could exceed these maximum ratings. You won't observe this spike with an oscilloscope because it should be shunted by internal diodes within a CMOS NOR gate to prevent damage – hopefully!

Furthermore, many CMOS logic chips dislike operating at intermediate logic levels – somewhere between Logic 0 and Logic 1 – which may be the case when the timing capacitor is in the process of charging up. Operating in "no man's land" causes the chip to operate in a *linear* mode which may cause excessive power dissipation in extreme cases.

Having said all that, there's no reason why gates can't be used in less demanding applications. The chances are that you can use logic gate multivibrators satisfactorily in many projects, but don't expect perfect accuracy or repeatability.

Where accuracy is needed, consider using a custom multivibrator chip such as the 555 instead. This has its threshold voltages set by an internal potential divider at 1/3 and 2/3 the supply voltage, so it's largely independent of the supply rail and is probably more dependable than relying on the triggering level of an individual logic gate.

You will still suffer from inaccuracies created by the poor tolerances on some components (electrolytics). So if you want to generate a really long monostable timing period, build a sub-system which incorporates a presettable counter. The counter will time out after a predetermined number of pulses has been generated – the ZN1034E timer i.c. works in this way and could time for *years* if you wanted – and is a whole lot more accurate.

Astable

Astable multivibrators can be constructed from logic gates too, such as that shown using two NOR gates in Fig. 2a, though for the same reasons as above, a separate multivibrator chip is preferable. Both gates are wired as inverters, so you could use separate inverters instead.

Again there are problems with excessive voltage peaks, this time appearing at the inputs to IC1a. The spikes should be shunted by the gate's internal protective diode network. Also note that a sawtooth is generated across the timing capacitor such that the voltage across C reverses every period; thus you cannot use a tantalum or electrolytic capacitor in this application as they are of course polarity-conscious.

The output of the astable is in theory a perfect square wave though this again depends on the characteristics of individual gates. The frequency of operation f is, as usual, equal to 1/t where t is the period of one complete cycle. The formula resolves to $f = 0{\cdot}7/RC$ which is probably accurate enough for most needs. Fig. 2b shows how you could vary the mark-to-space ratio of the output waveform using a diode network with a preset resistor or potential divider.

Over-elaborate

Mr. Mike Howell from South Africa set me thinking again about a very popular topic amongst *Circuit Surgery* readers: battery back-up systems. Recall that we checked out the ICL8211/ 8212 back-up chips in detail in earlier issues of *Circuit Surgery*. Mr Howell asks:

I made the battery-operated car False Alarm *(EE February 1990) which operates from four 1·5V batteries. I want to operate this "sentinel" from the 230V a.c. mains via a 6V d.c. power pack, and incorporate the batteries only as a back-up feature for mains failure. I've seen very simple diode arrangements for switching on the battery back-up, but I've also seen circuits controlled by i.c.'s such as the ICL7673. If simple diode networks are satisfactory (and cheaper/easier) then what advantage is there in using a more complex circuit with an i.c.? Are such circuits only required for serious applications like computers etc.?*

You are quite right when you consider the application of an ICL 7673 i.c. (or similar device) it is really intended for more sophisticated applications such as computer memory backup, where it may be important that a continuous supply voltage is maintained. Such equipment might incorporate 3V d.c. logic for example so obviously the design of the back-up power system becomes more demanding.

Battery back-up chips or "power supervisory i.c.s" are often customisable in use and are also very accurate. For instance, with the 8211 it's possible to determine very precisely the point when the back-up battery should be introduced, and also the chips themselves are designed to draw a minimal current so they don't drain the back-up battery unduly.

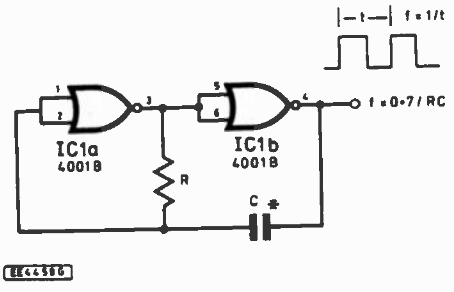


Fig. 2a. An astable multivibrator constructed with CMOS NOR gates.

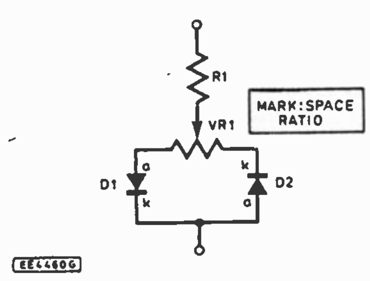


Fig. 2b. Diode network to control mark to space ratio. Replaces R in Fig 2a.

In less critical circuits it's perfectly acceptable to use a back-up formed from an ordinary dry cell battery in a diode network. You probably had in mind something like Fig. 3.

Whichever battery voltage is higher is the one which will power the load, so when the primary source (e.g. the mains power supply) falls below the secondary back-up, then the back-up will take over. The diodes D1 and D2 are necessary to prevent the lower-voltage source shunting the other supply.

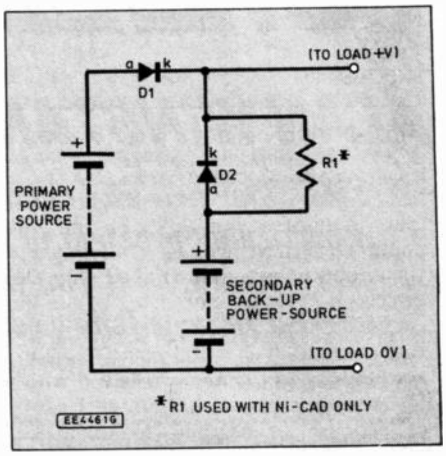


Fig. 3. Simple battery back-up circuit. Primary power source is a mains to 6V d.c. power pack.

Even better perhaps, a nickel-cadmium (NiCad) battery which is trickle-charged through resistor R1 in parallel with the diode D2, will provide a *maintenance-free* back-up for your project. (A typical trickle current is C/10, where C is the ampere-hour capacity of the NiCad. A lower rate such as C/50 is kinder to the NiCad though.) Obviously it's necessary that the primary source is higher than the secondary back-up voltage to provide a trickle current, so R1 is calculated as the required voltage drop across it divided by the desired trickle charge current.

Although very simple, the diode network is less precise than a purpose-made i.c. and it also causes an "insertion loss" of 0·6V (diode forward voltage) when either the main source or the back-up battery is operating. Otherwise the diode network is perfectly adequate for more straightforward needs.

Power Supervisor

The circuit of Fig. 4 shows how a Harris ICL7673 automatic battery back-up switch i.c. can be used with a rechargeable nickel-cadmium battery to make a completely maintenance-free arrangement. The advantage over the diode network is that there is minimal insertion loss when the battery takes over, tiny leakage between the two supplies and high sensitivity; a difference as low as 50mV between supplies causes a changeover.

It will drive *modest* loads directly. Also, by omitting the diode-resistor pair completely and you can use an ordinary dry cell battery in place of a NiCad for B1.

The ICL7673 you mentioned has two inputs – the primary supply (pin 8) and the secondary back-up supply (pin 2). The

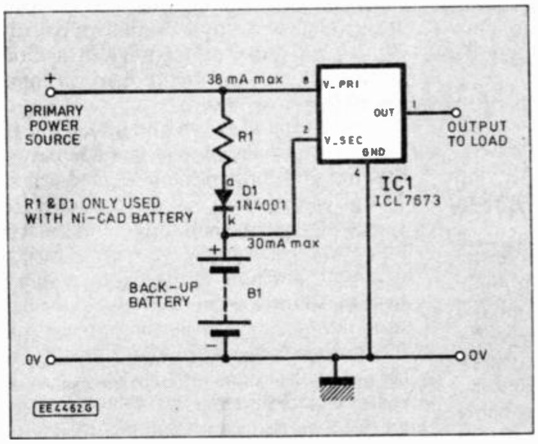


Fig. 4. Application circuit diagram using the ICL7673 automatic battery back-up switch i.c. (courtesy Harris).

chip monitors both voltages and will connect whichever voltage is the highest, to its output pin (pin 1). The chip can directly drive a low power load from pin 1, in the low tens of milliamps continuously. It has a tiny quiescent current of only 1·5µA so it won't drain the back-up battery in any way. There are two "status indicator" outputs (not shown) which sink up to 50mA each if used. Pin 6 (P BAR) sinks current when the primary supply is in use, and pin 3 (S BAR) sinks current when the secondary battery is working instead. These can be used to drive external *pnp* transistors so that the 7673 can control heavier loads and act as a high current back-up system – a technique I hope to cover in the not too distant future.

Education Service

If you are involved with the *teaching* of GCSE or GCE "A" Level Electronics (or a similar syllabus) then as part of our service to support education, *Circuit Surgery* will be happy to lend a hand! The various Syllabuses aren't all as helpful as they could be (as I found out after I researched each and every one of them when preparing our popular *Teach-In '93* series) and if there are any particularly puzzling aspects, or you would like me to expand on any topics in the interests of education, then please write to me at the usual address. I welcome comments and requests from teachers.

Don't forget that I'm also looking for good ideas, handy hints and quick tips to publish as a special round-up. If you have an appealing idea which might interest or benefit your fellow readers, then you can share it by writing to me: Alan Winstanley, *Circuit Surgery*, 6 Church Street, Wimborne, Dorset, BH21 1JH.

Please note, I cannot undertake to advise on the repair or modification of commercial equipment, and I cannot guarantee an individual response but I will try wherever possible to offer advice.

Next Month: Capacitor markings are causing some confusion. I will try to unravel one of life's greatest mysteries by describing typical manufacturer's coding methods. Plus more interesting ideas and readers' letters – keep them coming.

SHOP TALK
with David Barrington

MOSFET MkII Variable Bench Power Supply

The original *MOSFET Variable Bench Power Supply* was one of our most popular projects when it was first published many years ago and this new updated version should appeal to all serious experimenters and educational establishments.

The "mark two" version preserves all the previous features plus a switching preregulator for much higher efficiency, and you do not need a "massive" heatsink. Panel meters indicate volts and amps and the unit is fully variable down to "zero".

Only the specified toriodal transformer and MOSFET may be hard to come by. But this is easily overcome by purchasing the complete kit from **Magenta Electronics** (☎ *0283 65435*). The kit contains all parts, including a ready punched case and replacement meter scale cards, and is priced at £64.95 plus a £3 carriage and packing charge.

Magenta Electronics, Dept EPE, 135 Hunter Street, Burton-onTrent, Staffs, DE14 2ST. Quote kit code 845.

The printed circuit board is available from the *EPE PCB Service*, code 869.

CCD TV Camera/Frame Grab

Obviously, with a project like the *CCD TV Camera* and the companion *Frame Grab* card, some components are "specials" and may not be available generally. As the article explained two versions of the Philips image sensor chip (used in the camera) are available and this is reflected in the price of the camera. Also, some of the Frame Grab i.c.s work out fairly expensive.

A kit of all electronic components for the camera including hardware, but excluding cables, p.c.b.s and sensor chip, is available from the author for the sum of £77. The image sensor is only available as a separate item in two versions: sub-spec FT800P (as used by the author) for the sum of £25 and a "full-spec" version of the FT800P will cost £97.

Also available from the author is a complete kit of electronic components, *but excluding the printed circuit board*, for the Frame Grab card. This kit is priced at £67 inclusive.

The author has also written a control program in 8086 assembler and GW-Basic which took up too much space to be included in the article. However, he will be happy to supply a disc copy for £15 all inclusive. **John Becker, Dept. EPE, 8 Finucane Drive, Orpington, Kent, BR5 4ED.** (Mail order only).

It was decided that with a project of this quality and nature, that for the most consistent results we should make the Control printed circuit board, and the Frame Grab board, a "plated-through-hole" double-sided job. The Control board is available from the *EPE PCB Service*, code 865 and code 867 for the Frame Grab p.c.b. The video boards and test and extension plug boards have been combined to save costs and are available as code 866 and is a single-sided board (see page 327).

The camera lens will have to come from an old discarded camera (see article) or purchased from a photographic store.

SounDAC PC Sound Board

Having priced up all the individual components required to build the *SounDAC PC Sound Board* we came to what we considered a fairly reasonable figure, without the software disc. However, we find that we cannot beat the cost of a complete kit from **Greenweld Electronics** (☎ *0703 236363*).

We understand that the kit contains the printed circuit board, the software programs and a preset and rotary potentiometer and costs only £12.95 plus a post and packing charge of £3. **Greenweld Electronics, Dept EPE, 27D Park Road, Southampton, Hants SP15 3UQ.**

If you just require the sound driver program disc this is available from the author and details are given at the end of the article. The printed circuit board is available from the *EPE PCB Service*, code 868.

Impulse Clock Master Unit

We do not expect any component buying problems to be encountered when searching for parts for the *Impulse Clock Master Unit*. Finding an old "impulse clock" to renovate may, of course, be another matter!

If you should have any trouble locating the timing crystals then try **Cirkit** (☎ ***0992 444111***), they carry large stocks of crystals.

The type number of the diode appears to be a "military" code. However, the choice of D1 is not critical provided its peak reverse voltage exceeds the voltage across the clock coil when transistor TR2 first switches on (equal to the e.m.f. of cell B1) and it can carry the full coil current (150mA) as TR2 switches off. Most *rectifier* diodes should suffice.

Telephone Ring Detector

Looking down the list of parts required for the *Telephone Ring Detector* we find that most of the items are standard sock lines, except the relay.

The relay is from the "ultra" miniature range stocked by **Maplin** and is their 6V 100 ohm coil version, code FM91Y. Other relays can be used, but check that they will sit on the circuit board and that it only requires a low "holding" current before purchase. Also, check the relay pinout arrangement.

The piezoelectric transducer *element* should be stocked by most of our components advertisers. It used to be commonly referred to as the 2720 series.

The ring detector printed circuit board is available from the *EPE PCB Service*, code 864 (see page 327).

Circuit Surgery

Readers who are investigating the possibilities of *Battery Back-up* circuits, one of the subjects discussed in this month's *Circuit Surgery* feature, will find the little circuit presented there most interesting.

This circuit uses a Harris ICL7673 automatic battery back-up i.c. and will drive modest loads, low tens of milliamps, continuously. It is claimed, that by omitting the diode and resistor combination you can use a dry cell battery in place of the recommended NiCad cell.

The circuit is very simple and as always it is left to constructors to use their own initiative to assemble the project, working from the circuit diagram and information given as a guide. However, some readers may experience difficulty in locating the ICL7673 locally. It is currently listed by **Electromail** (☎ *0536 204555*), code 632-966 and **Maplin** (☎ *0702 554161*), code UH36P.

Home Base

Jottings of an electronics hobbyist – Terry Pinnell

Stopping at all Flaws

Some time shortly after the invention of electricity, when I was in the formative stages of this hobby, the last thing I used to be concerned about was the long term reliability of my projects. It's only in recent years that I've given it the weight it certainly deserves. Projects that work for a while then give up the ghost are a pain.

Needless to say they invariably seem to pack up when you need them most. This is true whatever they are doing for you, whether it's timing your eggs, protecting your house against unlawful entry or flashing "Hello!" in l.e.d.s from your bow-tie in a vain attempt to impress fellow party-goers.

But stepping back a few paces, "projects" is hardly the right word to describe the things I used to make in those first months of discovering electronics. Most of my early circuits were assembled in a spirit of curiousity, usually built experimentally on breadboards. My favourites were those S-Decs and T-Decs that you don't see much now. You had lots more space for discrete components, and, as the circuits became more ambitious, you could easily connect a few boards together. The new sort with 0·1 inch matrix spacing and rather small holes are more fiddly, although of course ideal if your circuits have lots of i.c.s.

When I did attempt a permanent construction, reliability took a very low priority, if it was considered at all. Just getting a few electrons to flow through the right components in the right direction was good enough then. Getting the circuit to actually do whatever it was supposed to do was a minor miracle. I certainly don't recall putting any effort into ensuring the finished thing would continue to perform for posterity.

Never Mind the Quality

Most of those primitive efforts have long since mercifully fallen apart of their own volition, or else been unsoldered for components. Examining any that have survived usually makes me wince. I suppose it wasn't just unreliability, which by definition needs time to become apparent, but poor quality in general, which is usually evident at once. The most obvious aspect was external appearance.

Flimsy cases, often with construction scratches, inaccurate drilling and such-like. Amateurish labelling, sometimes hand-drawn with felt-tip pen, or up market a notch to Dymo-tape, which still looked poor by comparison with the professional transfer-type lettering I adopted later.

Eccentric choice of knobs, switches and sockets, motivated more by what was to hand rather than any attempt to please: The l.e.d.s glued in place rather than placed in holders. Overall, a general cobble-it-together-fast approach – all these were obvious shortcomings of those early projects.

The insides look even worse. Probably the main fault was my misguided attempt to use the enormous quantity of solid core wire I had obtained from some surplus shop or other, instead of using proper flexible connecting wire. In mitigation, it wasn't just the fact that I had lots of the stuff in various colours, but also that it was easier to solder, didn't need twisting and tinning, and you could poke it through small holes first time.

Perfectly all right for short, straight links across perforated board, or for breadboard experiments, but not much else, especially not for connecting the board to pots, switches, batteries and so on. After dozens of occasions when faults were eventually tracked down to broken wires the penny finally dropped that solid core wire was not meant to be moved, and thereafter I duly mended my ways in that respect.

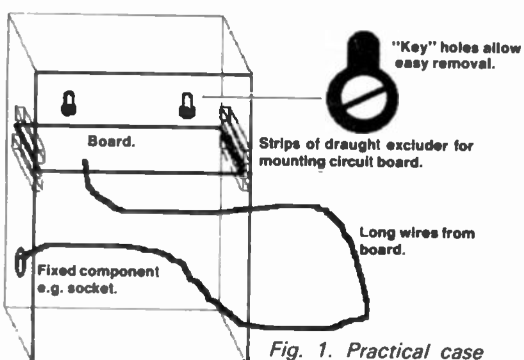


Fig. 1. Practical case considerations.

There were other less obvious manifestations of this low quality, such as my apparent failure to anticipate ever needing access to the innards of a project, especially its circuit board, for servicing or repair. Never seemed to occur to me then!

Once again I learned my lesson in the hard school of real life. On several occasions I found that I had to virtually remove all controls from the front of a project in order to change a single component or even adjust a control.

An Illuminating Example

For instance I well remember a touch-operated lamp I had proudly installed in the lounge. Based on capacitive reactance, its key element was a Colpitts r.f. oscillator running at about 100kHz. It was arranged so that oscillation was barely sustained and its amplitude would drop significantly when you touched the cylindrical metal casing of the lamp. The drop in a.c. amplitude was converted into d.c., which in turn triggered a bistable toggling the light on or off. The snag was that the oscillator turned out to be highly erratic, probably because it was unduly temperature-sensitive, and used to go on and off arbitrarily. Other similar lamps I had made seemed OK but this particular one seemed to have a mind of its own.

Actually, going on at random was almost an advantage, as it gave it a sort of burglar deterrent function in the small hours. I begrudged the wasted electricity in the daytime though, as well as the reduced bulb life. But the converse, plunging at least that corner of the room into darkness, had no redeeming features at all. Anyway, that's when I regretted what I had regarded as my cleverness in squeezing the circuitry deep within the lamp's innermost parts.

The crucial miniature preset for adjusting the oscillator so that it was at the critical setting of only just operating was impossible to reach without a major effort. Eventually I re-positioned it so that it was accessible externally, through a newly-drilled small hole in the base of the lamp. Trial and error was then painless and finally resulted in stability.

After a few repetitions of this sort of thing I started to think seriously about positioning controls and circuit boards more conveniently, and over the years it has paid off in saved time and lower blood pressure. If some fundamentals are observed then life can be much easier.

Just in Case

For example I always try to ensure that the circuit, whether on perforated board or p.c.b., is easily removable from the case so that it can be placed on my workbench without straining anything. Project boxes with ready-made slots make for such easy removal, or you can just stick strips of self-adhesive draught excluder vertically inside a plain case to achieve the same result.

You also need to allow adequate lengths of wire from the circuit to the case-mounted components like pots, switches, sockets, batteries, power transistors, large electrolytics and so on. With the circuit inside the case, a neat 50mm for such wires might seem a good idea, but 15 to 25cm is usually needed in practice.

For some domestic projects the case might need to be wall-mounted, and it's a good idea to anticipate these needing easy removal too. This is simple if you use the same approach as many commercial products.

Just drill a couple of holes, three if rigidity is critical, in the back of the case (the surface going against the wall) and make sure they're large enough to allow the heads of the permanently wall-mounted screws to go through them. If you file slots above these large holes, when the box is placed against the wall you can then slide it down and tighten the screws, or reverse that to quickly remove the case.

Of course, this assumes you also arrange for screwdriver access from the front of the case, usually after removing the cover or lid. If mains voltages are involved then it also goes without saying that you disconnect the supply first! These three practical points are illustrated in Fig. 1.

INTERFACE

Robert Penfold

PREVIOUS *Interface* articles covered the hardware aspect of EPROM programming using a computer. This month we will look at the software side of things, and the precise steps involved in programming, verifying, etc. The software does not actually need to be particularly sophisticated, but it is important that the hardware is controlled in precisely the correct manner if the system is to function properly.

ZIF

It is perhaps worth mentioning that an EPROM programmer is normally fitted with a zero insertion force (ZIF) socket into which the EPROMs are fitted. For the 2764 and 27128 EPROMs it is a 28-pin ZIF socket that is needed. An EPROM is simply dropped into the ZIF socket, and then the device is locked in place by operating a small lever. Setting the lever back to its original position releases the EPROM so that it can be lifted clear.

One advantage of a ZIF socket is that it enables the EPROMs to be fitted and removed without any risk of the pins being buckled or damaged in any way. Another advantage is that the EPROM is not connected to the programming hardware until the lever is operated and the device is locked in place. This ensures that the supply and control lines are connected to the EPROM simultaneously, and also disconnected from it simultaneously. This minimises the risk of "blowing" the EPROM in the wrong sense of the word!

Verification

Before programming any EPROM it is advisable to use a verification routine to check that it has been properly erased. An erased memory cell is set at 1, and a properly erased EPROM should therefore return a value of 255 from each address. An EPROM programmer can set bits from 1 to 0, but not vice versa. A change from 0 to 1 can only be achieved by erasing the entire contents of an EPROM using short wavelength ultraviolet light.

The first step in the verification process is to send a positive pulse to the reset input of the binary counter. This ensures that it is set initially to address 0. The control lines to the EPROM must be set up so that pin 22 (output enable) is low, and (if applicable) the chip enable input at pin 20 is also low. The data lines should be set as inputs so that they can read the outputs of the EPROM. The EPROM is then fitted into the ZIF socket.

Next a loop routine must repeat a simple test procedure. This just entails reading the data from the EPROM, and incrementing the binary counter by one if the returned value is 255. If it is not, the routine is brought to a halt and a message is displayed on the screen to indicate that the EPROM is not fully erased. The message can include the current address, which will presumably be the same as the current value in the loop counter. It can also include the value read from the EPROM.

Verifying that an EPROM has been programmed correctly uses the same basic set up. However, instead of checking that each address returns a value of 255, it is a matter of comparing the value at each address with the corresponding value in the array (or whatever) that contains the program data.

Programming

The programming process is also quite straightforward. The output enable pin of the EPROM is set high so that the EPROM's data lines act as inputs. The data lines of the interface are set as outputs, and a reset pulse is sent to the binary counter. Where appropriate, the chip enable input of the EPROM is set low.

It is then just a matter using a loop program to repeat a simple process. First the data for address 0 is placed on the data lines, and then the monostable is pulsed. The program must then wait until the output pulse from the monostable has come to an end. As the output pulse always has a duration of about 50 milliseconds, a timing loop can be used to provide this delay.

It is possible that a slow programming language would not move on to the next instruction fast enough, but even using one of the less powerful 8 bit computers it is likely that a "dummy" instruction or some simple form of delay will be needed. Using an excessive delay will not prevent the system from working reliably, but it will substantially increase the programming time. Therefore, it is worth experimenting a little to get the delay time just right. Once the first address has been programmed, a pulse is sent to the binary counter so that the EPROM is moved on to the next address. This cycle of events is then repeated until all the addresses have been programmed.

Alternative Method

The method described here keeps things simple by having the programming and verification processes entirely separate. The alternative is to incorporate one or both of the verification processes into the programming routine. It is probably best to keep the blank EPROM verification process separate from the programming procedure. Check that EPROMs have been properly erased as soon as they are removed from the eraser.

