Australia $1.75 New Zealand $1.95 Malaysia $4.95

PRACTICAL ELECTRONICS

JULY 1985 · £1·00

ROBOTICS · MICROS · ELECTRONICS · INTERFACING

Increasing LAMP LIFE

MTX 8 Channel A to D

Modems:
CIRCUITRY : SPECIFICATIONS : BT APPROVAL

New Regular Robotics Review

ROBOTICS

Powertran's "Hebot II" and "MicroGrasp" kits offer unrivalled value for money to colleges, schools and individual enthusiasts.

Put the kit together, plug into your micro and off you go!

Hebot II can perform a bewildering variety of actions under the control of a simple BASIC program. Features include independent control of two wheels, flashing "eyes" two-tone hooter and a retractable pen.

Complete kit **£85** + VAT

Universal computer interface board kit **£11** + VAT

MicroGrasp is a fully programmable electric robot arm with closed loop feedback for positive positioning. The robot can be driven from virtually all micros.

Robot kit with power supply **£215** + VAT

Universal interface board kit **£60** + VAT

Powertran kits are complete down to the last nut and bolt, with easy-to-follow assembly instructions.

COMPUTING

Cortex II. 16 Bit. 16 Colour.

Cortex II offers the speed and power of true 16-bit processing at the same price that you might pay for some of the 8-bit games machines on the market.

The standard kit has interfaces for TV, cassette and RS232 – others are available as optional extras. Add disc drives, printer and a monitor for a fully-fledged business system. Price: **£249** + VAT

TOP KITS FROM POWERTRAN CYBERNETICS LIMITED

MUSIC

Powertran's range of quality audio products offers top quality at low, low prices. All the products are finished in rugged metal cabinets suitable for 19" rack mounting or as free standing units.

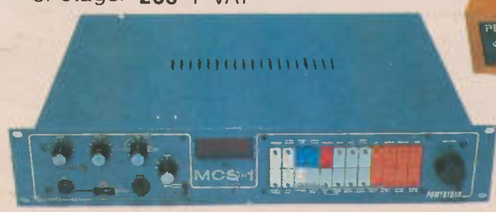
MPA 200 100 watt mixer-amplifier. Complete kit **£69.50** + VAT

SP2 200 2-channel 100 watt amplifier. Complete kit **£85** + VAT

Chromatheque 5000 5-channel light show controller. Complete kit **£79.50** + VAT

Digital Delay Line Studio quality effects – up to 1.6s delay. **£149** + VAT

Patchbay 16 pairs of jacks – for studio or stage. **£35** + VAT



Headphone Amp 2 x 3 sets of stereo phones from either one or two inputs. **£89** + VAT

Synth mix Stereo keyboard mixer with 3 aux sends on each of its 6 inputs. **£169** + VAT

MCS-1 MIDI-controlled sampling unit – doubles as a high quality effects unit. Complete kit **£599** + VAT

HOME SECURITY

Our Doppler Radar Alarm can detect intruders early enough (and loud enough) to offer your home *real* protection. Standard kit including two transmitters **£119** + VAT

Pair of extra transmitters **£39** + VAT

Special offer: extended kit including four transmitters **£139.50** + VAT

Send for demonstration tape to sample some of the sounds available **£2.50** + VAT

To Powertran Cybernetics Limited, Portway Industrial Estate, Andover, Hampshire SP10 3PE

Please send me the following kits ______

I enclose Cheque/Postal Order, value £ ______ (Don't forget to add V.A.T.)

Name ______ **Address** ______

Please allow 21 days for delivery. Offers subject to availability. Prices apply to UK only, are exclusive of V.A.T. and correct at time of going to press. Overseas customers - please contact our Export Department.

Access VISA

Access/Visa cardholders – save time – order by phone: 0264 64455.

PE ROBOTICS MICROS ELECTRONICS INTERFACING

ISSN 0032-6372

VOLUME 21 Nº7

JULY 1985

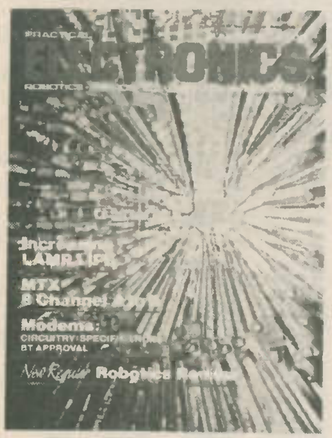
CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

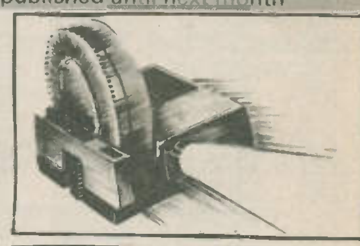
NEWS & COMMENT

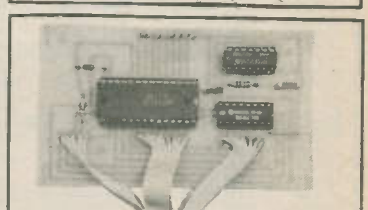
'RUR' HOBBY ROBOT—2

We regret that due to circumstances beyond our control Part Two of RUR will not be published until next month



This month's cover shows a cluster of probes monitoring a thin-film circuit while nichrome resistors are trimmed to a tolerance of closer than five hundredths of a per cent—courtesy of Mullard.





OUR AUGUST ISSUE WILL BE ON SALE FRIDAY, JULY 5th, 1985 *(see page 23)*

SPEAKERS
8Ω, 0·3W, 2", 2·25", 2·5", 3" 80p
0·3W, 2·5" 40Ω; 64Ω or 80Ω 80p

DIODES

AA119	8
AA129	10
AAY30	8
BA100	10
BY100	15
BY126	12
BY127	10
CRO33	198
OA9	10
OA47	10
OA70	9
OA79	10
OA81	10
OA85	10
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	12
1N5404	14
1N5406	15
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

BRIDGE RECTIFIERS (plastic case)

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	30
2A/50V	26
2A/200V	40
2A/400V	42
2A/600V	50
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	56

ZENERS
Range: 2V7 to 39V 400mW **8p each**
Range: 3V3 to 33V. 1·3W **15p each**

VARICAPS

BA102	30
BB105B	40
BB106	40

SCR's Thyristors

0·8A-100V	32
5A/300V	38
5A/400V	40
5A/600V	48
8A/300V	60
8A/600V	96
12A/100V	78
12A/400V	96
12A/800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5064	38
2N4444	130

DIAC
ST2 25

TRIACS

3A/100V	48
3A/400V	56
3A/800V	85
8A/100V	50
8A/400V	69
8A/800V	115
12A/100V	78
12A/400V	82
12A/800V	135
16A/100V	103
16A/400V	105
16A/800V	220
25A/400V	185
25A/800V	295
25A/1000V	480
30A/400V	525
T2800D	125

SOLDERCON PINS
100 45p
500 370p

OPTO
LEDS price includes Clips

TIL209 Red 3mm	10
TIL211 Green 3mm	14
TIL212 Yellow	14
TIL220 ·2" Red	12
0·2" Yel, Grn, Amber	14
Rectangular LEDs with two part clip. R, G & Y	45
Rectangl. Stackable LEDS	18
Triangular LEDs R&G	18
0·2" Flashing LED Red	56
0·2" Bi colour LEDs Red/Green	100
Green/Yellow	80
0·2" Tri colour LEDs Red/Green/Yellow	85
0·2" Red High Bright	59
High Bright Green or Yellow	100
LD271 Infra Red (emit)	45
TIL32 Infra Red (emit)	52
SFH205 (detector)	118
TIL78 (detector)	55
TIL38	50
TIL81 82; TIL100	90

7 Segment Displays

TIL321 ·5" C.An	140
TIL322 ·5" C.th	140
DL704 ·3" C.Cth	125
DL707 ·3" C.Anod	125
FND357 or 500	130
·3" Green C.A.	140
±1 ·3" Red or Green	150
Bargraph 10 seg. Red	275
Bargraph NSM3914	500

FERRIC CHLORIDE
Crystals 1lb
195p + 50p p&p

DALO ETCH RESIST
Pen plus spare tip **100p**

0·5" LCD DISPLAYS

3½ digit	495
4 digit	530
6 digit	625

OPTO

BPX25	250
BPW21	320
BPX65	320
ILD74	145
ILQ74	275
ILCT6 Darlington Isolator	135
TIL111	70
OCP71	120
ORP12	78
2N5777	50
4N33	135
Pin diode	720
Schmitt Receiver	715

OPTO SWITCH
Reflective
TIL139 225
Slotted similar to RS 186

ALUM.BOXES

4×2½×2"	100
4×2¾×2½"103	
4×4×2½"	120
5×4×2"	105
5×2¾×1½"	90
5×2¾×1½"130	
5×4×1½"	99
5×4×2½"	120
6×4×2"	120
6×4×3"	150
7×5×3"	180
8×6×3"	210
10×4¼×3"	240
10×7×3"	275
12×5×3"	260
12×8×3"	295

COPPER CLAD BOARDS

Fibre Glass	Single-sided	Double-sided
6"×6"	100p	125p
6"×12"	175p	225p

VEROBOARD

	Clad	Plain
2½×3¾"	95p	—
2½×5"	110p	—
3¾×3¾"	110p	—
3¾×5"	125p	95p
3¾×17"	420p	275p
4¾×18"	590p	—
Pkt. of 100 pins	55p	
Spot Face Cutter	150p	
Pin Insertion Tool	185p	

VQ Board	180p
DIP Board	395p
Vero strip	95p

PROTO-DECs

Veroblock	480
S-Dec	395
Eurobreadboard	580
Bimboard 1	695
Superstrip SS2	£13

VERO WIRING PEN and Spool 380p
Spare Wire (Spool) **75p**; Combs **8p** ea.
Wire Wrapping Stakes 100 **250p**

VOLTAGE REGULATORS
1A T0220 Plastic Casing

	+ve		−ve	
5V	7805	45p	7905	55p
12V	7812	45p	7908	55p
15V	7815	45p	7912	55p
18V	7818	45p	7915	55p
24V	7824	45p	7918	55p
100mA T092 Plastic Casing				
5V	78L05	30p	79L05	50p
6V	78L62	30p		—
8V	78L82	30p		—
12V	78L12	30p	79L12	50p
15V	78L15	30p	79L15	50p

ICL7660	248	LM317K	250
78H05 5V/5A	550	LM317P	99
78H12 12V/5A	640	LM323K	500
78HG+5 to +24V 5A		LM337T	175
	599	LM723	30
79HG −2.25V to −24V 5A		TBA625B	75
	685	RC4194	375
LM309K	120	RC4195	160
		78S40	225

SWITCHES

SLIDE 250V

1A DPDT	14
1A DPDT C/OFF	15
½A DP on/on/on	40

TOGGLE 2A 250V

SPST	35
DPDT	48
4 pole on off	54

PUSH BUTTON
Spring loaded

Latching or Momentary 6A	
SPDT c/over	150
DPDT c/over	200

SUB-MIN TOGGLE 2 amp

SP changeover	64
SPST on off	58
SPDT c/off	85
SPDT Biased	105
DPDT 6 tags	80
DPDT C/OFF	88
DPDT on/on/on	185
DPDT Biased	145
4-pole 2 way	220

MINIATURE
Non Locking
Push to make 15p
Push break 25p

ROTARY: (Adjustable Stop Type)
1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way **48p**

ROTARY: Mains 250V AC, 4 Amp **68p**

DIP SWITCHES: (SPST) 4 way **85p**; 6 way **80p**; 8 way **87p**; 10 way **100p**; (SPDT) 4 way **190p.**

AMPHENOL PLUGS

	IDC	Solder
24 way IEEE	465p	460p
36 way Centronix	450p	475p
24 way Female	480p	450p
36 way Centronic Female	470p	500p

ASTEC UHF MODULATORS
6MHz Standard 375p
8MHz Wideband 550p

ANTEX Soldering Irons

C15W	525p	C517W	545p
G18W	550p	XS25W	570p

DIL SOCKETS

	Low profile	Wire wrap
8 pin	8p	25p
14 pin	10p	35p
16 pin	10p	42p
18 pin	16p	52p
20 pin	20p	60p
22 pin	22p	65p
24 pin	25p	70p
28 pin	28p	80p
40 pin	30p	99p

ZIF SOCKET (TEXTOOL)

24 way	575p
28 way	695p
40 way	845p

DIL PLUGS (Headers)

Pins	Solder	IDC
14	38p	95p
16	42p	100p
24	88p	138p
28	185p	290p
40	195p	218p

RIBBON CABLE (price per foot)

Ways	Grey	Colour
10	15p	25p
16	20p	30p
20	25p	40p
26	40p	85p
34	50p	80p
40	60p	90p
64	90p	125p

SPECTRUM 32K UPGRADE

Upgrade your 16K Spectrum to full 48K with our RAM Upgrade Kit. Very simple to fit. Fitting instructions supplied. **ONLY £22**

IDC CONNECTORS (Speed block type)

2 rows	PCB Male with latch Strt. Pins	Angle Pins	Female Header Socket	Female Card-Edge Connector
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	195p
20 way	145p	166p	125p	240p
26 way	175p	200p	150p	320p
34 way	205p	236p	169p	340p
40 way	220p	250p	190p	420p
50 way	235p	270p	200p	470p

SPECIAL OFFER

	1+	10+
2764 – 250ns	425	415
27128 – 250ns	875	865
6116LP – 150ns	325	313
6264LP – 150ns	895	885

'D' CONNECTORS:

Pins	9 way	15 way	25 way	37 way
MALE				
Solder	55p	80p	120p	150p
Angle	110p	175p	225p	300p
Strait	100p	100p	160p	250p
FEMALE				
Solder	90p	125p	180p	275p
Angle	150p	200p	260p	390p
Strait	100p	125p	195p	355p
COVERS 75p	70p	70p	85p	

IDC 25 way Plg. **385p**, Skt. **450p**

TRANSFORMERS (mains Prim. 220-240V)
3-0-3V, 6-0-6V 100mA 130; 9-0-9V 75mA; 12-0-12V 75mA; 15-0-15V 75mA. 130p
6VA: 2×6V-5A; 2×9V-4A; 2×12V-0·3A; 2×15V-25A 250p
12VA: 2×4V5-1·3A; 2×6V-1·2A; 2×12V-5A; 2×15V-4A 345p (35p p&p)
24VA: 6V-15A 6V-1·5A; 9V-1·2A 9V-12A; 12V-1A 12V-1A; 15-8A 15-8A; 20V-6A 20V-6A 385 (60p p&p)
50VA: 2×6V-4A; 2×9V-2·5A; 2×12V-2A; 2×15V. 1·5A; 2-20V-1·2A; 2×25V-2A; 2×30V-0·8A 520p (60p p&p)
100VA: 2×12V-4A; 2×15V-3A; 2×20V-2·5A; 2×30V-1·5A; 2×40V-1·25A; 2×50V-1A 965p (60p p&p)

SIL Sockets 0.1"
20 way **65p**
32 way **95p**

EDGE CONNECTORS ·1"

2×18 way	210p
2×22 way	215p
2×23 way	175p
2×25 way	285p
2×28 way	190p
2×30 way	310p
2×36 way	360p
2×40 way	380p
2×43 way	450p
2×75 way	850p

TURNED PIN Low Profile Professional DIL SOCKET

8 pin	25p	22 pin	70p
14 pin	40p	24 pin	72p
16 pin	42p	28 pin	90p
18 pin	47p	40 pin	120p
20 pin	60p		

JUMPER LEADS
IDC FEMALE RECEPTACLE Jumper Leads 36"

	20pin	26pin	34pin	40pin
1 end	160p	200p	260p	300p
2 ends	290p	370p	480p	525p

COMPUTER CORNER

- **EPSON RX80** Printer **£209**
- **EPSON RX80** F/T Printer **£219**
- **EPSON FX80** Printer **£316**
- **EPSON FX100** Printer **£429**
- **KAGA/TAXAN KP810** Printer **£252**
- **KAGA/TAXAN KP910** Printer **£332**
- **BROTHER HR15** Daisywheel Printer **£329**
- **Centronics PRINTER CABLE** for all the above printers to interface with the BBC Micro **£7**
- **ZENITH 12" Hi-RES,** Green Monitor 40/80 column select switch, value for money. **£66**
- **MICROVITEC 14"** colour monitor. RGB input. Lead incl. **£165**
- **MICROVITEC 1451** Hi-res 14" Monitor incl. Lead **£237**
- **KAGA 12"** MED-res **£225**
- **KAGA 12"** Hi-res **£310**
- **TEX EPROM ERASER.** Erases up to 32 ICs in 15-30 min. **£30**
- **Spare** 'UV lamp bulbs **£8**
- **8½"** or 9½" Fan fold paper (1000 sheets) £7 (150p)

MANY MORE PRINTERS, MONITORS, INTERFACES, AVAILABLE. CALL IN AT OUR SHOP FOR DEMONSTRATION OR WRITE IN FOR OUR DESCRIPTIVE LEAFLET.

(P&P on some of the above items is extra)
Call in at our shop for demonstration of any of the above items. Be satisfied before you buy.

Plastic Library DISC STORAGE CASES

Holds ten 5¼" Diskettes **£1.80**

DISC ALBUMS

Attractively finished in beige leather-vinyl, these conveniently store up to 20 discs. Each disc can easily be seen through the clear view pockets.
ONLY £4.25

5¼" Disc Drive
HEAD CLEANING KIT
£9

BBC MICRO WORD PROCESSING PACKAGE

A complete word processing package (which can be heavily modified to your requirements, maintaining large discount). We supply everything you need to get a BBC Micro running as a word-processor. Please call in for a demonstration.

Example Package:
BBC Micro, with DFS Interface, Wordwise, Twin 400K TEC Disc Drives, 12" High-res green monitor, Brother HR15 Daisywheel printer, Beebcalc & Database software on Disc, 10 3M Discs, 500 sheets of paper, 4 way mains trailing socket, manuals and all cables.
Only: £1,089

CRYSTALS

32·768KHz	100
100KHz	575
200KHz	370
455KHz	370
1MHz	275
1·008M	275
1·28MHz	450
1·5MHz	420
1·6MHz	595
1·8MHz	545
1·8432M	250
2·0MHz	225
2·4576M	200
2·5MHz	225
2·56250M	220
3·2768M	150
3·57954M	98
3·6864M	300
4·0MHz	150
4·032MHz	290
4·194304M	200
4·433619M	100
4·608MHz	200
4·80MHz	200
5·0MHz	160
5·185MHz	300
5·24288M	390
6·0MHz	140
6·144MHz	150
6·5536MHz	200
7·0MHz	150
7·168MHz	250
7·68MHz	200
8·0MHz	150
8·08333M	395
8·867237M	175
9·00MHz	200
9·375MHz	350
10·0MHz	175
10·5MHz	250
10·7MHz	150
10·24MHz	200
12·0MHz	175
12·528MHz	300
14·31818M	170
14·7456M	175
14·765MHz	250
15·0MHz	240
16·0MHz	220
18·0MHz	180
18·432M	150
19·968MHz	150
20·0MHz	260
24·0MHz	170
24·930MHz	325
29·695MHz	150
26·670MHz	325
27·125MHz	295
27·145M	190
27·648MHz	300
38·66667M	240
48·0MHz	240
55·5MHz	400
100MHz	295
116·0MHz	300
145·8MHz	225

BBC MICROCOMPUTER

SPECIAL OFFER THIS MONTH .... **ONLY £299**
We stock the full range of BBC Micro peripherals, Hardware & Software like, Disc Drives (Top quality Cumana & Mitsubishi), Diskettes, Printers, Printer Paper, Interface Cable, Dust Covers, Cassette Recorder & Cassettes, Monitors, Connectors (Ready made Cables, Plugs & Sockets), Plotter (Graphic Tablet) EPROM Programmer, Lightpen Kit, Joysticks, Sideways ROM Board, EPROM Eraser, Machinecode ROM, The highly sophisticated Watford's 16K BEEB DFS, WORDWISE, BEEBCALC, Software (Educational Application & Games), BOOKS, etc. etc. Please send SAE for our descriptive leaflet.

DRIVES CASED WITH PSU & CABLES

- **CS100 – TEC** Single sided 40 track 100K 5¼" Single Disc Drive **£119**
- **CS200 – Epson** Double sided 40 track 200K 5¼" Single Disc Drive **£139**
- **CS400S – MITSUBISHI** Double sided 80 track 400K 5¼" Single Disc Drive **£149**
- **CD400 – EPSON** Double sided 40 track 400K 5¼" TWIN Disc Drives **£215**
- **CD800S – MITSUBISHI** Double sided 80 track 800K 5¼" TWIN Disc Drives **£295**
- **DFS** Manual (comprehensive) ..... **£7** (NO VAT)
- **TWIN** Disc Drive CASE with Power Supply to house your own Drives **£38**

N.B. All single drives with power supply with be supplied in a twin Case for later inclusion of a second Drive.

(Carriage on disc drives £7 Securicor)

WATFORD ELECTRONICS

Tel. (0923) 40588 Telex. 8956095

MARCO TRADING

BARCLAYCARD VISA — Access

MIN.D CONNECTORS

	9 way	15 way	25 way	37 way
PLUGS				
Solder Lug	52p	65p	88p	£1.45
Right Angle	89p	£1.34	£1.98	£3.48
SOCKETS				
Solder Lug	78p	98p	£1.33	£2.48
Right Angle	£1.18	£1.78	£2.70	£4.15
COVERS	95p	95p	98p	£1.00

RESISTOR KITS

¼W Pack 10 each value E12 10R-1M Total: 610 resistors ONLY 4.80

¼W Pack 5 each value E12 10R-1M Total: 305 resistors ONLY 2.75

½W Pack 10 each value E12 2R2-2M2 Total: 730 resistors ONLY 5.25

½W Pack 5 each value E12 2R2-2M2 Total: 365 resistors ONLY 3.50

50v Ceramic Kit 5 each value 125 Per Kit £3.50

PRE-SETS

Vert + Horiz 100R to 1M **10p**, 100 for **£6.50**

CERAMIC CAPACITORS

All 50V. 1p to 10 nf 4p each, 100 for £2.75

COPPER WIRE

Tinned + Enamelled Copper Wire. 2oz reels: 14 to 30 swg £1.00 per reel.