The initial part of each programming cycle remains as described above. The difference is that some extra stages need to be added before the binary counter is pulsed

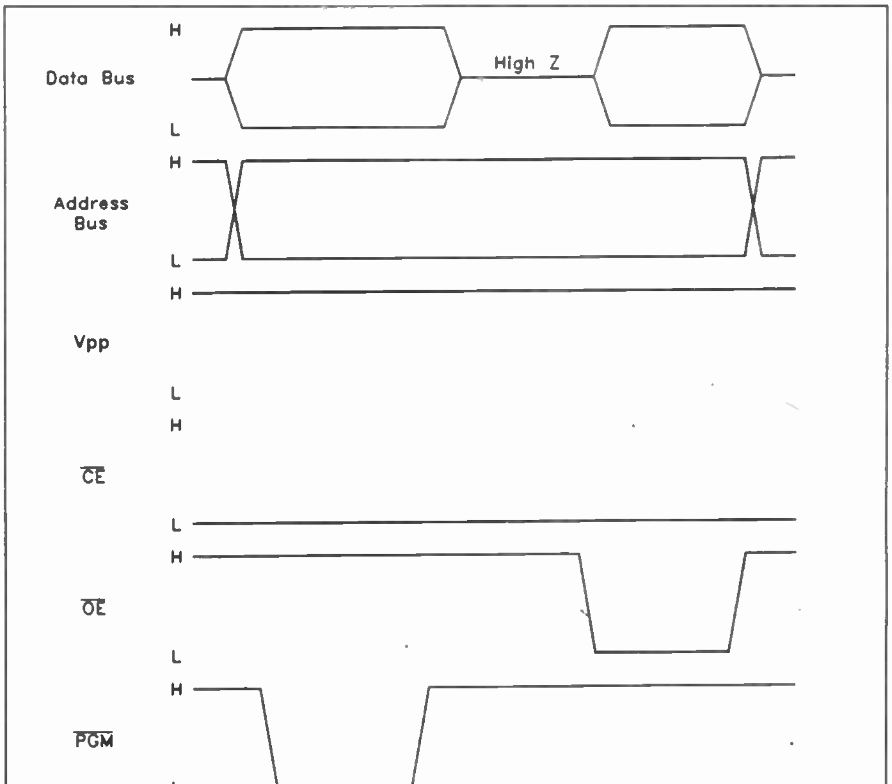
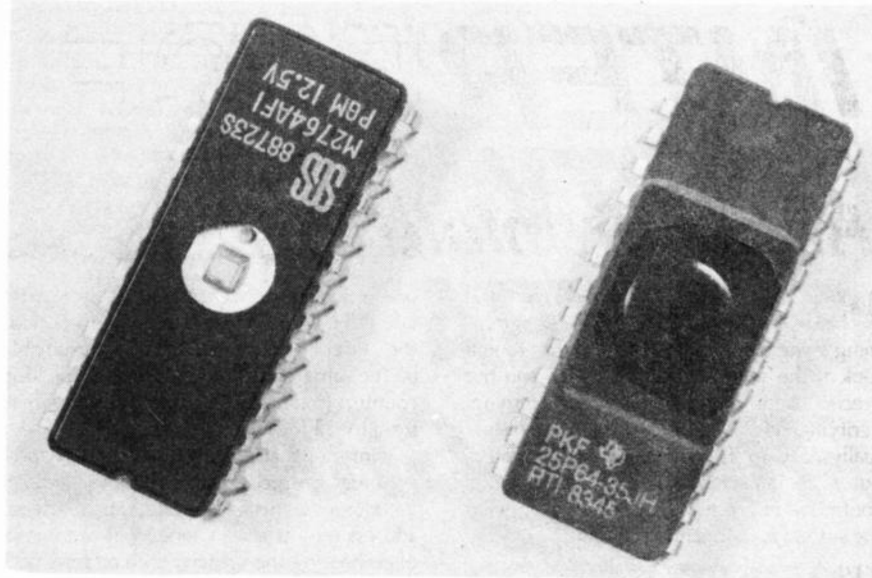


Fig. 1. Waveforms for an EPROM programming and verification cycle.

and the process moves on to the next address. The first of these additions is to set the data lines of the interface to inputs so that the EPROM can be read. The output enable terminal of the EPROM must be taken low before a reading is taken. This activates the outputs of the EPROM. It is important that the data lines are set to the input mode before the output enable terminal is taken low.

The reading from the EPROM is then compared to the value just written to that address. An error message is placed on the screen and the programming is brought to a halt if there is a discrepancy. If all is well, the output enable input is set high again, the data lines are set as outputs, the binary counter is incremented, and the next programming cycle is commenced. Fig.1 shows example waveforms for a programming cycle, and this should help to clarify the correct method of controlling the EPROM.



Cover the "window" of a programmed EPROM. This helps to avoid accidental erasure or overwriting.

In Use

Using EPROMs in you own designs is not too difficult since they are read only devices once programmed. Pin 1 (Vpp) and Pin 27 are unused after an EPROM has been programmed, and it is then controlled via the output enable and chip enable inputs. In a circuit that has two or more memory chips, the chip enable inputs are used to select the required memory device. This minimises the current consumption.

The output enable inputs are driven from the read/write control line. These inputs are taken low in order to read from an EPROM. In some applications the EPROM will be the only memory chip used, and the chip enable input is then wired to the 0 volt supply. In a very basic application the EPROM may be the only device driving the data bus, and it is then quite in order to simply wire the output enable terminal to the 0 volt supply so that outputs are permanently active.

It is common practice to put a piece of tape over the "window" of an EPROM once it has been programmed, or some users prefer to use a splodge of paint. This might help to prolong the life of the data stored in EPROMs, but its main purpose is to help prevent accidentally erasing or overwriting a programmed EPROM. Although EPROMs tend to be used as a truly permanent means of storing data and programs, most of them are only guaranteed to keep the stored information unchanged for about 5 to 10 years. In reality most EPROMs can retain their contents for much longer than the guaranteed period, but it is as well to bear in mind that they will eventually suffer from amnesia.

Making Tracks

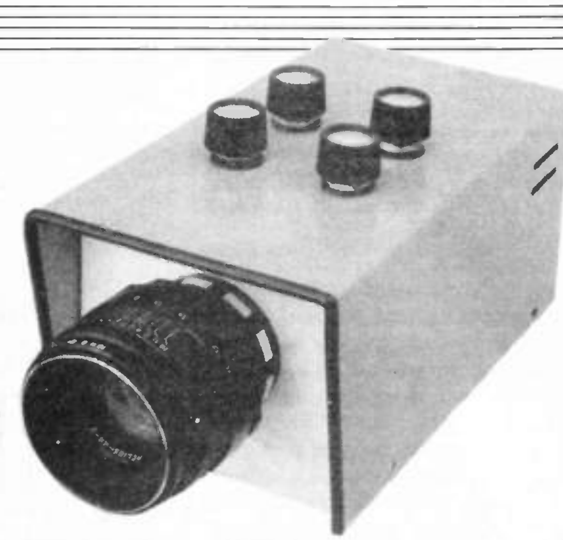
I am indebted to Mr.Alan Bradley of Belfast for information on the "PADs PCB" printed circuit design program which was reviewed in an *Interface* article last year. It seems that the shareware version of this program is no longer supported, and it is not possible to register a shareware copy of the program. The full commercial version of the program is still available in the U.K., but has a starting price of some £850.

Presumably it is still quite legitimate for anyone with a distribution copy of PADs PCB to carry on using it. There are a couple of problems though, one of which is that it is not possible to obtain a registered shareware version if you outgrow the limits of the distribution program. The other problem is that it seems unlikely that any updated versions of the distribution program will be produced, with new screen drivers, printer drivers, etc. In due course the distribution version will therefore become obsolete. I am note sure if it is still in order to make and distribute copies of the basic program, but it would probably be as well not to do so in case it is an infringement of someone's copyright.

The basic PADs PCB program is a rather less attractive proposition than it was originally. For anyone getting into computerised printed circuit design one of the other shareware programs might be a better bet, and the low cost commercial offerings should not be overlooked.

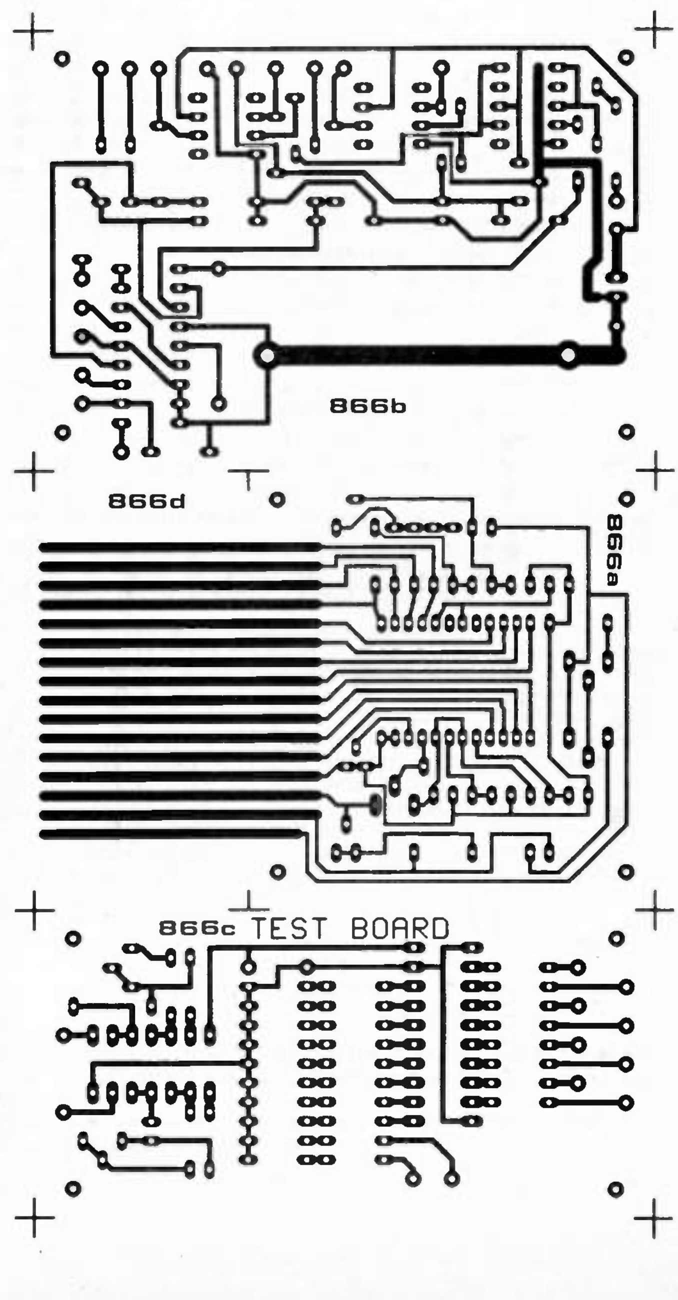
Constructional Project

CCD TV CAMERA FRAME GRAB



JOHN BECKER **Part Two**

Add a gear box interface to a PC-compatible computer for high speed analogue data collection and distribution.



BEFORE we tackle the add-on PC-compatible Frame Grab board we must complete the construction and setting up of the CCD TV Camera. Last month we introduced all the camera circuits and completed the assembly of the main Control Board, we continue now with the Sensor and Video boards.

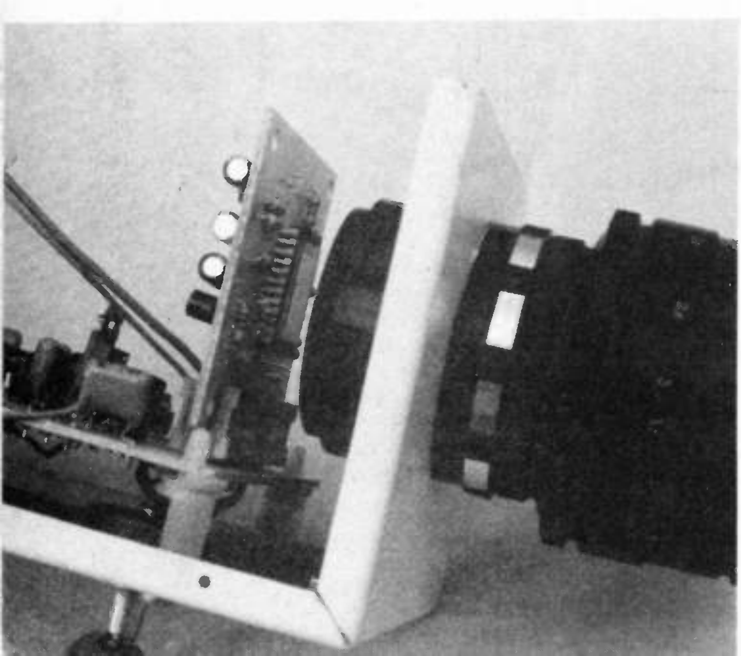
OTHER BOARDS

Moving on now to the board whose details are shown in Fig. 13. This, single-sided, board is a combination of the sensor circuit, video output module, extension plug and the test board and is available from the *EPE PCB Service*, code 866. With a small hack-saw, very carefully cut the board into its four parts.

Image sensor chip IC5 has unusual pin spacings and at the time of writing, a source of i.c. sockets for it had not been located. If you have a suitable socket, solder it in first. If not, solder the chip directly into the board *after all other parts have been mounted.*

If you have an old film camera, it may be possible to secure the sensor board to its body behind the lens. To achieve the necessary low profile on the imaging side of the board, capacitors, transistors and preset VR1 may be mounted on the rear of the board. Be doubly sure that they are correctly orientated.

The Sensor board is mounted to align the sensor chip with the lens.



CAMERA BOX

For use as a self-contained TV camera, all the circuitry and the lens are mounted in one box. The Control Board is mounted on the box base using pillar supports. Four slots are cut into the box to allow the supports to be moved so that the lens focuses correctly on the sensor chip. Additional bolts between the front of the box and the Sensor Board could be used to provide greater rigidity.

The lens mounting hole should be cut out so that the centre of the lens is in line with the centre of the sensor's active area.

Alternatively, the Sensor Board and lens may be housed in their own box. Connection back to the control box can be via ribbon cable terminated with a 16-pin edge connector and the Extension Plug section of the p.c.b. in Fig. 13.

The maximum cable length possible is not known, but when a Sensor Board was fixed to a plate camera via over four metres of cable, no problems were experienced.

The Video Output board and the four controls VR4 to VR7 are mounted in the box lid. Position the controls so that they are clear of the top of the Sensor Board when the lid is closed. The p.c.b. is fixed using supports with self-adhesive feet.

As shown in Fig. 14, VR8, SK2, SK3 and S1 are mounted on the rear of the box, with an additional hole to provide access to the output socket of the UHF Modulator. Ensure that the UHF Modulator body cannot touch the rear controls.

A pan and tilt mount was bolted to the base of the author's camera.

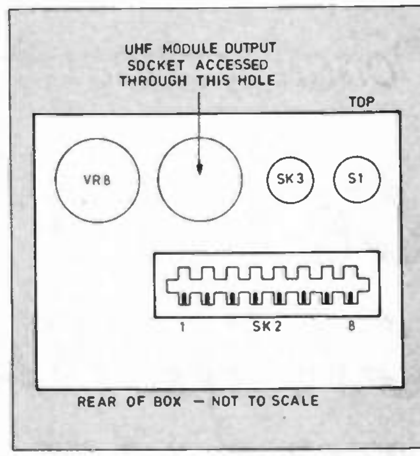


Fig. 14. Layout of components on the rear of the camera case.

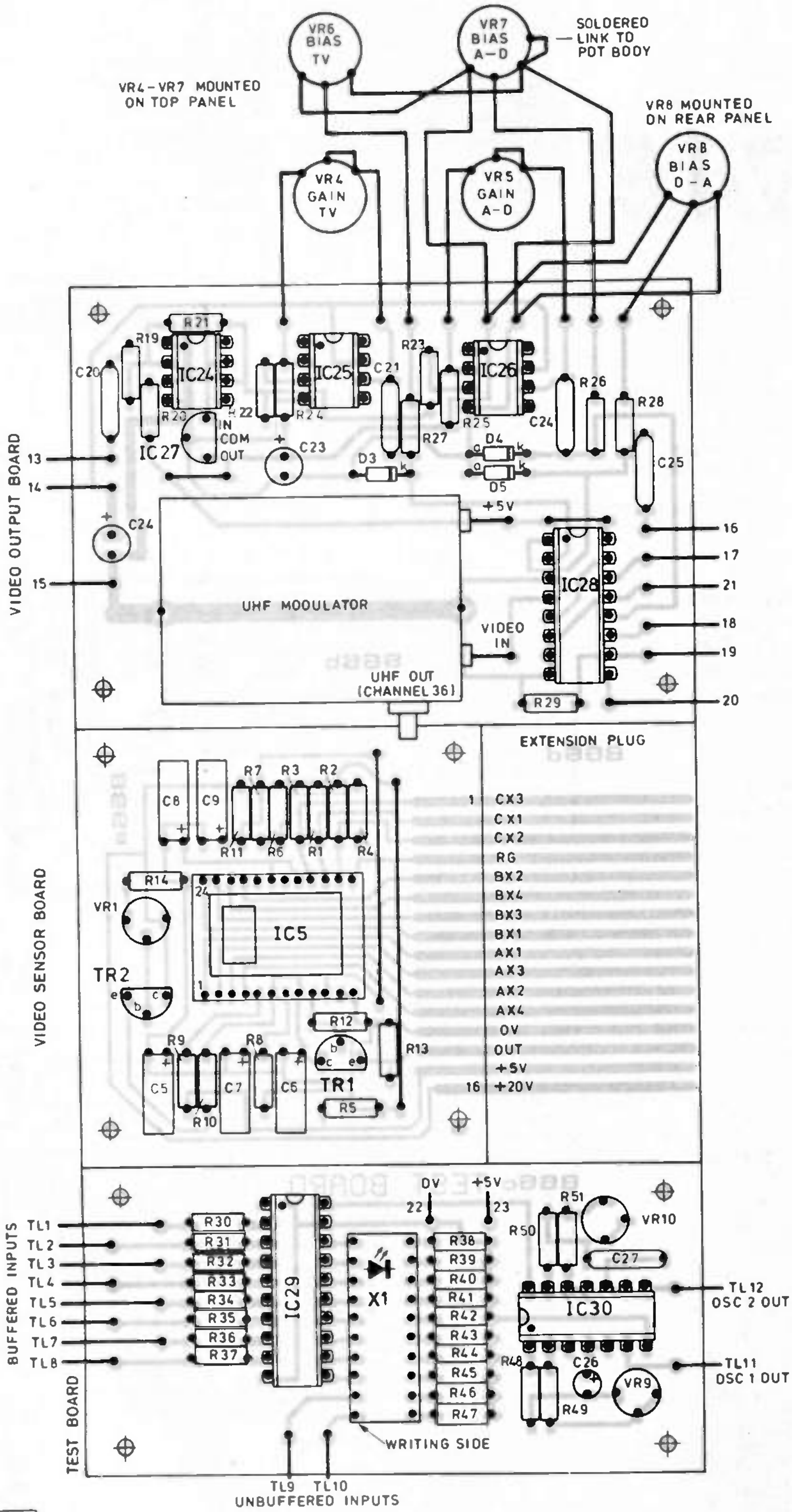
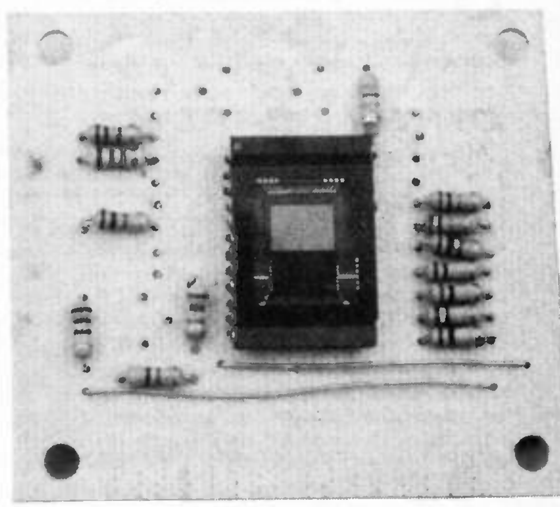
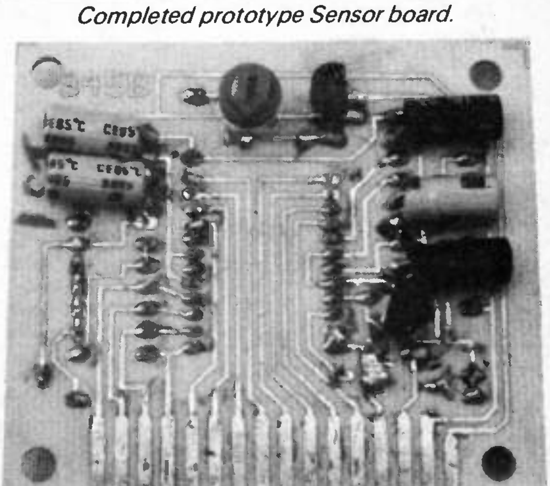


*Fig. 13. Printed circuit board(s) component layout and full size copper foil master pattern for the sensor circuit, video output module, extension plug and test circuit. Before mounting any components on the board it should be carefully cut, at the division guides, to provide the required four small boards. **Note:** the capacitors, transistors and preset on the image sensor p.c.b. go on the track side.*



Completed prototype Sensor board.



Capacitors, preset and transistors mounted on the track side.

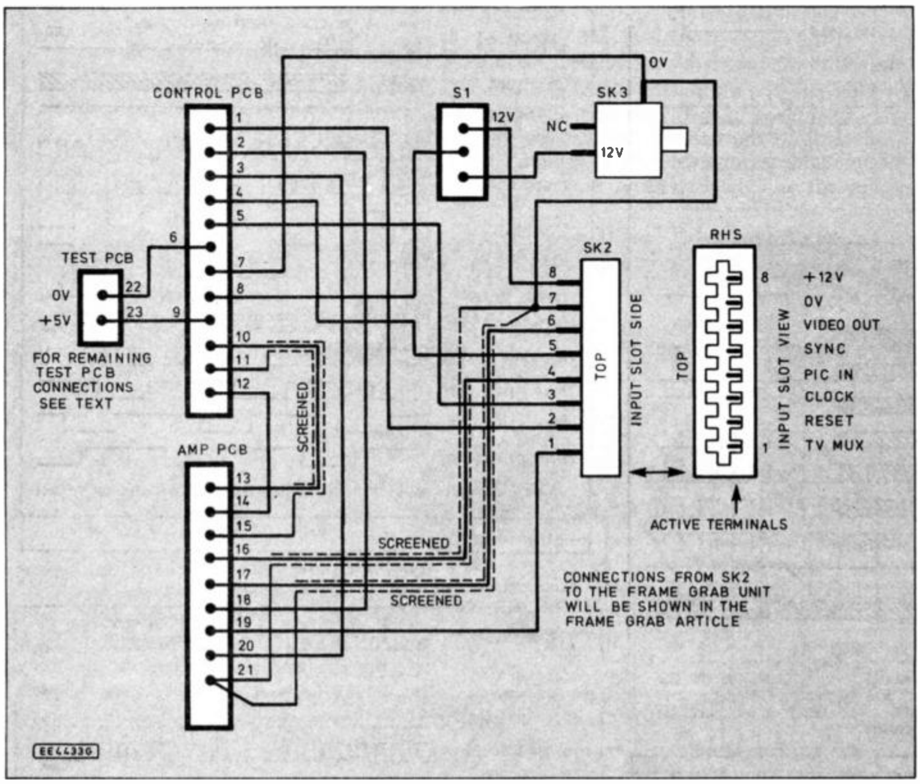


Fig. 15. Wiring from the control and output boards to the sockets and switch. Screened cable must be used where indicated (Sensor p.c.b. plugs directly into Control p.c.b.).

INTERWIRING

Interconnect the output board, control board, sockets and switch as shown in Fig. 15, using screened cable where indicated. Make wires slightly long at this stage to allow temporary board removal during testing. The wires can be shortened and neatly harnessed using cable ties when testing is complete.

TESTING

Do not plug in the Sensor Board or any other chips at this stage. Connect the unit to a 12V power supply and check that the regulator i.c.s deliver the correct output voltages.

If at any stage during testing unexpected results occur, the most likely reason is that a solder short exists, or a connection has not been correctly soldered. Switch off and visually recheck the area affected using a powerful watchmaker's magnifier, or electrically check tracking continuity with a multimeter.

Insert all remaining chips and plug in the Sensor Board. Switch on and recheck the output voltages of all regulator i.c.s. Additionally check that about +20V is present at SK1 pin 16.

Plug the camera into the aerial socket of a TV tuned to UHF Channel 36 (same channel as used by video recorders). Leave the box open. When the camera is switched on, the "snow" on the screen should disappear and be replaced by an even-density brilliance.

Rotating bias control VR8 back and forth should cause the screen to darken and lighten. Covering and uncovering the image sensor should also cause changes of screen intensity which can be further altered by rotating gain control VR4.

Adjusting preset pots VR2 and VR3 should cause sideways shifting of the display, and possible loss of synchronisation.

HARMONIC SHIMMER

Two points should be noted. Firstly, the 80MHz oscillator is subject to a warm-up period during which its frequency changes slightly. Secondly, there is a small amount of cross-modulation radiated by the 4MHz and 80MHz oscillators which manifests itself on the screen as an image "shimmer".

Following the warm-up period of about five minutes, the shimmer can be minimised by slight adjustment of VR2 to shift the harmonics of the two oscillators away from each other. Repositioning of the interconnecting leads may also help minimise the interference.

The use of screened leads where indicated is imperative. The interference was more noticeable on the author's high quality colour receiver than on the low cost monochrome receiver with which the camera is principally used.

ALIGNMENT

Place the camera a metre or two in front of a reasonably well-illuminated subject. Surround the sensor with dark paper so that it is illuminated only via the lens and not by room lighting falling directly on it.

Adjust control pots VR4 and VR6 and also the lens focus and aperture settings until a reasonable image is seen on the TV screen. Adjust preset pots VR2 and VR3 to improve the display stability. Adjustment of VR1 on the Sensor Board may also be beneficial to the picture quality, although the change may only be noticeable in conditions of high image-subject brightness and contrast.

Finally, measure the distance between the lens and the subject, turn the lens focussing ring so that its markings are set for the same distance. Then carefully adjust the Control Board on its sliding mounts until the screen image is sharp. Tighten down the p.c.b. supports and close the box. The camera is now ready for use.

In use, adjustment of the lens aperture setting should be the main method of controlling image intensity. It will be found that in most situations the gain control VR4 can be left at a fairly low setting. Normally a midway setting for the bias control VR6 will probably be best. Extreme settings of VR6 may upset the screen synchronisation.