ZENER DIODE

400 m/w 3v to 75v: **8p** each, 100 for **£6.00**. 1 watt 3v3 to 200v: **15p** each, 100 for **£12.50**

SOLDERING AIDS

Antex 15W iron	5.00
Antex 18W iron	5.00
Antex 25W iron	5.20
Antex Elements	2.00
Antex Bits	0.95
Antex stands	1.90
Desolder Tool	4.50
Spare nozzle	0.65
25W Kit-iron with 13A plug & stand	ONLY 7.20

NI-CAD CHARGER

Universal charger to charge PP3, AA, C, D PRICE 6.00

NI-CADS

PP3	£4.45,	4/16.00
AA	£0.95,	10/8.00
HPII	£2.30,	4/8.50
C	£1.95,	4/8.75

Fuseholders

20mm Panel Mounting	0.28
20mm Chassis Mounting	0.06
1¼in Panel Mounting	0.35
1¼in Chassis Mounting	0.342
Carline 1¼in Mounting	0.10

FUSES

QB 20mm 100mA to 6.3A: **6p** each, 100 for **£3.50**. Slow Blow 20mm 100mA to 200mA: **20p**, 100 for **£15.00**. 20mA to 800mA: 12p, 100 for **£7.50**. 1A to 6.3A: **10p**, 100 for **£5.00**.

L.E.D.s

RED: 3mm + 5mm **10p** each, 100 for **£6.00**. YELLOW: 3mm + 55mm **13p** each, 100 for **£10.00**. GREEN: 3mm + 5mm **13p** each, 100 for **£10.00**. Prices include counting clips.

SPECIAL OFFER

The complete set of three strip-fix plastic signs, containing over two thousand words. Transmitters, frequencies, dials, letters and symbols etc. Three for £3.75.

TELECOM EQUIP

BT Plug & 3M lead	1.25
BT MASTER SOCKET	2.85
BT Sec Skt	1.95
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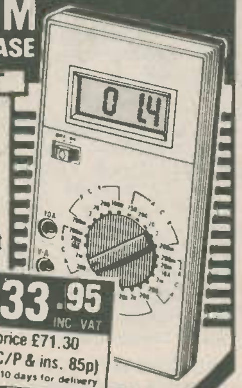

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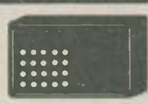

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PE VOLUME 21 Nº7 JULY 1985

UK LOSING GROUND

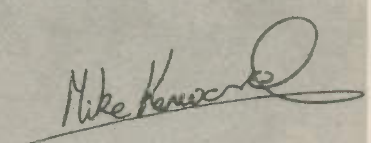
"WE ARE rapidly losing ground to our competitors in education generally, in technical education specifically". The words of the Chairman of STC to the Parliamentary Information Technology Committee. With virtually the whole of the UK electronics industry now needing qualified engineers, it does seem that the educational system is failing the employers. Fortunately schemes are being set up, in some cases with industry funding, to overcome these deficiencies. However we still appear to have some way to go before our educational system convinces our children (of both sexes) that engineering is more important and of higher standing socially, than the arts. Do we find it odd that art colleges still exist when we have no software colleges or IT colleges etc., outside of those funded by the industry?

The AEB 'O' level electronics course, based on a systems approach, which requires the student to build a project as part of the examination, claims less than 6,000 examinees this year. This course is the only true GCE 'O' level electronics course with more than a few hundred participants, and while it is growing each year the number still seems very small for such a large potential area of employment. It seems to us rather sad that such an interesting and rewarding 'O' level course can claim so few students when there are over 800,000 students of suitable age in the UK.

Our sister publication, *Everyday Electronics*, which caters for the "learning" end of the hobby sells more than 35,500 copies every month and, together with PE, could be said to be doing more for the industry than our educational system.

TWENTY YEARS OF STAGNATION

When I was at school—now more than twenty years ago—the electronics club and Ohms law in physics were the nearest we got to learning "electronics". It is a sad indictment of the system that for many students the situation has not changed in those twenty years, unless of course you know better? We would be very interested to hear from both students and teachers on just what is, or is not, going on in schools around the country as far as electronics is concerned. We would also like to hear any views you have on where the problems lie or even if you think everything is just fine! Let us hear from you so that we can expand on the above.



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We regret that lengthy technical enquiries cannot be answered over the telephone.

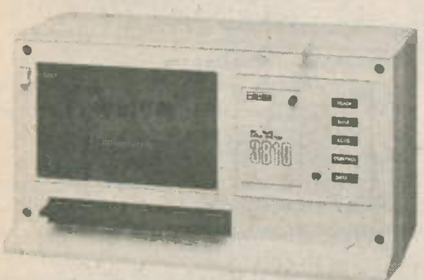
Items mentioned are available through normal retail outlets, unless otherwise specified. Prices correct at time of going to press.

...news &

A load off our minds

The problems encountered by micro users when loading programs via 'ordinary' cassette machines are by now legendary. Advice like 'turn up the volume' and 'is the head clean?' often only serve to further aggravate the frustrated user. Cheap High Street audio units may initially look like good value but perhaps, in the long run, a purpose-built cassette data recorder is the wiser buy.

The MC3810 from Waltham Electronics of Munich has already established itself in its home market. As a purpose-designed data recorder the unit has a precision tape



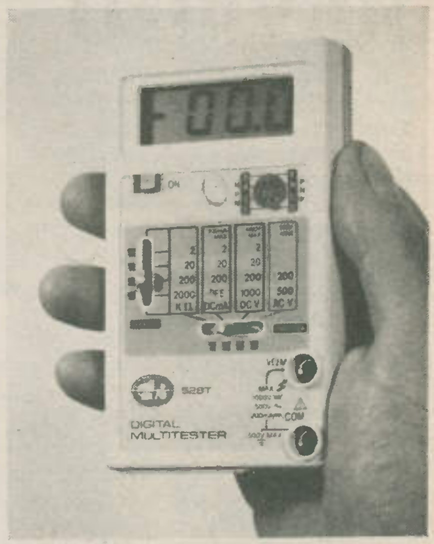
drive with a transfer rate of 1,200 baud. Motor control is from the computer, level control and switch off are automatic.

"Ready", "Save", "Load" and "Control" modes are displayed by a series of indicator lamps on the front panel. This unit is compatible (via interface cable) with the following micros: CBM64, VIC20, Atari 600/800, Spectrum, Spectrum plus, BBC, Electron, Sanyo Laser and MSX. An additional power supply unit is required for all but the Commodore machine. The read/write head is ajdustable from the outside of the machine, which also features an oil-damped eject mechanism with tape counter. A monitor socket is sited on the front panel. Prices are as follows: Recorder unit £25.95; Power Supply £5.70; Interface Cables £3.99 (prices include VAT). Further details from Twillstar Computers Ltd., 17 Regina Road, Southall, Middx. UB2 5PL (01-574 5271).

The second unit featured here is the Binatone data recorder, once again a purpose-designed unit with optimised "Load"/"Save" circuitry. The model 01/6560 is plug compatible wih the CBM64 and the VIC20. The model 01/6565, on the other hand, is compatible with a much wider range of machines, namely: BBC, Electron, Dragon, Spectrum, Spectrum plus and the MSX machines. This model features output level control and a monitor socket. Both models feature a 'pause' button and a soft eject mechanism.

The 01/6565 costs £29.95 and the 01/6560 £34.95 (prices include VAT). From Binatone International Ltd., Binatone House, 1 Beresford Avenue, Wembley, Middx. HA0 1YX (01-903 5211).

THAT'S HANDY



The availability of a very handy, 3½ digit multimeter has been announced by SSI Ltd. The 528T has a built-in transistor tester and measures just 115 × 65 × 24mm. Automatic zero and polarity adjustment are featured along with overload circuit protection.

Ranges are as follows: Voltage a.c. 0–500V; Voltage d.c. 0–1kV; Current d.c. 0–200mA; Ohms 0–2kΩ; Transistor hFE (forward current gain) 0–1000 pnp/npn.

Housed in a convenient 'book-like' case with manual, battery, leads and spare fuse, the 528T costs £37.15 inc VAT and p&p. From, Semiconductor Supplies International Ltd., Dawson House, 128/130 Carshalton Road, Sutton, Surrey SM1 4RS (01-643 1126).

BROCHURE

Saxon Entertainments, the disco and PA equipment manufacturer, has introduced a new brochure. The product range can be split into four main categories; disco console and loudspeakers, amplifiers (including slave and PA units), lighting equipment and accessories. A custom-building service is also available.

The company are the only disco equipment manufacturers to obtain GLC safety approval. In the twelve years since Saxon began trading they have developed a good reputation for quality and fair prices. All their products carry a two year warranty.

The free brochure can be obtained from Saxon Entertainments, 327/333 Whitehorse Road, West Croydon, CR0 2HS (01-684 8007). Please enclose SAE.

MAINTENANCE-FREE UPS

Mitsubishi (Tokyo) has developed what is believed to be the world's first maintenance-free UPS (Uninterruptable Power Supply). The machine will maintain a power supply if the regular supply suffers 'drop-outs' or voltage 'dips'. The system is designed to continue to provide power to computers or controllers of factory automation equipment and FMS (Flexible Manufacturing Systems).

A conventional UPS uses storage batteries whereas the new system employs a high-speed flywheel and a power generator hermetically sealed in a vacuum chamber.

The flywheel rotates at around 30,000 r.p.m. on utility power, when the supply is cut its inertia will provide 5kVA of power for up to one minute. High magnetic induction is achieved by using a rare earth magnet—eliminating the need for brushes. This gives the equipment a maintenance-free life of up to 10 years.

MARKET PLACE

Crofton's Bonanza

The very latest from Crofton Electronics is the imminent re-introduction of the PM-101, nine-inch monitor. This popular, metal cased monochrome unit was originally discontinued when the market trend swayed in favour of 12 inch units. Such trends, however, have a habit of reversing themselves and once again the nine-inch monitor is in demand. The PM-101 is available with a green or B/W screen and costs £82.80 inc. VAT and p&p.

For those who think that monitors are only useful as computer VDU's, then think again. The above monitor would make an ideal companion for the Ikegami one-inch vidicon camera when used as a simple Closed Circuit Television (CCTV) system. Why the Ikegami one-inch? Simply because this camera is presently on offer from Crofton. These cameras are refurbished units and are guaranteed for 12 months. They require a 240V mains supply and have a one-volt composite video output. Their low price would facilitate the construction of a very cheap CCTV system when used with the PM-101 monitor. The Ikegami one-inch vidicon camera (with a 16mm lens) costs £69.00 inc. VAT and p&p.

Both the above mentioned items have indeed been brought together as a complete CCTV package which includes a camera to monitor connecting lead and even a mains plug. This package along with many more DIY security kits will be featured in our special *DIY Intruder Alarms—Buyers Guide* in the September issue of PE.

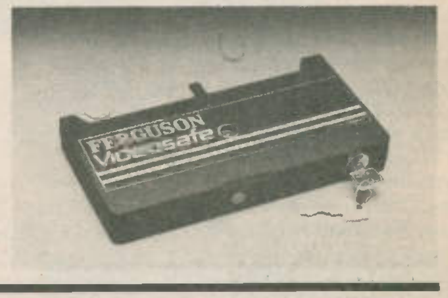
For the moment, however, more information can be obtained from, Crofton Electronics, 35 Grosvenor Road, Twickenham, Middx. TW1 4AD (01-891 1923).

IS YOUR VIDEOSAFE?

A useful anti-theft device is the latest VHS video accessory from Thorn EMI Ferguson. The "Videosafe" is shaped like a conventional video cassette but when armed and placed in a VHS video recorder it will emit a 98 decibel audible alarm if the machine is moved or an attempt is made to eject the device.

The unit is activated by simply locking it with the key supplied and a 15 second delay allows time for loading into the video recorder before it is armed. When deactivating, the eject mechanism brings the device to the eject flap where it is then unlocked with the key which turns off the alarm and releases the unit from the recorder. Videosafe costs around £25 and is available in the High Street.

Because Ferguson do not manufacture a Beta format machine they have not developed a Beta version of this idea—now there's an opportunity!



ROBOTICS

A construction kit which could be very useful for experiments with robotics will shortly be available from Magenta Electronics Ltd. The kit is for the Stepper Motor Interface which will be described in our sister publication Everyday Electronics (August '85 issue). Magenta also supply a very useful motor-gearbox assembly, the Fischertechnik robotics kits (with Spectrum and BBC interfaces) and a general range of well over 100 kits for published projects.

The range includes such items as: an Insulation Tester, a Computer Cassette Load Simplifier, Spectrum and Amstrad amplifiers, BBC Storage Scope Interface, Digital Multimeter, Mains Cable Detector, Ultrasonic Burglar Alarm, Quasi Stereo Adaptor, Ioniser and many other projects for the home-owner, musician, motorist and photographer etc.

A complete catalogue with price list is available for £1 in stamps or the price list can be obtained free by sending a 9 × 4 stamped self-addressed envelope. From Magenta (mail order only), 135 Hunter Street, Burton-on-Trent, Staffs DE14 2ST (0283 65435).

DRILL SPEED CONTROL KIT

If you are constantly having trouble with stopping your mini-drill going "walkabout" on your printed circuit board due to excessive speed of the chuck, then we can recommend the latest Speed Control Kit for Mini-Drills from Croydon Discount Electronics.

The speed controller is specially designed for the small mini-drills that are so useful for delicate p.c.b. work and only requires the connection of two wires to a suitable transformer. The control unit is claimed to be able to handle 2A continuously or 3A intermittently.

The unit is built in a strong plastic case which also has space to take a suitable transformer. The front panel acts as the mounting plate for the control potentiometer, l.e.d., fuse, p.c.b. and drill input socket.

For the smaller type of drill, a suitable transformer rated at 15V 1A continuous, 1·5A intermittent is available from Croydon Discount for the sum of £2.90 plus 80p postage and packing.

It is usual for this type of controller to be advertised at the asking price of anything between £10 to £20 and over, but the price for the Mini-Drill Speed Control Unit kit is just £4.50 plus 80p postage and packing.

If the kit and transformer are ordered together it will only be necessary to include one remittance for postage and packing. For more details readers should contact Croydon Discount Electronics, 40 Lower Addiscombe Road, Croydon, CR0 6AA (01-688 2950).

...NEWS & MARKET PLACE

DISPLAY DUO

Two dedicated 12" monochome monitors have been introduced by Ferguson. They differ only in the colour of the screen phosphor. The MMO2 (Green) and the MMO6 (Amber) are both fitted with anti-glare face plates.

A dynamic-focus feature allows sharp focusing of all characters and maintains spot size consistency across the whole screen. A comprehensive range of sync inputs gives a high degree of user flexibility. Both linear and TTL inputs are acceptable and a shaded display can be produced with a linear input. Fast line flyback makes it possible to display up to 100 characters per row (25 rows). Available from good computer outlets at around £80.

WHEELS — LIVE THE LEGEND OF THE MOTOR CAR

A unique new £1¼M historical/tourist adventure entitled "Wheels"— Live the Legend of the Motor Car, was officially opened this week (June 5) by HRH Prince of Wales, at the National Motor Museum, Beaulieu.

Visitors are transported in pods through a series of twenty individual display areas, each of which concentrates on a separate "theme" from the history of motoring in Britain, including robotic car manufacture to lunar space vehicles.

Sound

Four basic sound systems are used in the "voyage". The first is the commentary given individually in each pod. This equipment was designed by Electrosonic of Greenwich and the ES1320 Digital Sound Store captures any conventional recorded sound in digital form in non-volatile EPROM.

Background music originates from 16-track tape machines working in tandem. Special sound effects emanate from Mackenzie message repeaters and digital sound stores.

In the event of an emergency, a sound system with battery back-up has been installed to give evacuation instructions.

Video

All the required film to be used throughout the ride has been transferred to laser disc, with the appropriate sections transferred by Philips Laser disc players to the appropriate TV monitors.

Briefly...

From Japan comes the news that multi-layer p.c.b.s for hybrid circuits are being produced with capacitors, resistors and other components actually within the layers. The 10 to 15 layer boards are made in such a way as to coat each layer with an electroconductive or insulating paste material that functions as a capacitor or resistor.

POINTS ARISING...

RUGBY CLOCK
April/May '85

The following points have been brought to our attention regarding this project.

The four i.c.s IC4–IC7 should be 4015's and not 4008's as published.

For maintenance purposes the Rugby transmission is shut down for four hours on the first Tuesday of each month. Additionally there is a two week annual maintenance period which this year was May 23rd to June 10th.

For further information contact: The National Physical Laboratory, Queens Road, Teddington, Middx. TW11 0LW.

SIGNAL GENERATOR
February '85

When the sig/gen is used with power supply voltages greater than about 10V, the comparator trip point of IC3 requires that either the reference zener diode D5 is changed to approximately half the PSU voltage (e.g. 6V2 for a 12V PSU), or that the voltage at IC3 pin 14 be restricted to about 9V or 10V. For the latter insert a resistor of around 470Ω between IC3 pin 14 and the + ve line, with a 9V1 or 10V zener between pin 14 and 0V line, and a 22μF capacitor across this zener. Note that the output frequency amplitude at IC3 pin 8 is at the level set by D5.

Countdown . . .

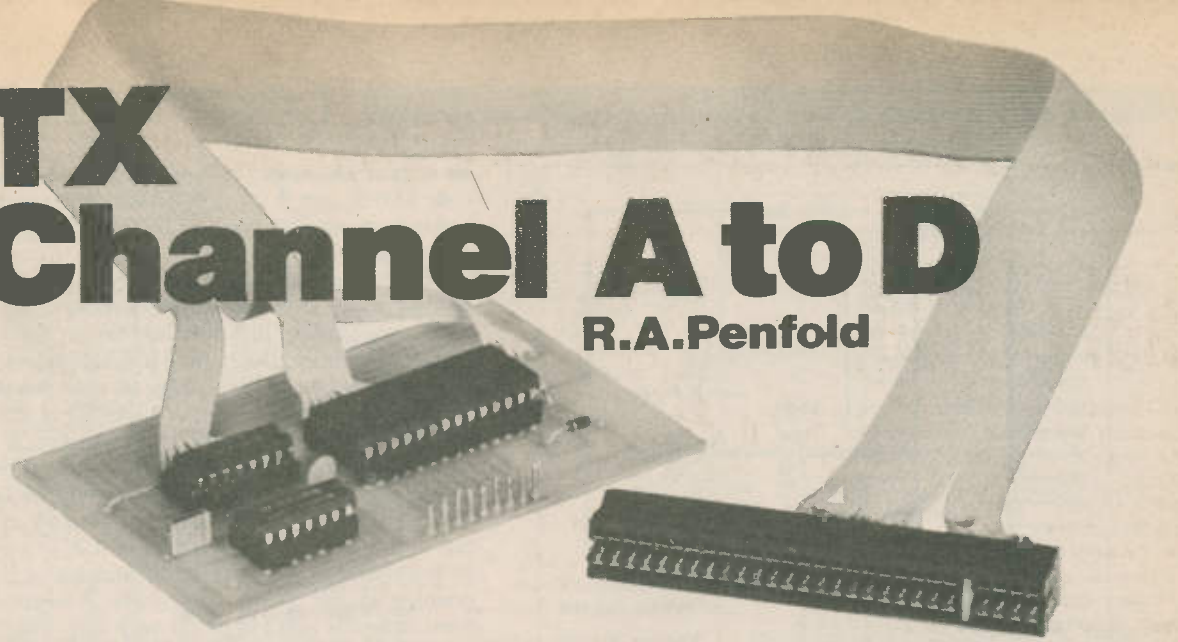
Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to Mike Abbott.

The Computer Fair June 13–16. Earls Court **K2**
Networks June 25–27. Wembley Conf. Cntr. **O**
Cable July 9–11. Metropole, Brighton **O**
Video Software Sept. 1–3, Olympia **G3**
Personal Computer World Show Sept. 18–22. Olympia 2 **M**
Leeds Electronics Show Sept. 24–26. University **E**
Electron & BBC User Sept. 27–29. UMIST, Manchester **L**
Computer Graphics Oct. 16–18. Wembley Conf. Cntr. **O**
Cellular Communications Int. Nov. 5–7. Wembley Conf. Cntr. **O**
Electronic Publishing Nov. 5–7. Wembley Conf. Cntr. **O**
Compec Nov. 12–15. Olympia **K2**
Electron & BBC User Nov 14–17. New Horticultural Hall, London **L**
Computers In The City Nov. 19–21. Barbican Cntr. **O**

E	Evan Steadman ✆ 0799 26699
G3	Link House Video ✆ 01-686 2599
K2	Reed Exhibitions, Surrey Ho., 1 Throwley Way, Sutton, Surrey.
L	Database ✆ 061-429 8157
M	Montbuild ✆ 01-486 1951
O	Online ✆ 01-868 4466

MTX 8 Channel A to D

R.A.Penfold



THE Memotech MTX500 and MTX512 computers have features which make them an attractive proposition for anyone wishing to use a computer in control or measurement applications. Two features of this type are the built-in assembler and the user port which provides eight digital inputs and eight digital outputs. One obvious omission from the specification is any form of analogue to digital converter (ADC). Although these machines have two Atari/Commodore type joystick ports, they do not have a simple resistance sensitive A to D converter of the type fitted to Atari and Commodore computers.

It is not difficult to add an analogue to digital converter to the MTX computers though, and a circuit of this type can be added to either the user port or the expansion port. This design is for an eight channel converter which connects to the expansion port. Using the expansion port rather than the user port has the advantage of leaving all 16 user port lines free for use, and gives the computer a formidable interfacing capability. Fitting the converter to the expansion bus rather than the user port does not result in a significant increase in its complexity, and the unit is in fact very simple.

7581 ADC

The simplicity of the circuit is facilitated by the use of a sophisticated ADC, the 7581. Fig. 1 shows the block diagram for this CMOS chip.

At the heart of this device is a fairly conventional successive approximation converter. This compares the input voltage with the output of an 8-bit DAC. Initially the eight inputs to this converter are set low, apart from the most significant bit (bit 7). If the output voltage from the DAC is greater than the input potential bit 7 is set low by the comparator, but if not it is left high. Then bit 6 is set high, and this bit is reset by the comparator if the output potential of the DAC is higher than the input voltage. Next bit 5 is set high and the same basic procedure is repeated. In fact this routine is repeated, in turn, for all 8 bits, until at the end of

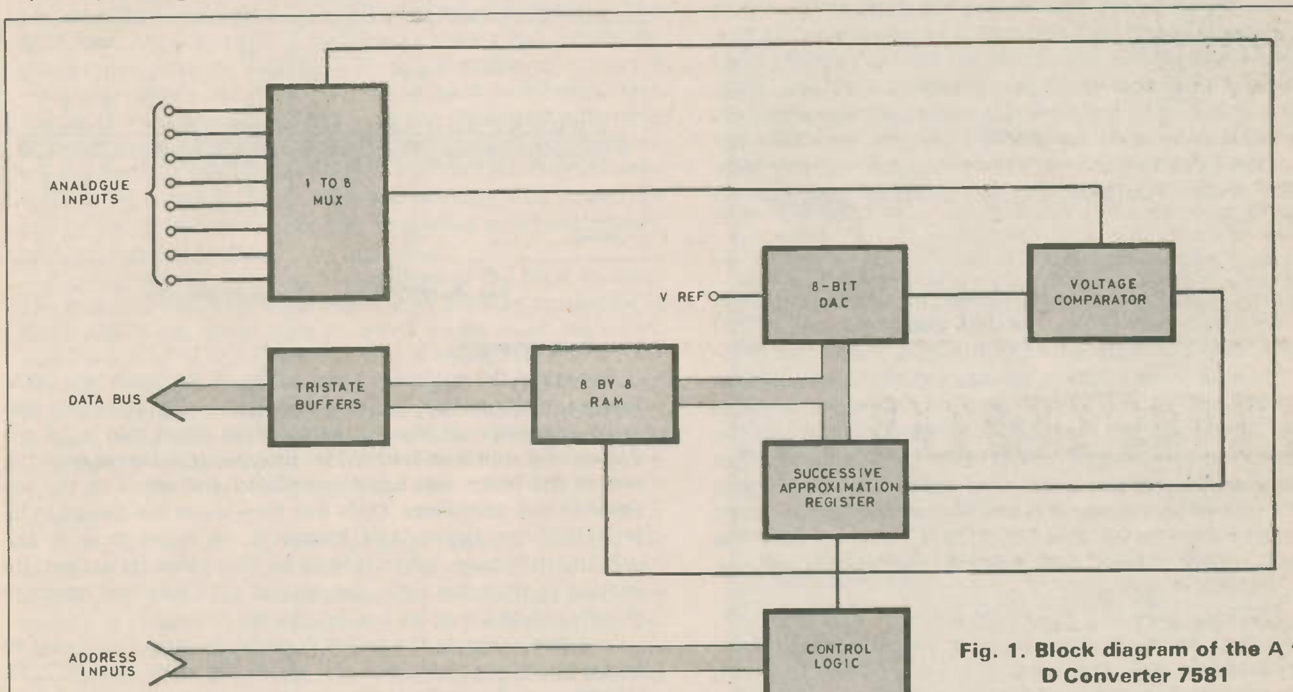


Fig. 1. Block diagram of the A to D Converter 7581

SEMICONDUCTOR CIRCUITS

TOM GASKELL BA (Hons) CEng MIEE

Voltage Controlled Amplifier (dbx 2150A)

IN the early 1960's *Dr. Robert Moog* proposed a new method of controlling audio signals which was known as 'voltage control'. The concept was that all parameters of an audio frequency signal should be controlled in a linear way by applied voltages. Hence, the frequency, amplitude, and spectral content (tone, or timbre) of a signal could all be varied independently by applying d.c., or even low frequency a.c. signals to relevant points in the circuitry. This apparently straightforward principle was quite revolutionary at the time, and led the way towards the first Moog synthesiser, forerunner of most modern music synthesis equipment. Voltage control techniques did not stop with synthesisers, however, as they proved ideal for other purposes in audio reproduction. Specifically, the Voltage Controlled Amplifier, or VCA, has been an important 'building block' in audio compressor/limiters, automatic gain systems, recording studio mixing desks, and sound reproduction equipment of all types.

Unfortunately, the VCA has achieved a certain notoriety with audio engineers and enthusiasts over the years. The design of a wide ranging, low noise, low distortion voltage controlled amplifier is an extremely demanding exercise, and for many years the results were either extraordinarily costly and complex, or were severely lacking in performance; sometimes even both! With the advent of 'automated' and computer controlled audio mixing desks, the industry was crying out for a high quality, low cost, simple to use VCA. A number of manufacturers have been providing hybrid or modular VCA devices for a number of years now, but at considerable cost. Recently, however, the American audio company 'dbx' have produced an 8-pin monolithic VCA integrated circuit which seems to answer most audio requirements—it is small, easy to use, high quality, and inexpensive. That device is known as the dbx 2150A, and is the featured i.c. this month.

BASIC OPERATION

The dbx 2150A is a bipolar i.c. fitted into an 8-pin single inline package. The pinout is shown in Fig. 1, with the basic principle of operation being shown in Fig. 3. The i.c. is a current in/current out device. To produce a varying input current from a varying signal voltage an input resistor R_i is used, the input pin of the i.c. being effectively a virtual earth point. The output of the i.c. is connected directly into the inverting input of an op-amp which has a feedback resistor R_f. This arrangement converts the output current from the dbx i.c. back into a voltage. The voltage applied to the control input determines the gain or attenuation of the circuit, with a control law of approximately 5·9 millivolts per dB change in output level. The 2150A is an inverting device, so when combined with the inverting action of the op-amp, the overall result is no inversion of the signal.

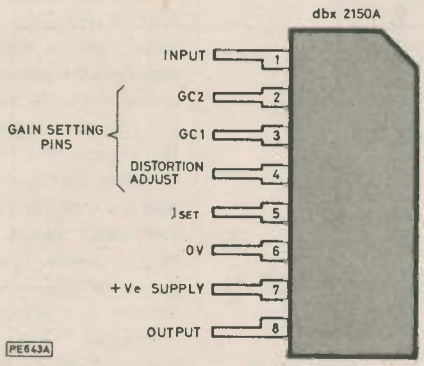


Fig. 1. Pin-out of the VCA

INPUTS AND OUTPUTS

The input to the i.c. must be a.c. coupled to ensure that d.c. offsets from other circuitry are not varied when altering the gain of the VCA. The input pin must be loaded with a source impedance of less than 20k at high frequencies (above 100kHz) to maintain stability. This is ensured by taking a resistor and capacitor to 0V; R2 and C2 in Fig. 7. At the recommended biasing current (i.e. the current drawn from pin 5) of 3mA, the maximum peak input current should not exceed 1·5mA.

The op-amp must have a small capacitor connected between its output and its inverting input to ensure stability. This capacitor should typically be in the range 47pF to 100pF. The audio quality of the final circuit is largely defined by the op-amp, so a BIFET type is recommended (TL071, ½ a TL072, or ¼ of a TL074), or for the highest quality systems, a 5534 or part of a 5532. At the recommended biassing current of 3mA, the sum of the input and the output currents should not exceed 1·78mA r.m.s. (The output current of the VCA i.c. is equivalent to the output voltage of the op-amp divided by its feedback resistor.)

CONTROL OF THE VCA

There are actually three gain control inputs to the VCA: GC1, GC2, and Distortion Adjust. A positive voltage on pins 2 or 4 will give gain, and a negative voltage will give attenuation. A positive voltage on pin 3, on the other hand, will give attentuation, and a negative voltage will give gain. More than one of these control inputs may be used simultaneously to give combinational effects of control inputs. Distortion can be adjusted, i.e. minimised, by applying a voltage between pins 2 and 4. Pin 4 should normally be driven by an impedance of 50 ohms, and pins 2 and 3 preferable from a very low impedance—less that 1 ohm. This would normally require an op-amp to drive directly into pin 2 or 3, but in Fig. 7 a higher impedance arrangement has been used for simplicity, albeit with a slight increase in distortion at higher levels.

In practice, it is normally GC1 (pin 3) which is used as the control input, with GC2 grounded, and the Distortion Adjust input taken slightly above and below 0V by a preset and potential divider, to allow nulling out of the distortion. The control law is between −5·8mV/dB and −6·0mV/dB at pin 3. The control law has a temperature coefficient of +0·33% per degree centigrade; in other words, at high temperatures, more control voltage is necessary to get the same gain or attenuation, and conversely if the control voltage is held constant, then the amount of gain, or the amount of attenuation, caused by the VCA will be reduced as the temperature rises. In practice, this effect is rarely a problem at normal operating temperatures, but if wide ambient temperatures are likely to be encountered and gain accuracy is important, then some form of temperature variation of the control voltage will be necessary to compensate for this effect.

The range of control of the i.c. is from −100dB to +40dB; a very considerable range which is adequate for most practical audio purposes except for variable high gain am-

Characteristic	Notes		Minimum Value	Typically	Max. Value	Units
Supply Voltage	All spec's measured at ±12V		±4·0	±12	±15·0	V
Bias Current, Iset	Current drawn from pin 5			3·0	4·0	mA
Power Dissipation					330	mW
Temperature Range			−10		+65	°C
Total Signal Current	Current into pin 1 + current out of pin 8			175	750	μA
Input Bias Current	No signal (current measured into pin 1)			5	8·0	nA
Gain Linearity	−60dB to +40dB gain			±1	±2	%
Output Noise (C.C.I.R. Weighted)	Input and output resistors = 20k	0dB gain		−93	−88	dBu
		+15dB gain		−84	−82	dBu
Output Offset Voltage	Input and output resistors = 20k	0dB gain		±1	±3·0	mV
		+15dB gain		±2	±3·0	mV
		+40dB gain		±10	±15	mV
Gain Control Constant	Over range −60dB to +40dB		5·8	5·9	6·0	mV/dB
Total Harmonic Distortion (T.H.D.) at 1kHz	Total signal Current *ie*, into pin 1 + out of pin 8 = 180μA	0dB gain		0·015	0·03	%
		±15dB gain		0·05	0·07	%
Intermodulation Distortion, 10kHz and 12kHz mixed equally	Measured as: $\left(\frac{\text{2kHz product level}}{\text{(10kHz signal level + 12kHz signal level)}}\right) \times 100\%$			0·01	0·02	%

Fig. 2. Specification

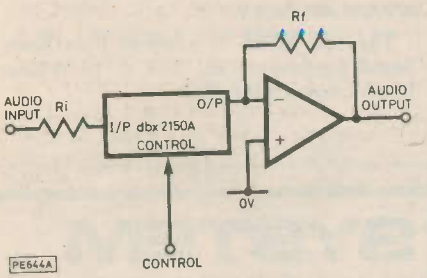


Fig. 3. Basic principle of operation

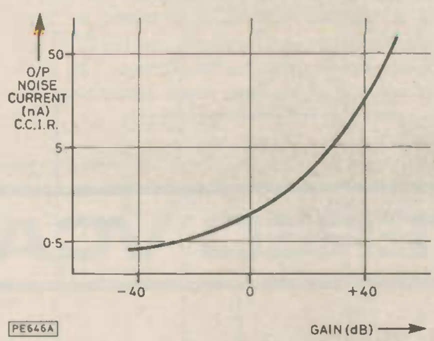


Fig. 5. Effect of gain on output noise current

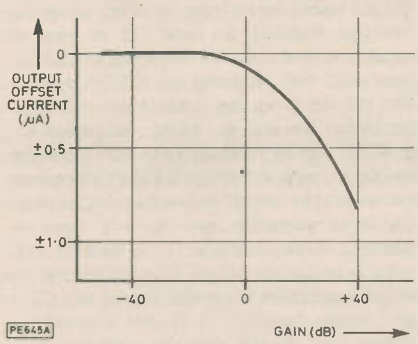


Fig. 4. Effect of gain on output offset current

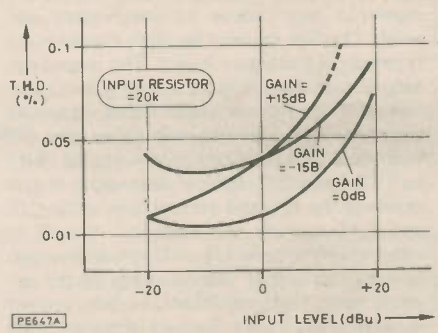


Fig. 6. Distortion vs. input level for different gains (worst case)

plifiers such as microphone amplifiers. A control voltage of 0V produces a gain of 0dB (unity, or x1 gain) with a tolerance of ±1dB.

When very rapid gain changes are made to occur in the i.c., a small transient d.c. offset may be produced at the VCA output. This is due to bias shifts within the VCA, and may be significantly reduced by connecting a 10k resistor between pins 3 and 5—R6 in Fig. 7, for example. Fig. 4 shows the effect of gain on the output offset current.

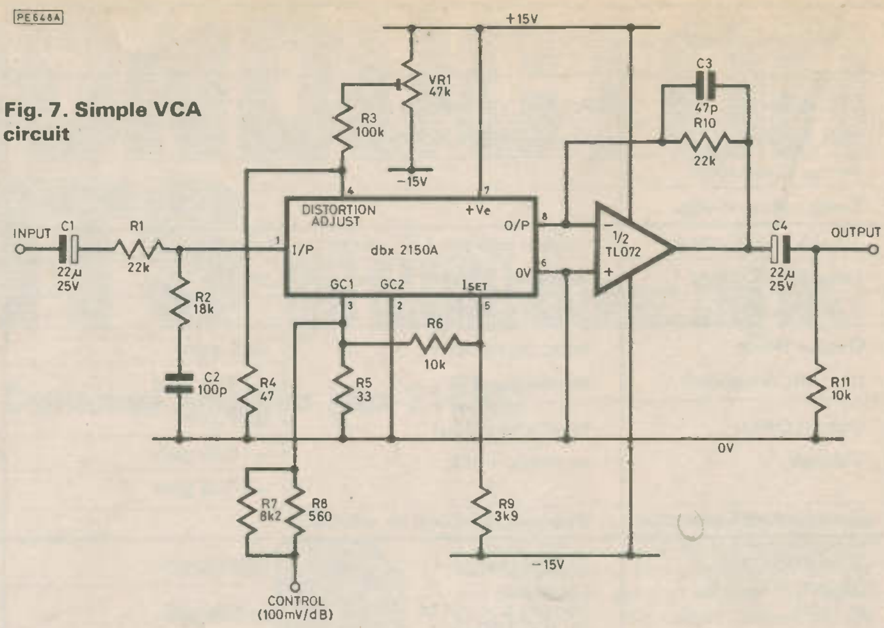
USING THE i.c.

As with all audio circuitry, there are tradeoffs and compromises to be made, especially between distortion and noise. 10k input and op-amp feedback resistors will produce the best noise performance; typically −99·5dBu with a 5534A op-amp as opposed to −94·5dBu when using 20k resistors. However, headroom and distortion are worsened. With 10k resistors, the maximum input level before clipping is extremely variable from one i.c. to the next, and is typically between +15·5dBu and +17·5dBu. The distortion prior to the onset of clipping varies from around 0·01% THD to 0·04% THD at 1kHz. With 20k resistors, the maximum level is higher than +19·5dBu, and the distortion just below clipping is almost exactly half that obtained with 10k resistors. (These figures are taken after distortion has been nulled out with the distortion adjust preset.) Fig. 5 shows the effect of different gains on the output noise current, and Fig. 6 shows the effect of different input levels and gains on distortion. In practice, the noise is sufficiently low that in most systems 20k or 22k resistors are the optimum choice.

The distortion adjust preset can only be set correctly by using a distortion measuring instrument or spectrum analyser. The distortion is worst at low or mid frequencies, so setting the preset for minimum total harmonic distortion at 1kHz is quite adequate.

Fig. 7 shows a simple circuit for use in general purpose uncritical applications. R7 and R8, with R5, scale the control input to give a control law of 100mV/dB, somewhat more practical than 5·9mV/dB. R9 has been increased from the normal 3·0k to allow for the i.c. being operated at ±15 volt supplies, although this will still give a worse performance than if ±12 volt supplies were used. Also, as previously explained, the relatively high impedance at the GC1 pin produces more distortion than the i.c. would normally be expected to produce with an impedance of less than 1 ohm at GC1. The way to reduce this distortion is to buffer the control input with an op-amp, selecting the gain of the op-amp to give the required 'millivolts per dB' control law. This is more thoroughly covered in this month's applications project.

Fig. 7. Simple VCA circuit



APPLICATIONS

The dbx 2150A is ideal for use in a myriad of audio applications, from a simple remote level control to a complex mixing desk. As a voltage controlled gain element it can also prove ideal for use in test equipment, voltage controlled oscillators, equalisers, filters, etc. If the i.c. is being considered for non-audio applications, be aware that it is not intended to operate down to d.c. The frequency response is limited in practice by the input and output decoupling capacitors, and by the op-amp's feedback capacitor. Also note that the control law is linear volts per dB of gain; in other words, linear control voltage changes produce logarithmic gain changes. Since only 5·9mV of control change is necessary to produce 1dB's worth of level variation, then care must be taken to prevent noise or interference from getting into the control pin. Such effects would immediately manifest themselves as audio noise or distortion.

Two other similar i.c.s are also available from dbx; the 2151 and the 2155. The former is a 'selected' 2150A, guaranteed to have slightly better specifications, and the 2155 is a lower input/output current version. The 2151 is unlikely to be very much better than the 2150A, however, since the latter seems to be very consistent in performance, and usually exceeds its specifications by a considerable amount.

The dbx 2150A has done much to dispel the concern that once was rampant in the audio industry about the poor quality of VCAs. It offers an excellent solution to a whole range of level control problems, its performance is good, and the price is very reasonable.

AVAILABILITY

The dbx 2150A is available from **Sonic Sound Equipment Ltd., Unit 2, 10 William Road, London NW1 3EN.**

A HI-FI STEREO VCA SYSTEM

A GENERAL purpose stereo VCA circuit for use in the most demanding audio systems is shown in Fig. 8. Its Veroboard layout is given in Fig. 10. Most of the principles employed in this circuit have already been described, but specifically note that although ±15 volt rails are assumed for the circuit as a whole, separate ±12 volt regulators have been provided for the VCAs to obtain maximum quality. The values of R10 and R28 have been adjusted to suit this ideal supply voltage. R4 and R22 have been made 51 ohms, giving a more correct 50 ohm impedance at pin 4, rather that the 'nearest fit' 47 ohms used in Fig. 7. The audio buffer op-amps have been chosen to be halves of a 5532 very-high quality op-amp. R8 and R26 provide some measure of decoupling capacitive loads from the op-amp output, maintaining stability, while R7 and R25 in series with the feedback capacitors again help stability at very high frequencies, sustaining the gain of the op-amps.

IC4 is an ordinary quad op-amp—any quad '741' or similar type will be quite adequate. (The prototype circuit used an MC3403P.) R11 and C8, and R15/C9, provide simple low-pass filters on the control inputs to help reduce h.f. interference and noise. The first op-amp for each control input is merely a unity gain buffer. The second op-amp in each case is in an inverting configuration with the resistor values being chosen to scale down the control voltage to give the equivalent of a nominal 100mV per dB. VR3 and VR4 adjust the control attenuation to give precisely the required control law, while C10 and C11 provide yet more h.f. roll-off to remove interference. D5 to D10 are arranged to limit the output voltage range of the op-amps under fault conditions, to help prevent damage to the VCAs. Because of the inverting action of IC4 in the two control paths, note that the control inputs now give gain for positive voltages, and attenuation for negative voltages, over the range −100dB (−10V) to +40dB (+4V).

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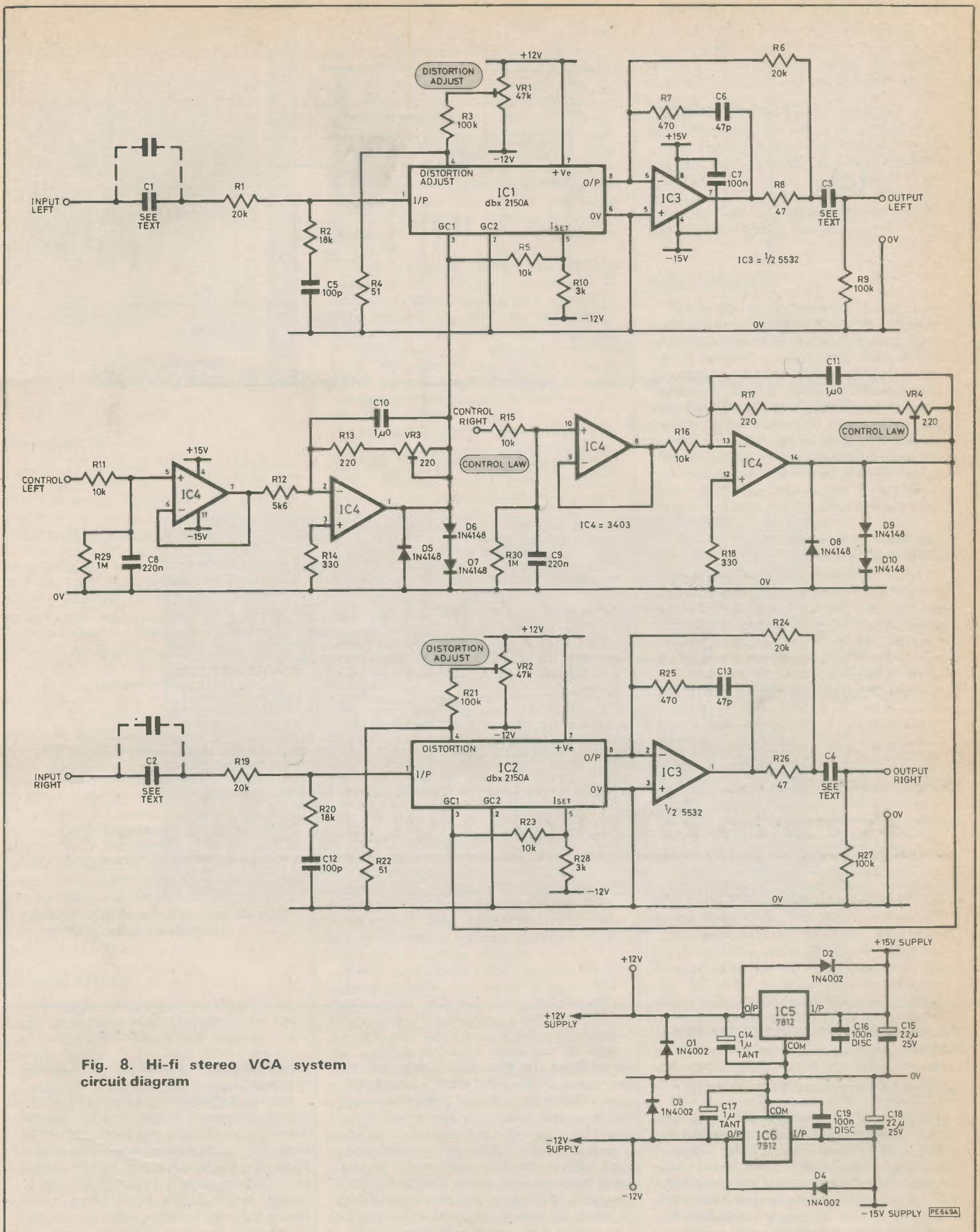


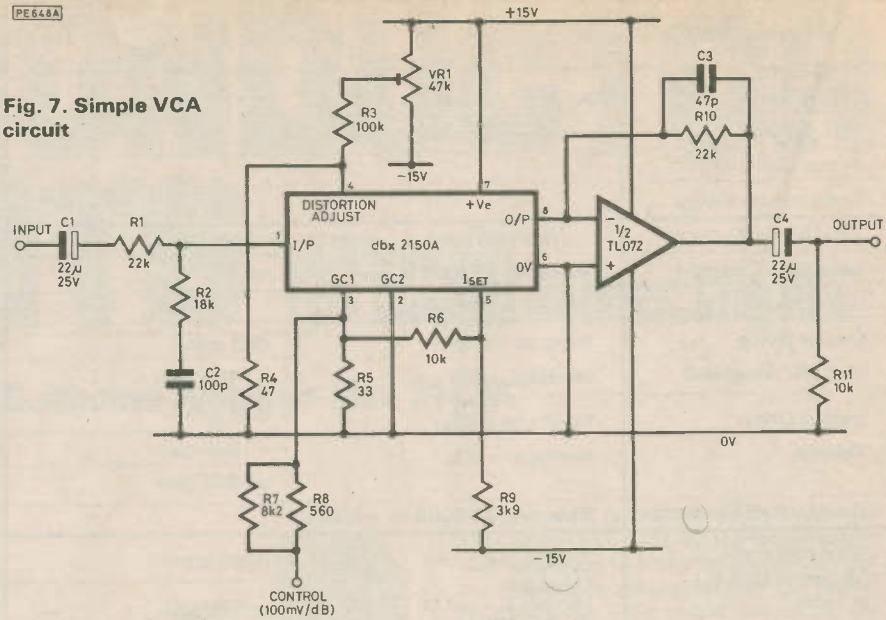
Fig. 8. Hi-fi stereo VCA system circuit diagram

effect of different gains on the output noise current, and Fig. 6 shows the effect of different input levels and gains on distortion. In practice, the noise is sufficiently low that in most systems 20k or 22k resistors are the optimum choice.