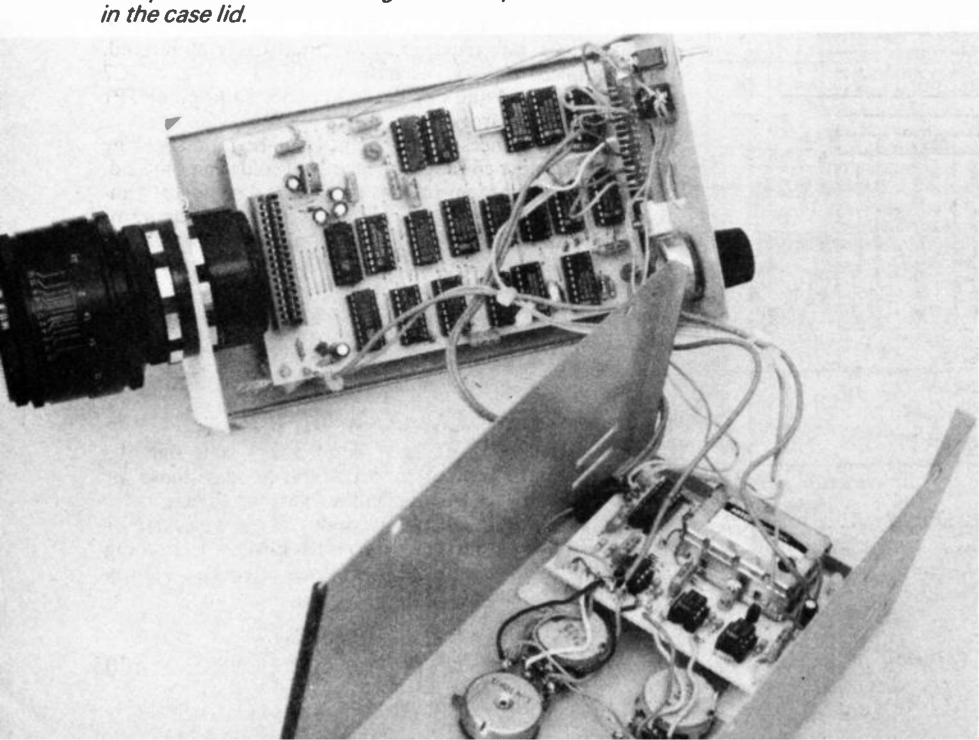
WAVEFORM GRAPHS

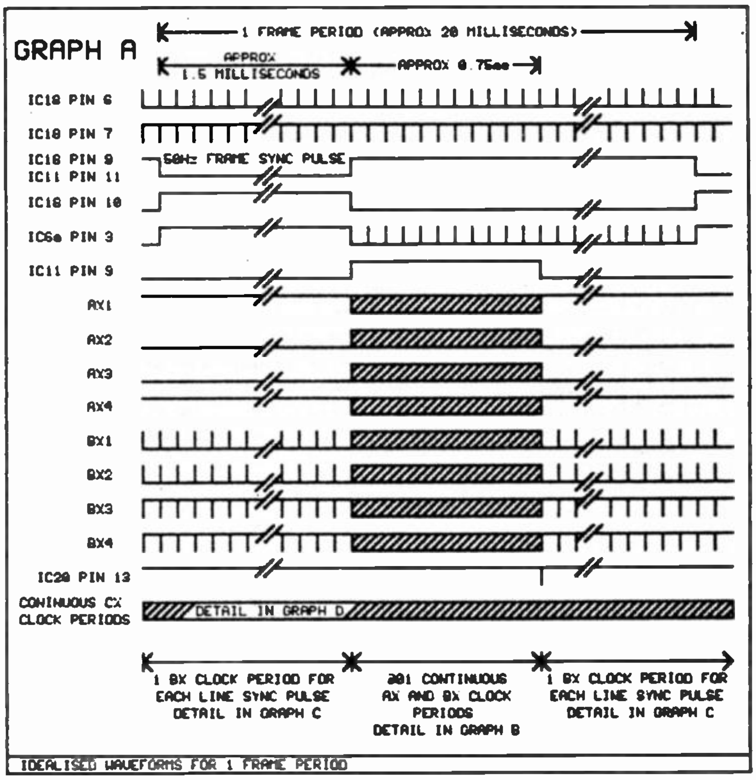
The graphs in Fig. 16 illustrate the waveforms to be found at some of the crucial points in the circuit. They will be of assistance not only to the understanding of the camera's operation, but also in checking out the circuit. The waveforms occurring at the points not covered by the graphs can be deduced logically through examination of the circuit diagrams.

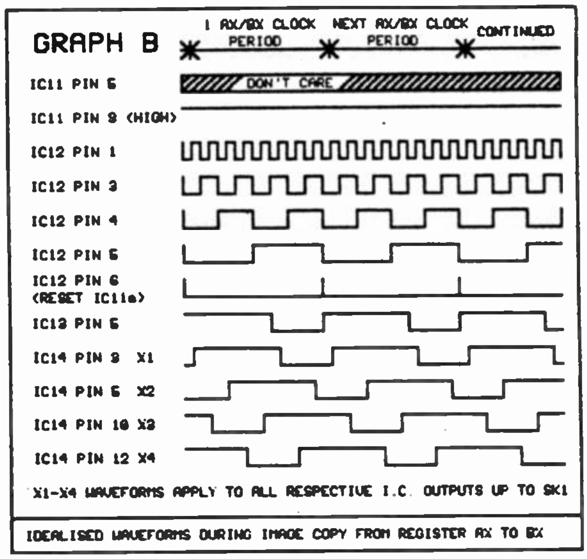
With the author's Image Sensor Board, the following d.c. voltages at the positive pins of the capacitors were found with VR1 set for the maximum output voltage at transistor TR2 emitter:

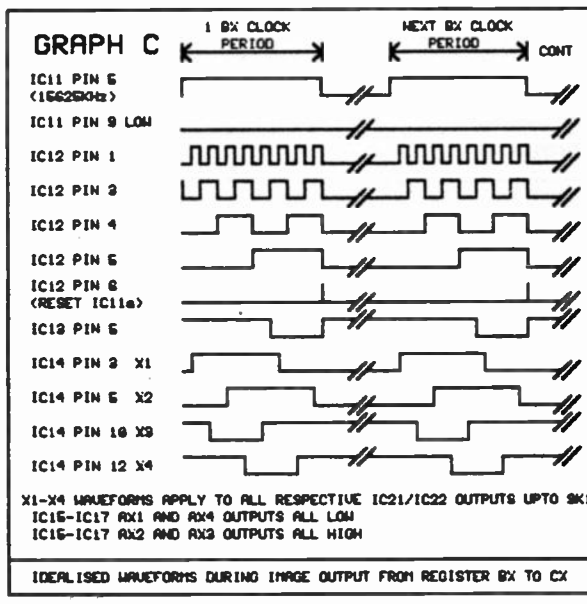
C5 5V; C6 18·5V; C7 5·5V; C8 18·5V; C9 12·7V

Completed camera showing video output board and controls VR4 to VR7 mounted in the case lid.









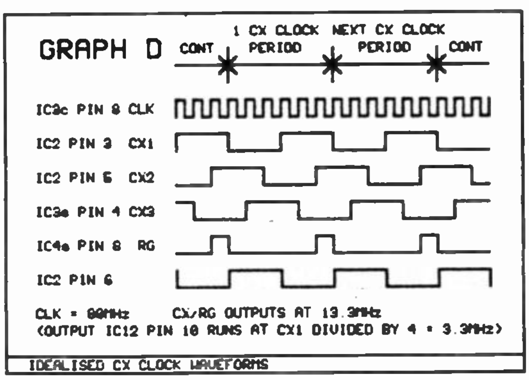


Fig. 16. Idealised waveforms to be found at some crucial points in the circuits.

TEST BOARD USE EXAMPLES

MONITORING CX CLOCK SIGNALS PRIOR TO CAPACITORS C1-C4

REMOVE LINK TP2-TP3

CONNECT	TO
TEST OSC 1	TP2 (IC2 PIN 8)
TL1 (LED 1)	IC2 PIN 2 CX1
TL2 (LED 2)	IC2 PIN 5 CX2
TL3 (LED 3)	IC3 PIN 4 CX3
TL4 (LED 4)	IC4 PIN 8 RG

STEP	LED 1	LED 2	LED 3	LED 4
1	0	1	0	0
2	0	1	1	0
3	0	0	1	0
4	1	0	1	0
5	1	0	0	0
6	1	1	0	1
REPEAT				
1 = ON 0 = OFF				

DISPLAY SEQUENCE FOR ONE CX CLOCK PERIOD AS IN GRAPH D

MONITORING AX & BX CLOCK SIGNALS AT INPUT TO IC15

REMOVE LINK TP2-TP3

CONNECT	TO
TEST OSC 1	TP2 (IC2 PIN 8)
TL1 (LED 1)	IC15 PIN 2 AX1/BX1
TL2 (LED 2)	IC15 PIN 5 AX2/BX2
TL3 (LED 3)	IC15 PIN 11 AX3/BX3
TL4 (LED 4)	IC15 PIN 14 AX4/BX4

STEP	LED 1	LED 2	LED 3	LED 4
1	0	0	1	1
2	1	0	1	1
3	1	0	0	1
4	1	1	0	1
5	1	1	0	0
6	1	1	1	0
7	0	1	1	0
8	0	1	1	1
REPEAT				
1 = ON 0 = OFF				

DISPLAY SEQUENCE FOR ONE AX/BX CLOCK PERIOD AS IN GRAPH B

Fig. 17. Two examples of using the Test Board. Above left, monitoring CX clock signals prior to C1-C4 and above right monitoring AX and BX clock signals at input to IC15. In both cases the link between test points TP2 and TP3 has been removed.

USING THE TEST BOARD

The l.e.d.s of the Test Board may be used to monitor any points of the control circuit. Two examples of Test Board use are given in Fig. 17.

The choice of which test oscillator to use will depend on the final clock rate required at the point being monitored. For example, to check the outputs of IC9 in Fig. 5, IC7 would be removed and Oscillator 2 connected to point TP1 on the Control Board.

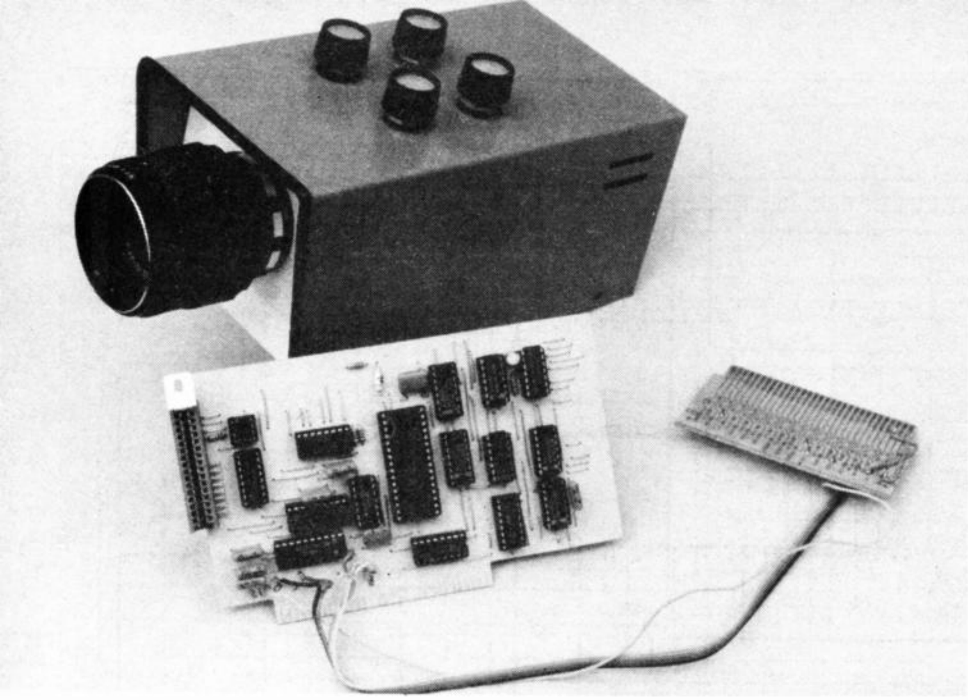
In several instances circuit points can be monitored by removing the next chip in sequence, and soldering the l.e.d. wires to the relevant upper pins of a spare d.i.l. socket temporarily inserted in place of the removed chip. To monitor the outputs of IC21 in Fig. 8, for example, remove IC22 and, replace it with the spare socket to which the l.e.d. wires are soldered to pins 3, 5, 7, 11 and 14.

When using the test p.c.b. it is preferable to connect its unused input points to the 0V line.

SENSOR CLEANING

The manufacturers of the FT800P sensor state that the chip's electrostatic precautions are not as good as those for standard CMOS devices and offer the following advice:

When cleaning the glass window *only use alcohol* or *acetone*. Rub the window carefully and slowly. Dry rubbing of the window may cause static charges which can destroy the device.



The Frame Grab board ready for "field trials".

THE Frame Grab (FG) project is a two-way interface unit which enables high speed analogue data to be processed by a PC-compatible computer. It was designed principally for use with the CCD TV Camera (TVC), but it can also be used for other analogue data interfacing purposes.

The Camera generates live data at a rate faster than the software run on most PC-compatible computers can handle directly. The purpose of the FG, therefore, is to act as a "gear box", slowing down the data to a more readily accessible rate.

The "frame grabber" consists of a high speed analogue to digital converter (ADC) whose output data is recorded by a 128Kb memory at half the full output transmission rate of the camera. When the memory has been filled, its contents can be read and processed by the computer at a slower rate suitable to the software. Processed data can be sent back to the Frame Grab memory, from where it can be transmitted to a TV receiver via the camera.

The block diagram for the Frame Grab and it's schematic interconnection to the CCD TV Camera is shown in Fig. 18. Fig. 19 shows the full circuit diagram.

ADDRESS INTERFACE

Most PC-compatible computers have several expansion sockets into which customised control boards can be plugged. The sockets can be accessed by the computer via any of 32 address codes between &h300 and &h31f (decimal 768-799) allowing different functions to be controlled from the same expansion slots.

As seen in the bottom left of Fig. 19, the FG's control address decoder is formed around IC1, IC10, IC12a and IC16b. Six addresses are decoded in a block from &h300 to &h305. Other blocks of six consecutive addresses could be selected instead by connecting IC10 $\overline{CS2}$ to alternative Y outputs of IC1. Additionally, IC10 outputs Y6 and Y7 could be used for other addressed control purposes.

There are four modes of Frame Grab operation controlled by the decoded address calls:

Mode 1: Record TV camera data into FG memory.

Mode 2: Transfer FG memory data into computer.

Mode 3: Transfer computer data to FG memory.

Mode 4: Output FG memory to TV receiver via TV camera.

TV RECORD MODE

For Mode 1, the FG is set so that its memory addressing and video data input is controlled by clock and sync signals from the TV Camera.

The computer first sends a write command (it could also be a read command – it does not matter) to each of addresses &h301, &h302, and &h305. Respectively, these commands briefly take low each of IC10 outputs Y1, Y2 and Y5. The latter two actions reset both parts of the dual flip-flop IC11, whose functions will be seen later.

The pulse from IC10 output Y1 triggers flip-flop IC9a so that its QA output (pin 5) goes high, so enabling one side of NAND gate IC2a (pin 5). On receipt of a 50Hz start pulse from the camera via resistor R6, the other side of IC2a (pin 4) is briefly enabled and the gate's output pin 6 goes low.

This action has two effects. First, it resets IC9a so that IC2a cannot respond to any more start pulses until IC9a has been clocked again by the computer. Secondly, and the principal purpose of this part of the circuit, the output pulse from IC2a passes via inverting gate IC2b and OR gate IC12d to reset memory address counters IC4 and IC5.

The input-to-output routing is set by the status of control inputs A0 and A1 of IC3, a dual multiplexing gate. At this stage of the cycle, both controls are held low, switching the signal routing to the DA0/OUT A and DB0/OUT B paths.

From the camera, a 13MHz clock signal is sent to flip-flop IC9b (pin 11) which is connected as a divide-by-two stage producing a pair of split-phase signals on its QB and $\overline{QB}$ outputs.

The QB output of IC9 is routed via the DA0/OUT A path of IC3 to the clock input of IC4. Counters IC4 and IC5 are connected in series and set the internal address to which the D0 to D7 data input/output lines of memory IC7 are connected. The $\overline{QB}$ output of IC9 is routed via the DB0/OUT B path of IC3 to control the $\overline{WR}$ (read/write) input of the memory IC7.

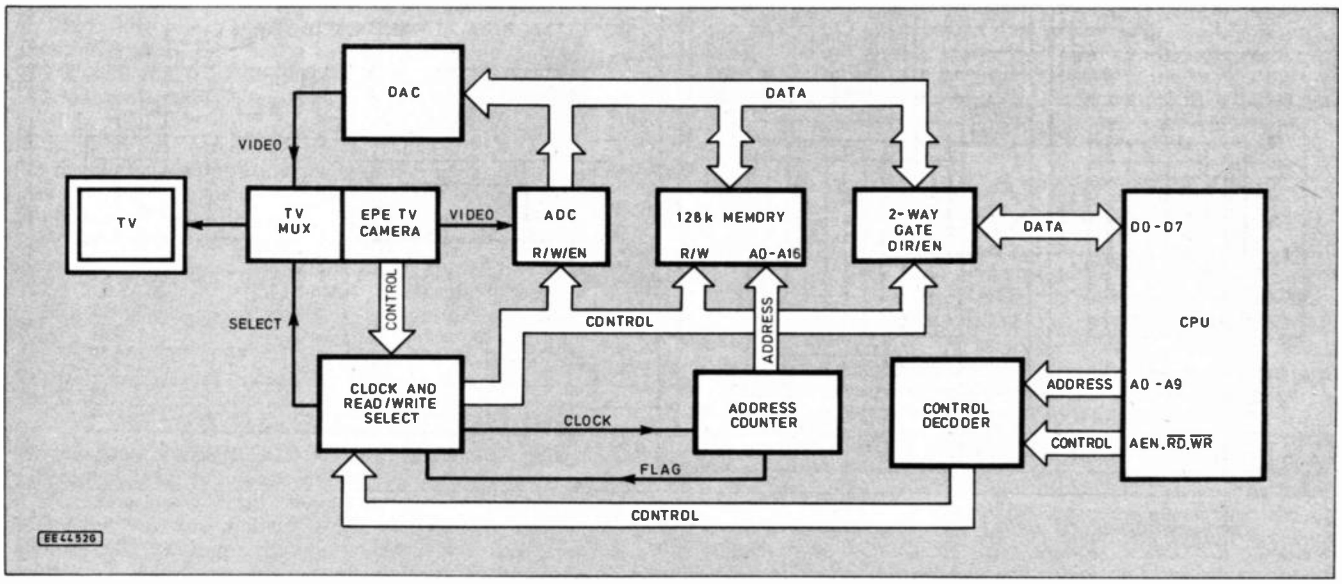


Fig. 18. Block diagram for the Frame Grab and it's schematic interconnection to the CCD TV Camera.

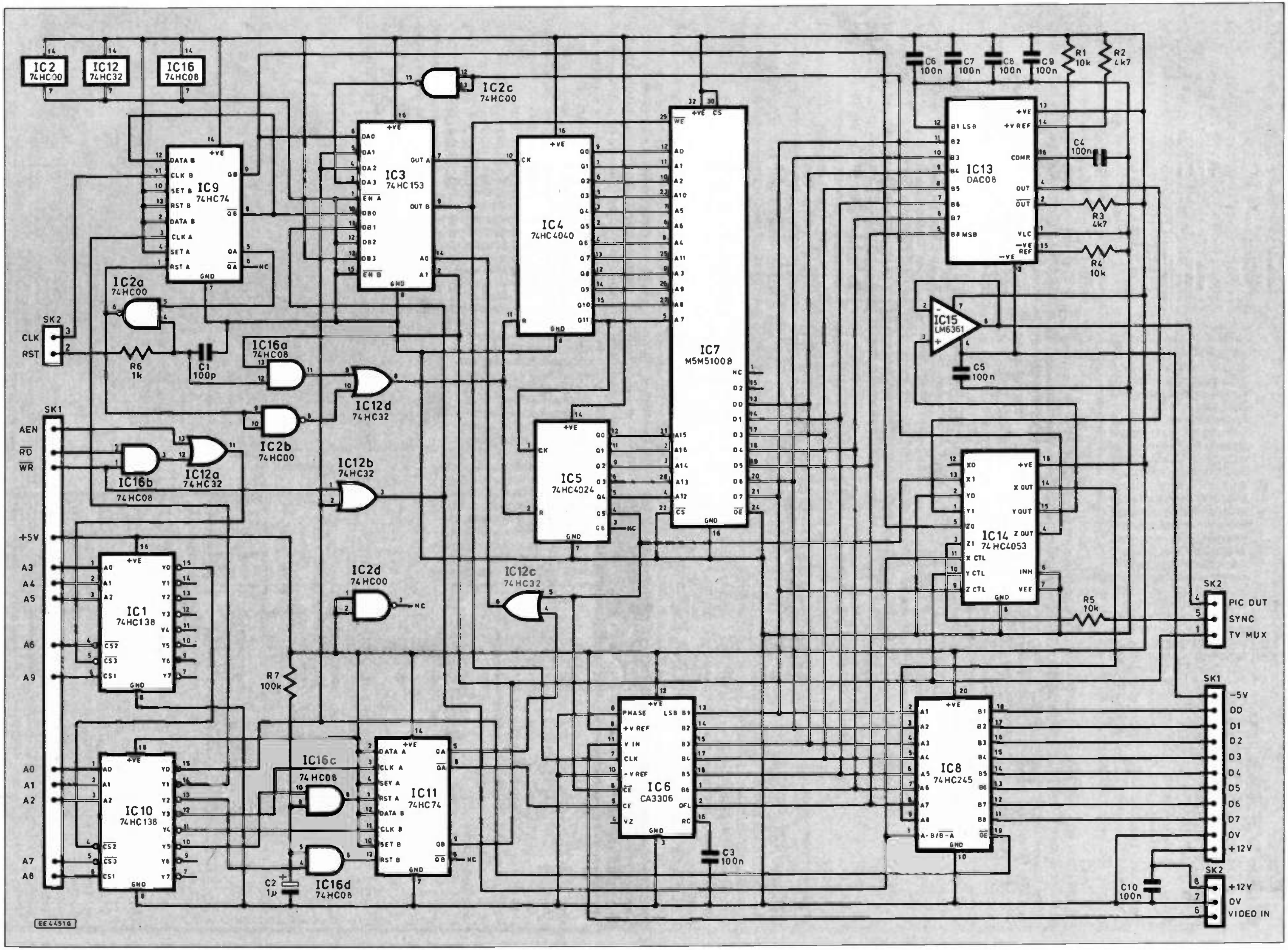


Fig. 19. Complete circuit diagram for the Frame Grab high speed analogue data interfacing "card".

VIDEO CONVERSION

The $\overline{QB}$ signal of IC9, via the DBO/OUT B path of IC3, also controls the clocking of the analogue-to-digital converter (ADC) IC6. Video signals from the camera are brought into IC6 pin 11, via socket SK2. In Mode 1, IC6 is enabled by the combination of a high logic level on pin 5, supplied from the $\overline{QA}$ output of IC11a, and by a low logic level on pin 6, controlled by IC5 Q5.

Each clock pulse on IC6 pin 7 causes the ADC to convert the analogue signal to a digital equivalent at outputs B1 to B6 and the OFL (overflow) pin 2. The outputs of IC6 are coupled via a data bus to the data lines of IC7. Synchronously with the conversion, the memory records the data, and its address counter is incremented.

The recording process continues until IC5 Q5 (pin 4) goes high which, via IC6 pin 6 ($\overline{CE}$), sets the ADC outputs to a high-impedance state. Simultaneously, via OR gate IC12c, Q5 switches IC3's signal routing to paths DA1/OUT A and DB1/OUT B. The FG has now automatically been set for Mode 2.

INPUT TO COMPUTER

In Mode 2, the Frame Grab memory address clocking and stored data reading are controlled by the computer.

A Data-Ready signal is made available to the computer by routing the high output from IC5 Q5 via path X1/X OUT of the triple 2-way gate IC14 to A8 (pin 9) of the octal 2-way gate IC8.

The A1 to A8 and B1 to B8 data lines of IC8 can be routed in either the A to B, or B to A direction, as controlled by the logic level on IC8 pin 1. In either direction, the data lines can be enabled by setting IC8 $\overline{OE}$ low.

In Modes 1 and 2, IC8 is set for the A to B direction. At any time during these modes the computer can read data from IC8 by making a read call to address &h300. The call takes IC10 pin 2 (Y0) low, which in turn sets IC8 $\overline{OE}$ low, so enabling the computer to read the output data.

When the computer has recognised that IC5 Q5 (pin 4) is high it can start reading valid data from the memory IC7, which is held in read mode throughout FG Mode 2. In Mode 2, each call to &h300 also sends a clock pulse via IC3 to IC4, so incrementing the memory address count.

The computer continues to read from &h300 until it has input all the data it requires from the memory. The amount of data will normally be less than the full memory contents.

Should the computer try to read more data than the memory address counter permits, IC5 Q5 will go low and the FG will automatically return to Mode 1. Software should take this into account.

Upon completion of its data input, the computer can send a reset signal to the FG by making a write call to &h301. The FG then awaits the next start signal from the camera, upon receipt of which the next batch of video data will be recorded.

Processing of the input video data is now up to the controlling software. The TV receiver will continue to show a live picture and be unaffected by the actions of the Frame Grab and computer. Until told otherwise, that is!

COMPUTER TO TV REPLAY

Any form of computer data can be output to the TV receiver via the Frame Grab and CCD TV Camera. The data can be that which has just been input from the camera, or previously recorded and stored on disc, or a picture which has been created entirely from software.

The computer's output data is recorded into the FG's memory, at a rate to suit software, in Mode 3. The memory replay rate is then placed under control of the camera's high speed clock and sync signals, in Mode 4.

COMPUTER TO FRAME GRAB

To set the FG for Mode 3, the computer makes a write call to &h303. IC10 Y3 (pin 12) goes low, triggering IC11a $\overline{QA}$ (pin 6) low, so disabling ADC IC6. IC11a QB (pin 5) goes high and, via OR gate IC12c, forces a high logic level on IC3 A0 (pin 14). Input A1 (pin 2) remains held low by IC11b QB (pin 9), therefore IC3 is set for the same routing as in Mode 2.

The computer now writes data to the FG at &h300. As in Mode 2, the action increments the memory address counter and enables the bus gate IC8. The action also causes a negative-going pulse from the computer's $\overline{WR}$ line to be passed through OR gate IC12b to IC8 and IC3.

The pulse briefly changes the data direction of IC8 to the B to A route and, via IC3 DB1/OUT B path, sets the memory to write mode. As a result, the memory records the data sent by the computer.

Byte-by-byte, line-by-line, the data for one TV picture frame is recorded into the FG memory. Only six bits per byte are used for picture data. The seventh bit, sent to memory line D7, is used for sync purposes, being set high by software for one count at the end of each picture line.

The eighth data line (computer line D7) is not used in Mode 3. Although the bit logic is passed through IC8, it is disconnected from IC5 immediately IC14 is switched to the X0/X OUT path when IC8 is set for the B to A direction.

COMPONENTS

Resistors

R1, R3, R5	10k (3 off)
R2, R4	4k7 (2 off)
R6	1k
R7	100k

All resistors 0·25W 5% carbon film or better.