The distortion adjust preset can only be set correctly by using a distortion measuring instrument or spectrum analyser. The distortion is worst at low or mid frequencies, so setting the preset for minimum total harmonic distortion at 1kHz is quite adequate.

Fig. 7 shows a simple circuit for use in general purpose uncritical applications. R7 and R8, with R5, scale the control input to give a control law of 100mV/dB, somewhat more practical than 5·9mV/dB. R9 has been increased from the normal 3·0k to allow for the i.c. being operated at ±15 volt supplies, although this will still give a worse performance than if ±12 volt supplies were used. Also, as previously explained, the relatively high impedance at the GC1 pin produces more distortion than the i.c. would normally be expected to produce with an impedance of less than 1 ohm at GC1. The way to reduce this distortion is to buffer the control input with an op-amp, selecting the gain of the op-amp to give the required 'millivolts per dB' control law. This is more thoroughly covered in this month's applications project.

Fig. 7. Simple VCA circuit



APPLICATIONS

The dbx 2150A is ideal for use in a myriad of audio applications, from a simple remote level control to a complex mixing desk. As a voltage controlled gain element it can also prove ideal for use in test equipment, voltage controlled oscillators, equalisers, filters, etc. If the i.c. is being considered for non-audio applications, be aware that it is not intended to operate down to d.c. The frequency response is limited in practice by the input and output decoupling capacitors, and by the op-amp's feedback capacitor. Also note that the control law is linear volts per dB of gain; in other words, linear control voltage changes produce logarithmic gain changes. Since only 5·9mV of control change is necessary to produce 1dB's worth of level variation, then care must be taken to prevent noise or interference from getting into the control pin. Such effects would immediately manifest themselves as audio noise or distortion.

Two other similar i.c.s are also available from dbx; the 2151 and the 2155. The former is a 'selected' 2150A, guaranteed to have slightly better specifications, and the 2155 is a lower input/output current version. The 2151 is unlikely to be very much better than the 2150A, however, since the latter seems to be very consistent in performance, and usually exceeds its specifications by a considerable amount.

The dbx 2150A has done much to dispel the concern that once was rampant in the audio industry about the poor quality of VCAs. It offers an excellent solution to a whole range of level control problems, its performance is good, and the price is very reasonable.

AVAILABILITY

The dbx 2150A is available from **Sonic Sound Equipment Ltd., Unit 2, 10 William Road, London NW1 3EN.**

A HI-FI STEREO VCA SYSTEM

A GENERAL purpose stereo VCA circuit for use in the most demanding audio systems is shown in Fig. 8. Its Veroboard layout is given in Fig. 10. Most of the principles employed in this circuit have already been described, but specifically note that although ±15 volt rails are assumed for the circuit as a whole, separate ±12 volt regulators have been provided for the VCAs to obtain maximum quality. The values of R10 and R28 have been adjusted to suit this ideal supply voltage. R4 and R22 have been made 51 ohms, giving a more correct 50 ohm impedance at pin 4, rather that the 'nearest fit' 47 ohms used in Fig. 7. The audio buffer op-amps have been chosen to be halves of a 5532 very-high quality op-amp. R8 and R26 provide some measure of decoupling capacitive loads from the op-amp output, maintaining stability, while R7 and R25 in series with the feedback capacitors again help stability at very high frequencies, sustaining the gain of the op-amps.

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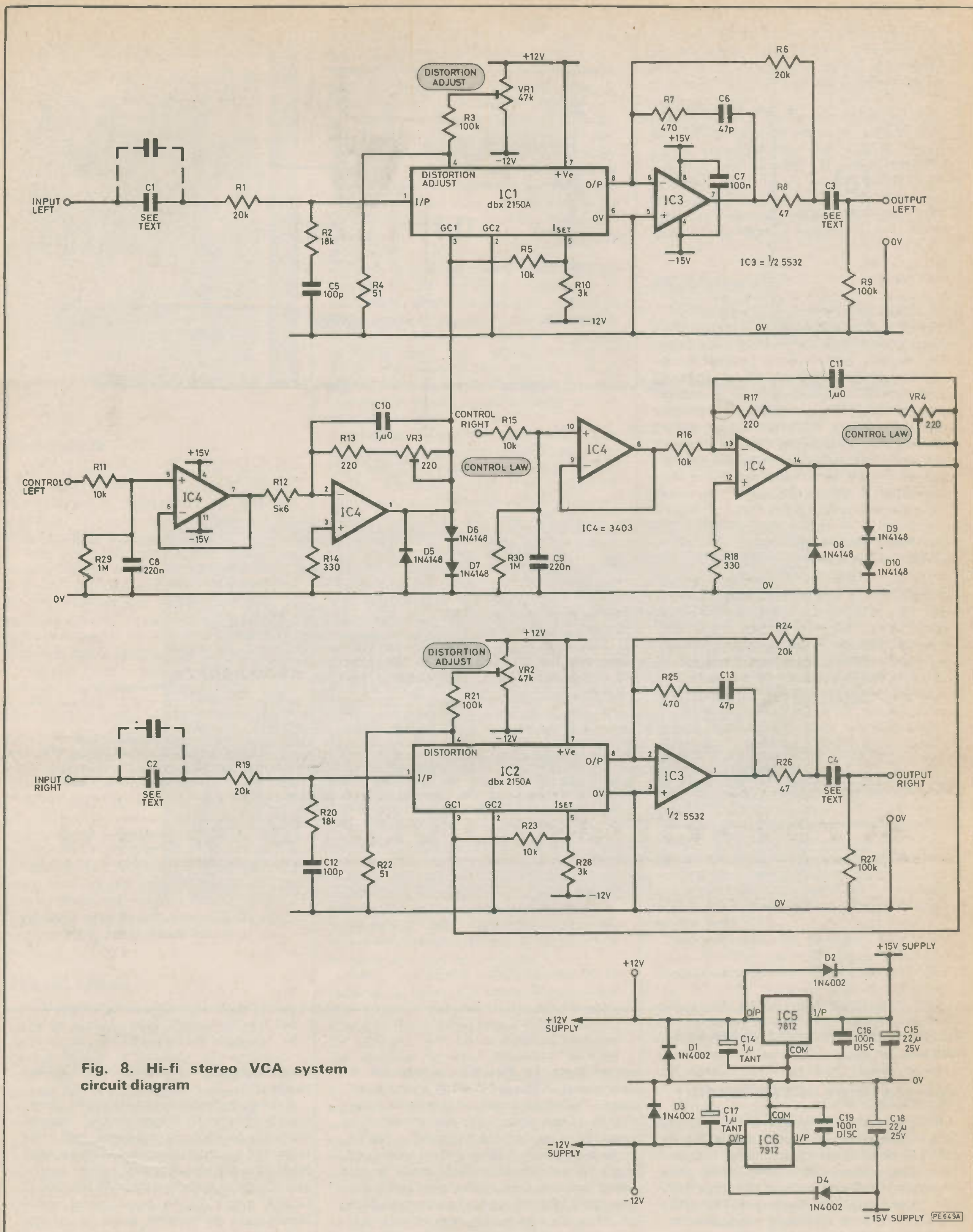


Fig. 8. Hi-fi stereo VCA system circuit diagram

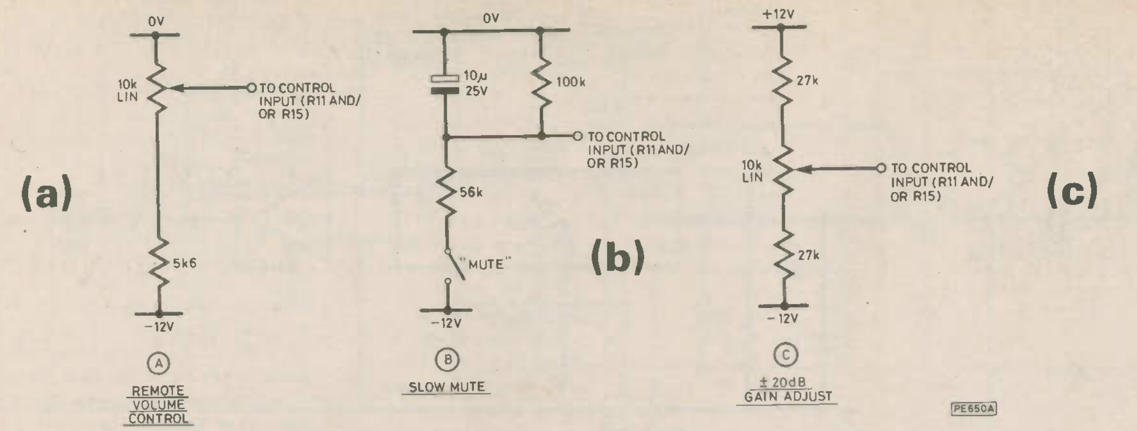


Fig. 9. Examples of simple control inputs. (a) Remote Volume Control, (b) Slow Mute, (c) ±20dB Gain Adjust

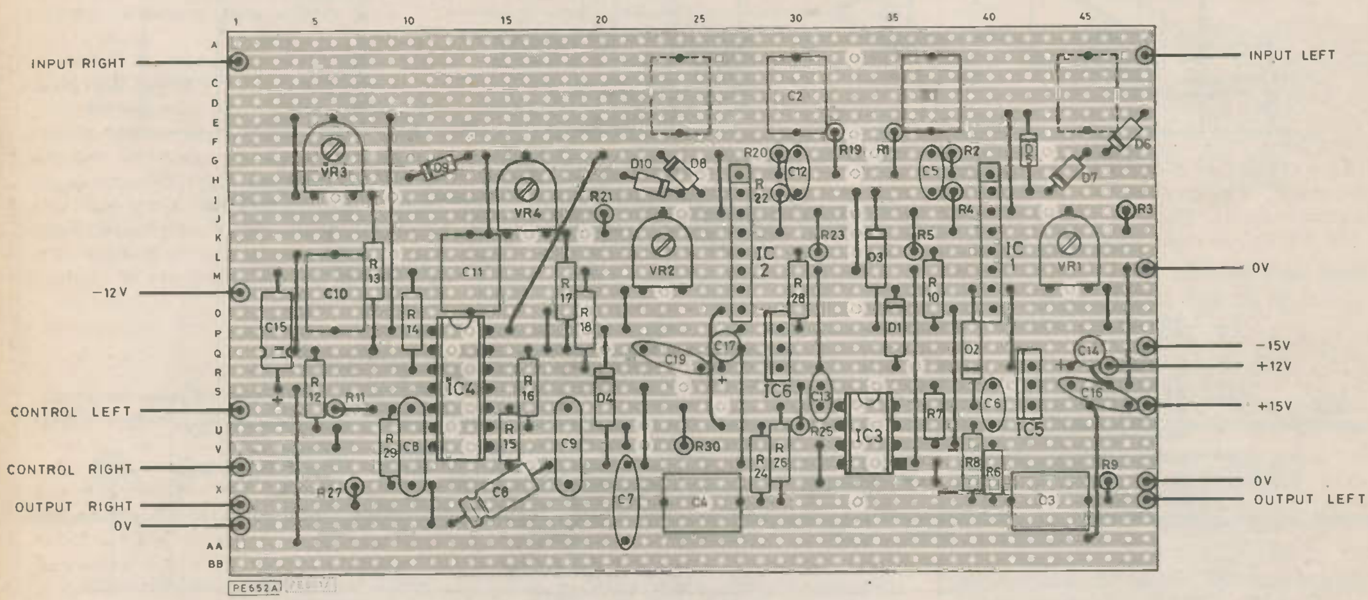


Fig. 10 Stripboard layout of the VCA system

APPLICATIONS OF THE CIRCUIT

As a very simple example of the type of control techniques which are available, Fig. 9 shows three different control input circuits. The remote volume control allows for the gain of the circuit to be varied over the range 0dB to −80dB with a 10k linear pot. The 5·6k resistor limits the maximum attenuation to 80dB (i.e.−8V) even though the regulated −12V supply is used to derive the control voltage from. In Fig. 9(b) a capacitor is charged and discharged to act as a 'slow mute' control. When the switch is closed the audio level is turned down over the period of a second or so, and when it is released it rises up again fairly slowly, taking several seconds to reach full volume. This would make an excellent and very high quality mute circuit for use with a Hi-Fi system (when answering the telephone, for example), or even an automatic fader for use at the end of recordings. Finally, Fig. 9(c) shows a ±20dB gain trim circuit, to illustrate the use of a positive control voltage to give gain.

Further applications could involve noise-sensing circuitry to change the Hi-Fi volume depending on the background noise level in the room, and a sophisticated remote level control using infra-red signalling and remote control i.c.s. Unlike so many systems with this type of facility, a dbx 2150A based circuit would benefit from the excellent sound quality and performance that these VCAs are capable of producing.

INDUSTRY NOTEBOOK

By Nexus

Prospects

With employment now the dominant topic of political and economic debate, there is ample reassurance for qualified electrical and electronic engineers and for those studying to enter the profession.

This year's IEE salary survey reveals that unemployment in the membership is just 0·6 per cent compared with 1·1 per cent for the previous year. The national average is of the order of 13 per cent although there are considerable variations in types of occupation and in geographical locations.

The IEE figures highlight once again the chronic shortage of engineers. The Manpower Services Commission estimates an immediate shortfall of 1,500 engineers in the field of information technology alone and still rising and it is by no means the only engineering discipline in need of additional engineering skill.

It is safe to assume that qualified engineers will continue to be in demand. The prospects for the three million plus registered as available for, but not in, work is less certain. It is worthy of record that *none* of the major political forces now offers a cure for unemployment, only a suggestion that if certain courses are adopted some alleviation should follow.

World Trade

The future of our industry depends far more on external than internal events. The great locomotive of economic advance, the United States, is running out of steam. Countries like Brazil and Argentina are grotesquely in debt. South Africa is in turmoil. Iraq and Iran are still fighting after four years. And Sudan has a new military government following a bloodless coup.

The entry of Spain and Portugal into the European Common Market will have little immediate impact on the UK electronics industry, although in the longer term there should be more opportunity for exports of capital equipment in telecommunications and industrial electronics.

China and Russia provide more intriguing probabilities. China's dash for growth has run into inflationary difficulties with a consequent freeze on wages but the modernisation programme involving western technology should not be affected.

Kremlin watchers have so far been unable to determine how 54-year-old Mr Gorbachov will drag the USSR into the computer age or, indeed, whether he will be able to do so. First signs are that he is anxious for increased trade with the west in the general interest of the economy and in particular in importing more western technology.

There is growing nervousness over the success of the Hungarian experiment in permitting, albeit limited, free enterprise which has been successful and popular, not to mention the dramatic economic growth of China since their reforms started in 1978. My guess is that he will have to reform the economy in the light of raised domestic expectations but will only be able to hasten slowly.

A heartening sign for world trade is that Japan, under increasing pressure from the USA and Europe, is to allow easier access to the Japanese market. It is a reluctant concession and in no way weakens Japan's determination to become the world's greatest economic power.

The world development that is having the most immediate effect on the UK economy is the volatility in currency rates. An increase of 20 per cent in the value of the pound against the dollar in as many days, as happened last March, is unhelpful to industry planners whether importing or exporting. It reflected uncertainty on the stability of the US economy and reminds us once again that world trade is influenced more by confidence than bald statistics.

Big Package

GEC, frustrated in an earlier attempt to buy British Aerospace, finally opted to spend some of its cash mountain on the purchase of naval shipbuilder, Yarrow.

It seems odd to write of GEC as shipbuilders, but the acquisition makes good sense. GEC can now offer the complete naval package incorporating Marconi communications, radar, navigation equipment, action information systems, weapon control and even some of the weapons.

Naval hulls should have a service life of at least 20 years. But because electronics and weapons systems advance technically at a very much faster rate a typical frigate, for example, will be completely re-fitted and updated to new standards at least twice, more often three or four times during the lifetime of the ship. It's almost worth supplying the original equipment at cost and take profit later during modernisation. I don't suggest that GEC performs in this manner, the point I am making being the on-going business following the initial sale with the customer virtually locked in.

On the other hand, GEC is not too proud to play a lesser role as a sub-contractor. For example, supplying under sub-contract to Hyundai of Korea the v.h.f. and u.h.f. train radio system for Iraq's railways. This subcontract, worth some £2 million to Marconi's mobile radio division, demonstrates the international nature of the electronics business and a little of the complexities of overseas trade.

Another example, again involving Marconi, is a prime contract for the supply of an earth terminal for the Yemen Arab Republic, but the order came from Cable & Wireless. The earth station will work through the *Arabsat* satellite and will be ready for use next September, only nine months after signing the contract.

High Density

Further to my comments last month on surface mounting of components and consequent increase in circuit complexity per square inch of p.c.b. I note that British Telecom is also following the fashion. System X, largely modular, allows rapid adaptation to different operational requirements and improved manufacturing methods. In the new System X trunk exchanges the processor subsystem does the same job in two racks as the original design did in ten racks. As System X has been around for some years I imagine the saving is through the availability of VLSI superseding LSI rather than surface mounting but the principle is the same and the result equally uncomfortable for employment.

Oh, for the happy days of yester-year when every telephone subscriber had his own uniselector at his local exchange, costly to manufacture and to maintain but employing thousands of people. But how rotten the service then compared with today. Electronics is both a curse and a boon.

Wealth

The purchasing power of the pound sterling today is only about five per cent of that in 1938. This means that today's millionaire ain't what he (or she) used to be. In fact, the richest hundred people in the UK all command at least £6 million according to Inland Revenue figures. Those below are still millionaires but compared with the top hundred can be classified only as also-rans.

Readers may be pleased, disgusted, proud, horrified, envious, jealous, critical or congratulatory in the knowledge that the top hundred include 40 electronics millionaires. Of the newer entrants Sir Clive Sinclair variously estimated as being worth around £100 million, is probably the wealthiest but he is a poor man compared, say, with pop star Paul McCartney with an estimated £250 million.

Readers in the disgusted category may derive some satisfaction from the fact that few of the very rich can go to the bank and draw out a million. Their fortunes are in paper shares in their companies and they have to work harder than most of us producing results to maintain their value.

Myself, I say good luck to them. For I, too, am a millionaire—if measured in Italian lira.

increasing LAMP LIFE

E.W. Hunter

An inexpensive circuit idea that can extend the life of projector or photoflood lamps, by allowing them to progressively reach their rated power

Most photographers will be aware that projector lamps and photoflood lamps have a very limited life, in the case of photofloods as short as a few hours. The main reason for this is that these lamps are slightly overrun to give a brighter and whiter light that is more suitable for photographic work. It will also have been noticed that these lamps, indeed lamps in general, almost always fail when switched on from cold.

Obviously something happens to the lamp when it is first switched on to cause it to blow. Can anything be done to extend the life of these lamps? What is the reason for the failure at switch-on?

LOW RESISTANCE

The answer to the second question is quite simply that the filament of an incandescent lamp, be it photographic or otherwise, has a very low resistance when the lamp is cold, and its resistance increases with increasing temperature. When power is first applied to the filament, the current flow rises to a peak value, which is many times higher than the lamp is rated for, and then falls back to a lower value as the resistance of the filament rises to its working value. This inrush of current reduces the working life of the lamp, and is the reason that an old lamp usually fails at switch-on.

The answer to the first question, "Can the life of the lamp be extended?" is yes. The circuit described here reduces the switch-on current surge and thus increases the lamp life. It is intended for use with projector or photoflood lamps which have very limited lives and are very expensive to replace, so the saving made by extending the life of the lamp can offset the cost of the circuit quite quickly.

The resistance of a typical projector lamp is shown increasing in Fig. 1, as its power and therefore its temperature increases. The resistance was found by passing varying currents through the lamp, and measuring the voltage developed across it. The graph shows that the resistance of the lamp is approximately 0·11Ω when cold, therefore a current of over 50A could in theory flow if a six volt supply was connected across the lamp. Fortunately, the lamp supply will have a certain internal resistance, and so the current surge will be limited. While doing these measurements, a current surge of more than eight times the rated current for the lamp occurred if the six volt supply was connected across a cold lamp. The surge peak only lasted for a few milliseconds, and then fell steadily to the rated current. The power supply used for this experiment was of very low internal resistance, and so the surge was very large, but it clearly shows the short warm-up period of the lamp.

A very simple way of preventing the current surge through a lamp is to wire a high power thermistor in series with it. The thermistor has the opposite characteristics from the lamp filament, i.e. the resistance of the thermistor falls as its

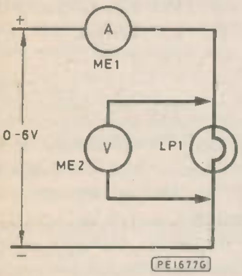
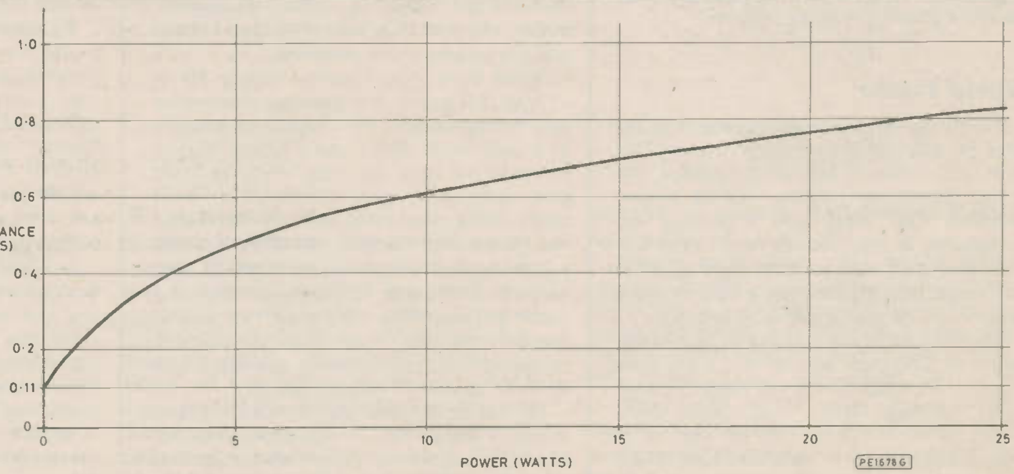


Fig. 1. The graph, opposite, shows the increase of a lamp's resistance with power increase. Above, the simple arrangement used to obtain the data for the graph



temperature increases. Unfortunately its resistance never falls to zero, so the thermistor always limits the current through the lamp, and thus the lamp will never reach its working current. Also the thermistor has to dissipate a large amount of power, and thus will run very hot. A switch could be wired across the thermistor to short it out after a few seconds, but this must be done before the thermistor gets too hot, and then returned to the un-shorted position at switch-off so it is ready for the next time. The circuit shown here provides automatic control of the lamp current, and manual intervention is not required.

CIRCUIT OPERATION

The circuit uses a triac in series with the lamp as the current-controlling device, much as is done in conventional lamp dimmers. If the triac is turned on by a pulse on its gate, it will continue to conduct until the current through the device falls to zero. This occurs at the end of each half cycle of the supply, as shown in Fig. 2. If the gate pulse occurs late in each half-cycle, then the current through the lamp will be small, and the lamp dim. If now the pulse occurs earlier in each subsequent half-cycle, then the lamp current will gradually increase, and the filament will have time to warm before it receives full current. Thus the usual current surge will be eliminated.

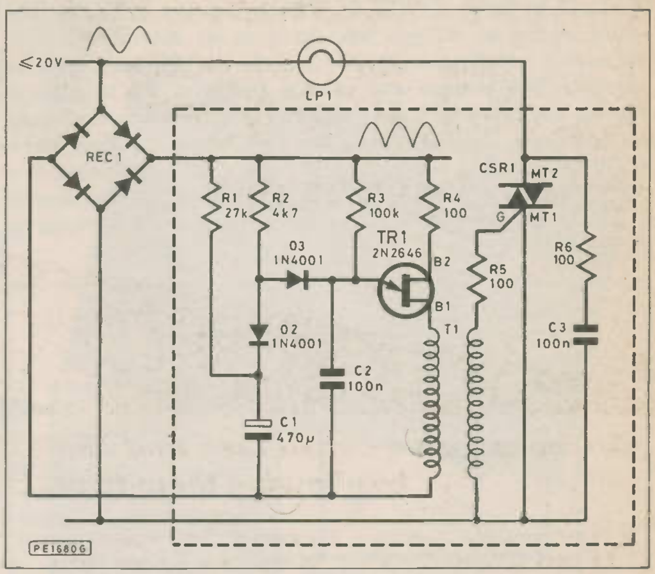


Fig. 3. The circuit for increasing lamp life

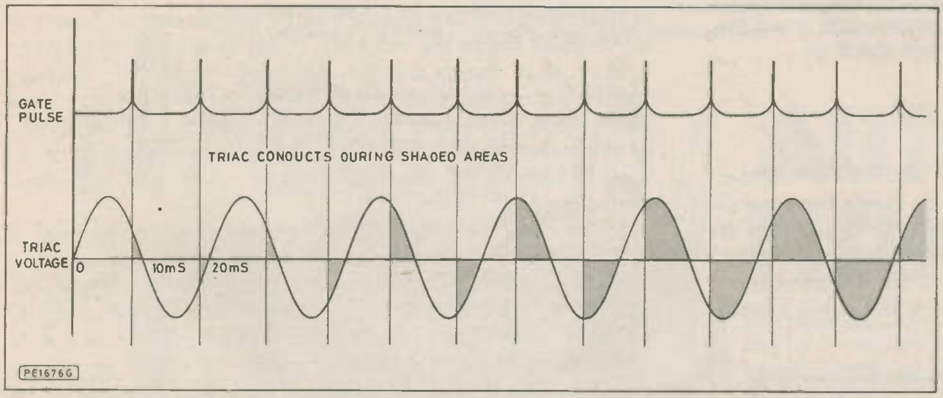


Fig. 2. Representation of the controlled increase in lamp current after switch-on

The circuit, Fig. 3, uses a unijunction transistor to generate the trigger pulse for the triac. This pulse is coupled to the triac gate via the 1:1 pulse transformer T1, and this isolates the trigger circuit from the supply side. The unijunction circuit is basically a conventional relaxation oscillator. The capacitor C2 is charged through R3 until the emitter voltage of the unijunction reaches the peak point voltage (about 0·7 times the voltage between B2 and B1).

TURN-ON POINT

At this point the unijunction transistor turns on and the resistance between the emitter and base 1 becomes very low. C2 then discharges through the emitter/base 1 junction and through the primary of the transformer and thus induces a pulse across the secondary of the transformer. The time taken for the peak point voltage to be reached is approximately R3 × C2. When the emitter voltage falls to about two volts, the unijunction ceases to conduct, and the capacitor begins to charge again from this two volt pedestal.

The supply for the trigger circuit is provided by full-wave rectification of the a.c. voltage. The supply line is not filtered, thus the voltage at base 2 of the unijunction reaches zero at the same time as the a.c. supply. When this happens, the unijunction triggers and discharges the capacitor through R4 so that the circuit is synchronised with the a.c. supply. The capacitor will now begin to charge again, and after a period determined by R3 × C2 (a little over 9ms) will be discharged into the transformer.

Up to this point, the circuit would allow only a small current to flow in the load, and the additional components R1, R2, C1, D2 and D3 are required to make the circuit gradually increase this current after a short warm-up period. When power is first applied to the circuit, C1 is discharged and begins to charge through R2 and D2 (some current also flows through R1). The voltage at the junction of R2 and D2 which is about 0·6 volts above the voltage on C1 will slowly rise until D3 becomes forward biased. This allows additional current flowing through R2 to charge C2 and causes a change in the trigger point; refer again to Fig. 2.

When C1 is fully charged, the time constant becomes R2 in parallel with R3 × C2, which with the values given is less than 1ms. Therefore the triac will conduct for most of each half-cycle. The diode D2 prevents C1 from discharging back through R2 as the supply falls to zero at the end of each half-cycle, or to charge C2 through D3. R1 is included to provide a discharge path for C1 when the supply is removed so that the circuit will operate correctly if switched back on after a short period. The time constant of R1 and C1 is about 12 seconds. The components across the triac reduce the amount of radio-frequency interference caused by the circuit.

The circuit as it stands can be used on a.c. supplies up to about 20V, but for use on 240V mains, the circuit must have some additional components as shown in Fig. 4. The Zener diode D1 and R7 limit the maximum voltage swing to 20V. The value of R7 is calculated to limit the current through the Zener diode to less than 20mA, so its value for 240V mains will have to be about 15k for a Zener current of 15mA. The power rating of R7 will also have to be sufficiently high, because it will dissipate 3·3W, therefore a 5W device will be required. The current and voltage rating of the triac must also be adequate for the application. A triac with a minimum voltage rating of 50V is adequate for a 20V a.c. supply, but a 400V triac would be required for use on 240V mains. The current rating of the triac will depend upon the wattage of the lamp, and can be found by dividing the lamp wattage by its voltage.

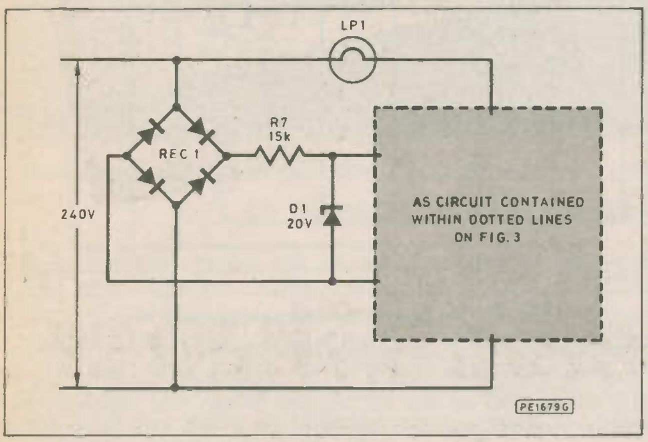


Fig. 4. Alternative additional circuitry for operating 240V a.c. mains lamps. The resistor R7 must be adequately rated for the power dissipation required, and so must the triac

COMPONENTS . . .

Resistors

R1	27k
R2	4k7
R3	100k
R4–R6	100 (3 off)
R7	15k 5W (optional)

All $\frac{1}{4}$W ±5% except R7

Capacitors

C1	470μ 25V elect.
C2	100n 50V ceramic
C3	100n 500V ceramic

Semiconductors

REC1	W04 bridge rectifier
D1	BZY88C20 Zener (optional)
D2,D3	1N4001 (2 off)
TR1	2N2646
CSR1	Triac (see text)

Miscellaneous

T1 1:1 pulse transformer.
Veroboard; heatsink; triac mounting kit; optional diecast box (e.g. M5004); stand-off spacers.

CONSTRUCTION

The circuit, which can be built on a piece of Veroboard 1·5 × 3 inches, is small enough to mount inside the case of most projectors. Because of the small size and simplicity of the circuit, a p.c.b. was not used; a suitable Veroboard layout is shown in Fig. 5. It is impossible to give fitting instructions because of the great variety of projectors, but some simple guidelines may be given.

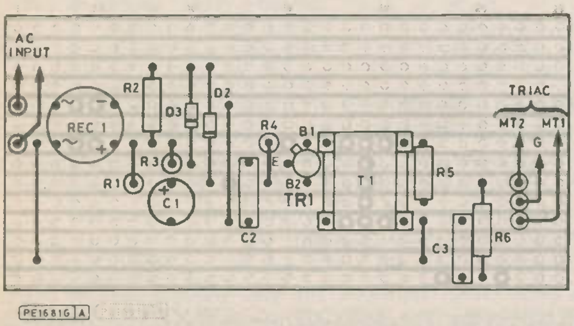


Fig. 5: Layout of components on Veroboard, shown actual size. The triac is mounted separately

All components are mounted on the board with the exception of the triac, which will need a heatsink. Either a proper heatsink can be used, or a suitable metal surface inside the projector can be utilised. Many projectors have fan cooling, and if possible the triac should be mounted in the air flow to assist cooling. The triac should be mounted using an insulated mounting kit, so that it is electrically isolated from the equipment. This is important even if a low voltage supply is used, because the supply may be connected to chassis at some point inside the machine. Great care must be taken to ensure that there are no whiskers of solder between Veroboard tracks, and that all the breaks in the tracks have been made, especially between the primary and secondary of the transformer. If this is not done, then the circuit could well be destroyed, especially if it is being used to control mains lamps.

If the circuit is to be used with photoflood lamps, then it will have to be built into a box of some kind, preferably a metal box which will conduct the small amount of heat dissipated by the circuit to the outside air. A diecast box would be ideal for the job because of its robustness. A few simple precautions should be taken to make the circuit as safe as possible. The first of these is to ensure that all parts of the circuitry are well insulated from the metalwork of the box.

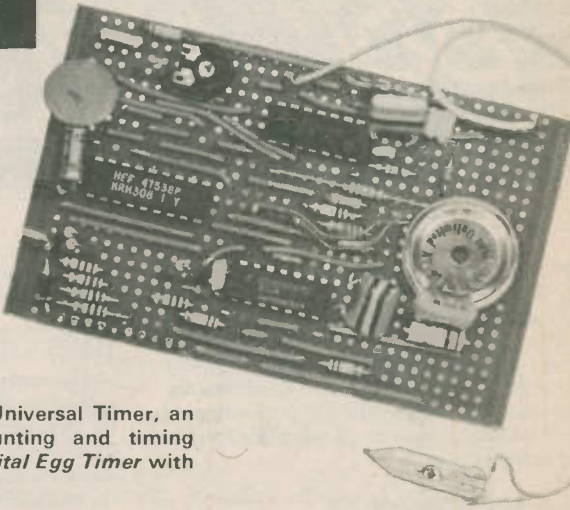
An air gap of at least half an inch should be allowed between any component and the box, and the board should be mounted on insulating spacers to ensure a similar gap. The triac should be mounted on a small heatsink which should be insulated from the box. The box must be well earthed so that in the event of a live wire coming adrift and touching the metal, the fuse will blow and thus protect the user.

IN USE

I have had this circuit installed in my own projector for the last sixteen months and find that it has functioned very well and has apparently lengthened the life of the lamp. I say apparently, because I have no way of knowing how long the lamp would have lasted without the circuit. Because the lamp life is affected by the number of on/off cylces as well as the time it is illuminated, it is very difficult to get a measure of improvement, but eliminating one cause of premature ageing is obviously a good move. The previous projector lamp I used lasted about eleven months, so the present lamp is already ahead. ★

all in your AUGUST issue!

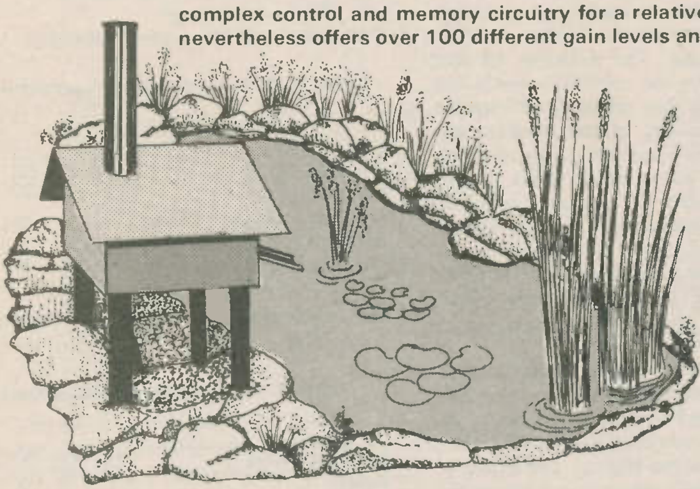
Semiconductor Circuits - Universal Timer



The data sheet this month covers the HEF4753B Universal Timer, an extremely versatile i.c. capable of complex counting and timing operations. The project based on this device is a *Digital Egg Timer* with audible warning

Computer Envelope Shaper

Electronic music generation using digital techniques is common now, but "stand-alone" units are expensive. This project shows how to use a Commodore or BBC computer to provide the complex control and memory circuitry for a relatively simple add-on sound synthesiser, which nevertheless offers over 100 different gain levels and virtually any envelope shape desired.



AUTOMATIC FISH FEEDER

We show you how to feed your pond fish whilst on holiday (*you*—not the fish!). Alternatively, the self-test electronics could be used to water your tomatoes every 12/24 hours.

modems - *Getting Started*

This final part of our short series looks at modem applications and includes a "getting started" Buyer's Guide.

PRACTICAL ELECTRONICS

ROBOTICS · MICROS · ELECTRONICS · INTERFACING

AUGUST ISSUE ON SALE FRIDAY, JULY 5

BBC Micro Forum...

David Whitfield MA MSc CEng MIEE

THIS month features software for the real time clock project described in the last *BBC Micro Forum*. Also starting in this issue is *Book Corner*, a look at a selection of the books available for the BBC Micro. Having explored the user port in some detail (but not yet exhausted its potential!), it is then time to start looking at another of the micro's ports; the analogue port.

SETTING THE CLOCK

Listing 1 shows a BASIC routine for setting up and starting the clock. The overall scheme followed is first to stop the clock, reset it, load the chosen start time into the clock registers, and finally re-start the clock when the chosen instant arrives. As before, the listing includes only the basic elements necessary for a working program. It excludes any error handling, range checking, comments or 'pretty' screen formats. Multi-statement lines have also been used in the interests of space economy. The program instructs the user to change the mode switch between read and write modes at the appropriate points. When the clock has been started, the clock read program (here called "RTCread") is CHAIN'ed. The structure of the program is summarised in Table 1.

WHAT TIME IS IT?

Having set the clock running, the next requirement is obviously to be able to read time. After all, there is little point having a clock without a "face"! Listing 2 shows a program suitable for producing a continuous time display; if you are using it in any other year than 1985, it will be necessary to alter line 240, since it is not possible to read the clock's year register. Exit from the program is achieved by pressing **ESCAPE**.

The overall structure of the program is summarised in Table 2. The actual read routine is written in assembler to achieve the necessary speed. The problem otherwise is that the clock will tend to 'lose', depending on how often it is read, because of the length of the read strobe when driven from BASIC. The routine makes use of the area in memory between &70 and &8F (called Time in the listing) which is reserved in BASIC for user applications. The valid contents of registers 2 to 12 are copied into locations (&70+2) to (&70+12). These are then picked up by the BASIC part of the program, and displayed to the user. In passing, this program is an interesting demonstration of the way in which BASIC is good for the overall stucture and user display functions, while the time-critical and hardware I/O operations are best carried out in assembler.

TIMELY REMINDERS?

The read program above is obviously only a demonstration, and will need to be amended for inclusion in any practical application. This, for example, could be a program which runs automatically whenever the micro is switched on, and checks a file of birthdays or other important dates to give a timely warning. Could this end the need for *"Sorry I forgot"* greetings cards?

For the adventurous, the second of the books in *Book Corner* may encourage you to add some new * commands specially for the clock. Similarly, there is no reason why the machine code routine to read the clock cannot be present even when another BASIC program is running. The technique for this was described (for the numeric keypad) last month. All that is then needed is an interrupt to trigger the reading of the clock at appropriate intervals. One useful way of doing this (which also allows much of the keypad code to be re-used) is to make the clock generate a suitable interrupt, e.g. every minute. Fortunately the clock i.c. includes the necessary facilities to cause such interrupts, as shown in Table 3, and the clock circuit already has the interrupt line connected to CB1.

If the clock set-up routine is amended so that an appropriate value is written to register 15 before the clock is started, the clock will then raise a user interrupt (IRQ) on CB1 when the chosen interval has elapsed. The setting of bit 3 in the register determines whether the timer is in a one-shot or a continuous mode. The interrupt is reset by reading back the value in register 15, and this automatically restarts the timer when in continuous mode. The value read from register 15 will be shown in Table 4, and to ensure correct operation, the clock interrupt should be serviced within 16·7ms. These facilities should allow the keen machine code programmer to create a constant display of the time in a dedicated screen area, and update it every minute. Readers with suggestions for solution to this problem are encouraged to write to BBC Micro Forum Letters.

THE ANALOGUE PORT

Even now there are still many unexplored aspects of the user port. For the moment, however, readers should by now have a basic idea of its capabilities, and so I will move on to look at the analogue port. As with the rest of the micro, this port is a little more than the name suggests, and I will begin this month with a quick look at the port's connector. Even a brief look gives a hint that the analogue port is really more of a collection of ports which happen to share a common connector, than a single port.