Capacitors

C1	100p polystyrene
C2	1µ elect. 63V
C3 to C10	100n polyester (7 off)

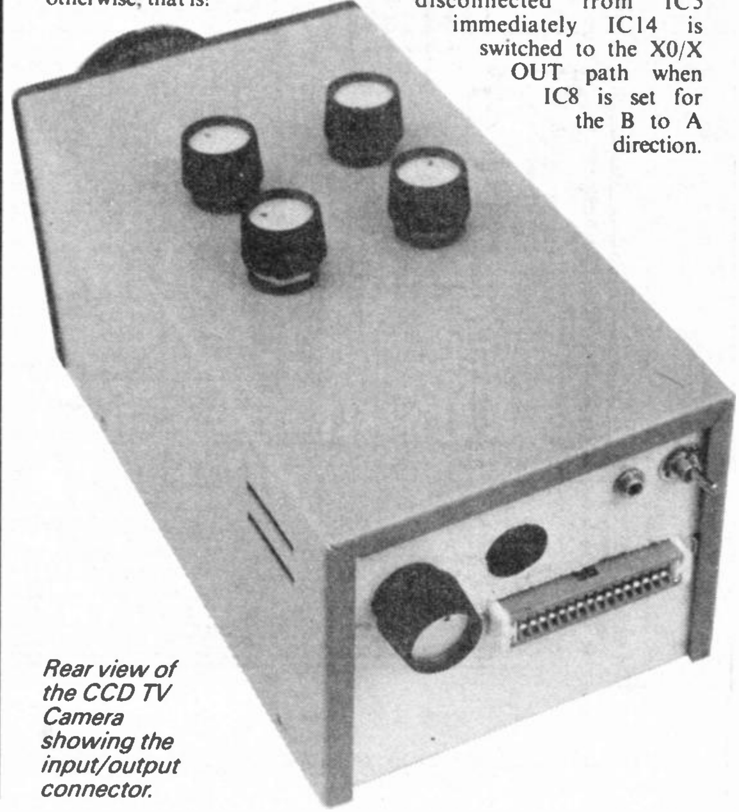
Semiconductors

IC1, IC10	74HC138 1-of-8 decoder (2 off)
IC2	74HC00 quad 2-input NAND gate
IC3	74HC153 dual 4-input data selector
IC4	74HC4040 12-stage binary counter
IC5	74HC4024 7-stage binary counter
IC6	CA3306 6-bit flash ADC
IC7	M5M51008-P12 131072-word by 8-bit CMOS SRAM (see text)
IC8	74HC245 octal tri-state non-inverting bus transceiver
IC9, IC11	74HC74 dual type-D flip-flop (2 off)
IC12	74HC32 quad 2-input OR gate
IC13	DAC08 or DAC0800 8-bit DAC
IC14	74HC4053 triple 2-channel analogue multiplexer
IC15	LM6361 high speed op. amp
IC16	74HC08 quad 2-input AND gate

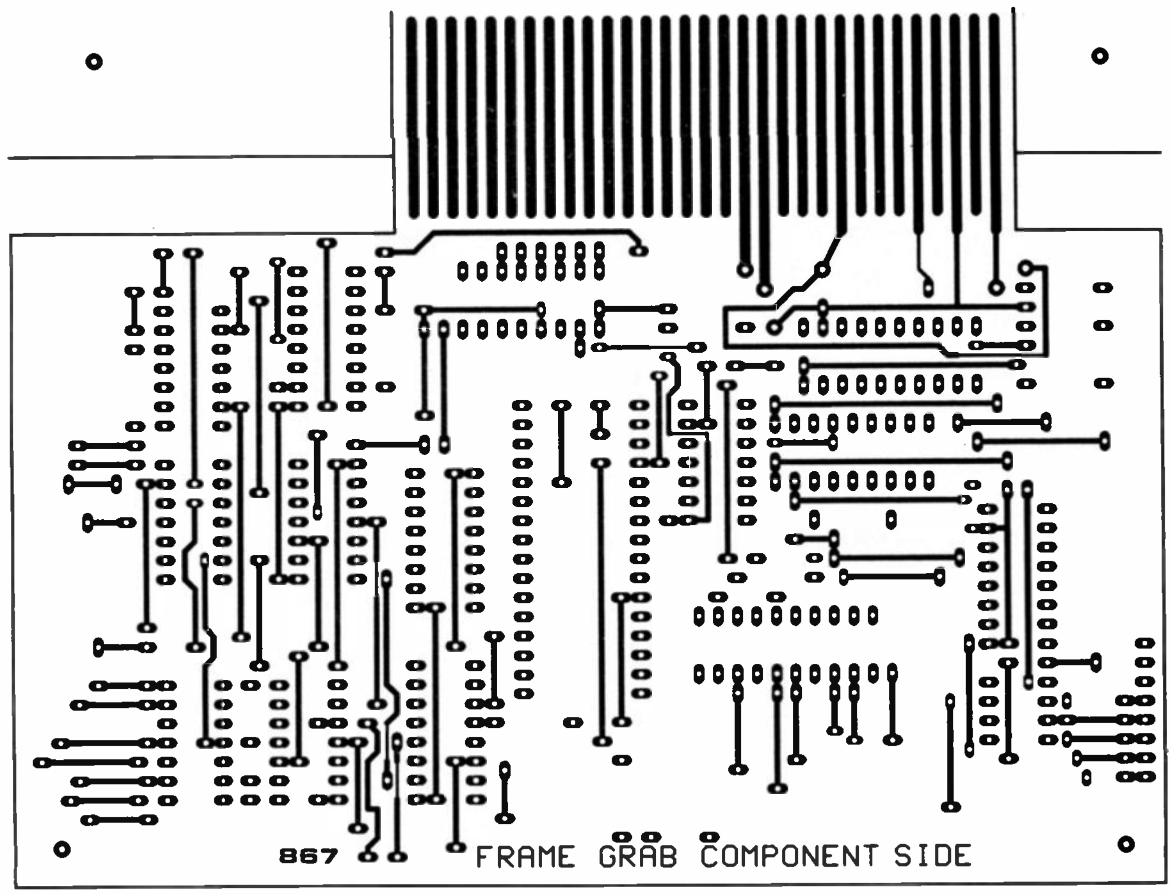
Miscellaneous

Double-sided PTH printed circuit board available from the *EPE PCB Service*, code 867; 8-pin d.i.l. i.c. socket; 14-pin d.i.l. i.c. socket (6 off); 16-pin d.i.l. i.c. socket (6 off); 18-pin d.i.l. i.c. socket; 20-pin d.i.l. i.c. socket; 32-pin d.i.l. i.c. socket; SK1 is the computer's expansion socket; SK2 p.c.b. mounting edge connector socket 8-pin; 31-way double-sided PC-compatible expansion socket (see text); ribbon cable, stereo twin-screened cable, 4-way cable, lengths to suit; 24 s.w.g. tinned copper wire (see text); solder etc.

Approx cost guidance only **£82**



Rear view of the CCD TV Camera showing the input/output connector.



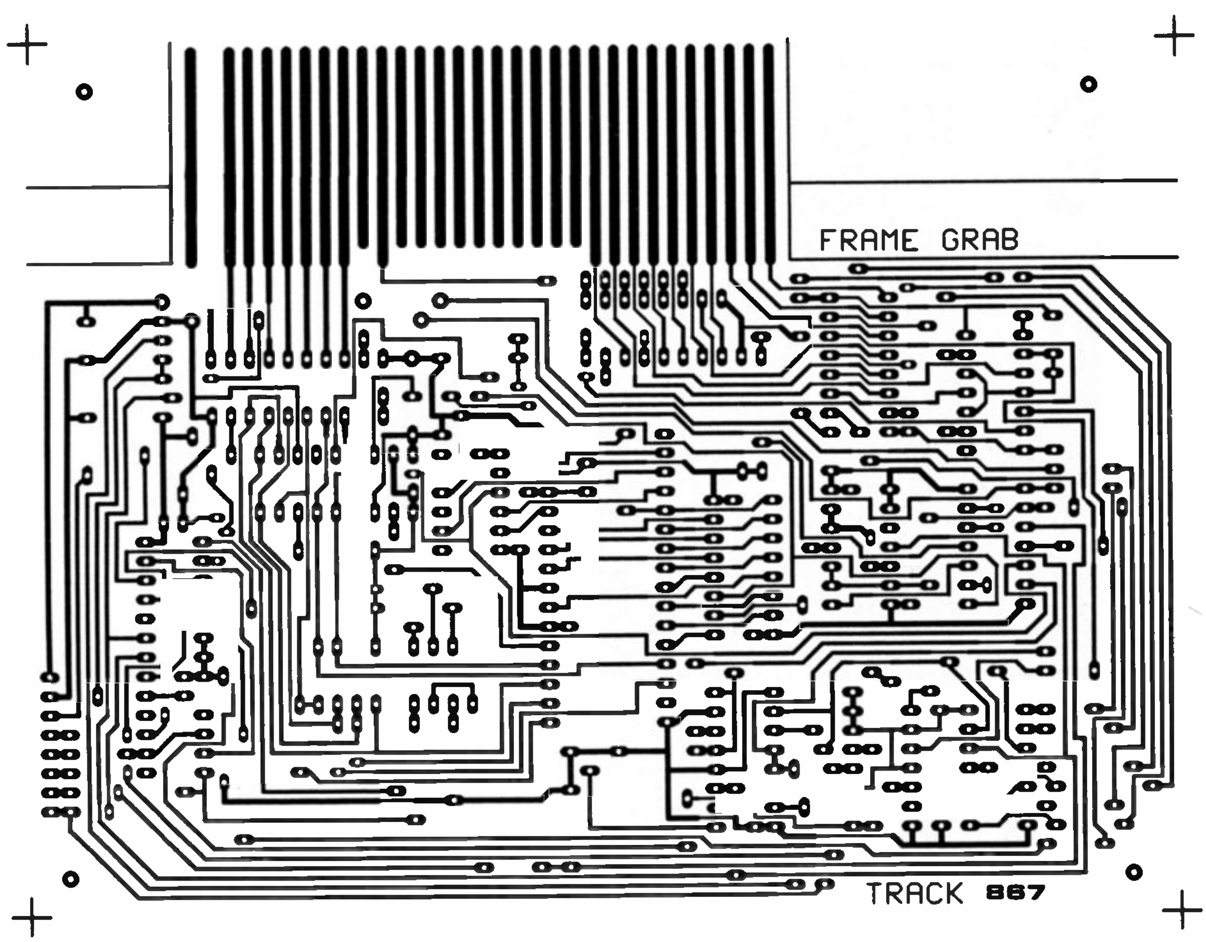


Fig. 20. Full size component side (top) and undeside copper foil master patterns for the recommended double-sided plated-through-hole (PTH) Frame Grab Board.

FG MEMORY OUTPUT TO TV

In Mode 4, memory data is repeatedly output onto the data bus and to the digital-to-analogue converter (DAC) IC13. Since software can digitally modify the effective signal level, the DAC has been given a fixed output conversion range, as set by resistors R1 to R4.

From the DAC IC13, the converted signal passes through gate IC14, buffer op.amp IC15, and back to the camera, via SK2, for routing to the TV receiver.

After a full frame of picture data has been transferred to the FG memory, the computer makes a write call to &h304. IC10 Y4 goes low, triggering IC11b QB high.

When IC11b QB is high, the DAC output is switched through IC14 Y1/Y OUT path to the op.amp, and out to the camera. Until this point the opamp input has been grounded via the IC14 Y0/Y OUT path.

IC11b QB is also fed back to the camera, where a high QB level causes the camera multiplexer IC28 to route the FG video signal to the TV receiver.

The high QB level of IC11 is also applied to IC3 A1. Since IC3 A0 is still held high, data routing is set for the DA3/OUT A and DB3/OUT B paths. The latter path holds the memory in the read-only mode.

The DA3/OUT A path of IC3 routes high speed, but gated, clock signals to IC4 pin 10. The signals originate from the camera but, following their output from IC9 QB, are input to IC14 Z0. To IC14's Z1 input, via R5, are brought the combined line and frame sync signals from the camera. IC14's Z OUT signal is fed via inverting gate IC2c to IC3 DA3.

Data for each line of picture is output from the memory IC7 at the fast clock rate until memory line D7, the sync marker line, goes high. Applied to IC14 input Z CTL, the high level switches IC14's Z signal routing to the Z1-Z OUT path.

The clocking of IC4 now ceases until a line sync pulse from the TVC provides the next clock pulse. The memory is then stepped on to the next address, where output D7 is once again low. The counter is now back under control of the high speed clock signals. The routine repeats until all lines of screen data have been output.

Memory output synchronisation to the TV receiver frame rate is achieved by resetting the counter from the 50Hz start pulse generated by the camera. The pulse is brought in via R6 to one input, pin 12, of the AND gate IC16a. The other input, pin 13, is controlled by IC11a QB (pin 2).

When the latter is high, as it is in Mode 4, the 50Hz pulse passes through IC16a and OR gate IC12d to the reset inputs of IC4 and IC5. In the other modes, IC16a is held closed to the start pulses.

Once in Mode 4, memory data will be continually cycled out to the TV receiver via the TVC until Mode 1 is reselected. Because the sampled rate is half that of the live data rate, the picture quality will be slightly less sharp.

To set the FG back to Mode 1, the computer makes write calls to &h302 and &h305, resetting both halves of IC11. Resetting of IC11 also occurs at computer switch-on. The reset inputs of IC11 are controlled via AND gates IC16c and IC16d. At switch-on, the outputs of both gates remain low until capacitor C2 has charged up via resistor R7 to the gate trigger threshold, whereupon the outputs of both gates go high. Until that point is reached, both parts of IC11 are held reset.

CONSTRUCTION – FG CONTROL BOARD

The prototype topside component layout for the FG control printed circuit board (p.c.b.) is shown in Fig. 21. In keeping with the TV Camera, and to ensure consistent results, the final p.c.b. is a double-sided plated-through-hole (PTH) board and the full size top and underside copper foil master patterns are included in Fig. 20. This board is available from the *EPE PCB Service*, code 867.

The board has been designed with the edge-connector tracks longer than are needed for the computer socket. Using a small hacksaw, cut off the excess length up to the printed marker line seen in Fig. 21 The removed section is a plug suitable for use with the test board described later.

As advised for the TV Camera, the FG p.c.b. has been manufactured as a double-sided board with PTH (plated-through-hole) interconnections between track sides and none of the link wires shown in the component layout of Fig. 21 are required. The link wires *are needed*, though, if it is decided to make up your own single-sided non-PTH board.

Board construction is fairly straightforward and should start with the i.c. sockets, this gives a handy guide for positioning of the other components. However, if you have made your own single-sided board, then the link wires *must* be soldered in position and double checked first as some are located beneath the i.c. holders, see Fig. 21. The use of 24 s.w.g. tinned copper wire is recommended for the links.

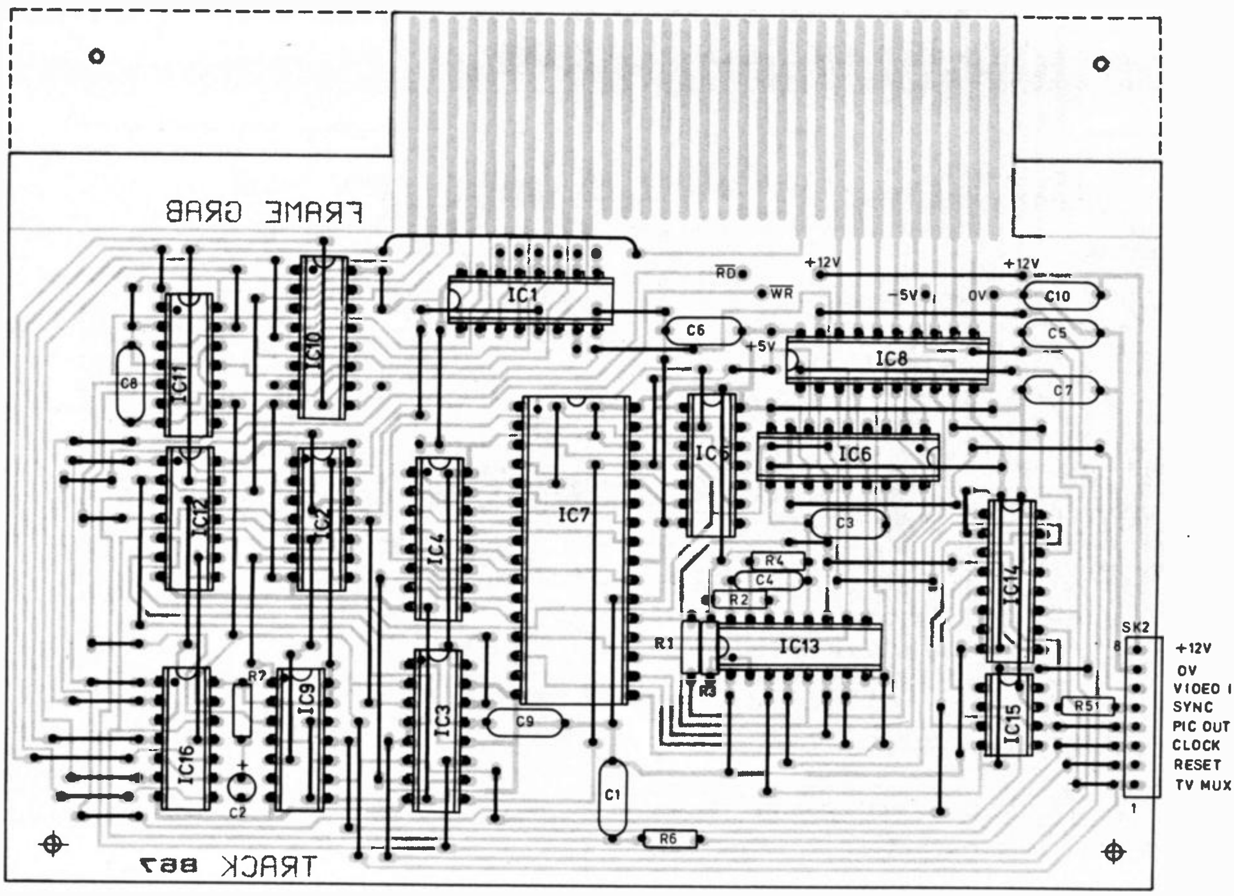


Fig. 21. Printed circuit board component layout for the Frame Grab board. The layout above is for the single-sided prototype version and includes all necessary link wires. The component layout for the recommended double-sided board is identical, but without all the link wires.

When inserting the i.c.s into their holders make sure that they are the correct way round and also check the polarity of the electrolytic capacitor C2 before soldering it in place on the board. The rest of the capacitors and resistors are not polarity conscious and can be connected either way round.

Finally, to complete the FG control board, the multi-pin socket SK2 and solder pins can be mounted on the board.

TEST BOARD

The copper tracking for a combined test and extension plug board is shown in Fig. 22. This board is part of the combined camera video board and is also available from the *EPE PCB Service*, code 866. A component mounting drawing is not needed for this board.

Carefully cut the board into its two main parts. The larger part can have a PC-compatible edge connector socket soldered into the centre holes for use in detailed test examination of the control board.

Cut the small board part in half to make two boards each having eight tracks. These sections are used as 8-way plugs for interconnecting the Frame Grab and CCD TV Camera.

CAMERA CONNECTIONS

The FG to TVC interwiring details are shown in Fig. 23. Note the use of twin-screened cable, which also carries the power supply. Normal stereo screened cable was used with the author's units. For the other connections, 4-way burglar alarm cable was used.

The maximum interconnection cabling length permissible is not known, but over four metres are currently used by the author. It is likely that much longer lengths can be used satisfactorily.

PRELIMINARY TESTS

Following complete assembly and checking of the board, but *before* any i.c.s are inserted or connections to the TVC made, plug the board into one of the computer's expansion sockets. The pinning order of the sockets is consistent between all PC-compatible computers.

Socket orientation within the computer, however, can vary between models. Fig. 24 shows the orientation found in an Amstrad 1640, the computer with which the author's unit is used.

If at any stage of testing, the computer fails to behave normally, immediately switch off and recheck the board, checking particularly for solder shorts between tracks or pins. All i.c.s are CMOS devices and the usual handling precautions should be observed.

Give the board a preliminary electrical integrity check by switching on the computer. Check again with all i.c.s inserted, except interface chip IC8. Check again with IC8 inserted, and again after the FG has been connected to the TVC, with switch S1 of the latter supplying power from the computer.

These initial separate tests narrow down the causes should the computer malfunction. Final tests can be made once the software has been loaded.

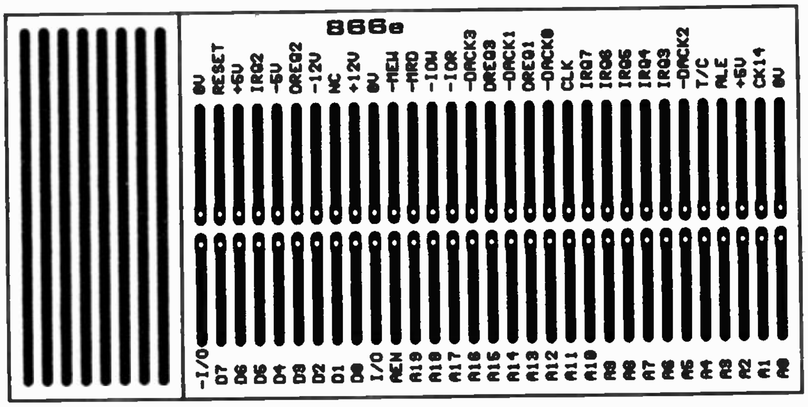


Fig. 22. Combined test board and extension plug copper track master.

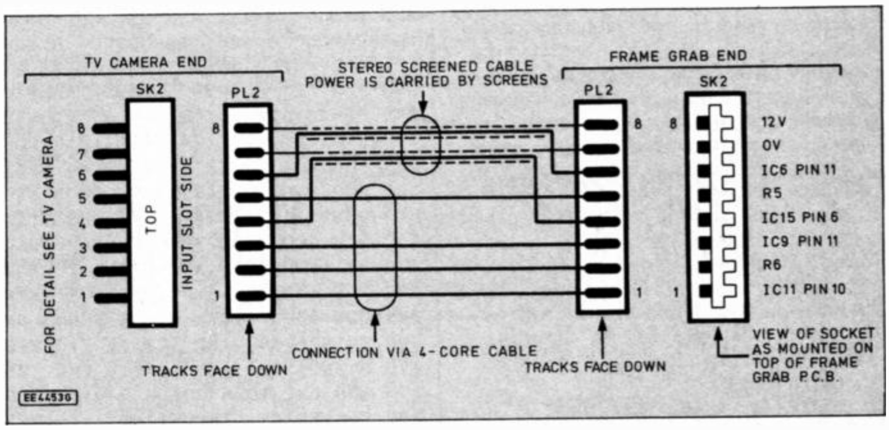
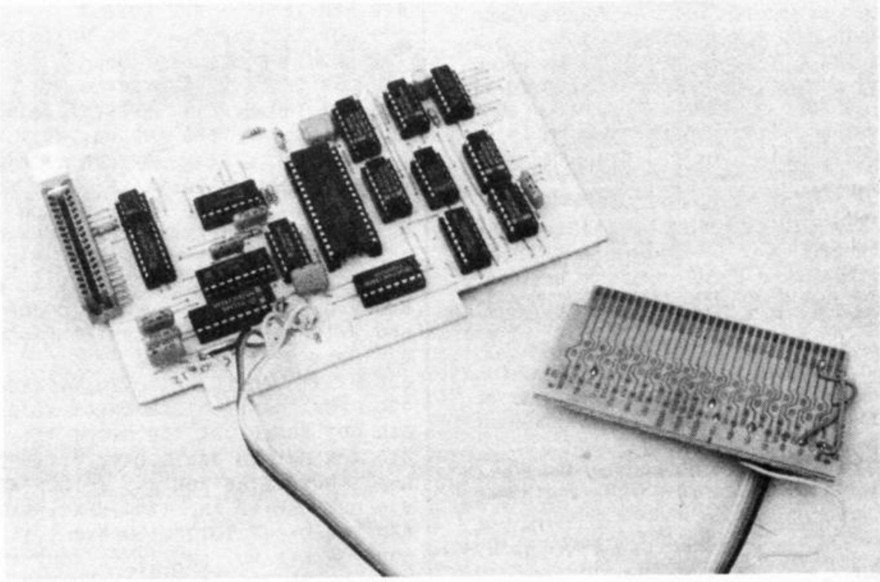


Fig. 23. Interwiring details between the CCD TV Camera and Frame Grab board.



Complete Frame Grab board wired to the test board.

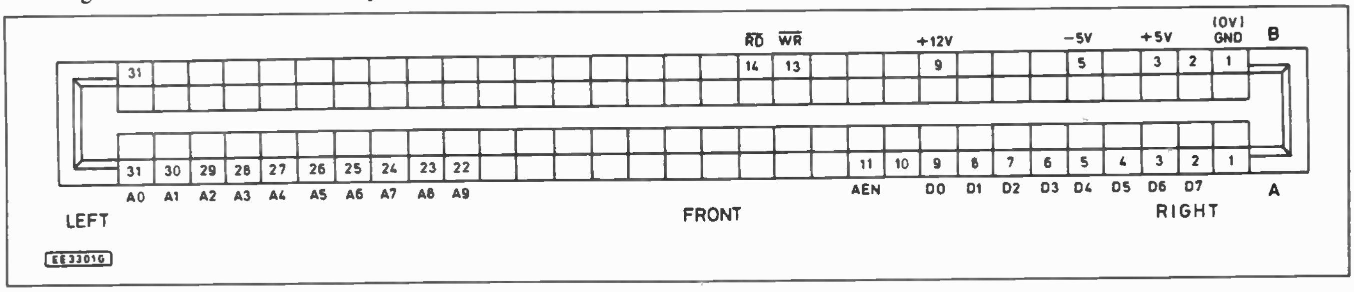


Fig. 24. Pinning details for the Amstrad 1640 computer expansion socket.

TROUBLE-SHOOTING

If the FG misbehaves and you have difficulty finding the likely soldering error, the test extension board referred to above can be used. Its use is suggested since it may be difficult to test-probe the FG board once inserted into the computer.

Solder lengths of ribbon cable (about a metre or so) to the relevant tracks of both sides of the extension plug, and to the equivalent tracks on the extension socket board. Insert the plug into the computer and the FG board into the extension. Probing the Frame Grab board is now practical.