I have (quite rightly) been taken to task by *Mr. Boylett* of Letchworth for skating over some important practical points when it comes to describing connectors, and I will do my best

10– 70	Initialisation and symbols
80–110	Stop/reset clock, set mode
120–160	Clear interrupt latch
170–220	Request start time from user
230–320	Set start time on clock
330–370	Start clock on user command
380–440	Write value to a register
450–480	Wait for space key
490–540	Read a register value

Table 1. RTC set-up program structure

10– 80	Initialise and assemble code
90–280	Main loop: read/display time
290–300	Error handler and exit
310	Read register value from "Time"
320–450	RTC register read routine

Table 2. RTC read program structure

Function	D3	D2	D1	D0
No interrupt	X	0	0	0
Interrupt at 60 sec intervals	0/1	1	0	0
Interrupt at 5 sec intervals	0/1	0	1	0
Interrupt at 0·5 sec intervals	0/1	0	0	1

D3 = 0 for single interrupt   D3 = 1 for continuous

Table 3. Interrupt register (write)

Interrupt Status	D3	D2	D1	D0
Reset	0	0	0	0
60 sec signal	0/1	1	0	0
5 sec signal	0/1	0	1	0
0·5 sec signal	0/1	0	0	1

D3 = 0 for no interrupt   D3 = 1 for interrupt

Table 4. Interrupt register (read)

```
 10 REM BBC Micro Forum RTC Set-up
 20 REM -------------------------
 30 MODE 7:PCR = &FE6C:InOut = &FE60
 40 DIR = &FE62:In = &F0:Out = &FF
 50 PRINTTAB(10)CHR$141"Clock Set-up"
 60 PRINTTAB(10)CHR$141"Clock Set-up"
 70 ?PCR = (?PCR AND &1F) OR &E0
 80 ?DIR = Out
 90 PRINT '"Set mode switch to WRITE"
100 PROCSpace:PROCOutput(0,0)
110 PROCOutput(14,0):PROCOutput(15,0)
120 PRINT "Set mode switch to READ"
130 PROCSpace:?DIR = In
140 FOR I = 1 TO 3:PROCInput(15):NEXT
150 PRINT "Set mode switch to WRITE"
160 PROCSpace:?DIR = Out
170 INPUT "Year:                 "Y%
180 INPUT "Month (1-12):         "M%
190 INPUT "Day of Month (1-31): "D%
200 INPUT "Day of Week (1=Mon): "DoW%
210 INPUT "Hours (0-23):         "Hrs%
220 INPUT "Minutes (0-59):       "Min%
230 PROCOutput(4,(Min% MOD 10))
240 PROCOutput(5,(Min% DIV 10))
250 PROCOutput(6,(Hrs% MOD 10))
260 PROCOutput(7,(Hrs% DIV 10))
270 PROCOutput(8,(D% MOD 10))
280 PROCOutput(9,(D% DIV 10))
290 PROCOutput(10,DoW%)
300 PROCOutput(11,(M% MOD 10))
310 PROCOutput(12,(M% DIV 10))
320 PROCOutput(13,(2^(4-(Y% MOD 4))))
330 PRINT '"Clock set up ready to go"
340 PROCSpace:PROCOutput(14,1)
350 PRINT "Clock now running"
360 PRINT "Reset mode switch to READ"
370 PROCSpace:CHAIN "RTCRead"
380 DEF PROCOutput(Reg%,Value%)
390 Value% = Value% AND &0F
400 Reg%   = (Reg% AND &0F)*16
410 ?InOut = Value% OR Reg%
420 ?PCR   = (?PCR AND &1F) OR &C0
430 ?PCR   = (?PCR AND &1F) OR &E0
440 ENDPROC
450 DEF PROCSpace:*FX15,0
460 PRINT "Press SPACE when ready ";
470 REPEAT UNTIL GET=32
480 PRINT:PRINT:ENDPROC
490 DEF PROCInput(Reg%)
500 ?InOut = (Reg% AND &0F)*16
510 ?PCR   = (?PCR AND &1F) OR &C0
520 Temp   = ?InOut
530 ?PCR   = (?PCR AND &1F) OR &E0
540 ENDPROC
```

Listing 1. Clock set-up

```
 10 REM Real Time Clock Display
 20 REM -----------------------
 30 DIM MC% 100:ON ERROR GOTO 290
 40 InOut = &FE60:DIR  = &FE62
 50 PCR   = &FE6C:Time = &70
 60 PROCAssembler:?DIR=&F0
 70 MODE 7:VDU 23,1,0;0;0;0;
 80 ?PCR = (?PCR AND &1F) OR &E0
 90 REPEAT:CALL ReadTime
100 Secs%=FNInput(2)+FNInput(3)*10
110 Mins%=FNInput(4)+FNInput(5)*10
120 Hours%=FNInput(6)+FNInput(7)*10
130 Day%=FNInput(8)+FNInput(9)*10
140 DoW%=FNInput(10)
150 Month%=FNInput(11)+FNInput(12)
160 IF DoW%=1 Day$="   Mon"
170 IF DoW%=2 Day$="  Tues"
180 IF DoW%=3 Day$="Wednes"
190 IF DoW%=4 Day$=" Thurs"
200 IF DoW%=5 Day$="   Fri"
210 IF DoW%=6 Day$=" Satur"
220 IF DoW%=7 Day$="   Sun"
230 PRINTTAB(7,9)Day$;"day ";Day%;
240 PRINT " / ";Month%;" / 1985  "
250 FOR I = 12 TO 13:PRINTTAB(13,I);
260 PRINT CHR$141;Hours%;" : ";Mins%;
270 PRINT " : ";Secs%;"  ":NEXT I
280 UNTIL FALSE
290 VDU 23,1,1;0;0;0;:PRINTTAB(0,15)
300 ?PCR = (?PCR AND &1F) OR &E0:END
310 DEFFNInput(Reg%) = ?(Time + Reg%)
320 DEF PROCAssembler
330 FOR opt% = 0 TO 3 STEP 3:P% = MC%
340 [OPT opt%
350 .ReadTime LDA #2:STA Time
360 .NextReg  LDA Time:ASL A
370 ASL A:ASL A:ASL A:STA InOut
380 LDA #&DF:AND PCR:SEI:STA PCR
390 LDX InOut:ORA #&20:STA PCR:CLI
400 TXA:AND #&0F:CMP #&0F
410 BEQ ReadTime:LDX Time:STA Time,X
420 LDA #12:CMP Time:BEQ Done
430 INC Time:JMP NextReg
440 .Done RTS
450 ]NEXT opt%:ENDPROC
```

Listing 2. Clock read

1	+5 Volts		
2	0 Volts		
3	0 Volts		
4	ADC Channel 3	10	Push-button 1
5	Analogue Ground	11	Reference Volts
6	0 Volts	12	ADC Channel 2
7	ADC Channel 1	13	Push-button 0
8	Analogue Ground	14	Reference Volts
9	Lightpen Strobe	15	ADC Channel 0

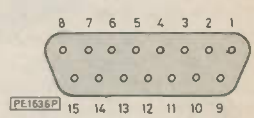


Fig. 1. Analogue port connector

to make amends this time. Fig. 1 shows the analogue port connector, and the view shown is looking *into* the connector from outside of the micro. The connector itself is a 15-pin D-type, with a socket on the micro; the *plug* mounts on the cable. Unlike the user port, there is no confusion as to which way up the connector fits. Hopefully you will now be able to avoid my mistake; anybody got a project which involves a 15-pin D-type socket? Remember, you need a plug to connect to the analogue port.

BOOK CORNER

This month *Book Corner* takes a brief look at two books, one old and one new. The first is the **Advanced User Guide**, by Bray, Dickens and Holmes, published by the Cambridge Microcomputer Centre at £12·95. This book is described as an essential companion for the User Guide, so much so that it even resembles the original in size and presentation. The book covers the MOS in great detail, and is perhaps best described as an advanced user's guide to the MOS. The AUG is available either spiral bound (like the standard User Guide) or in a hard folder. A matching folder is also available separately for the User Guide.

The AUG starts with a 10-page re-run of the operating system commands (the * commands). This is not really new, but it does provide a useful reference section. The next section of 4 chapters covers assembly language programming. This comprises a 20-page introduction to the subject (not quite enough if you really are new to the subject), followed by 60 pages detailing the assembler mnemonics. The third section covers the operating system interfaces, and provides a wealth of invaluable detailed information covering the full set of FX calls, the use of memory, vectors, interrupts and the paged ROM system; beware, the latter may cause your head to ache! The remaining filing systems, however, receive only a cursory examination. The final section is concerned with the hardware, and provides detailed coverage of the various interfaces. As before, coverage of the optional filing system interfaces is rather limited. Finally, there are a number of useful appendices. These include summaries of the various calls (VDU, FX, OSBYTE and PLOT), a description of the p.c.b. links, and step-by-step disc upgrade instructions. Very useful at this point is that the manual also includes a full circuit diagram for the micro.

Verdict: **Highly recommended.**

• • • • •

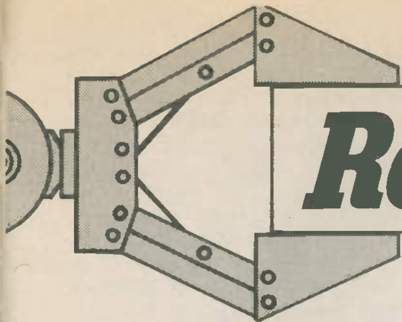
The second book really picks up one of the areas covered by the AUG; the sideways ROM filing system. The discussion in the AUG is complete, but may leave you feeling that a gentler introduction might restore your battered ego! If this is the case, then **The BBC Micro ROM Book**, by Bruce Smith, published by Collins at £9·95, is an excellent remedy.

The book is written in a pleasantly readable style, and is well illustrated with software examples and screen illustrations. The sideways ROM paging system is explained in a detailed and logical manner. The method of writing your own ROM software is built up a step at a time. As with all subjects of this type, practical examples of other people's work is always the easiest way to learn, and this book makes profuse and effective use of extracts from commercial ROMs to get its points across.

The first 9 chapters cover the various stages in writing your own ROM-based software. There is then a chapter on the merits of the various add-on ROM/RAM systems. This is followed by a design (software and hardware) for an EPROM programmer. The next two chapters look at a selection of BASIC toolkit ROMs, and other language ROMs, respectively. Finally, there is a section on the BASIC II ROM. If you do not own an MEP bar code reader, this is effectively where the book stops, because what remains is 70 pages of bar code listings of the longer programs in the book. If you have a suitable reader, this will save your fingers, but if not the listing will provide encouragement to investigate this concept further (a contact address is provided).

Verdict: **A good book, long overdue.**

NEXT MONTH: *BBC Micro Forum* will be looking at the analogue port in greater detail.



Robotics Review

Nigel Clark

THE Russians might soon be enjoying the latest in British micro-technology. **Cybernetic Applications** of Andover, one of the leading innovators in small robot arms, has appointed an agent for the USSR. Richard Becker, managing director, said that he had not had any orders yet but was looking forward to the day when Neptunes and Mentors would be heading behind the Iron Curtain.

The move is part of the growing appreciation of British innovation in personal robots all over the world. Becker himself has sold his machines, which cost from £500 to £2,800, to the major markets in America and Germany as well as Australia and Norway.

But he is not holding his breath waiting for a red order. He is busy adding more robots to his range. The latest, named the Serpent and costing around £1,700, was launched at Automan in May.

It is a scara robot which Becker describes as like a normal arm but working on its side, hence the name of Serpent. It has four axes plus a gripper, can lift 1kg and has a claimed accuracy of 1mm.

It is powered by DC motors with potentiometers providing the feedback. Most of the popular micros, BBC B, C64 and Spectrum, can control it and software is being developed for these machines.

. . Commander X "a hero figure" . .

The robot market consists of three fairly distinct sections—toys, hobbyist and educational. Many products however break down those classifications and the latest of these is the robotics kits from Milton Bradley.

MB, an American company, is already well known in Britain for its Big Trak robot truck. The company has decided to introduce a product which is a little more complicated with kits that can be used to build a variety of devices.

Unlike the Fischertechnik kit, which has been on sale for some time and is intended as a tool for learning robotics, the imaginatively-named Robotix series is biased towards the toy market.

There are three main kits available, which can be used to build Commander X, "a hero figure" with a 12 page explanatory booklet, a Space Technician or Dr Steel "with removable helmet".

Imagination and two kits of extras will allow the more serious robotier to escape from having to play with dolls.

The essential elements are high torque, bi-directional motors and power droids which control the motors, a five-channel control console and any number of plastic components. The control console is available only with the most expensive kit.

One accessory kit contains a motor and power droid, the other more plastic parts.

One of the kits has been on sale in Harrods since before Christmas. The top people's shop was so impressed that it imported them specially.

For the rest of us the kits will cost between £20 and £80.

Remaining in the serious toy market, the Movit range is expanding. **Commotion** has taken over the distribution and another five models have been added to the original five already on sale in Britain.

At £16.95, Peppy 3 is a three-wheeled model which is sound activated, and Medusa 3 is a tripod which moves in response to the voice and costs £19.95. Avoider costs £29.95 and has an infra-red obstacle sensor and for the same price Navius is a programmable mobile. It is controlled by a card which is coloured to give the required instructions.

Top of the range is the Wizard. It costs about £75 and can be controlled from a Commodore 64.

As with the earlier Movits the new range comes in kit form, which is said to be simple to put together. Only a screwdriver and nimble fingers are required.

Commotion is also launching a Commodore version of the highly-successful Snap vision system. Until now the system has only been available for the BBC B at a cost of about £120.

The available software allows the system to capture images, freeze and print them, store and replay a series of images and build-up a grey-scale picture. It can also recognise non-overlapping objects.

. . simple mobile robots or "beer-can buggies" . .

For the inquisitive who prefer to learn about robotics under skilled tutors rather than play around with kits there is an event being held for the first time at the beginning of July.

In association with the First European Personal Robotics Conference and Exhibition there will be a series of workshops. Details were being worked out as we went to press but it was intended that a wide range of practical assistance would be available including the use of control languages like Logo and the building of simple mobile robots or "beer-can buggies".

There are also plans to hold the first public competition in the Robat contest. That is the latest challenge issued by John Billingsley, the man behind the Micromouse contests.

Robat is a form of robot table tennis. It was first announced more than a year ago since when interest has been high on both sides of the Atlantic and enthusiasts have been working hard to produce a workable device.

A workshop was held earlier this year for the swapping of ideas and it is hoped that some good solutions will be on display.

. . 70 entries in the Robot Butler section . .

Another contest that is reaching its climax is BP Oil's Build-a-Robot, part of the company's Challenge for Youth. There have been 70 entries in the Robot Butler section and 50 in the freestyle group for any domestic task.

About ten regional finals will be held throughout this month (July) with the finals on October 28 at the Army School of Electronic Engineering at Arborfield, Berkshire. All the regional winners, as well as other good entries, will compete for the first prize of £1,000 in the finals. There is total prize money of £3,000.

The butler, working in an enclosed area, will have to offer drinks to two people, asking them what they want from a list and serve it to them. The freestyle section can be for moving or stationary devices but they must be able to carry out some domestic task such as cutting the lawn or vacuum cleaning a carpet.

Ian Pitkethly, BP Oil's community affairs manager, said: "This time the challenge is more ambitious but we are sure that today's youngsters are equal to it."

The company held its first robot competition in 1983 when 400 schools throughout the country expressed interest and 20 entries reached the finals which were also held at Arborfield.

Robotics projects and features published in PE have generated so much reader interest that we are pleased to bring you a regular monthly update on news and developments in this field.

If your company produces items which might be of reader interest please let us know.

Voltmeter MEMORY ADAPTOR

JAN ERIK BORGE

ONE of the problems with using voltmeters in confined spaces is the lack of spare hands to support the meter, hold the probes in the correct position and concentrate on reading the scale — all at the same time. This project provides a reliable yet simple solution to the problem in the form of a memory adaptor.

This compact unit can be used in conjunction with any analogue or digital multimeter to provide voltage readings up to about 24 volts, and with some additions could be extended to any voltage. This makes it particularly suited to working under car bonnets or testing equipment where a 'slipped probe' could mean disaster.

To reset the meter, the capacitor, Cx, can be shorted by the probes or if a new voltage is measured it will automatically force the output to the new reading. A full circuit diagram is shown in Fig. 2.

The transistors, TR1–TR3, form a d.c. current amplifier and TR4 and TR5 configured as a Darlington pair are used to drive the voltmeter. Because of the high gains in the circuit, it would be prone to oscillation, which in this case is prevented by the inclusion of C2. Power is supplied by three PP3 batteries which allows readings to be taken up to about 25V d.c. A single AA size (1·5V) battery provides a separate negative supply to bias the transistors.

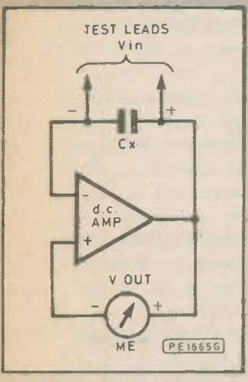


Fig. 1. Block diagram of the Voltmeter Memory Adaptor

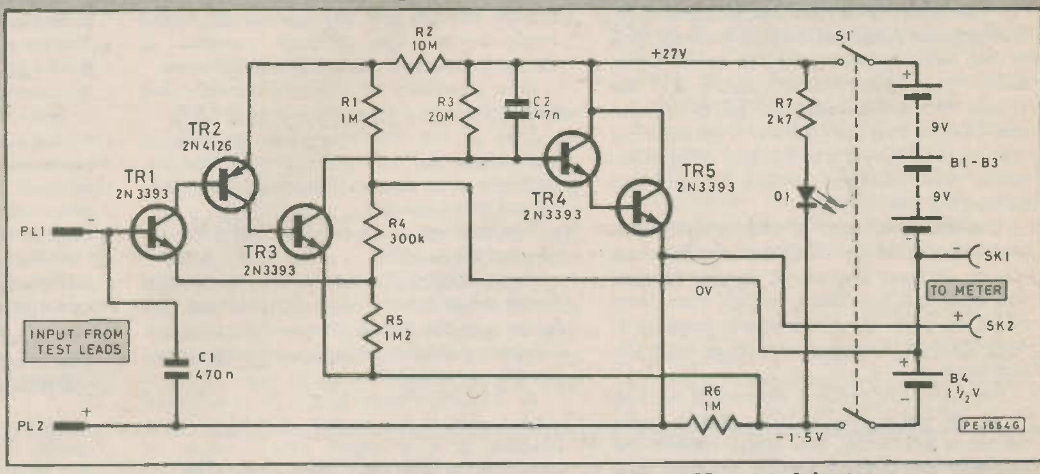


Fig. 2. Full circuit diagram of the Voltmeter Memory Adaptor

CIRCUIT OPERATION

From the block diagram (Fig. 1.), it can be seen that the set-up is quite simple. The voltmeter is connected between the output and the non-inverting input of a high gain d.c. amplifier; and the test leads between the output and the inverting input. Also the inverting input is tied to the output via a capacitor, Cx. When a voltage is applied to the test leads, the amplifier will develop a voltage (V out) across the meter.

$$V\ out = V\ in\ (1-1/G)\ [\text{where } G = \text{gain}]$$

Since the gain is very high, 1/G is negligible, so we can assume that V out = V in.

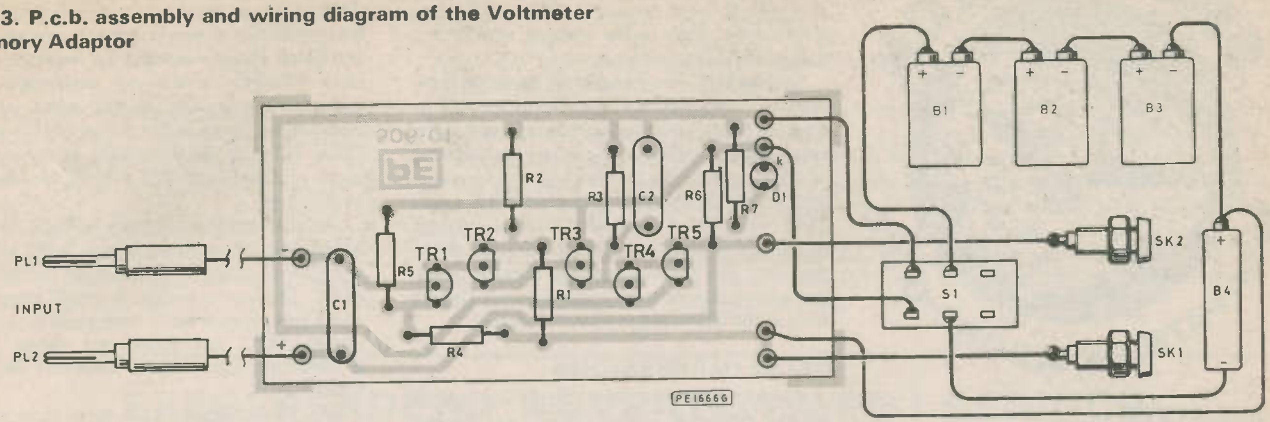
When the test leads are removed, the input voltage will be held on the capacitor, which provides strong differentiating negative feedback which will resist any change in the output voltage. This causes the output voltage to remain stable for about one minute after the probes have been removed—plenty of time to surface from the depths of the car electrics to check the reading.

CONSTRUCTION

Most of the discrete components are mounted on a small p.c.b. and normal care should be taken when soldering to avoid component damage or short circuits. The order of mounting the components is not critical as there is ample space and no hidden difficulties.

For the prototype a small case measuring 120 × 65 × 40mm was used to house all the components, batteries and the p.c.b. There is little space to spare so great care must be taken when mounting the switch, sockets and the battery as

Fig. 3. P.c.b. assembly and wiring diagram of the Voltmeter Memory Adaptor



slight misjudgements could cause a problem. The 9V batteries were held in place by suitably adapted P-clips which proved to be satisfactory and the AA size battery was held in place by a purpose made holder.

As can be seen from the wiring diagram and the photographs, wiring was very easy, the wires held in form by small cable clips. The meter cable is taken from the back of the unit via a grommeted hole and the input test leads are fitted into 4mm test sockets mounted on top, together with an l.e.d. to provide power-on indication.

EXPANSION

As was mentioned earlier the unit can be adapted to measure much greater voltages. There are, however, a few points which must be taken into consideration.

One of the main problems is the availability of a suitable power supply with sufficient voltage output. Because the unit is designed to be easy to use and portable, it is unlikely that you will find suitable batteries. Also the transistors used must be capable of withstanding higher operating voltages. ★

COMPONENTS . . .

Resistors

R1,R6	1M (2 off)
R2	10M
R3	20M
R4	300k
R5	1M2
R7	2k7

All resistors ¼W 5% carbon

Capacitors

C1	470n encapsulated radial
C2	47n encapsulated radial

Semiconductors

D1	0·2" red l.e.d.
TR1,TR3–TR5	2N3393 (4 off)
TR2	2N4126

Miscellaneous

PL1,PL2 4mm test sockets (2 off)
SK1,SK2 4mm test plugs
P.c.b. PE 506–01
Batteries and holders
Test leads
P-clips
Wire, solder, etc.

Constructor's Note

If alternative transistors are used for TR1–TR5, any general purpose types will do providing that they have low leakage characteristics.

Pin 1. Collector
Pin 2. Base
Pin 3. Emmitter

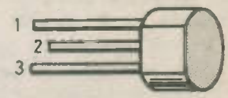


Fig. 4. Pin connections of TR1–TR5

PE1667G

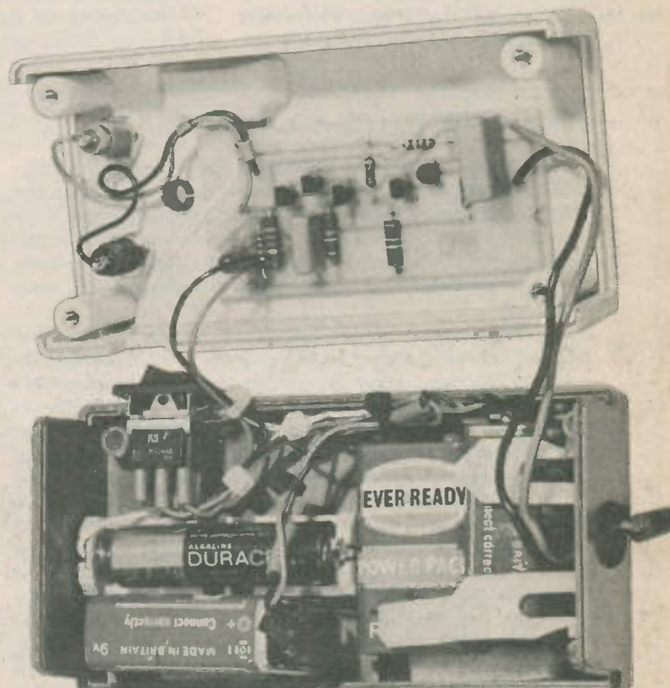


Photo illustrating the internal view of the Voltmeter Memory Adaptor

STARBURSTS

It cannot yet be said that we have a complete picture of the evolution of a star, but at least we are on much firmer ground than we used to be only a few years ago. There is no doubt that a star begins its career by condensing out of interstellar gas and dust: in fact, out of the material in a nebula. The Orion Nebula, M.42 is a typical stellar birthplace, and we have even caught stars in the act of blowing away their enveloping cocoons.

Our Galaxy is a spiral system, containing about 100,000 million stars; it is of the order of 100,000 light-years in diameter, and the Sun lies about 30,000 light-years from the galactic centre (the exact value is still a matter for debate). It is thought that "pressure waves" rotate around the nucleus and stars form inside these pressure waves.

The most massive stars, which run through their evolutionary cycles quickest, pass through their main sequence and giant stages, and many explode as supernovae; while they are obtrusive we see a spiral arm. This means that no spiral arm is a permanent feature.

Not all galaxies are alike, and by no means all are spiral. Recently there has been a great deal of interest in a strange system known as Arp 220. It lies in the constellation of Serpens Caput (now high in the evening sky) and is only of the 14th magnitude.

Originally it was thought to be either composed of two galaxies in collision, or else an unusual galaxy with a double nucleus. It is exceptionally powerful in the infra-red, and was, of course, carefully surveyed by the very successful *IRAS* satellite, launched in January 1983 and which continued to operate for most of the rest of that year. It has been calculated that Arp 220 emits about fifty times as much energy at infra-red wavelengths as our Galaxy does at the whole range of wavelengths!

FALSE IMPRESSIONS

Earth-based researches carried out mainly at the Whipple Observatory on Mount Hopkins, in Arizona, by R. Burg and R. E. Schild seem to show that these early interpretations were wrong. It is more likely that Arp 220 is simply a single galaxy crossed by an obscuring dust-line, giving the false impression of a double nucleus.

It is, however, one of a pair of galaxies, the other being IC 4554, and there may well be tidal interactions between them. Moreover, observations carried out with the 1000-foot Arecibo radio telescope indicate that Arp 220 is an intense source of hydroxyl (OH) maser emission.

Bearing in mind that the distance of Arp 220 is of the order of 300,000,000 light years, it is hardly surprising that we cannot observe it in detail, but there are grounds for believing that it is one of those systems which are becoming known as "starburst" galaxies. In other words, the intense emission and the very high luminosity indicate exceptionally energetic star-formation is going on there.

According to the *IRAS* data, the main infra-red source is comparatively small (less than half a minute of arc in diameter as seen from Earth). Obviously it is tempting to infer the presence of a super-massive Black Hole. This is by no means out of the question; it may well be that active galaxies do have central Black Holes—notably the Seyferts, which have relatively condensed nuclei and only weak spiral arms. On the other hand, we must be cautious. Some astronomers tend to regard Black Holes in the same light as some politicians regard North Sea oil: as remedies for everything!

Another starburst galaxy is M.82, in Ursa Major (the Great Bear), which is the smaller, irregular companion of the more conspicuous M.81. (Both are visible in small telescopes, and I can glimpse M.81 with good binoculars, though M.82 has eluded me unless I use a telescope; keener-eyed observers may do better.)

M.82 was formerly believed to show indications of a cataclysmic internal outburst. This is not now thought to be correct, and that tidal interactions with M.81 are responsible for its characteristics, but this does not mean that there is no starburst phenomenon; there probably is.

Material from M.81 streams down on to the nucleus of M.82, and shock-waves produced by the compression trigger off starbursts. But though M.82 is a strong infra-red and radio-wave emitter, it is by no means as powerful as Arp 220, and it is also very much closer to us—only about 8,500,000 light-years, not so very far beyond the boundary of our Local Group.

The idea of starbursts is relatively new, but it is of great importance. *IRAS* is dead, and we must wait for some years for the launch of its successor, planned for the early 1990s; meantime the *IRAS* data is still being analyzed, and ground-based infra-red work is being carried out at many observatories, including that on the top of Mauna Kea at an altitude of some 14,000 feet above sea-level.

THE SKY THIS MONTH

The June nights are obviously the worst for star-gazing, as the hours of darkness are short, and when the Moon is obtrusive there is no proper darkness at all. This month the Moon is full on 3 June, and new on 18 June; the next full moon is on 2 July, so that only the middle part of the month will be suited to see the stars in their full glory.

Of the planets, Venus continues to be visible as a brilliant morning object in the eastern sky; it reaches its greatest western elongation from the Sun (46 degrees) on 12 June. Jupiter is also brilliant, in the south-east in the morning, but it is so far south of the celestial equator that British observers will have problems when trying to chart telescopic detail. Saturn, in Libra, is also in the southern hemisphere, while Mercury and Mars are too close to the Sun in the sky to be seen at all.

The night sky—when dark—is dominated by the three brilliant stars Vega, Altair and Deneb, which make up a large triangle—about a quarter of a century ago, in a Sky at Night *programme, I nicknamed this the "Summer Triangle", and everyone now seems to use the term, though it is completely unofficial, and the three stars are in different constellations; Vega is the leader of Lyra (the Lyre), Deneb of Cygnus (the Swan) and Altair of Aquila (the Eagle).*

Of the three, Deneb appears much the faintest but, as so often in astronomy, appearances are deceptive. Deneb is a true cosmic searchlight, at least 60,000 times as luminous as the Sun, and is so remote that we are now seeing it as it used to be in the time of the Roman Occupation, whereas Altair is a mere 10 times as powerful as the Sun, and is less than 17 light-years away. Of the first-magnitude stars, only Sirius, Procyon and Alpha Centauri are closer to us than Altair.

The brilliant orange Arcturus, in Boötes (the Herdsman) is high in the north-west, while the Square of Pegasus is just starting to come into view in the east in the early hours of the morning. This is the best time of the year to look for the Scorpion, led by the red super giant Antares, and the star-clouds of Sagittarius, the Archer. Both may be seen low in the south after dark. It is a pity that they are always so low down from Britain (from North Scotland they barely rise at all); the Sagittarius star-clouds indicate the direction of the centre of the Galaxy, which we cannot see directly because of interstellar dust.

If you have a telescope, look at the globular cluster M.13, in Hercules, which is now very high up. It is just visible with the naked eye; the only two globular clusters which are brighter, Omega Centauri and 47 Tucanae, are too far south to be seen from anywhere in Europe.

Arp 220 and other systems of the same kind have presented us with many problems, but there is no reason to doubt that within a few decades from now we will have found out just what is really happening inside them.

IN BRIEF

Uranus, the planet discovered by William Herschel in 1781, is very much in the news. (It comes to opposition, this month, on 6 June, when it will be 2,703,000,000km from the Earth, and of magnitude 5.8, so that it is just visible with the naked eye; it lies in the rather barren constellation of Ophiuchus). *Voyager 2* is now on its way there, and will rendezvous with Uranus next January. Pictures of the planet have already been obtained, and are superior to any Earth-based photographs, though as yet they do not show much detail.

The rings of Uranus were discovered in 1977, as a result of observations of the occultation of a star; both before and after occultation the star "winked", and the existence of the rings was subsequently confirmed visually by infra-red and then by CCD Charge Coupled techniques. On 25 June there may be an occultation of a 9th-magnitude star, SAO 184819, by the rings though not by the planet itself.

The predicted time of closest approach is 21.45 GMT. Energetic efforts will be made to observe the phenomenon, particularly to look for any unknown satellites, but sophisticated equipment will be needed to obtain any worthwhile results.

Meanwhile, occultation techniques have led to the suspicion of a ring round Neptune. I had forecast that there would be no Neptunian ring, because of the presence of a large satellite (Triton) moving in a retrograde orbit; if these observations are confirmed, I will have to eat my words!

On a sad note, we must record the death of William Hoyt of the Lowell Observatory. He was one of astronomy's leading historians, and published two major books, one dealing with Mars and the other with Planets X and Pluto.

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CELESTION speaker wanted (3·5" × 7") elliptical, ridged lines radiating from centre of diaphragm. Contact Mark—Tel: Medway (0634) 30822.

UK101, Wemon, games, case available if required. £60. Mr. P. Richardson, 30 Whitehouse Avenue, Great Preston, Leeds 26. Tel: Leeds (0532) 871291.

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TELEPRINTER—Creed 444 50 baud speed. As new. £45. Buyer must collect. K. W. Scott, 38 The Gardens, Monkseaton, Whitley Bay, Tyne & Wear NE25 8BG. Tel: 091 252 7141.

BI-DIRECTIONAL dot matrix printer. Very little use £85. Complete with manual. Seen working. Phone Southampton 788278.

EXCHANGE Nakamichi BX2 tape deck + cash for portable, modernish, dual trace oscilloscope. Roy S. Fletcher, 29 Hirst Close, Long Lawford, Rugby, Warwicks.

TELETEXT adaptor Ayr model T11. Converts any television to teletext and remote control. £70. Mr. J. B. Rudge, 138 Mendip Road, Halesowen, W. Midlands B63 1JH. Tel: 021 550 1273.

WANTED software/hardware manual EG2330 or technical information in any form for colour Genie EG2000. Muneer A. Khan, BS-160 Bagh Sardaran, Rawalpindi, Pakistan.

PE 1969–78; PW 1959-65; PW 1969–76 and EE 1971-77 in Easibinders. Offers for all or part. C. T. Watts, 27 Fairview Court, Manor Road, Ashford, Middx. TW15 2SN. Tel: 07842 51485.

WANTED Audio timer or control unit. Exchange with speed reading course or cash. S. Leadle, 1 Church Close, Ormesby, Middlesbrough, Cleveland TS7 9AN. Tel: 0642 322124.

TEKTRONIX oscilloscope 502 with factory manual. Good condition. A comprehensive low frequency scope £60 o.n.o. Mr. A. Bouskill, 129 Lyminster Road, Sheffield S6 1HY. Tel: 0742 311191.

ADVICE needed on equipment required for recording 78 RPM accoustic records to acceptable quality for tapes. C. W. Burnell, 6 Meadhurst Road, Chertsey, Surrey. Tel: 09328 62417.

AQUARIUS COMPUTER. Help wanted—manual or any information required. Various collection of computer parts. Offers? R. Reynolds, 32 Common Approach, Benfleet, Essex SS7 3LA.

CLEARING OUT 1000 components for only £2. Plus £1 postage and packing. Paul Birt, 44 Mathie Crescent, Gourock, Renfrewshire, Scotland PA19 1YX.

DISC DRIVES $5\frac{1}{4}$ Shugart SA400 £80 each, £140 pair. Controller FD1771 £12. Radar modules CL8960 £20. K. Termie, 6 Parkland Drive, Oadby, Leicester. Tel: 0533 717516.

STUDENT requires scope for experimental work. Donation would be appreciated but can afford up to £30. S. Laws, 68 Nunnery Street, Castle Hebingham, Halstead, Essex. (0787) 61637.

SOFTY Eprom programmer/emulator, £100 post paid. Mr. D. H. Slater, 16 Blenheim Terrace, Foulridge, Colne, Lancashire BB8 9BJ.

ROBOTICS, Genesis P101 6 axis robot arm and processor, £500. Equipment worth £1000+ built, tested and working. Mr. T. Smith, 79 Ford Lane, Tricketts Cross, Ferndown, Dorset BH22 84B. Tel: Bournemouth 895925.

PRINTER RS232C 300 Baud suits UK101 80Col letter quality. Offers please. Also Kode power supply (large). C. J. Hellen, Vine Cottage, Main Rd., Alresford, Colchester CO7 8UD. Tel: (020622) 5671.

PE Nov. 1964 to Jan. 1974, only three missing, most in binders, any offers? Mr. A. E. Bourne, 27 Nightingale Drive, Epsom. Surrey KT19 9EN.

2764 Eproms £2.50. ITT Cannon RC rack and panel plugs and sockets, 16 pin, £2.50 per set. N. E. Spiers, 114 Grenway, Tunbridge Wells, Kent TB2 3JN. Tel: (0892) 44070.

FOR SALE Solartron Solar Scope dual beam ex-army 64 valves, very heavy, needs three valves. £80. John Horton, 149 Mill Road, Deal, Kent CT14 9BB.

PHILIPS 1700 video tapes wanted. Tel: 034 61376 evenings.

CASIO FX-702P pocket computer, mini printer with charger and cassette interface, as new. £40. No splits. Chris Warwick, 8 Hartfield Road, Chessington, Surrey KT9 2PW. Tel: 01-397 9878.

PE Gemini stereo power amplifier with Sugden C51 pre-amp high quality sound, £50. Brentwood (0277) 219639.

SECURITY pressure mats, large. £3.50 each + 50p post; also 9V d.c. buzzers, high output, 90p each + 20p post; all new, Mr. P. C. Bellamy, 137 Garland Road, Redhill, Surrey RH1 6NY.

ATARI 400 computer, £40. Jim Fulton, Derryraseen, Dromore, Co. Tyrone BT78 3BE.

200 assorted components for £1.90. 550 assorted semi-conductors for £4.00. S. Russell, 203 Southbourne Road, Eastbourne, EN22 8RG. Tel: 0323 641036.

modems

M. TOOLEY BA and D. WHITFIELD MA MSc CEng MIEE

THIS month we continue our study of modems by looking at some of the techniques currently available for designing a modem. At the very outset, however, we must stress that before any modem can be connected to the BT system, it *must* first have been approved for the purpose. We will not, therefore, be including practical modem constructional details. Instead we will be concentrating on the fact that a knowledge of modem techniques can be of great value in trying to assess the suitability of a particular unit for an application. In addition, the diagnosis of problems in practical situations is considerably simplified if you know what *should* be happening at each point in the communications link.

We will start, therefore, by looking at the regulations which must be satisfied in order for a modem to gain approval for connection to the public network, since these are the underlying requirements for many modem design features.

THE REGULATIONS

The regulations which relate to modems exist for two broad categories of reasons. The first is to ensure the safety of both the modem user and other BT users, and the second is to ensure technical compatibility with the telephone system, both national and international. The principal requirements which must be satisfied by modems are described in a series of British Standards, of which the principle ones are listed in Table 1.

Since 1983, the responsibility for approving modems for connection to the BT network (and awarding that essential green approval sticker) has been with the British Approvals Board For Telecommunications (BABT). (The board's address is included in Table 1.) The original intention behind the transfer of approval authority from BT to BABT was to speed up the approval of telecommunications equipment, following the relaxation of the BT monopoly under the 1981 legislation. Unfortunately, the move has not greatly reduced the time, bureaucracy or cost of gaining approval for a modem.

The 1983 scale of fees, for example, indicates that to gain approval for a modem will cost around £2,800 in fees alone. If you think that is a bit steep, it costs £1,238 just to gain approval for a type 601A jack plug! However, although in true British fashion the mechanics of the process may arguably leave room for improvement, the underlying reasons for the approval regulations remain extremely sound. In the USA, for example, the FCC have similar approvals procedures, but they do seem to be able to carry them out rather more rapidly.

SAFETY

The safety considerations applied to modems are intended to safeguard users, BT's staff and its equipment. The requirements for safety are contained in BS6301, and BABT require to be satisfied that this standard has been met before approval can be given. The standard relates to the protection from hazards arising from the modem, and to protection of the user from the line potential.

This is all very well, but it may leave you wondering what is dangerous about a telephone line? A standard BT line operates on a nominal 50V d.c., rising to around 75V a.c. when ringing current is being transmitted. The line current is limited at the exchange to a maximum of around 120mA. Although not lethal to a healthy adult, the line potential is enough to give a shock, and could have more serious effect on young children or anyone not enjoying full health. It is important, therefore, that the design of a modem should protect the user from exposure to the line potential.

In addition, BT is rightly concerned for the safety of both its staff and its other customers. To ensure continuity of service, BT also needs safeguards against the possibility of damage to its network equipment. Of particular concern in this area is the possibility of mains voltages being accidentally connected to the BT network. Clearly, the advent of the new-style BT plugs and sockets as standard fittings for all new installations serves to heighten concern over safety since user equipment is now normally connected directly to the network.

TECHNICAL COMPATIBILITY

In order not to upset the efficient working of both the BT network and the international networks, it is necessary that a modem is compatible with the telephone system. The regulations in this area serve to prevent undesirable effects on the network's normal operation being caused by a modem. There are various frequency bands where signals are not permitted because of the possible effects on BT's signaling equipment. The requirement (described in BS6305) concerning transmitted spectra is illustrated in Fig. 1. This shows that the bandwidth available for data transmission is quite small, and hence the design of modem filters is an exacting task. Other technical requirements which must be satisfied are detailed in BS6305.

DESIGNING A MODEM

The British Standards and the various signal standards (Bell, CCITT, etc.) give a starting point for designing a modem by specifying some of the requirements that must be satisfied. The remainder of this article looks at three different ways of approaching the modem design problem. This brief survey does

MODEM APPROVAL

Addresses

BABT,
Mark House,
9/11 Queen's Road,
Hersham,
Walton-on-Thames,
Surrey, KT12 5NA.

Enquiry Section,
British Standards Institution,
Linford Wood,
Milton Keynes,
MK14 6LE.

British Standards

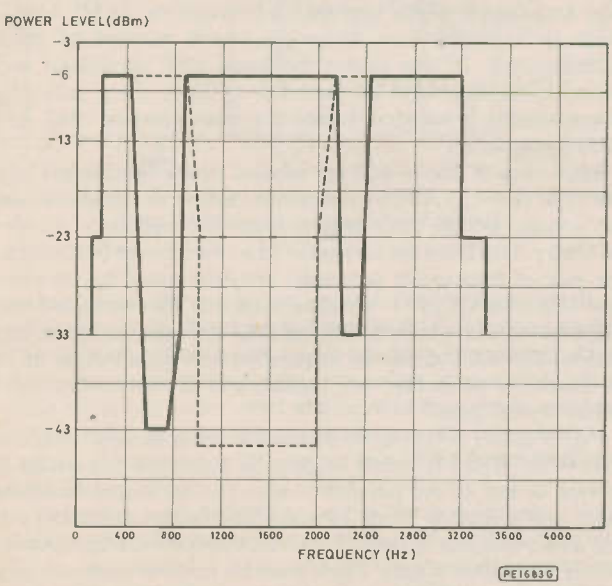
BS6301 Safety requirements for apparatus for connection to British Telecommunications networks.
BS6305 General requirements for connection to the British Telecommunications public switched telephone network.
BS6320 Modems for connection to the British Telecommunications public switched telephone network.

Approvals

The following standards have been approved by the Secretary of State:
82/001S Plugs suitable for connecting subscriber's apparatus to BT networks.
82/002S General safety requirements for apparatus for connection to the BT networks.
82/003S General requirements for connection to the PSTN run by BT.
82/004S Simple extension telephones for connection to a single exchange line of the BT PSTN.
82/005S Data modems and associated call set-up equipment for connection to the BT PSTN.

Table 1. Gaining approval for a modem

Fig. 1. Permitted transmitted spectra (BS6305)



not claim to be complete; indeed, that would require a book just to do justice to the subject of filter design. Instead, it serves to illustrate some of the techniques which can be found in today's modems. The techniques are discussed in chronological order of their introduction, and it is a measure of the speed of technical advance that examples of all three can be found in modems which are on the market at the present time.

We start our study of modem design techniques by briefly reviewing the basic elements required in a modem. These basic elements are illustrated in Fig. 2, and their functions are summarised in Table 2. Our interest this month lies in the different

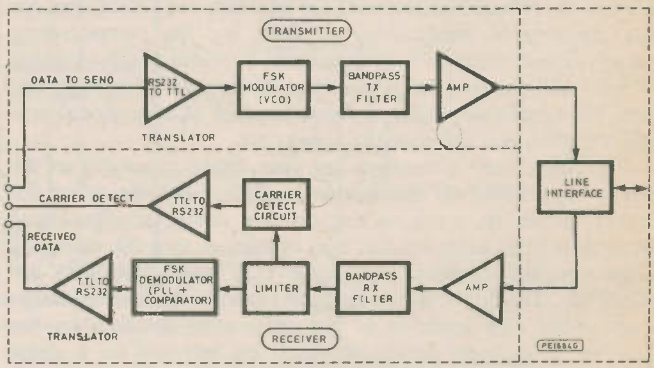


Fig. 2. Basic modem elements

Table 2. Functions of modem elements

MODEM FUNCTIONS

Transmitter

Translator Converts from the RS232 levels to the logic levels used within the modem, usually TTL-compatible.
Modulator The FSK modulator is a voltage controlled oscillator whose output frequency depends on the data level to be sent (logic 0 or 1). Different frequency pairs need to be produced for different speeds, standards and modes.
Filter The transmit filter must prevent unwanted frequencies from being passed to the telephone line. This is particularly required to suppress any harmonics of the transmit signal which may be produced by the VCO.
Amplifier This matches the transmit signal to the level required by the line interface.