For many checks, it may be feasible to use the l.e.d. test board described with the TV Camera. Although direct reading of the computer address and data lines cannot be made with the TVC test board, many other parts of the FG circuit can be monitored by the l.e.d.s. Slowing down the TVC clock rate and stepping through the software routines should help.

TEST SOFTWARE

Examples of how the computer can process the camera data is given in the software Listing 1. It is written in GW-Basic, but is also compatible with QuickBasic.

Running the Test 1 and Test 2 routines will confirm that the FG is inputting video data correctly, after which the other routines can be run.

It cannot be denied that Basic is a slow language for inputting and processing high speed data. In the end, though, it still achieves results and readers who use and expand the Basic software shown will find the FG a valuable extension to the TVC. None-the-less, readers who can write machine-code are recommended to do so.

As an example of the speed increase offered by machine code, the routine which inputs data from the TVC and displays it in computer Screen Mode 7 takes about five minutes in GW-Basic on an Amstrad 1640, but only a couple of seconds in 8086 machine code. Outputting to disc, printer, or back to the TVC, are similarly speeded up.

OTHER USES

The Frame Grab can be used separately from the CCD TV Camera as a general purpose ADC/DAC computer interface. The maximum data acquisition rate is about 8MHz, as restricted by the response speed of memory IC7 (M5M51008-P12, but faster versions may be used). The ADC is capable of handling a clock rate of 15MHz, while the DAC has a maximum limit of about 12MHz.

When used independently of the TVC, the FG must be supplied with a start pulse sent via resistor R6, a clock signal sent to IC9 pin 11, and an analogue signal in the range 0V to +5V sent to IC6 pin 11.

If software is written to prevent IC7 D7 from going high in Mode 4, resistor R5 can be grounded, otherwise an additional sync pulse must be provided to this point.

Software controls the modes as follows (values in brackets are the decimal equivalents):

LISTING 1: TEST PROGRAM

```
100 REM FRAME GRAB/TV CAMERA TEST PROGRAM
110 REM PROGRAM MAY BE MODIFIED AND ENHANCED AS DESIRED
120 OUT 770,0:OUT 773,0:REM RESET FRAME GRAB TO MODE 1
130 S=9:SCREEN (S):REM SET SCREEN MODE (MAY BE 1,2,7,8 OR 9)
140 REM SET PICTURE PARAMETERS
150 W(1)=312:W(2)=360:W(7)=312:W(8)=360:W(9)=360
160 L(1)=199:L(2)=199:L(7)=199:L(8)=199:L(9)=288
170 D(1)=4:D(2)=3:D(7)=7:D(8)=15:D(9)=15:DIM C%(64):CLS
180 REM W(X)=PICTURE WIDTH IN PIXELS:L(X)=LINES:D(X)=COLOUR LIMIT
190 REM ANY OF THE NEXT 5 'GOTO' STATEMENTS MAY BE REINSTATED
200 REM GOTO 390:REM GRAPH
210 REM GOTO 470:REM TEST1
220 REM GOTO 500:REM TEST2
230 REM GOTO 570:REM RECORD FROM CAMERA TO DISC
240 REM GOTO 620:REM OUTPUT DISC TO CAMERA
250 CLS:PRINT"INPUTTING CAMERA PIC FOR SCREEN";S
260 REM SET COLOUR LOOKUP TABLE:SEE NOTE 1
270 SS=40:SF=50:FOR A=0 TO 4:C%(A)=0:NEXT:FOR A=5 TO SS-1:C%(A)=1
280.NEXT:D=D(S)/(SF-SS+1):B=0:FOR A=SS TO SF:B=B+D:C%(A)=B:NEXT
290 FOR A=A TO 63:C%(A)=D(S):NEXT:GOSUB 350
300 FOR D=0 TO L(S):E=0:GOSUB 330:FOR A=1 TO W(S):F=INP(768) AND 63
310 PSET (A,D),C%(F):NEXT:NEXT:IF S<7 THEN 530 ELSE STOP
320 REM LOOK FOR SYNC MARKER (VALUE BELOW ABOUT 6, USUALLY 0)
330 IF (INP(768) AND 63)>5 THEN 330
340 FOR A=1 TO 16:F=INP(768):NEXT:RETURN:REM BYPASS SYNC MARK
350 OUT 769, 0:REM RESET FRAME GRAB COUNTER
360 F=INP(768) AND 128:IF F>0 THEN 360:REM WAIT TILL IC5 Q5 LOW
370 F=INP(768) AND 128:IF F=0 THEN 370:REM WAIT TILL IC5 Q5 HIGH
380 FOR B=1 TO 6:GOSUB 330:NEXT:RETURN:REM BYPASS FIRST 6 LINES
390 CLS:PRINT "INPUTTING";L(S)*W(S);"GRAPH SAMPLES"
400 PRINT:PRINT "BE PATIENT FOR A FEW MINUTES!":GOSUB 330
410 K=0:FOR D=0 TO 63:C%(D)=0:NEXT:FOR D=0 TO L(S):GOSUB 330
420 FOR G=1 TO W(S):F=INP(768) AND 63:C%(F)=C%(F)+1:NEXT:NEXT:PRINT
430 PSET (0,180):FOR D=0 TO 63:E=180-(C%(D)/128):IF E<0 THEN E=0
440 LINE -(K,E),1:K=K+4:NEXT:REM OCCURRENCE OF INPUT VALUE
450 K=0:FOR D=0 TO 6:LINE (K,175)-(K,185),1:K=K+40
460 NEXT:STOP:REM MARKER AT 10 POINT INTERVALS OF VALUE FROM 0 TO 63
470 REM TEST1 - SEE NOTE 2
480 OUT 769,0:FOR A=1 TO 20:PRINT INP(768) AND 128;:NEXT
490 PRINT:PRINT:GOTO 480
500 REM TEST2 - SEE NOTE 3
510 OUT 769,0:PRINT "RESET":PRINT:FOR A=1 TO 1200
520 PRINT INP(768) AND 63;:NEXT:PRINT:PRINT:GOTO 510
530 REM BLOCK SAVE PICTURE TO DISC - SEE NOTE 5
540 DEF SEG=&HB800:BSAVE "PICTURE",0,16384:DEF SEG:STOP
550 REM BLOCK LOAD PICTURE FROM DISC - SEE NOTE 5
560 CLS:DEF SEG=&HB800:BLOAD "PICTURE",0:DEF SEG:STOP
570 PRINT "OUTPUT TV CAMERA TO DISC":REM SEE NOTE 6
580 OPEN "CAMPIC" FOR OUTPUT AS £1:GOSUB 350:G=390:FOR D=1 TO 286
590 E=0:LOCATE 2,1:PRINT D:GOSUB 330:FOR H=1 TO 2:FOR A=1 TO G/2
600 F=INP(768) AND 63:PRINT £1,CHR$(F+63);:NEXT:PRINT £1,""
610 NEXT:NEXT:CLOSE £1
620 PRINT "OUTPUT DISC TO TV":REM SEE NOTE 7
630 OPEN "CAMPIC" FOR INPUT AS £1
640 OUT 769,0:OUT 770,0:OUT 771,0:REM SET FG TO MODE 3
650 FOR D=1 TO 286:LOCATE 4,1:PRINT D:FOR H=1 TO 2
660 INPUT £1,A$:FOR A=1 TO LEN(A$):F=ASC(MID$(A$,A,1))-63
670 OUT 768,(F AND 126):NEXT:NEXT:OUT 768,1:NEXT:CLOSE £1
680 FOR D=287 TO 326:LOCATE 4,1:PRINT D:REM FILL MEMORY
690 FOR A=1 TO (LEN(A$)*2):OUT 768,62:NEXT:OUT 768,1:NEXT
700 OUT 769,0:OUT 772,0:REM SET FG TO MODE 4
710 PRINT "HOLDING - PRESS ANY KEY TO RESET TV TO NORMAL"
720 IF INKEY$="" THEN 720
730 OUT 770,0:OUT 773,0:STOP:REM RESET TO MODE 1
```

MODE 1:

(automatic record from ADC to FG memory until IC5 Q5 high)

Read or Write &h302 (770)	Reset IC11b
Read or Write &h305 (773)	Reset IC11a
Read or Write &h301 (769)	Reset address counters
Read &h300 (768)	Read FG data bus

MODE 2:

(automatically available following end of Mode 1)

Read &h300 (768)	Read contents of FG memory

MODE 3:

(output computer data to FG memory)

Read or Write &h303 (771)	Set IC11a
Read or Write &h301 (769)	Reset address counters
Write &h300 (768)	Write to FG memory

MODE 4:

(Output FG memory via DAC to external world)

Read or Write &h301 (769)	Reset address counters
Read or Write &h304 (772)	Set IC11b

PROGRAM NOTES

The following notes are those referred to in the test program Listing 1.

1: COLOUR LOOK-UP TABLE

The colour look-up table may be changed or re-created as desired, even randomised. The values of SS = 40 and SF = 50 in the table calculation give the minimum and maximum values within which the calculated range can be placed and should be selected after the Graph routine has been run.

The graph represents the number of times an input value has occurred, it is not an amplitude display in the normal sense. It will be colourfully informative to experiment with the table values.

2: TEST 1

This routine checks for the resetting of the FG. Each loop should start with one or more 128s followed by a few zeroes, followed by more 128s. The loop length may be changed.

3: TEST 2

Several consecutive values below about numeral 5 (line sync pulses) should appear amongst other moderately consistent 2-digit (video data) values. Adjusting FG control potentiometers VR5 and VR7 should cause video values to be changed at each RESET call. The loop length may be changed.

4: SCREEN DUMP TO PRINTER

No routine is shown for this but it is available for Screen 1 via MS-DOS. Return to MS-DOS, type GRAPHICS <RETURN>, then reload the FG software. To print a complete picture to Screen 1, press SHIFT and PRTSC keys together. See MS-DOS books for more information.

Warning, the MS-DOS Graphics software consumes much memory! All REM statements in the FG Test listing may need to be deleted to run it, and maybe the Test routines. It is best to write a customised routine for graphics screen outputting to a printer.

5 – SAVING IN SCREENS 7 TO 9

Only Screens 1 and 2 can be block-saved from the test software. Saving from other screen modes is too complex to describe here. Note that BLOAD and BSAVE do not appear to work correctly when Graphics has been called from MS-DOS 3.1. The file names shown may be changed as preferred (as they may with the direct recording and replay routines).

6 – DIRECT RECORDING FROM CAMERA

The line length value for G may need changing slightly to optimise replay line lengths. The value is dependent upon the sampling rate as determined by VR2 in the TVC.

7 – REPLAY FROM DISC TO TV

The final output value of each picture line must be decimal 1, which is the sync marker value. The value for F (the video outputting value) can be modified as desired, by adding to it, subtracting, multiplying, dividing, inverting, etc. ANDing F with 126 prevents undesired sync marker setting. Final TV picture replay intensity can be changed using VR8 of the TVC.

CONSTRUCTORS NOTE

The author has also written a control program in 8086 assembler and GW-Basic, but which is too long to permit publication here. However, he will be happy to supply readers with a *disc copy* of the software for £15 all inclusive (see *Shoptalk*).

The software speeds up the main processing events and can have its Basic commands extended by the user. It also includes machine code routines for outputting to printer and saving to disc from screen modes 0, 1, 2, 7, 8 and 9.

The disc is only available in 5·25 inch SSSD format, and is for use with readers' own GW-Basic software on PC-compatible computers which recognise 8086 machine code. Included on the disc are the 8086 source code and the published test program. □

We have been asked about the possibility of using the Camera with an astronomical telescope. We are investigating this an hope to publish details soon.

Special Series

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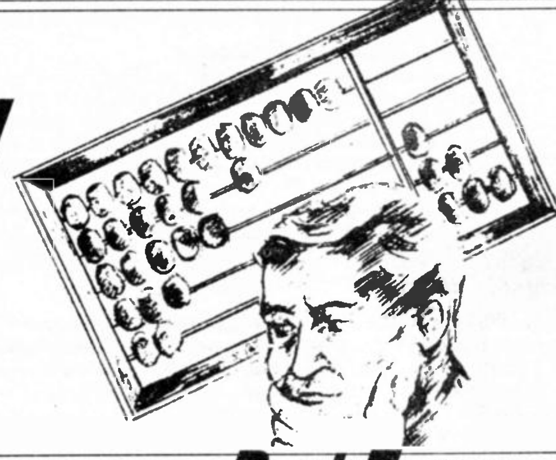


STEVE KNIGHT

Part Four

This series is designed to help you make your way, at your own pace, through the often imagined fears of mathematics, as this is applied to electronic and electrical engineering matters.

THE two basic instruments for measurement purposes are the ammeter and the voltmeter. Whatever else we might do without, we cannot do without these. A simple study of them also gives us plenty of opportunity to further practice Ohm's law.

AMMETERS AND VOLTMETERS

An ammeter is an instrument with a *low* internal resistance used to measure current. It has to be placed in *series* with that part of a circuit through which the current is passing so that the same current flows through both parts, see Fig. 4.1(a). A *low* internal resistance is necessary as one with a high resistance, particularly if used in an otherwise low resistance path, will reduce the current to a lower value and the meter indication will be less than the actual current that was flowing before the ammeter was introduced. Hence the act of making the measurements affects the things we are trying to measure.

The same is true when a voltmeter is used. A voltmeter must have a very *high* resistance and be used to measure potential difference. It is therefore placed in *parallel* with the component across which the p.d. is to be measured, see Fig. 4.1(b). A high resistance is necessary as a low resistance will seriously affect the p.d. by its parallel presence, effectually lowering the value of the resistance which existed in the circuit before the voltmeter was connected.

The following worked examples illustrate these points. As usual, the only bit of mathematical equipment you need is Ohm's law.

1. The resistance of a coil is measured using the circuit of Fig. 4.2. The ammeter has a resistance of $R_A = 0{\cdot}25\Omega$ and reads 0·75A, and the voltmeter reads 10·5V. What is (a) the approximate resistance of the coil, (b) the actual p.d. across the coil, (c) the true resistance of the coil.

Ignoring the presence of the ammeter resistance, and applying Mr Ohm directly to the meter readings we have

(a) Approximate resistance of the coil $= \frac{V}{I} = \frac{10{\cdot}5}{0{\cdot}75} = 14\Omega$

This is approximate because *all* of the applied 10·5V does not appear across the coil. So carrying on

(b) Voltage drop across the ammeter $= I \times R_A = 0{\cdot}75 \times 0{\cdot}25$

$= 0{\cdot}1875V$

$\therefore$ the voltage across the coil $= 10{\cdot}5 - 0{\cdot}1875 =$ **10·3125V**

(c) The true resistance of the coil $= \frac{10{\cdot}3125}{0{\cdot}75} =$ **13·75Ω**

Notice here that it is *only* the resistance of the ammeter which introduces an error in the measurement of the coil resistance; the resistance of the voltmeter does not affect things.

If the coil resistance was high relative to the ammeter, the error would be very small, hence we might conclude that this way of arranging the instruments was best suited to the measurement of *high* resistance.

Let us try the alternative arrangement of having the voltmeter directly across the resistance we are measuring; this circuit is shown in Fig. 4.3.

2. A relay coil resistance is being measured: the voltmeter reads 25V and has an internal resistance of 25kΩ, while the ammeter reads 5mA. Find (a) the approximate resistance of the coil, (b) the true resistance of the coil.

We can deduce from this arrangement that the voltmeter will indicate the p.d. acting across the coil, but the reading on the ammeter will *not* be the true value of the current flowing through the coil, as a proportion of the 5mA will now be passing through the voltmeter.

Ignoring the effect of the voltmeter, then, we have

(a) Approximate resistance of the coil $= \frac{V}{I} = \frac{25}{5} \times 10^3\Omega$

$=$ **5,000Ω**

(b) We need first to find what current is flowing through the voltmeter. This will be given by

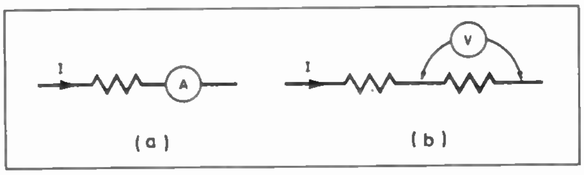
$$I_V = \frac{\text{voltage across voltmeter}}{\text{resistance of voltmeter}} = \frac{25}{25{,}000}A$$

$$= \frac{1}{1{,}000}A = 1mA$$

$\therefore$ the current through the coil is $(5-1) = 4mA$

The true resistance of the coil $= \frac{V}{I_X} = \frac{25}{4} \times 10^3 =$ **6,250Ω**

The presence of the voltmeter, even with a resistance of 25kΩ, here has a serious effect on the current passing through the coil and hence upon its calculated resistance. If the coil resistance is low relative to the resistance of the voltmeter or (what is the same thing) the resistance of the voltmeter is high relative to the coil



Fit. 4.1. How ammeters and voltmeters are connected into circuits.

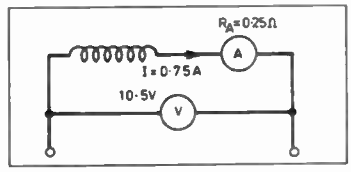


Fig. 4.2. What is the true resistance of the coil?

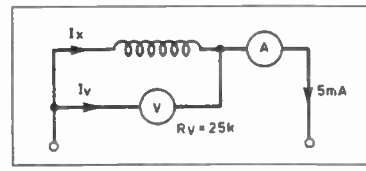


Fig. 4.3. What effect does the voltmeter now have?

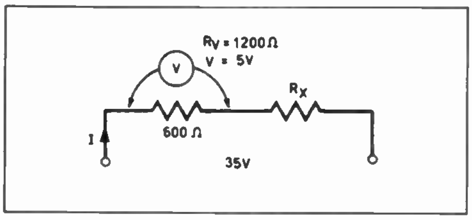


Fig. 4.4. A problem in resistance measurement.

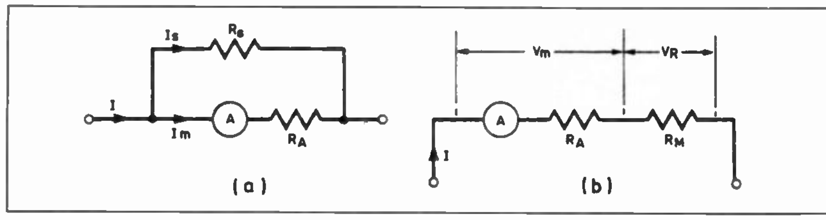


Fig. 4.5. Extending a current range at (a), and a voltage range at (b) using a basic sensitive meter.

resistance, the error would be much smaller, hence we might conclude that this circuit arrangement is best suited to the measurement of *low* resistance.

3. A 600Ω resistor in series with an unknown resistor R_X is connected to a 35V d.c. supply. A voltmeter having a resistance of 1,200Ω when connected across the 600Ω reads 5V. What is the value of R_X. Is this a true or an approximate solution?

The equivalent resistance of the 600Ω resistor and the 1,200Ω voltmeter in parallel is, looking at Fig. 4.4, and remembering the rule

$$\frac{600 \times 1{,}200}{600 + 1{,}200} = \frac{7{,}200}{18} = 400\Omega$$

Hence the potential indicated by the voltmeter (5V) is actually acting across a resistance of 400Ω, not 600Ω as it would be if the resistance of the voltmeter was infinitely great. Bear in mind that the voltmeter is not giving us a *wrong* indication – it is simply giving us the p.d. which is now existing across the *parallel* combination.

The current I in the circuit is therefore $\frac{V}{400} = \frac{5}{400} = 0{\cdot}0125\text{A}$

The p.d. across R_X is therefore $(35 - 5) = 30\text{V}$, and 0·0125A flows through it.

$$\therefore \quad R_X = \frac{30}{0{\cdot}0125} = \mathbf{2{,}400\Omega}$$

This is the true solution; the approximate answer would come if we *ignored* the resistance of the voltmeter. See if you can show that the approximate solution is 3,600Ω.

MULTIMETERS

A meter with a single fixed scale reading, whether ammeter or voltmeter, is rarely used as such in general electronic work. Instead, an analogue type of *low* current meter, say, 50 or 100μA full-scale-deflection (f.s.d.) is used and a range of parallel resistors **(shunts)** or series resistors **(multipliers)** are switched into the system to make a versatile combination reading a wide range of currents, voltages and resistance values; hence the name **multimeter.** An Avometer is an excellent example of such an instrument.

Digital meters are basically high resistance *voltage* measuring devices with a low basic range, typically 200mV for hand held models. A range of switched voltage dividers accommodate higher ranges of voltage while currents are measured by the voltage drop across known resistors through which the input current is passed.

There are a number of formulae relating to the problems of extending meter ranges but it is best, as always (and I keep repeating this), to simply apply Ohm's law to each particular situation.

EXTENSION OF CURRENT RANGES

To extend the current range of a basic meter, a shunt resistor R_S is connected in parallel with the meter, see Fig. 4.5(a), and from this we have $I = I_M + I_S$ where the p.d. across both meter and shunt is equal to $I_M R_A$ *or* $I_S R_S$.

To convert the basic meter to read voltage (and to extend such voltage ranges) a series multiplier resistor R_M is connected to the meter as Fig. 4.5(b) shows. From this diagram we can see that $V = V_R + V_M = IR_A + IR_M = I(R_A + R_M)$.

Let us apply these relationships (with a good dash of common-sense reasoning) to a few examples.

4. You have obtained a panel meter which has a f.s.d. of 0·5mA and an internal resistance of 360Ω. How would you adapt this meter to measure (a) currents up to 50mA, (b) voltages up to 50V?

To extend the current range calls for a shunt resistor R_S, and Fig. 4.6(a) shows the required arrangement. Let us forget about formulae and apply reasoning. The current *through the meter* must never exceed 0·5mA even when it is put into a circuit where up to 50mA may be flowing. Hence, for a maximum current of 50mA, the excess current $(50 - 0{\cdot}5) = 49{\cdot}5\text{mA}$ must be diverted through the shunt.

Now the voltage V developed across the 360Ω meter at its f.s.d.

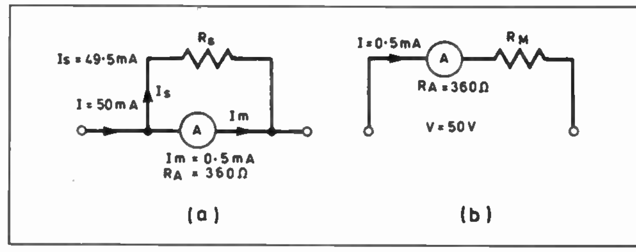


Fig. 4.6. Calculate the value of a shunt resistance R_S and a multiplier R_M

of $0{\cdot}5\text{mA} = 360 \times 0{\cdot}5 \times 10^{-3}$ volts or 0·18V. This same p.d. also exists across the shunt which carries a current of 49·5mA.

Hence $\quad R_S = \frac{0{\cdot}18}{49{\cdot}5 \times 10^{-3}} = \mathbf{3{\cdot}64\Omega}$

An alternative solution is to say that the ratio of the two currents is inversely proportional to the ratio of the resistance of meter and shunt, that is $I_S/I_M = R_M/R_S$.

Hence $\quad \frac{49{\cdot}5}{0{\cdot}5} = \frac{360}{R_S}$

and $\quad R_S = \frac{360 \times 0{\cdot}5}{49{\cdot}5} = \mathbf{3{\cdot}64\Omega}$

(b) To convert the 0·5mA ammeter into a 50V f.s.d. voltmeter calls for a series multiplier resistor and here the circuit of Fig. 4.6(b) is used. Again, the current through the meter must not exceed 0·5mA even when 50V is applied across the series combination. Hence the *total* circuit resistance of meter *and* multiplier must be such that only 0·5mA flows through it with 50V applied.

$$I = \frac{V}{R_A + R_M} \text{ or } 0{\cdot}5 \times 10^{-3} = \frac{50}{360 + R_M}$$

$$\therefore \quad 360 + R_M = \frac{50}{0{\cdot}5 \times 10^{-3}} = 100 \times 10^3 = 100{,}000\Omega$$

$$\therefore \quad R_M = 100{,}000 - 360 = \mathbf{99{,}640\Omega}$$

Notice that although it is now serving as a voltmeter, the basic meter is still acting as a sensitive ammeter and indicating the circuit current.

BRIDGE CIRCUITS

If the electrical potential at each end of a conductor is the same, no current will flow through the conductor. The potential does not have to be zero; it can be +5V or −8V or any other level you care to name. Provided there is no potential *difference* between the ends, there can be no flow between them. This is the principle on which measuring bridges are based.

Suppose two wires, of arbitrary lengths and overall resistances, are wired in parallel across a voltage source as shown in Fig. 4·7. The current I divides into parts I_1 and I_2 at the junction points A and these re-unite at junction C. The potential gradient acting between points A and C is identical for both wires. If any point B is now chosen on the upper wire, it is always possible therefore to find a point D on the lower wire which is at the same potential as point B. Hence if B and D are joined together by a piece of wire (or a current meter) no current will flow and a meter will read zero. This is an elementary **Wheatstone bridge**.

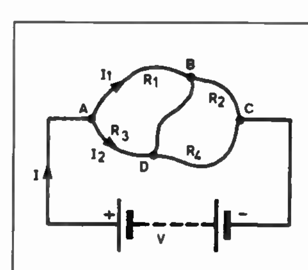


Fig. 4.7. An elementary Wheatstone bridge.

We can find a relationship between the four resistance paths making up the bridge when this "balanced" condition is established: the p.d. between A and B must equal

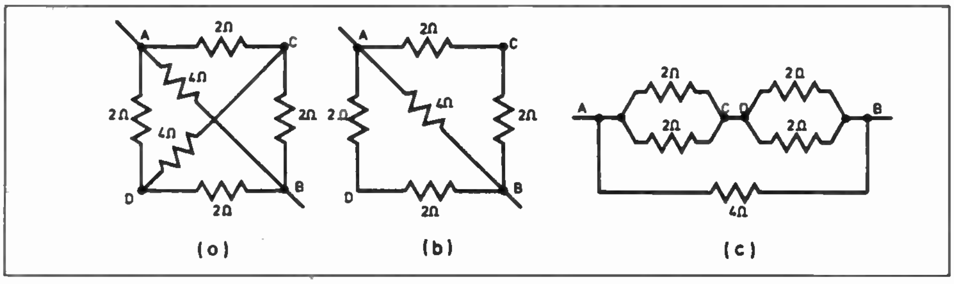


Fig. 4.8. Using the bridge principle to solve an awkward network.

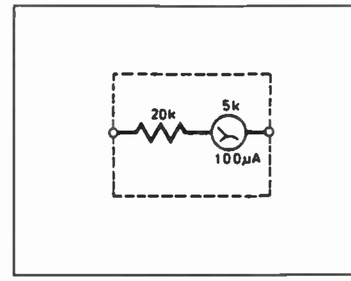


Fig. 4.9. Simple voltmeter circuit.

that between A and D, or $I_1R_1 = I_2R_3$; and the p.d. between B and C must equal that between D and C or $I_1R_2 = I_2R_4$. Dividing the first of these by the second gives us

$$\frac{I_1R_1}{I_1R_2} = \frac{I_2R_3}{I_2R_4} \text{ from which } \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

If then we know any three of these resistances when the bridge is balanced, the fourth can always be found.

The bridge principle can often be used to solve resistor networks which would otherwise be difficult. The next example will illustrate this.

5. What is the equivalent resistance between corners A and B of the network shown in Fig. 4.8(a).

Here we have a square and its diagonals made up of resistors. Although there are a number of sophisticated methods of solving this problem, the one we can use here depends upon the bridge principle and makes things relatively easy.

If we ignore for the moment the 4Ω diagonal between points A and B, we can see that the points C and D must be at the same potential relative to any voltage applied between A and B. No current would flow through this resistor and hence it could be removed without affecting the total current drawn by the network and therefore its total resistance. The circuit may consequently be reduced to that of Fig. 4.8(b).

This is now simply three 4Ω resistors wired in parallel, of which the equivalent resistance is 4/3 = 1·33Ω.

Alternately, since there is no potential difference across points C and D, we could short these points together with a zero resistance path to produce the equivalent circuit of Fig. 4.8(c). This then gives us the same result of 1·33Ω between A and B.

THIS MONTH'S PROBLEMS

We conclude as usual with a few problems to work out on your own. They can all be answered with the information we have covered up to this time. Last month's answers follow.

1. A voltmeter having a resistance of 10kΩ is connected in series with an unknown resistor across a 100V d.c. supply. If the meter reads 60V, what is the value of the resistor?
2. The voltmeter shown in Fig. 4.9 is required to measure a f.s.d. of 10V. Can it be used as it stands, or will it need a shunt or multiplier; state which? What value of shunt or multiplier (if any) might be needed?
3. A panel meter has a resistance of 5Ω and a f.s.d. of 15mA. When a 495Ω resistor is connected in series with the meter across a voltage source, a half scale deflection is obtained. What is (a) the source voltage, (b) the deflection when this source is 5V? What power is consumed by the meter when f.s.d. is obtained?
4. An experimenter who had a 1mA panel meter used it with a 1MΩ, 0·5W series multiplier to be able to read up to 1,000V, arguing that the meter resistance was so negligible compared with the 1MΩ multiplier that he could ignore it. Was this justified? Explain why, when he used the meter in this way, he nevertheless had a problem.
5. You have a panel meter which has a f.s.d. of 1mA and a resistance of 150Ω, and would like to make yourself a simple voltmeter having voltage ranges of 1V, 10V and 100V selected by a switch. Fig. 4.10 shows two ways of building such a switched voltmeter, using three multiplier resistors. Which of these ways would possibly be preferable in a practical design; give your reasons? Calculate the required values of the resistors needed for each circuit.
6. What is the potential difference between points X and Y in the circuit Fig. 4.11? What change would need to be made to the value of the 3Ω resistor so that X and Y were both at the same potential?
7. What is the resistance between any two vertices e.g. A and B, of the network of Fig. 4.12?

Last month's answers: 1. 0·59W, 1W; 2. 19·6Ω; 3. False; 5. (a) 0·39A, (b) 1·96V, (c)27·4J; 6. 10·9V, 1·8W; 7. 0·48A, 6·67Ω, 5·4W; 9. 4·8Ω, 0·5A, 0·75A, 1·25A.

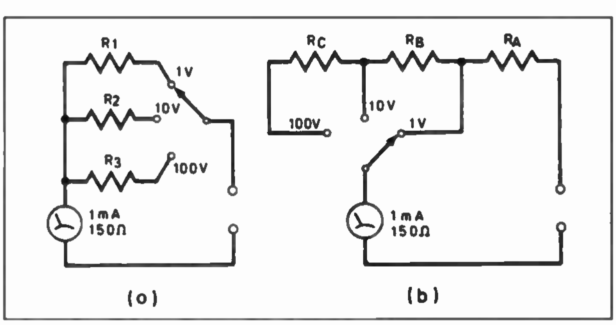


Fig. 4.10. Two simple voltmeter circuits – which would you choose?

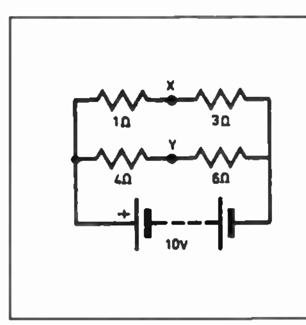


Fig. 4.11. Bridge calculation circuit.

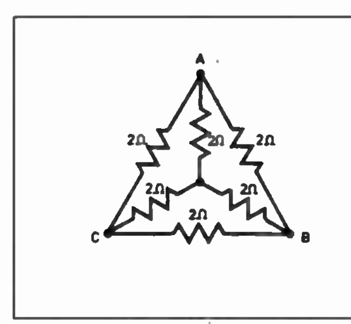
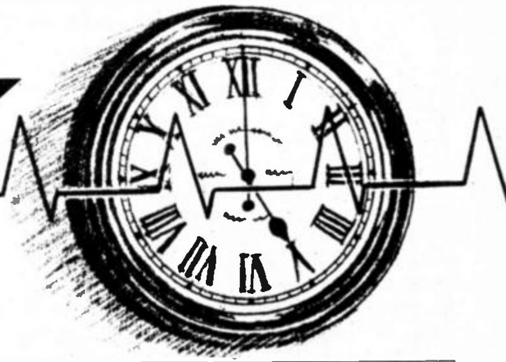


Fig. 4.12. A resistance problem.

IMPULSE CLOCK MASTER UNIT



HUW GRIFFITHS

Bring back to life an old impulse clock by building this simple quartz-controlled master unit.

THE author was fortunate in acquiring an old impulse clock which had hung unused in a building for many years. The clock (see photographs) appeared to have been part of the original time-keeping system installed in the building which dates from 1906. Such clocks were common in offices and factories from about the turn of the century and provided a modern alternative to traditional clockwork timepieces.

Normally, a highly accurate pendulum clock (though probably not matching quartz accuracy) served as the master. This clock was electrically powered and provided an impulse of current, every 30 seconds, to a chain of impulse clocks. As the impulse clocks were very simple in construction, presumably they required less maintenance than clockwork clocks and were more economical when a large number of clocks were needed.

ON IMPULSE

Impulse clocks were of many types: the older ones, such as this example, contained an electromagnet which, on each impulse, operated a lever and pawl mechanism to advance a ratchet wheel (Fig 1). These clocks normally had a low-resistance, high-current coil (typically 5Ω, 200mA) and a group of clocks would be wired in series.

Another, quieter type contained an iron rotor positioned between the poles of an electromagnet and a permanent magnet. On each impulse the rotor turned through half a revolution.

A third type had a permanently magnetised rotor, again positioned between the poles of an electromagnet, and required pulses of alternating polarity to effect rotation. A similar system is employed in modern quartz clocks and watches.

Some impulse clocks had high-resistance, low-current coils (typically 3kΩ, 8mA) and, in this case, a group of clocks would be wired in parallel. Master clock – impulse clock systems were fitted in buildings right up until the 1970s when they were superseded by battery powered quartz clocks which became available for the mass market.

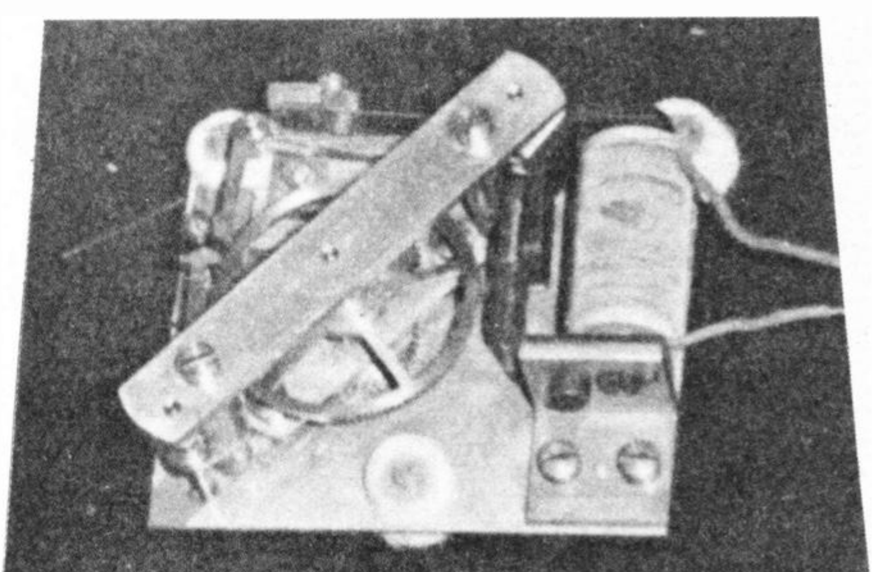


Fig. 1. The "works" of an electric impulse clock. On receiving an impulse, the electromagnet (right) operates a lever and pawl mechanism to advance the rachet wheel.

Whereas clockwork clocks have now become collectors' items, impulse clocks have not, the reason being that they are useless as working timepieces without a suitable master unit to provide the impulses. To the author's certain knowledge many have simply been thrown out as buildings have been converted to modern quartz time-keeping. By constructing this circuit, new life can be breathed into these interesting period-pieces which, one day, might also become collectable.

CIRCUIT DESCRIPTION

The circuit shown in Fig. 2 was designed for the clock shown in the photographs, which functions satisfactorily with current impulses of amplitude 110mA and duration 250ms. As will be seen later, the circuit can easily be adapted to other impulse clocks which might require different amplitudes of current impulses. The circuit, in its present form, cannot be used for clocks needing pulses of alternating polarity.

The circuit (Fig. 2) is constructed from the 4000 series CMOS logic i.c.s and other components which are readily available. IC1 forms the master oscillator, producing a square-wave output at 32·768kHz. A full description of this type of oscillator and details of all the CMOS devices can be found in Reference 1.

Timekeeping is controlled by a 32·768kHz crystal X1, a standard clock or watch replacement crystal. Trimmer capacitor VC1 serves as the load capacitance for the crystal, and its value can be adjusted in order to fine-tune the frequency.

Resistor R7 and capacitor C6 form a low-pass filter from IC1 which rejects any spikes on the waveform which could cause multiple triggering of the later stages in the circuit. IC2 divides the frequency by 4096, producing an output at 8Hz. IC3 divides by a further factor of 16 to give 1/2Hz. IC4 is configured as a divide-by-15 counter and brings the frequency to the required 1/30Hz.

The 4047 multivibrator IC5 is configured as a monostable producing 270ms pulses which are then fed to transistors TR1 and TR2 for current amplification. Resistor R6 is used to limit the current through the electromagnet coil in the clock, L1. In this example the resistance of L1 was five ohms, and R6 limits the current to about 150mA with a fully charged battery, B3.

Diode D1 quenches the back-e.m.f. spike produced each time the current through the clock coil L1 is switched off. The choice of D1 is not critical provided its peak reverse voltage exceeds the voltage across the coil during the impulse (only 150mA × 5Ω = 0·75V in this case) and it can carry the full coil current (150mA) as transistor TR2 switches off. Most rectifier diodes would suffice.

Switch S1 has two settings, "Normal" and "Fast". On the "Normal" setting the circuit pulses the clock at the correct frequency, 1/30Hz. On the "Fast" setting the frequency is increased by a factor of 32, to approximately 1Hz, for advancing the clock. When the push button switch, S2, is depressed IC3 and IC4 are reset, immediately bringing on the next impulse to the clock for accurate setting of the time.

POWER SUPPLY

The 4000 series CMOS i.c.s require a minimum supply voltage of 3V. The three 1·5V cells in series, B1, B2 and B3, provide 4·5V, allowing for some battery run-down.

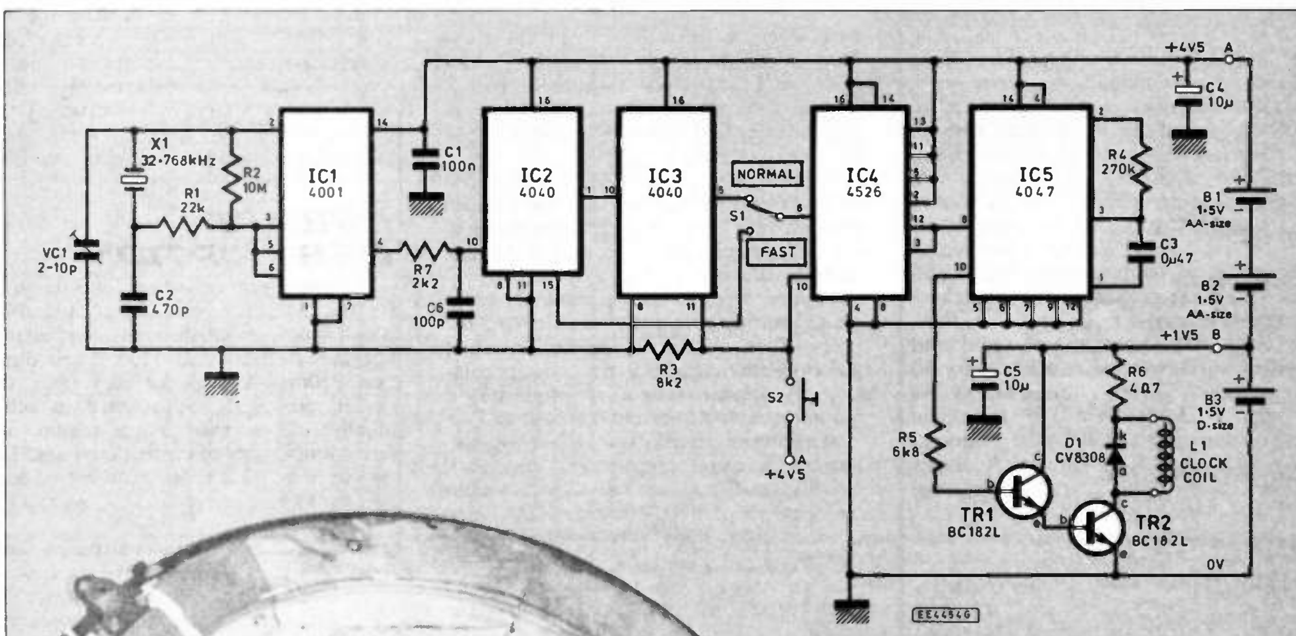
As the clock needs only 0·55V (110mA x 5Ω) for its operation it is unnecessary to draw the clock current from all three cells. Therefore, the supply for the output stage of the circuit (point B) is taken from B3 only, *which must be of a higher capacity than B1 and B2.*

With fully charged batteries the continuous current taken by the logic circuitry is 100μA. The current supplied to the clock, averaged over time, is 1·35mA (150mA x 270ms/30s) giving a total average current of 1·45mA to be supplied by B3.

The useful life of a battery, in this circuit, is the time taken for its e.m.f. to fall to 1·1V. At this point sufficient voltage is still available across R6 and L1 to drive impulses of 110mA and, if all three cells have discharged to this level, the logic circuitry will still function at 3·3V.

For B3 a size D alkaline cell is used (e.g. Duracell MN1300). From the manufacturer's data sheet (Ref. 2), the area beneath the discharge curve between the fully charged state and an e.m.f. of 1·1V leads to

Fig. 2 (below). Complete circuit diagram for the Impulse Clock Master Unit. Note that coil L1 is the clock mechanism electromagnet.



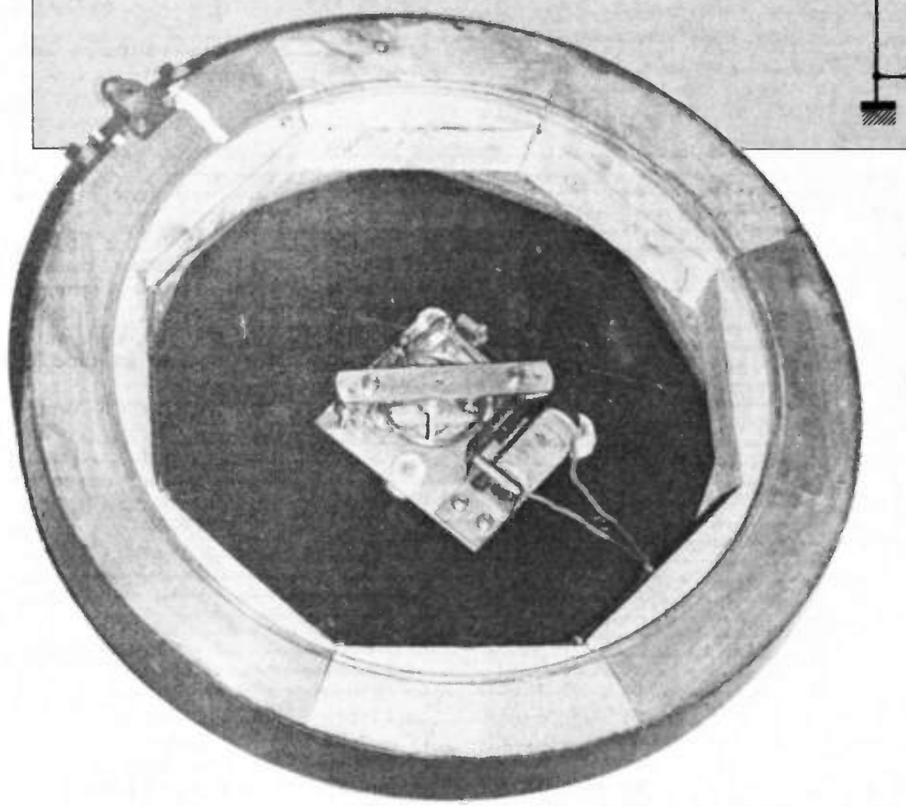
a figure of 13·6Ah. This would give a life for cell B3 of more than one year.

For B1 and B2, size AA cells (e.g. Duracell MN1500) are chosen as these only have to supply 100μA. A similar calculation from the discharge curve predicts a life of more than two years. In fact, cheaper zinc-carbon cells can be used for B1 and B2 and should still power the circuit for at least one year. In practice, the battery lifetimes may be even longer than calculated as the circuit will draw less current as the power supply voltage falls.

CONSTRUCTION

Before construction can commence, the current needed to operate the clock must be determined. This can be done by means of a power supply connected to the clock in series with a resistor.

The supply can be touched momentarily onto the clock terminals to complete the circuit and, as the power supply voltage is increased, the value at which the clock operates satisfactorily can be found. The current is then calculated by Ohm's law knowing the value of the resistor and the resistance of the clock coil. The value of resistor R6 in Fig. 2 can then be chosen.



The clock mechanism is mounted on the rear of the clock face which is housed in a polished wood surround.

The circuit is constructed on a piece of 0·1 inch matrix stripboard, 28 strips × 40 holes. The board topside component layout and details of breaks required in the underside copper strips is shown in Fig. 3.

Start by cutting the stripboard to size and then breaking the copper tracks as indicated. Before soldering any of the components, fit the board to the lid of the box as follows.

Drill the three fixing holes in the board and in the lid. Make sure that the board is positioned right at one end of the lid allowing just enough clearance for the corner pillars of the box. Countersink the holes on the outside of the lid. Now bolt the board onto the lid with nuts and locking washers, first adding an extra nut on each bolt to act as a spacer between the board and the lid.

Bolt the battery holders to the floor of the box ensuring that battery B3 is fitted as near to the end of the box as possible, away from the board, to allow room for switches S1 and S2 on the board above. Bolt the 2-way terminal block to the floor of the box approximately in line with trimmer capacitor above. Drill a hole in the end of the box and fit a grommet to carry the wires to the clock.

Now un-bolt the stripboard and populate it with the components, noting the polarity of the diode, D1, and the capacitors, C4 and C5. It is unnecessary to mount switches S1 and S2 on the case as they should only need to be operated when initially setting the clock to the correct time after replacing the batteries. Un-bolt the battery holders and connect them to the board with fairly long wires (25cm). Similarly, wire the board output to the terminal block. Finally, bolt everything back in position – see photograph.

SETTING UP

With the clock connected to the "master unit" it needs to be advanced to within a few minutes of the correct time by switching S1 to "Fast" and then back to

COMPONENTS

See SHOP TALK Page

Resistors

R1	22k
R2	10M
R3	8k2
R4	270k
R5	6k8
R6	4Ω7 (see text)
R7	2k2

All 0·25W 5% carbon film

Capacitors

C1	100n polyester
C2	470p polystyrene
C3	0μ47 polyester
C4, C5	10μ tantalum bead, 16V (2 off)
C6	100p polystyrene
VC1	2p to 10p trimmer

Semiconductors

D1	CV8308 or similar diode (see text)
TR1, TR2	BC182L *npn* transistor (2 off)
IC1	4001 quad 2-input NOR gate
IC2, IC3	4040 12-stage binary ripple counter (2 off)
IC4	4526 binary divide-by-N counter
IC5	4047 multivibrator

Miscellaneous

X1	32·768kHz timing crystal
S1	S.P.D.T. slide switch, p.c.b. mounting
S2	Keyboard switch, p.c.b. mounting
B1, B2	1·5V AA-size alkaline or zinc-carbon cell: Duracell MN1500 or Ever Ready R6B
B3	1·5V D-size alkaline cell: Duracell MN1300 or Every Ready LR20

Stripboard 0·1 inch matrix 28 strips × 40 holes; ABS plastic case, size (internal) 186mm × 106mm × 56mm; 14-pin d.i.l. socket (2 off) 16-pin d.i.l. socket (3 off); battery holders, single D-size and double AA-size; 2-way screw terminal block; multistrand connecting wire; single-core link wire; rubber grommet; 2mm bolts (countersunk heads), nuts, locking washers; solder etc.

Approx cost guidance only **£13** *excluding Batts.*

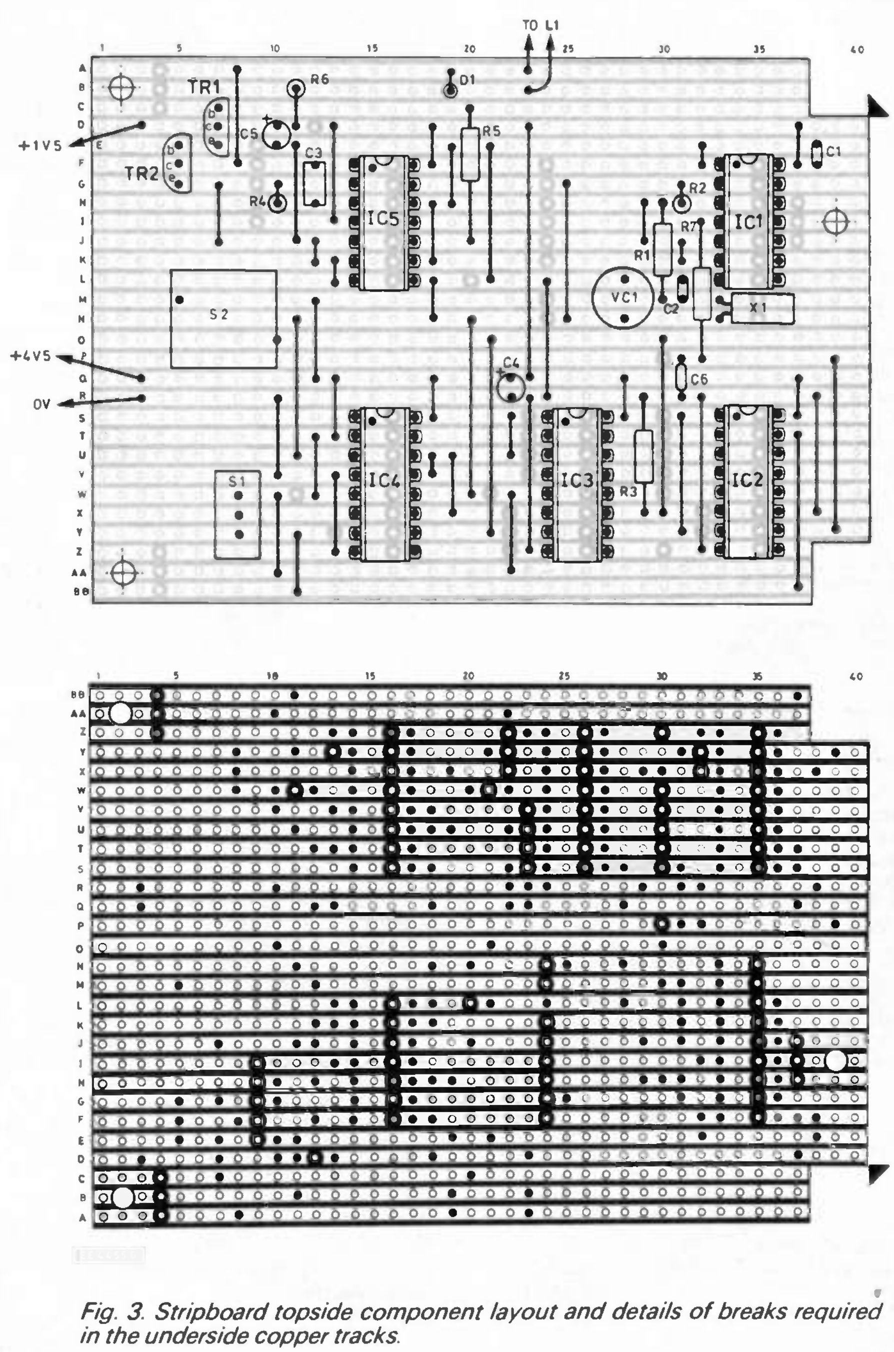


Fig. 3. Stripboard topside component layout and details of breaks required in the underside copper tracks.

"Normal". The last few impulses are provided by pressing the pushbutton switch S2 momentarily the necessary number of times to bring the clock exactly to time.

The final impulse must be given so that the clock is 15s fast initially. Thereafter as the pulses are provided automatically by the circuit, every 30s, the clock will always be within 15s of the correct time.

CLOCKING-ON

With the circuit as it stands, two clocks *(both of the low-resistance type)* could be driven in series, with resistor R6 short-circuited. Up to six clocks in series could be driven by taking the supply for the output stage (point B) from the 4·5V rail instead of from the 1·5V rail. All three batteries would then need to be of size D.

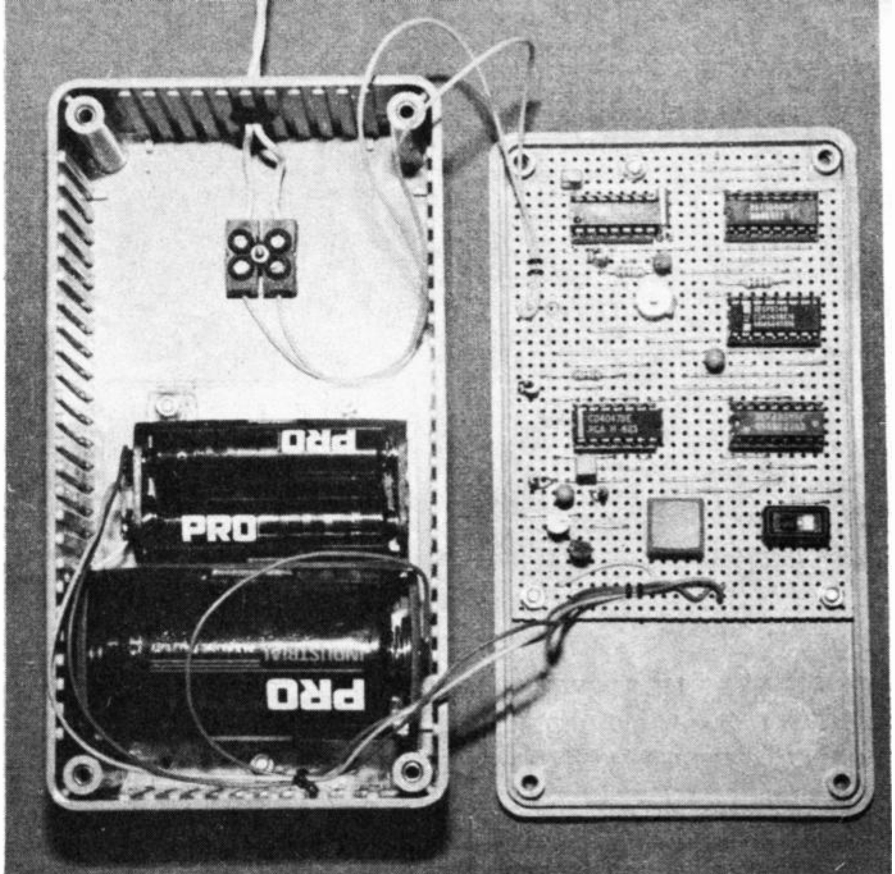
A larger number of clocks still could be driven in series by adding more cells to increase the potential of point B. Alternatively the transistor output stage of the circuit (R5, R6, C5, TR1, TR2 and D1) could be replicated.

Each additional output stage could be housed in its own case, with a power supply of cells, and would drive its own group of clocks. The inputs to all the output stages would be taken from pin 10 of IC5. This method is particularly suitable if some of the clocks require different currents. The current in each output stage is then set appropriately.

If the *high-resistance* type of clock is to be used the power supply needs to be changed to three 9V cells (e.g. size PP3) which could still be accommodated in the same size of box. The power rail voltages would then be 9V and 27V.

The logic circuitry (point A) would be supplied from the 9V rail and the output stage (point B) from the 27V rail. Capacitor C5 must then be of a sufficiently high working voltage (e.g. 35V).

As before, the value of resistor R6 needs to be chosen to drop the voltage to the correct level for the clock. For a 24V clock (often marked on the electromagnet itself) R6 can be omitted altogether. Two or more clocks can be driven in parallel without altering the circuit.


The battery holders and terminal block are mounted on the floor of the case and the circuit board bolted to the rear of the lid. The board should be mounted at the opposite end to the holders so that the switches do not foul on the batteries when the lid is closed.

IN USE

The impulse clock has now been running successfully for several months and keeps time as accurately as any of the other quartz clocks in the author's home. Now that it too is quartz controlled, this fine old clock probably keeps time better than it ever did during its working life. □

References

1. D. Lancaster, *CMOS Cookbook*, 2nd Edition, Howard W. Sams & Company, Indiana, 1977.
2. Duracell Batteries Ltd., Duracell House, Church Rd, Lowfield Heath, Crawley, West Sussex RH1 10PQ. Data sheet: *Procell/Duracell Alkaline MnO_2 Range*.

FOX REPORT

by Barry Fox

Secret Radio Frequencies

Just how secret are secret radio frequencies? "Official" frequency listings, like the DTI's *Table of Radio Frequency Allocations*, contain a lot of big gaps, with very vague headings like "Fixed" and "Mobile".

I can take a trip to the Edgware Road and buy the much less official *"Complete VHF/UHF Frequency Guide"* which fills in many of the gaps. It lists aircraft frequencies, both civilian and military, and civilian emergency services. I am told that very unofficial lists, of police frequencies, circulate amongst owners of scanners. If I knew where to get one I would not pass on the information, so do not bother to write in and ask.

I would however feel free to refer anyone to the 1994 edition of *WRTH*, the *World Radio TV Handbook* (published by Billboard Books). This has 600 pages of small print, listing every radio and TV station in the world, their transmission frequencies and contact addresses.

At first I thought it would be nice to pack with my portable short wave radio, for foreign trips on which I usually only find the BBC's World Service on the day I am leaving. But as *WRTH* weighs around ten times as much as my radio, I thought better of it. But before putting *WRTH* on the bookshelf I had a quick flip through the adverts. These turned out to be quite an eye-opener.

What are you missing, asks one from a Box Number in New Jersey. *The Confidential Frequency List* gives the transmission frequencies used by organisations that prefer to keep their frequencies secret. The list covers speech, broadcast fax and broadcast electronic mail.

The list promises the chance to listen to the giant USAF Globemaster ferrying troops to the world's hot spots, the Coast Guard, and daring rescues at sea. Or you can hunt down criminals with Interpol. And test your decoding skills in the mysterious number stations for spy messages.

After reading about Bill Clinton's troubles over phone calls allegedly made to lady friends, I do think someone should warn the President of something else the advert promises for its cover price of just $23. "Listen to President Clinton on Air Force One".

Disk Conditioner

Private record collectors can now clean up the sound from their old disks using digital technology previously available only to professional studios. The studios use computer-controlled scratch suppressors when preparing old music for release on CDs. The Signal Conditioner, just going on sale for £450 from Philips' Japanese subsidiary Marantz, plugs into a hifi and lets collectors remove scratch noise while copying music from their old 78s and LPs.

The Conditioner converts the analogue signal into digital code. The code goes to a buffer memory which stores it for a few milliseconds. During this short time an analyser checks the sound for any peaks which rise and fall very rapidly. These signify scratches because even the most percussive musical sounds decay slowly.

Every non-musical peak is then removed by muting the sound for the exact duration of the blemish. So the signal which leaves the buffer has brief gaps where there were previously scratches. Marantz's designer Ken Ishiwata believes this is more acceptable to the ear than doing as the professional systems do and bridging the gaps with a false signal.

Because the Conditioner can sometimes be fooled into mistaking music for scratches, the user can adjust a control which forces the system to focus on large, deep scratches or small, shallow ones.

Constructional Project

TELEPHONE RING DETECTOR

ANDY FLIND

Detects when the telephone rings without direct electrical connection to the BT phone line. Linking the "ring detector" to last month's Visual Doorbell will alert anyone with hearing problems that the phone is ringing or someone is at the door.

THIS design started life as an add-on for the *Visual Doorbell Indicator* project published last month. The original aim was to provide a voltage signal for the second opto-isolator in the doorbell circuit. However, it's versatility has been extended by a relay output which can be used in various ways.

A large extension bell for the garden or workshop is one obvious application, no doubt others will occur to readers. The relay is optional, if it is not required it and associated components may be omitted to save cost and complexity.

In case some readers are muttering "Pardon?", a "telephone ringing" indicator for the acoustically-challenged is not as daft as it sounds. A variety of devices exist to enable them to use the phone, including handsets with amplification and inductive couplers to operate suitably equipped hearing aids.

Even the totally deaf are catered for, as a compact acoustically-coupled teletext device is available for visual communication via a standard phone. A snag with this is that it can only be used with similarly-equipped distant phones, but at least one such link is often provided for use in emergencies. This project makes it possible for the distant end of the link to call back.

LINK UP

To operate a telephone bell, BT transmit a high voltage, low frequency signal over the line. This would be easy to detect save for one minor snag; it is still illegal to connect non-approved electrical apparatus to a BT line.

The challenge then, is to find a way of sensing the ringing without direct electrical connection. The method selected was to take a plug-in extension bell, which can be bought quite cheaply in most telephone accessory shops, carefully prise off the cover, and Araldite a "piezo transducer" disc to the bell itself.

The output from the transducer when the bell rings is quite sufficient to forward-bias a transistor, enabling the design of a circuit which draws no current in "standby" mode. Also as there is no direct electrical connection to the BT line, there should be no legality problem.

CIRCUIT DESCRIPTION

The full circuit diagram of the Telephone Ring Detector appears in Fig. 1. The "Microphone" MIC1 is the piezo transducer Araldited to the bell. Resistor R1 normally biases transistor TR1 "off", but when the bell rings a relatively high a.c. voltage is generated by the transducer. Positive half-cycles turn on TR1, negative half-cycles pass through diode D1.

In "standby", capacitor C1 is charged by resistor R2. This ensures that the input to IC1a is high, so the output from the paralleled gates IC1c and IC1d are low, at negative rail potential. (The gates of IC1 are all "NAND" types which invert signals applied to them).

When transistor TR1 conducts, it discharges C1 and IC1 gates change state, positive feedback from capacitor C2 ensuring a rapid switching action. The output voltage is then positive, and the relay is energised.

Component values in this part of the circuit have been chosen so that the outputs are energised continuously whilst the ringing signal is present, but turn off rapidly enough to follow the typical "burr-burr" pattern of a ringing phone.

The voltage output from IC1 pins 10 and 11 can drive the "Auxiliary" input of last month's "Doorbell" project directly,

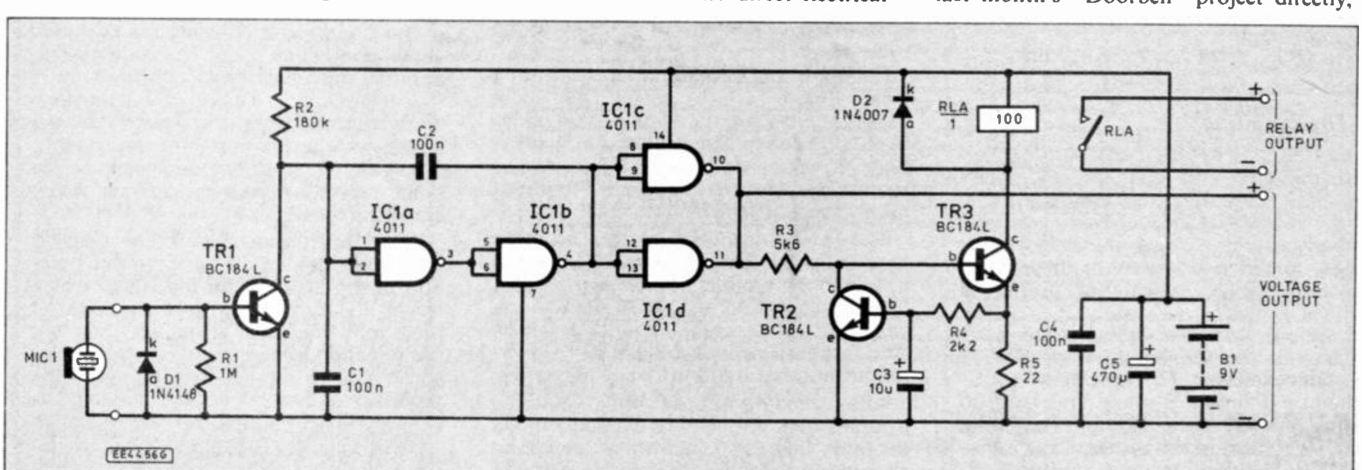


Fig. 1. Complete circuit diagram for the Telephone Ring Detector. MIC1 is a piezoelectric transducer element which is glued directly onto the bell of a plug-in extension bell.

so if this is all that is required the relay and associated components can be omitted. When used with the doorbell project the lights will flash in time with the telephone ringing, so unless there is someone at the door at the same time there should be no difficulty discerning which is being rung.

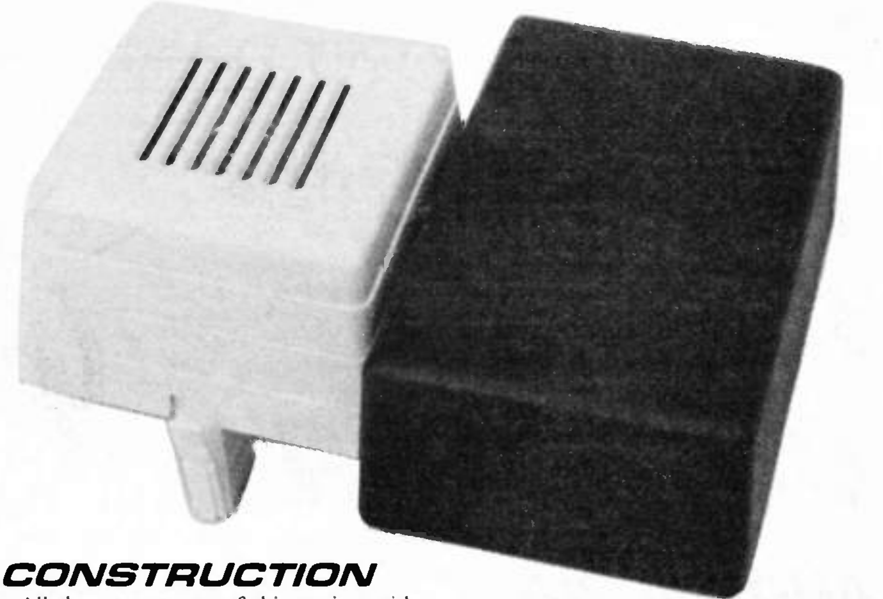
As the standby current is zero and the average current when ringing only a couple of milliamps, an alkaline PP3 should last for well over a year in most installations.

RELAY DRIVER

If the relay RLA is fitted, the supply current requirement increases. The type specified has a 6V coil with a resistance of 100 ohms, so direct operation from a fresh 9V battery would result in a drain of some 90 milliamps. To improve on this the circuit around transistors TR2 and TR1 has been devised.

Whilst the relay RLA needs full power to initially operate, the "holding" current required to keep it operated is much lower. Transistors TR2 and TR3 with resistors R4 and R5 form a constant-current circuit supplying about thirty milliamps, enough to ensure reliable holding of the relay, but resistor R4 and capacitor C3 prevent TR2 operating for a few milliseconds when the circuit is first energised so, for this brief period, the relay receives full power.

This arrangement provides reliable operation from about a third of the current that would otherwise be needed, with a bonus in that this current does not vary with supply voltage. The prototype operates reliably down to about five volts, making relay operation from a PP3 feasible, though if frequent operation is envisaged a larger battery or mains power might be preferable.



CONSTRUCTION

All the components of this project with the exception of the microphone, battery, and any sockets, are fitted on a single printed circuit board (p.c.b.). This board is available from the *EPE PCB Service*, code 864.

Unlike the Visual Doorbell project it is very compact, in order to fit in a box attached directly to the casing of the bell unit, so some care and a fine-tipped soldering iron are needed for construction.

The diodes and three of the resistors are mounted vertically to save space, whilst capacitor C5, although a radial lead component, lies horizontally to fit in the box. The location of the p.c.b. in the box can be seen from the photographs.

It may be necessary to trim the corners of the board a little to clear the edges of the lid. A hole is drilled through the board at one end to allow the battery connector leads to pass through to the battery compartment.

Component positions are shown in the topside layout, Fig.2. These can all be fitted, although a socket is recommended for IC1 which should not be inserted until testing is under way. If the relay output option is not required it can be omitted, along with components R3, R4, R5, C3, D2, TR2 and TR3.

COMPONENTS

Resistors
R1 1M
R2 180k
R3 5k6
R4 2k2
R5 22
All 0·6W 1% metal film

See SHOP TALK Page

Capacitors
C1, C2, C4 100n polyester layer (3 off)
C3 10µ radial elect. 50V
C5 470µ radial elect. 16V

Semiconductors
D1 1N4148 silicon diode
D2 1N4007 1000V 1A rect. diode
TR1, TR2, TR3 BC184L *npn* silicon transistor (3 off)

Miscellaneous
MIC1 Piezoelectric transducer element, 27mm diameter
RLA 6V 100ohm coil ultra min. relay, with 2A 24V d.c. contacts

Printed circuit board available from the *EPE PCB Service,* code 864; telephone extension bell (see text); PP3 alkaline battery and clips; ABS plastic box, size 83mm x 53mm x 31mm; 14-pin d.i.l. socket; solder pins (8 off); connecting wire; adhesive; solder etc.

Approx cost guidance only **£10** *excluding ext. bell*

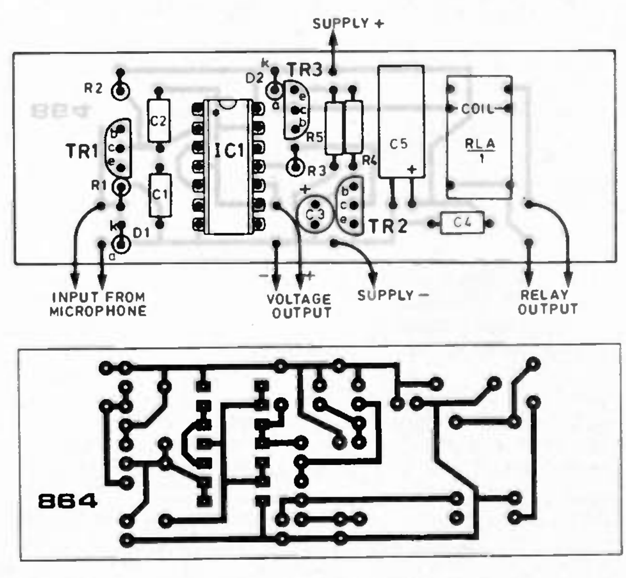
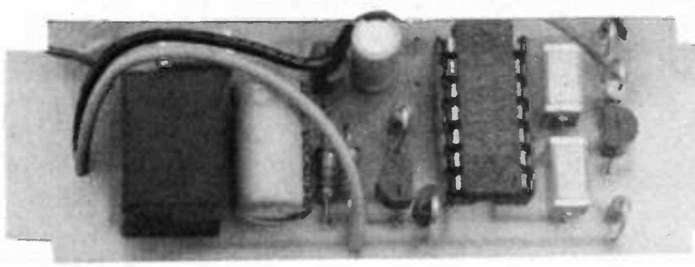


Fig. 2. Printed circuit board component layout and full size underside copper foil master pattern.



The finished p.c.b. showing the supply leads passing through the board for connection to the battery.

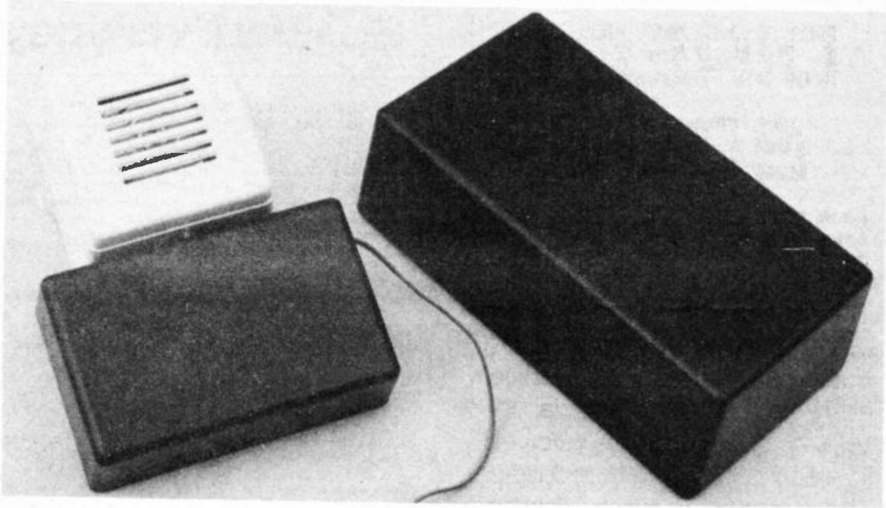
RING SENSOR

Construction of the "ring" sensor is fairly simple. A cheap plug-in extension bell is required. In case there are any which "chirrup" like many modern phones, the type needed is a mechanical one, with a real metal bell, rung by a solenoid arrangement.

If there is any doubt, shake the unit, the solenoid will rattle and cause the bell to "ping". It will have a plastic cover which is normally glued into place around it's base, so careful work with a craft knife will be required to prise it open.

The transducer, a piezoelectric disc about 27mm diameter, is attached to the side of the bell with a blob of Araldite adhesive, whilst ensuring that it will not touch the plastic casing when this is refitted. Connections are thin flexible wire, soldered directly to the disc. Polarity of the leads is not important, though it is recommended that the larger, outer part of the disc is "ground" and the smaller, inner one is "signal" going to the base of TR1.

Following this modification the bell will rattle rather than ring, but in view of the intended purpose this should not matter. After circuit testing, the cover can be glued back into place with the leads fed out through a suitable hole to the circuit.



The completed Telephone Ring Detector together with last month's Visual Doorbell. The "doorbell" can drive up to five 100W light bulbs and can, when linked to the "bell", pulse in time with the 'phone.

TESTING

To test the unit it will be necessary to ring the bell. This can be achieved by use of the local BT engineering test number where this is known, or by enlisting the aid of a suitable volunteer to call back as necessary.

For circuit testing, the input and power supply should be connected, and a meter connected across the negative supply and pin 1 of IC1 socket. The actual voltage reading obtained will depend upon the loading imposed by the meter, but tapping on the side of the bell should cause it to drop a bit. Ringing the bell should cause the voltage to drop to zero, following the "burr-burr" ringing pattern.

If this works correctly, IC1 can now be fitted. Tapping the bell should now cause the voltage output to blip high, and the relay, if fitted, to chatter a bit. Ringing the bell should produce the expected voltage output and relay operation.

Current drawn from the supply should be around 30mA if a relay is being driven, almost negligible without it. Measured standby current should be practically non-existent, which is why this project does not have an on-off switch.

The unit does not have to be mounted directly to the bell casing as shown, though the high impedance of the input makes it advisable to keep the leads to the sensor as short as possible. If they are more than a couple of inches long, screened lead should be used.

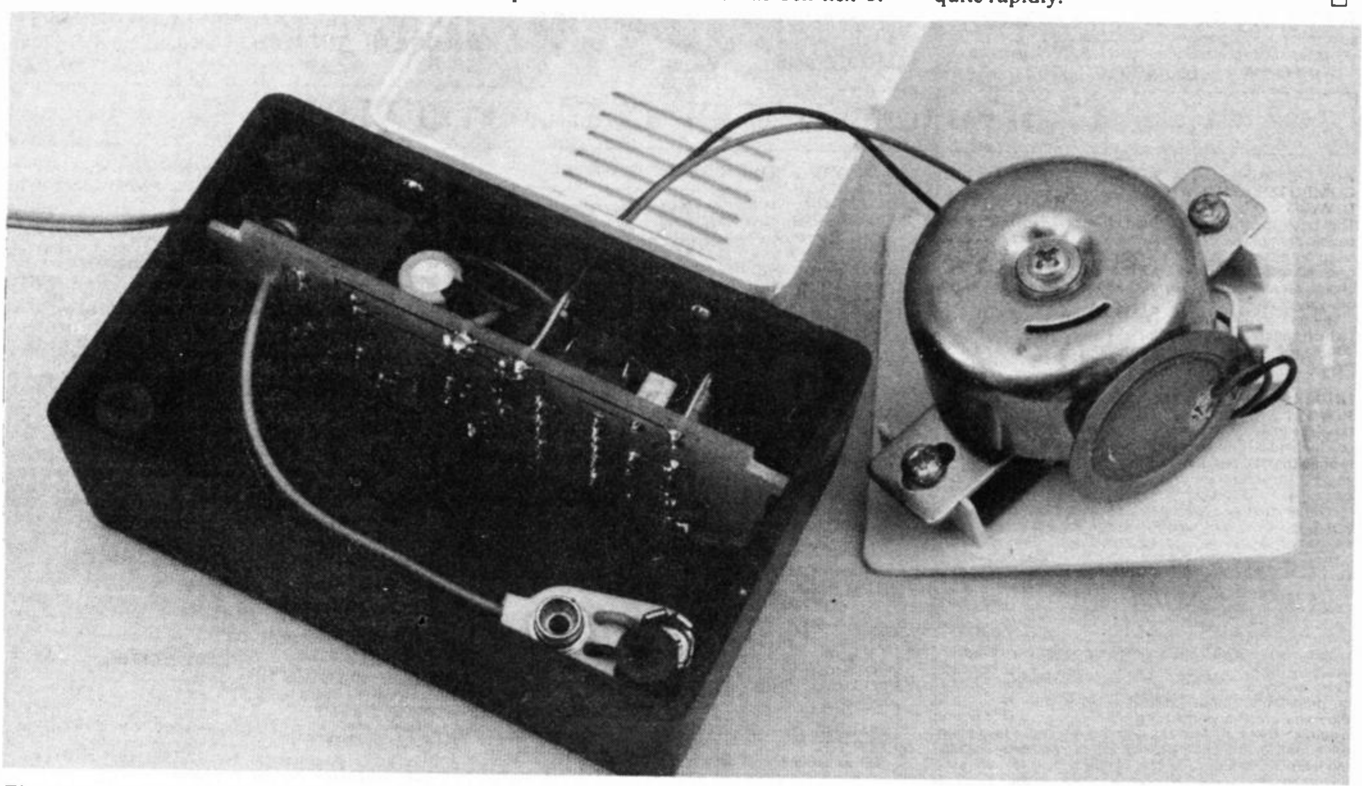
For use with the Visual Doorbell project, the voltage output is connected straight into the auxiliary opto-coupler (IC3) input which has it's own current limiting resistor. As only a battery supply is used the link between the two units can be made with cheap conductor wires such as bell flex or speaker wire. Correct polarity of connections must be observed, of course.

RELAY

The specified relay RLA has a contact rating of 2A for a voltage of 24V d.c. or 120V a.c. This rules out use with mains devices, though quite a hefty extension bell could be operated by it, either battery or transformer powered. If mains is to be switched, the associated project should be used anyway, as it eliminates possibility of contact failure and in addition provides zero-crossing synchronisation.

Alkaline batteries are preferable to standard ones as they can deliver greater current, and have a better shelf life. Even if only the Voltage Output is used, they will still give a better life.

It might be advisable to replace the battery with a small mains power unit if frequent relay operation is envisaged, as the 30mA current would deplete a PP3 battery quite rapidly. □



The completed p.c.b. slotted in the case and the extension bell removed from its housing showing the piezo transducer element glued to the side of the bell.

DIRECT BOOK SERVICE

The books listed have been selected by Everyday with Practical Electronics editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page. For another selection of books see next month's issue.

ELECTRONIC PROJECTS – BOOK 1
Published by *Everyday Electronics* in association with Magenta Electronics.
Contains twenty of the best projects from previous issues of EE each backed with a kit of components. The projects are: Seashell Sea Synthesiser, EE Treasure Hunter, Mini Strobe, Digital Capacitance Meter, Three Channel Sound to Light, BBC 16K Sideways Ram, Simple Short Wave Radio, Insulation Tester, Stepper Motor interface, Eprom Eraser, 200MHz Digital Frequency Meter, Infra Red Alarm, EE Equaliser Ioniser, Bat Detector, Acoustic Probe, Mains Tester and Fuse Finder, Light Rider – (Lapel Badge, Disco Lights, Chaser Light), Musical Doorbell, Function Generator, Tilt Alarm, 10W Audio Amplifier, EE Buccaneer Induction Balance Metal Detector, BBC Midi Interface, Variable Bench Power Supply, Pet Scarer, Audio Signal Generator.
128 pages (A4 size) Order code EP1 **£2.45**

ELECTRONICS TEACH-IN 88/89 – INTRODUCING MICROPROCESSORS
Mike Tooley BA (published by *Everyday Electronics*)
A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc. Starting with basic terminology, integrated circuits, logic families and numbering systems the text builds in stages, with revision and assessments built in, up to programming, languages, flow charts, etc. The course is ideal for the newcomer to the subject.
80 pages (A4 size) Order code TI-88/89 **£2.45**

Special Everyday Electronics Books

ELECTRONICS TEACH-IN No. 3 – EXPLORING ELECTRONICS (published by *Everyday Electronics*)
Owen Bishop
Another EE value for money publication aimed at students of electronics. The course is designed to explain the workings of electronic components and circuits by involving the reader in experimenting with them. The book does not contain masses of theory or formulae but straightforward explanations and circuits to build and experiment with.
Exploring Electronics contains more than 25 useful projects, assumes no previous knowledge of electronics and is split into 28 easily digestible sections.
88 pages (A4 size) Order code TI3 **£2.45**

ELECTRONICS TEACH-IN No.4 INTRODUCING DIGITAL ELECTRONICS (published by *Everyday Electronics*)
Michael J. Cockcroft
Although this book is primarily a City & Guilds Introductory level course (726/301), approximately 80% of the information forms a very basic introduction to electronics in general, it therefore provides an excellent introductory text for beginners and a course and reference book for GCSE students.
Full details on registering for C&G assessment, details of assessment centres, components required and information on the course in general are given.
The City & Guilds introduction to module 726/301 reads: "A candidate who satisfactorily completes this module will have a competence to identify basic components and digital integrated circuits and connect them together to form simple working circuits and logic units." This provides an excellent introduction to the book.
112 pages (A4 size) Order code TI4 **£2.95**

ELECTRONICS TEACH-IN No.5 GUIDE TO BUILDING ELECTRONIC PROJECTS
Published by EVERYDAY ELECTRONICS
Due to the demand from students, teachers and hobbyists we have put together a range of articles from past issues of *Everyday Electronics* that will assist those involved with the construction of electronic projects.
The book contains the complete *Project Development for GCSE* series.
Contents: Features – First Steps in Project Building; Building with Vero; Project Development for GCSE; Getting your Project Working; Guide to Printed Circuit Boards; Choosing and Using Test Equipment – The Multimeter, The Oscilloscope, P.S.U.s, Logic Probes, Digital Frequency Meters, Signal Generators, etc; **Data** – Circuit Symbols; Component Codes; Resistors; Identifying Components; Capacitors; Actually Doing It – Understanding the Circuit Diagram, Component Codes, Mounting circuit boards and controls, Understanding Capacitors; **Projects** – Lie Detector; Personal Stereo Amplifier; Digital Experimentsr's Unit; Quizmaster; Siren Effects Unit; UV Exposure Unit; Low-cost Capacitance Meter; Personal Radio.
88 pages (A4 size) Order code TI5 **£2.95**

ELECTRONICS TEACH-IN No. 6 DESIGN YOUR OWN CIRCUITS (Published by *Everyday with Practical Electronics*)
Mike Tooley B.A.
This book is designed for the beginner and experienced reader alike, and aims to dispell some of the mystique associated with the design of electronic circuits. It shows how even the relative newcomer to electronics can, with the right approach, design and realise quite complex circuits.
Fourteen individual p.c.b. modules are described which, with various detailed modifications, should allow anyone to design and construct a very wide range of different projects. Nine "hands-on" complete DIY projects have also been included so readers can follow the thinking behind design, assembly, construction, testing and evaluation, together with suggested "mods" to meet individual needs. The practical projects have each been designed to stand on their own as complete items of equipment. P.C.B.s for all the modules and projects are available by mail order.
The subjects covered in each chapter of the book are: Introduction and Power Supplies; Small Signal Amplifiers; Power Amplifiers; Oscillators; Logic Circuits; Timers; Radio; Power Control; Optoelectronics.
The nine complete constructional projects are: Versatile Bench Power Supply; Simple Intercom; Bench Amplifier/Signal Tracer; Waveform Generator; Electronic Die; Pulse Generator; Radio Receiver; Disco Lights Controller; Optical Communications Link.
136 pages Order code TI6 **£3.45**

Computers and Computing

HOW TO CHOOSE A SMALL BUSINESS COMPUTER SYSTEM
D. Weale
This book is for anyone intending to buy an IBM compatible computer system, whether it is their first system or a replacement. There are sections on hardware, application and systems programs and how to actually make your choice as well as sections on the law, ergonomics and a glossary of common terms.
The text contains many useful tips and some warnings (which could save much effort and expense).
114 pages Order code BP323 **£4.95**

UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold
If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.
This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM: RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!
104 pages **Temporarily out of print**

AN INTRODUCTION TO 68000 ASSEMBLY LANGUAGE
R. A. & J. W. Penfold
Obtain a vast increase in running speed by writing programs for 68000 based micros such as the Commodore Amiga, Atari ST range or Apple Macintosh range etc., in assembly language. It is not as difficult as one might think and this book covers the fundamentals.
112 pages Order code BP184 **£2.95**

THE ART OF PROGRAMMING THE ZX SPECTRUM
M. James, B.Sc., M.B.C.S.
It is one thing to have learnt how to use all the Spectrum's commands and functions, but a very different one to be able to combine them into programs that do exactly what you want them to. This is just what this book is all about – teaching you the art of effective programming with your Spectrum.
144 pages Order code BP119 **£2.50**

A CONCISE INTRODUCTION TO MS-DOS
N. Kantaris
This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.
The guide covers versions 3.0, 3.1 and 3.2 of both PC-DOS and MS-DOS as implemented by IBM and other manufacturers of "compatible" microcomputers, including the AMSTRAD PC's. It covers both floppy disc-based systems and hard disc-based systems.
64 pages Order code BP232 **£2.95**

MAKING MS-DOS WORK FOR YOU
N. Kantanis & P. R. M. Oliver

This book was written with the busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the book has also been designed to be circular, which means that you don't have to start at the beginning and go to the end.
The book explains: How to write customised batch files which allow you to display what you want on your screen, and in the form and order you want it, instead of being forced to use the DOS prompt on a blank screen. How to design and set up a fast interactive and professional looking menu system, so that you or anyone else can run utility applications or commercial software packages easily. How the ANSI.SYS display and keyboard commands can be used to position the cursor on any part of the screen, change the intensity of the displayed characters or change their colour. How the Edit screen editor or the Edlin line editor can be used to enter ESCape (ANSI.SYS) commands into simple ASCII files to allow control of both your screen display and your printer. How to control the operation of the two main types of printers in use today, Epson compatible dot matrix and HP compatible laser printers. How to use several useful routines, such as moving and finding files, protecting files from accidental erasure, a simplified backup process, a screen saver, and a disc cataloguing system.
The Debug program and how it can be used to create, see and change the contents of any file, including those of programs written in assembler code. This includes how to find your way around the names and tasks of the CPU registers and the meaning of some simple assembler mnemonics.
182 pages Order code BP319 **£4.95**

AN INTRODUCTION TO CP/M
R. A. Penfold
In order to run and use programs operating under CP/M it is not essential to have an understanding of the system, but a reasonable knowledge of the subject can certainly be of immense help when minor problems occur, and also in fully exploiting the possible potential of the system. This book tells the story!
84 pages Order code BP183 **£2.95**

Audio and Music

ACOUSTIC FEEDBACK – HOW TO AVOID IT

Feedback is the bane of all public address systems. While feedback cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem.

Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce or reduce feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.

92 pages Order code BP310 **£3.95**

PRACTICAL MIDI HANDBOOK
R. A. Penfold

The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.

The Practical MIDI Handbook is aimed primarily at musicians, enthusiasts and technicians who want to exploit the vast capabilities of MIDI, but who have no previous knowledge of electronics or computing. The majority of the book is devoted to an explanation of what MIDI can do and how to exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those manuals.

128 pages Order code PC101 **£6.95**

PREAMPLIFIER AND FILTER CIRCUITS
R. A. Penfold

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases).

The preamplifier circuits featured include:– Microphone preamplifiers (low impendance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

Other circuits include:– Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls

92 pages Order code BP309 **£3.95**

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN
V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

148 pages Order code BP256 **£2.95**

COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.

174 pages Order code PC107 **£8.95**

ELECTRONIC PROJECTS FOR GUITAR
R. A. Penfold

This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner, Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.

110 pages Order code PC110 **£8.95**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. penfold

Practical constructional details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. Includes MOSFET and bipolar transistor designs.

96 pages Order code BP277 **£3.95**

Theory and Reference

ELECTRONIC HOBBYISTS HANDBOOK
R. A. Penfold

Provides an inexpensive single source of easily located information that the amateur electronics enthusiast is likely to need for the day-to-day pursuance of this fascinating hobby. Covers common component colour codes. Details the characteristics and pinouts of many popular seimiconductor devices, including various types of logic ICs, operational amplifiers, transistors, FETs, unijunctions, diodes, rectifiers, SCRs, diacs, triacs, regulators and SMDs, etc. Illustrates many useful types of circuits, such as timers and oscillators, audio amplifiers and filters, as well as including a separate section on power supplies. Also contains a multitude of other useful data.

88 pages Order code BP233 **£4.95**

FROM ATOMS TO AMPERES
F. A. Wilson

Explains in crystal clear terms the absolute fundamentals behind electricity and electronics. Really helps you to discover and understand the subject, perhaps for the first time ever.

Have you ever: Wondered about the true link between electricity and magnetism? Felt you could never understand the work of Einstein, Newton, Boltzmann, Planck and other early scientists? Just accepted that an electron is like a little black ball? Got mixed up with e.m.f. and p.d.? Thought the idea of holes in semiconductors is a bit much?

Then help is at hand with this inexpensive book, in as simple a way as possible and without too much complex mathematics and formulae.

244 pages Order code BP254 **£3.50**

ELECTRONICS – A "MADE SIMPLE" BOOK
G. H. Olsen

This book provides excellent background reading for our *Introducing Digital Electronics Teach-In* Book and will be of interest to everyone studying electronics. The subject is simply explained and well illustrated and the book assumes only a very basic knowledge of electricity.

330 pages Order code NE10 **£6.95**

A REFERENCE GUIDE TO PRACTICAL ELECTRONICS TERMS
F. A. Wilson

Electronic devices surround us on all sides and their numbers are increasing without mercy. Ours is the problem therefore in keeping up with this relentless expansion. unfortunately we cannot know it all and most of us do not wish to afford the cost of large reference books which explain many concepts in fair detail. Here is an answer, an inexpensive reference guide which explains briefly (but we hope, well) many of the underlying electronics features of pratical devices, most of which, to a certain extent, control our lives.

This book is in effect more than just a dictionary of practical electronics terms, it goes a stage further in also getting down to fundamentals. Accordingly the number of terms may be limited but the explanations of the many which are included are designed to leave the reader more competent and satisfied – and this is without the use of complicated mathematics which often on first reading can even be confusing.

For those who also wish to get right down to the root of the matter, there is a second volume entitled *A Reference Guide to Basic Electronics Terms* (BP286), each of the books referring to its companion as necessary.

A reference guide for practically everybody concerned with electronics.

432 pages Order code BP287 **£5.95**

NEWNES ELECTRONICS POCKET BOOK
E. A. Parr

Newnes Electronics Pocket Book has been in print for over twenty years and has covered the development of electronics from valve to semiconductor technology and from transistors to LSI integrated circuits and microprocessors. To keep up to date with the rapidly changing world of electronics, continuous revision has been necessary. This new Fifth Edition takes account of recent changes and includes material suggested by readers of previous editions. New descriptions of op.amp. applications and the design of digital circuits have been added, along with a totally new chapter on computing, plus other revisions throughout.

315 pages (hard cover) Order code NE02 **£12.95**

ELECTRONIC MODULES AND SYSTEMS FOR BEGINNERS
Owen Bishop

This book describes over 60 modular electronic circuits – how they work, how to build them, and how to use them. The modules may be wired together to make hundreds of different electronic systems, both analogue and digital. To show the reader how to begin building systems from modules, a selection of over 25 electronic systems are described in detail, covering such widely differing applications as timing, home security, measurement, audio (including a simple radio receiver), games and remote control.

200 pages Order code BP266 **£3.95**

Project Building

HOW TO GET YOUR ELECTRONIC PROJECTS WORKING
R. A. Penfold

We have all built projects only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

96 pages Order code BP110 **£2.95**

HOW TO DESIGN AND MAKE YOUR OWN P.C.B.s
R. A. Penfold

Deals with the simple methods of copying printed circuit board designs from magazines and books and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.

80 pages Order code BP121 **£2.50**

A BEGINNERS GUIDE TO MODERN ELECTRONIC COMPONENTS
R. A. Penfold

The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.

166 pages Order code BP285 **£3.95**

BEGINNER'S GUIDE TO BUILDING ELECTRONIC PROJECTS
R. A. Penfold

Shows the complete beginner how to tackle the practical side of electronics, so that he or she can confidently build the electronic projects that are regularly featured in magazines and books. Also include examples in the form of simple projects.

112 pages Order code 227 **£1.95**

ELECTRONICS SIMPLIFIED – CRYSTAL SET CONSTRUCTION
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Especially written for those who wish to participate in the intricacies of electronics more through practical construction than by theoretical study. It is designed for all ages upwards from the day one can read intelligently and handle simple tools.

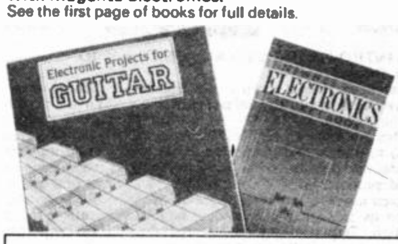
80 pages Order code BP92 **£1.75**

GUIDE TO BUILDING ELECTRONIC PROJECTS
Published by *Everyday Electronics*

See the first page of books – ELECTRONICS TEACH-IN No.5 – for full details.

ELECTRONICS PROJECT BOOK
Published by *Everyday Electronics* in association with Magenta Electronics.

See the first page of books for full details.



Testing and Test Gear

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits. plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators.

104 pages Order code BP267 **£3.50**

Circuits and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop

This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

88 pages **Temporarily out of print**

ELECTRONIC ALARM CIRCUITS MANUAL
R. M. Marston

One hundred and forty useful alarm circuits, of a variety of types, are shown in this volume. The operating principle of each one is explained in concise but comprehensive terms, and brief construction notes are given where necessary.

Aimed at the practical design engineer, technician and experimenter, as well as the electronics student and amateur.

124 pages Order code NE11 **£13.95**

ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF MODEL RAILWAYS
R. A. Penfold

The projects consist of various types of interface and controllers, including a high quality pulse type, as well as circuits for train position sensing, signal and electric points control etc.

The use of computers does not have to be restricted to massive layouts. Something as simple as an oval track with a single siding can be given a new dimension by adding computer control and much fun can be had from these relatively simple set ups.

88 pages **Temporarily out of print**

DIGITAL LOGIC GATES AND FLIP-FLOPS
Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages Order code PC106 **£8.95**

ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS
Robert Penfold

Robots and robotics offer one of the most interesting areas for the electronics hobbyist to experiment in. Today the mechanical side of robots is not too difficult, as there are robotics kit and a wide range of mechanical components available. The micro controller is not too much of a problem either, since the software need not be terribly complex and many inexpensive home computers are well suited to the task.

The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge this gap.

92 pages **Temporarily out of print**

ELECTRONIC POWER SUPPLY HANDBOOK
Ian R. Sinclair

This book covers the often neglected topic of electronic power supplies. All types of supplies that are used for electronics purposes are covered in detail, starting with cells and batteries and extending by way of rectified supplies and linear stabilisers to modern switch-mode systems, IC switch-mode regulators, DC-DC converters and inverters.

The devices, their operating principles and typical circuits are all dealt with in detail. The action of rectifiers and the reservoir capacitor is emphasised, and the subject of stabilisation is covered. The book includes some useful formulae for assessing the likely hum level of a conventional rectifier reservoir supply.

136 pages Order code PC108 **£7.95**

50 SIMPLE LED CIRCUITS
R. N. Soar

Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components – the light-emitting diode (LED). Also includes circuits for the 707 common anode display.

64 pages Order code BP42 **£1.95**

BOOK 2 50 more l.e.d. circuits Order code BP87 **£1.95**

CIRCUIT SOURCE BOOK 1
A. Penfold

Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.

The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.

Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.

182 pages Order code BP321 **£4.95**

CIRCUIT SOURCE BOOK 2
R. A. Penfold

This book will help you to create and experiment with your own electronic designs by combining and using the various standard "building blocks" circuits provided. Where applicable, advice on how to alter the circuit parameters is provided.

The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.

The topics covered in this book include: 555 oscillators; sinewave oscillators; function generators; CMOS oscillators; voltage controlled oscillators; radio frequency oscillators; 555 monostables; CMOS monostables; TTL monostables; precision long timers; power supply and regulator circuits; negative supply generators and voltage boosters; digital dividers, decoders, etc; counters and display drivers; D/A and A/D converters; opto-isolators, flip/flops, noise generators, tone decoders, etc.

Over 170 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.

192 pages Order code BP322 **£4.95**

HOW TO USE OP-AMPS
E. A. Parr

This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.

160 pages Order code BP88 **£2.95**

MICRO INTERFACING CIRCUITS – BOOK 1
MICRO INTERFACING CIRCUITS – BOOK 2
R. A. Penfold

Both books include practical circuits together with details of the circuit operation and useful background information. Any special constructional points are covered but p.c.b. layouts and other detailed constructional information are not included.

Book 1 is mainly concerned with getting signals in and out of the computer; Book 2 deals primarily with circuits for practical applications.

BOOK 1 *112 pages* Order code BP130 **£2.75**
BOOK 2 *112 pages* Order code BP131 **£2.75**

Radio, TV, Satellite

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include:– An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap for combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and usefull circuits for short wave enthusiasts.

92 pages Order code BP304 **£3.95**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.

This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages Order code BP257 **£3.50**

SIMPLE SHORT WAVE RECEIVER CONSTRUCTION
R. A. Penfold

Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to construct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.

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REPORTING AMATEUR RADIO

Tony Smith G4FAI

SHAPE OF THINGS TO COME?

According to a recent *W5YI Report*, the Department of Environmental Protection and Energy of New Jersey is proposing to charge a fee to owners of r.f. generating devices. If approved, this proposal will require owners of sources of radio frequency and microwave radiation, between the frequencies of 300kHz and 100GHz, having the potential of exposing workers or the general public to specified radiation levels, to register their sources.

An initial registration fee is proposed plus an annual renewal fee. If the scheme is approved, the average fee for commercial users will be around $500 per antenna. No fees are mentioned for amateur radio stations. However, amateur radio is referred to in several sections of the proposal as being a significant source of radio frequency radiation posing health risks to the general public.

Extensive r.f. radiation measurements by the U.S. Environmental Protection Agency have shown that sources likely to produce the highest environmental levels are TV and radio broadcast stations. Other significant but less intense sources of r.f. radiation are transmitting satellite earth station antennas, microwave point-to-point communications antennas, cellular telephone cell-site antenna base stations, amateur radio stations (see this column, November 1993), navigational aids and radar.

A steady increase in the number of r.f. sources, coupled with a better understanding of their biological effects on human beings has, according to the report, heightened concern in the scientific community, and among the public, about the potential adverse health effects from exposure to this type of radiation. The fees charged will support the employment of enforcement staff and it is anticipated this will have a positive impact in reducing the levels of r.f. radiation in the environment.

So what has a proposal in the State of New Jersey to do with us in the UK? Well, as W5YI comments, if the N.J. proposal is implemented it could be justification for a national ruling on radio frequency radiation. And if the USA as a whole adopts such a measure, how long will it be before other countries, including the UK, follow suit?

IMPACT ON AMATEUR RADIO?

Once enforcement staff are active, and seeking to justify their existence, how soon, too, before they start looking more closely at the radiation fields of amateur radio stations? Depending on how the levels of radiation are defined, and the range of fees imposed, such a regime could have a significant impact on the hobby, the types of antenna used, and the levels of r.f. power permitted from individual transmitters.

Coincidentally, the same issue of the *W5YI* Report has details of a news release from the Long Island Section of the Institute of Electrical and Electronics Engineers about a.m. radio transmitters in Long Island, N.Y. These are estimated to waste 620 million watt-hours of electric energy each year, and to pose a radiation hazard to those in the vicinity of the high power transmitter sites 20dB (100 times) greater than needs be.

This was concluded in a study by Dr. Stephen Blank, Professor of Electrical Engineering at New York Institute of Technology. His study further concluded that both the waste and the radiation hazard could be eliminated by changing from the present (FCC mandated) circularly polarized method of transmission to vertical polarization. This, it is claimed, could be accomplished at low cost, and without sacrificing performance or area coverage, by changing the antennas at the transmitter sites.

Of course, the power levels of amateur transmitters are only a fraction of this order, but it is worth re-quoting the conclusions of the EPA, which I mentioned last November. Precautionary measures were suggested for "ham shacks" which, says the EPA, should be sufficient to prevent exposure of the operator and other persons to r.f. levels in excess of protection guidelines.

These measures included:

★ Using the minimum power necessary for a transmission.
★ Minimizing transmission time so that time-average exposures are acceptable.
★ Determining where high-field areas exist and restricting access to them during transmissions.
★ Mounting antennas as high above the ground as practical.

Under a fee-paying system as visualised above, such measures could well be the basis of a statutory code of practice, subject to inspections, and to penalties for failure to observe the code.

YOUNG OPERATORS' CLUB

The Young Operators' International Radio Club (YOP) is a Russian based international organisation of young people, under 30 years of age, intended to promote friendship and a better understanding of each other by sharing ideas and information about radio and other hobbies through radio communication and a newsletter.

The organiser is Andy Trubachov, UA3PIP, who, while trying to improve his English by talking to other operators on the amateur bands, found that the majority were much older than him. At the same time he discovered there were younger operators too and he had the idea of bringing both licensed amateurs and SWLs under 30 together through an international club.

He felt that a newsletter would extend their ability to communicate with each other, especially those restricted by their licences to VHF-UHF operation, while those trying to get into amateur radio would also be very welcome to join. The newsletter is planned to give members the opportunity to share their ideas and experiences of radio and other interests, including computers, travel, music, languages, etc.

The idea is still in its early stages, but Andy says "If you're under 30, male or female, and enjoy ham radio, join us! Let's have fun together!" Anyone interested is invited to send a photograph and brief information about themselves and their hobbies to Andy Trubachov, 301264 Tula Obl., Lipki P.O. Box 1, Russia. A couple of IRCs for return postage would be helpful.

NZ in CEPT

New Zealand has become the first country outside Europe to participate in the CEPT Amateur Radio Common Licence arrangement. Through the European Conference of Postal and Telecommunications Administrations (CEPT), the licences issued by more than twenty European countries, including the UK, are valid for temporary operation in each of the participating countries with the minimum of formality.

A "table of equivalence" translates the classes of licence issued by each country to one of two CEPT classes. Class 1 conveys full operating privileges, including h.f., and Class 2 gives full privileges above 144MHz.

Novice licences are not at present included in the scheme, and those with limited h.f. privileges at home may be limited to v.h.f. by the CEPT licence. For example, New Zealand General class licensees qualify for CEPT Class 1 privileges, and Limited class licensees for Class 2. UK Class B licensees also qualify for Class 2.

ISWL CLUB STATION

The International Short Wave League's club call, GX4BJC or GX4BJC/P, will be active throughout 1994. A variety of modes and bands will be used, and will originate from the location of a different ISWL member each month.

The club's QSL card will be sent to anyone who works or hears the station in operation and subsequently sends their own QSL or SWL reception report. These may be sent via the ISWL bureau or direct to Dave Beale G0DBX, "Kenwood", London Road, Louth, Lincs LN11 8QH. As the ISWL is a voluntary organisation an s.a.e. would be appreciated for direct QSLs.

The ISWL bureau will forward QSLs or SWL reports to all ISWL members worked or heard on-the-air, and these should be sent to the club's new QSL Manager, Tony Gale G7NUR, 115 Bruce Street, Swindon, SN2 2EN.

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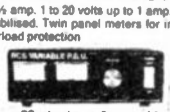

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