Receiver

Amplifier This boosts the a.c. signal from the line to the necessary level for the receiver circuits.
Filter This is a critical stage in determining the performance of the modem. The filter must remove any extraneous signals, and have a sharp roll-off characteristic to exclude the locally generated transmit frequencies. It must also have good phase characteristics to avoid corrupting the received pulses.
Limiter The limiter provides the following stages with a symmetrical square wave from a sine wave.
Demodulator The FSK demodulator is a combination of a PLL and comparator. The comparator output represents the direction of the frequency difference between the carrier and the received signal.
Detector The carrier detector indicates whether an in-band carrier has been detected.
Translator These convert from the logic levels produced by the receiver to the RS232 levels.

ways in which these basic elements may be realised in practice.

For today's modem user, the prospect of building a modem totally from discrete components is best regarded as an academic exercise. To meet the exacting demands imposed by the various standards, this represents a cumbersome and expensive approach. Modern designs are all based on integrated circuit technology of one sort or another, and our study therefore concentrates on this area. Anyone interested in the 'traditional' methods may be interested to note that the cheapest such modem in 1980 cost around £1,500. Not surprisingly, modems were then almost exclusively the province of professional and commercial users!

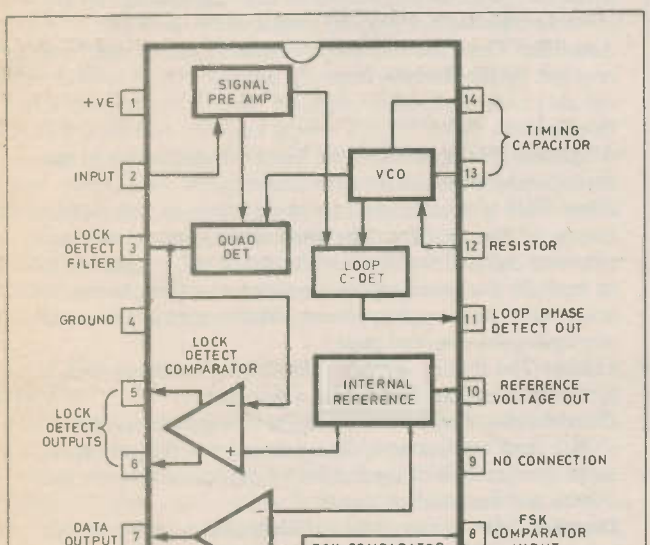
Technology has now advanced to the point where operational amplifiers are 3-terminal devices, and are used in much the same way as the robust transistors of the late '60s and '70s. Gone, for the majority of applications at least, are the compensating networks and offset null arrangements of yester-year. Anything which once required large numbers of discrete transistors can now be accomplished by a small handful of operational amplifiers, often at a substantially lower cost.

The filters used in modems are now almost invariably of the active type, based on operational amplifiers as their active elements. Similarly, many of the discrete circuit configurations have now been incorporated into integrated circuits, including some specially designed for digital data communications applications. The factor which tends to separate the various design approaches now tends to be the scale of integration, i.e. the number of different functions which are included on a single chip.

SMALL SCALE INTEGRATION

The receiver in a basic SSI modem is usually based on an i.c. phase-locked loop (PLL) device. The input to the receiver is derived from the telephone line interface, via an amplifier and bandpass filter. The PLL itself operates by detecting frequency shifts away from the nominal carrier frequency. The digital data is then recovered from the received signal via the phase comparator, which measures the difference between the input signal and the locally-generated carrier. A typical device used for the heart of a PLL receiver of this type is shown in Fig. 3.

Fig. 3. Typical PLL receiver device (XR2211)



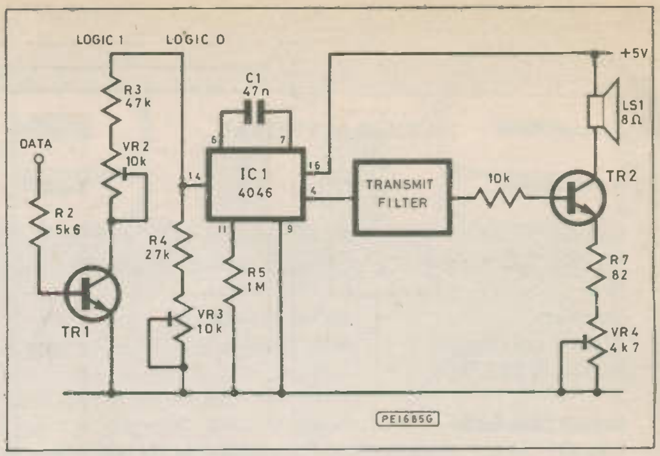


Fig. 4. VCO transmitter section

In the transmitter stage, the digital data to be sent is modulated onto the audio carrier by means of a voltage controlled oscillator (VCO). Fig. 4 shows the basis of a transmitter of this type. The two frequencies used for logic 1 and logic 0 are set by the combination of C1 and VR2/VR3, respectively. The input logic level from the computer determines the effective resistance in the oscillator section by means of the active switch, TR1. Following the VCO section is a filter to prevent unwanted frequencies being passed to the line interface.

In the transmitter and receiver circuits shown, the interface to the telephone line is via an acoustic coupler. This is simply to illustrate one type of connection; the basic circuit ideas apply equally to direct connect modems. In the descriptions above, we have omitted any consideration of the signal filter sections. Even so, performance is clearly dependent on the R–C timing components, and hence such a modem is dependent on the accuracy and stability of these components. One consequence of this dependence is that this type of modem is susceptible to temperature effects. Designing a modem to meet the performance requirements can thus be an exacting task.

MEDIUM SCALE INTEGRATION

Moving on from small scale integration, the next level of integration provides all of the basic signal processing on a single chip. An example of this approach is provided by the MC14412, which is available from Motorola and a number of other manufacturers. In this device the basic FSK modulator and demodulator stages are all included on chip, along with pin-programmable frequency bands for the standard Bell and CCITT standards.

Baud rates of 300 or 600 are selected by a single control line. The type (US or CCITT) and mode (answer or originate) are also selected by two more control lines. The modulator encodes the binary data from the computer into two discrete frequencies. The pair of frequencies generated are determined by the standard (USA or CCITT), the data rate, and the mode selected. The demodulator performs the logically opposite functions, and decodes the received pair of frequencies into binary data. All of the functions performed are digital, and are controlled by a master crystal clock.

Fig. 5 shows a typical configuration for a modem using the MC14412. Whilst it would be possible to extend this circuit to operate in any of the possible modes, the additional bandpass filters and switching tends to make this rather unattractive in any cost-conscious system. To give an idea of the circuitry involved in the filter stages, Fig. 6 shows a suitable bandpass filter for a 300 baud Bell 103 originate modem. This input filtering is

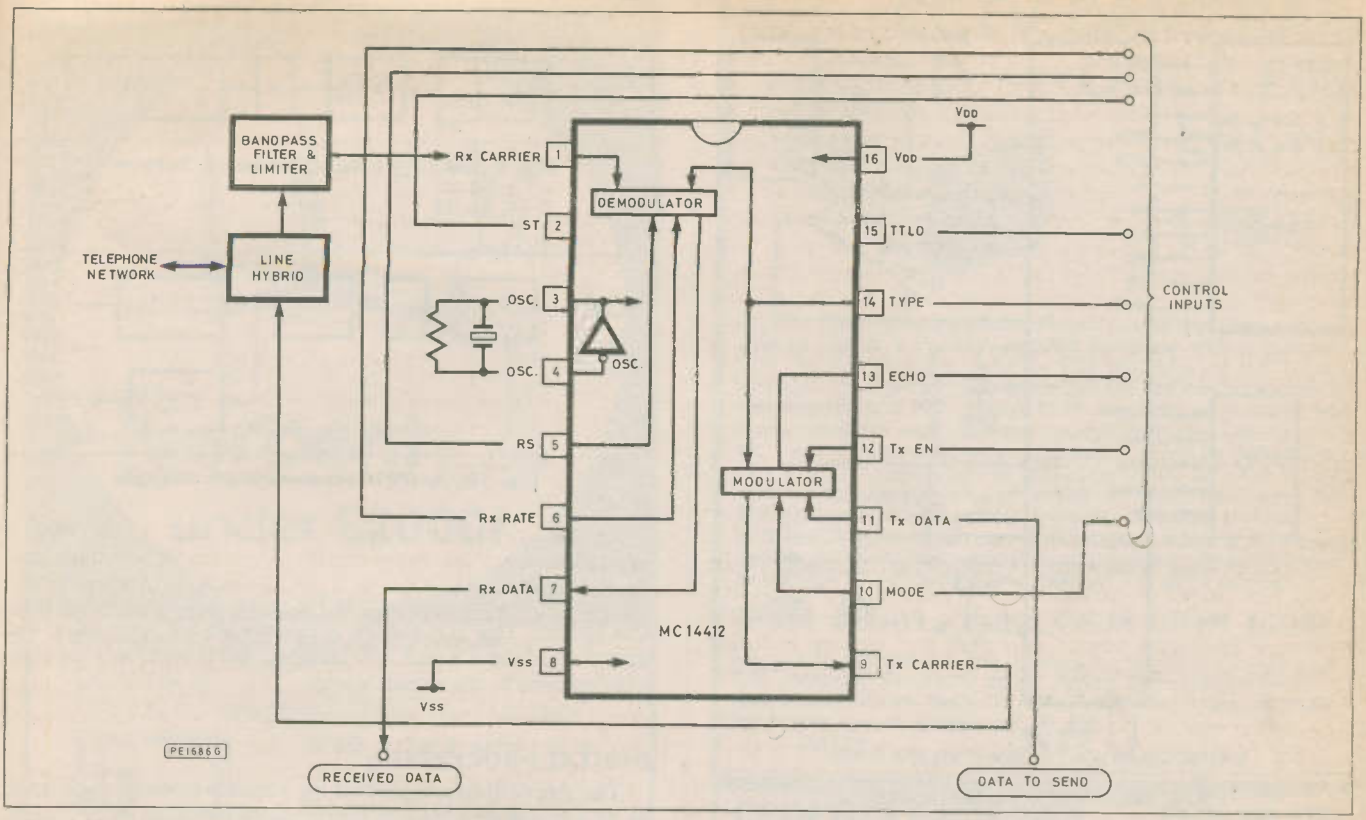


Fig. 5. Typical MC14412 modem configuration

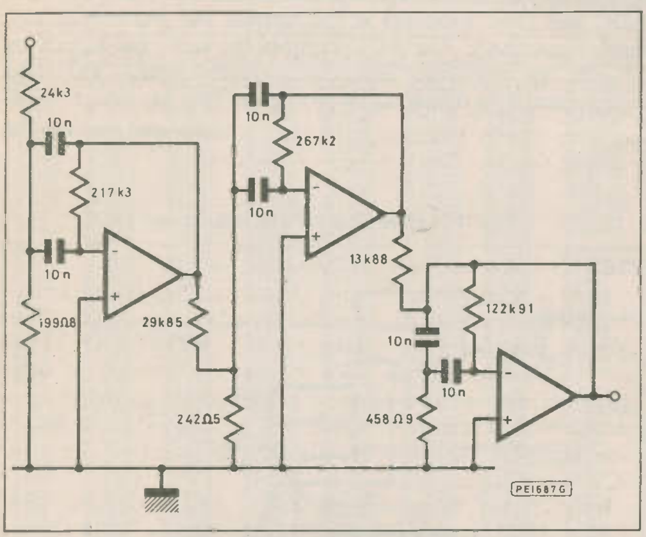


Fig. 6. Bandpass input filter stages

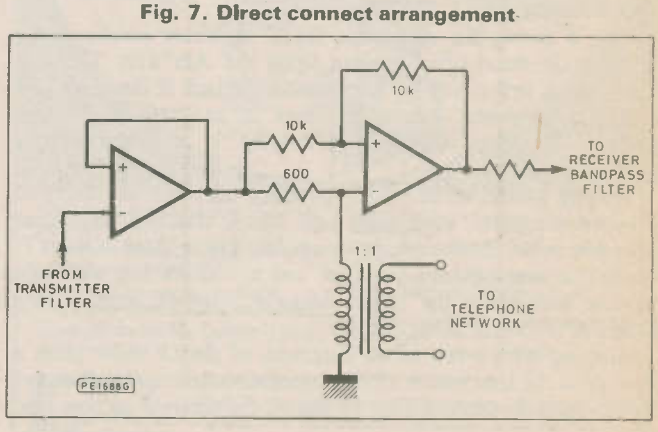
necessary in order to remove unwanted extraneous signals, and to give the signal detection circuits the best chance of working. The bandpass filter needs to be carefully designed to have a small and constant group delay over the passband; if not, the pulse edges will be smeared in time, and data errors will occur. Also it must allow data to be received at the same time as the modem is transmitting on another pair of frequencies along the same line.

Typically, a 6-pole filter is used in the receiver, but a simpler filter usually suffices for the transmitter. The limiter stage which follows the receiver filter is included to provide the demodulator with TTL/CMOS-compatible signals. The carrier for the transmitter is a digitally synthesised sine wave. The transmit filter prevents the transmission of unwanted signals.

By comparison with the acoustic coupling arrangement described earlier, a direct connection to the telephone line using a transformer-coupled arrangement is shown in Fig. 7. The most important item to note here is the transformer. This needs to be a 1:1 600Ω isolating type which meets the appropriate speçifications (e.g. HED 25819). High voltages (mains in particular) must be prevented from reaching the line, and this is usually effected by the transformer.

Another key feature of the transformer must also be its ability to maintain its signal performance whilst carrying up to 120mA d.c. in the primary (line) winding. Other requirements include a very high proof voltage, good isolation, linearity over a wide signal level range and very low insertion loss. Surprisingly, in view of these stringent requirements, such transformers are actually available at quite reasonable cost.

Fig. 7. Direct connect arrangement



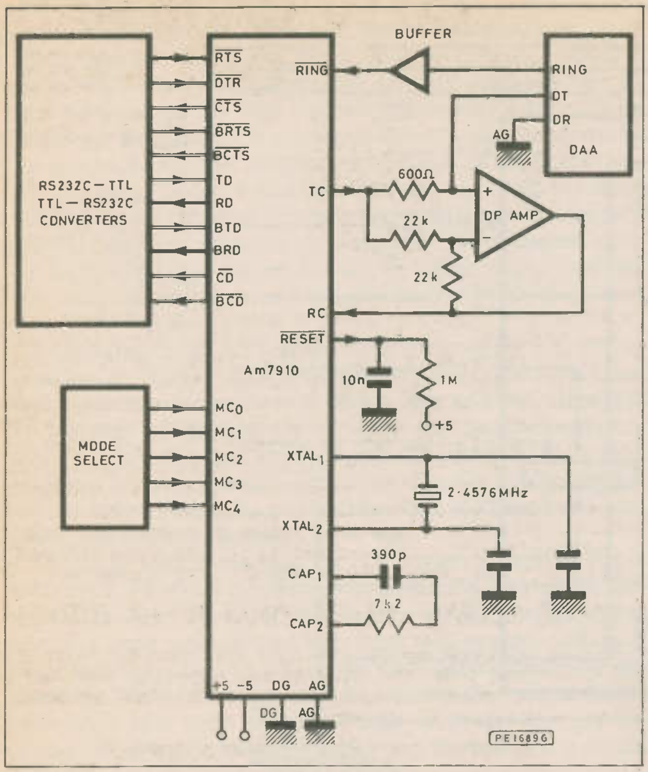


Fig. 8. Multi-mode modem schematic

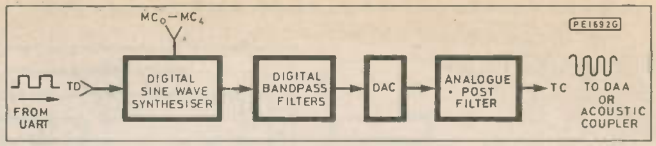


Fig. 9. Am7910 transmitter block diagram

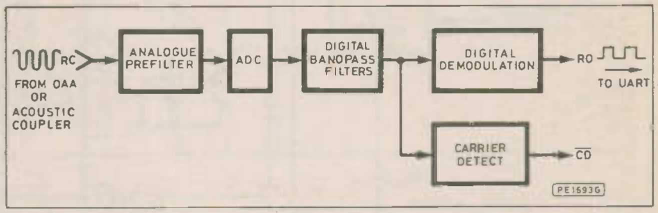


Fig. 10. Am7910 receiver block diagram

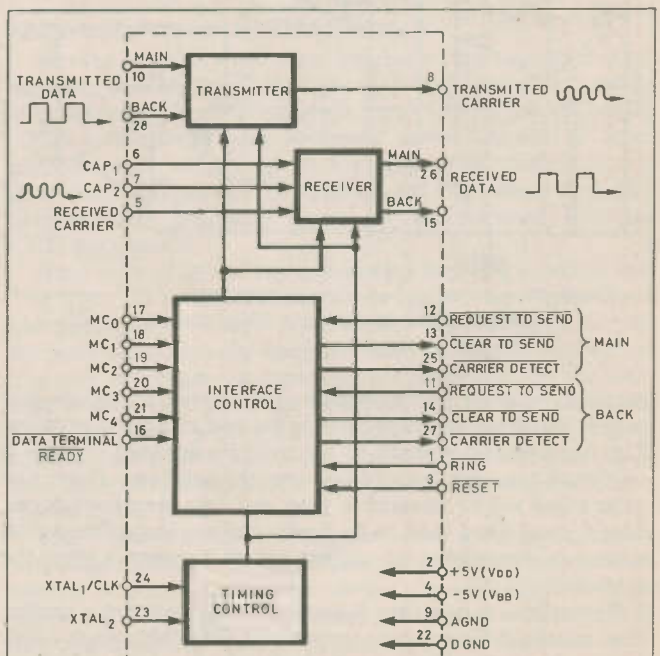
the remaining section, shown in Fig. 11, is the interface and control section. This last section is responsible for supervising the operation of the TX and RX sections, and it interfaces the control functions to the outside world.

DIGITAL PROCESSING

The Am7910 has eliminated the need for those most difficult of all sections of a modem (particularly for multi-mode types); the analogue filters. It does this by performing all of its signal processing operations digitally, and this is the reason for the ADC and DAC elements in the receiver and transmitter sections, respectively. The ADC samples the audio line signals to 11 bits of precision, and the digitised signals are then manipulated by a digital signal processor. This has 24k of ROM

Continued on page 42

Fig. 11. Overall Am7910 schematic



As we have seen, this scale of integration gives a convenient way of producing a single-mode modem. The same circuit layout is suitable for any of the possible configurations of mode, speed and standard. To change any of these requires only a different set of filter components and control input settings. A dual-mode modem is a reasonably straightforward switching problem, but thereafter things become rather more involved. At this point, the attractions of the simplification offered by the LSI approach begin to predominate over the rather high chip costs.

LARGE SCALE INTEGRATION

With the increasing popularity of modems, it was perhaps inevitable that a custom, all-singing, all-dancing modem chip would arrive on the scene before too long. Not surprisingly, it came from the home of the hacker, the USA. Even when introduced here in 1983 at around £55 in one-off quantities (yes, that was pounds each!), AMD's Am7910 World-Chip FSK Modem caused quite a stir. It requires only a quick look at the specification sheet to see why it was greeted with such enthusiasm.

Fig. 8 shows the schematic for a minimum configuration multi-mode stand-alone modem using the Am7910. The first thing which strikes you in this circuit is the lack of filters and external components; indeed, the lack of external circuitry in general. However, all that is missing is a power supply (±5 volts).

Having looked earlier at the circuitry normally necessary to produce a modem, even using i.c.s, this is clearly a significant advance from the designer's viewpoint. "How does it work?" seems the next obvious question, and to answer this we really need to look inside the 28-pin package; after all, there is very little else to look at in the circuit!

Starting with a few block diagrams of the i.c. soon gives a clue as to the true nature of this impressive device. Fig. 9 shows the transmitter section, Fig. 10 shows the receiver section, and

BOOK REVIEWS

INTERFACING THE BBC MICROCOMPUTER

Author Brian Bannister and Michael Whitehead
Price £7.50 limp
Size 230 x 150mm 153 pages
Publisher Macmillan
ISBN 0-333-37157-7

Got a Beeb? Interested in hardware and interfacing? If the answer is yes to both questions then this might be the book for you. It's a bit pricey at £7.50, but it's got lots of useful information about BBC hardware which is not covered in the standard manual.

This book is not intended for the beginner in either electronics or programming, but it does include plenty of background information which should prove useful to budding interfacers at any level. Also included are a selection of data sheets on some of the most common interfacing chips for the 6500 family.

Chapter One is a general introduction to hardware facilities offered by the BBC Computer, and the following chapters go on to deal with the subjects of: the user port, analogue signal handling and the 1Mhz bus, in great detail. The last chapter introduces a few applications using a variety of transducers and input/output methods, with a little bit of electronics thrown in. Appendices include: TTL, machine code, memory map and a summary of connections.

On the whole, I think it is a well organised and clearly illustrated guide to interfacing the BBC micro, and on second thoughts it's not that expensive at £7.50.

R.M.B.

DYNAMIC SEMICONDUCTOR RAM STRUCTURES

Author A. Cardon and L. J. L. Fransen
Price £60 Hardcover
Size 235 x 150mm. 488 pages
Publisher Pergamon Press
ISBN 0-08-030578-4

This survey of the evolution of dynamic random-access memory structures (DRAMs) must rank as the definitive text. The authors are examiners at the European Patent Office, The Hague, but they have not confined their review to those patents filed only in Europe—there is extensive analysis of Japanese and U.S. documents as well, and one from the Soviet Union.

The introduction is a wide-ranging but economical survey of the development of single-cell-technology DRAMs, from 1k memories to 256k and 1M chips. The authors expect 1M DRAMs to be in mass production before 1990, using deep UV, X-ray, or electron-beam exposure techniques: the minimum exposable linewidth of a photoresist image has now reached the limit at 1·5 microns.

The technology to produce 1M and larger DRAMs exists, but their production will obviously depend on demand. The market for memory chips is volatile: at the time of writing there is no longer a shortage of 64k chips, for example, but a glut. The experience of the last 20 years, however, seems to indicate that when a faster, more compact, higher-density memory circuit exists, it will find a market. And eventually the device becomes widely available.

The glossary is placed sensibly at the beginning of this monograph, and includes such exotic items as GIMICs, MESFETs, HEEs, and LOCOS. At the end, the topic is separately indexed by subject, company, inventor, and patent number.

The survey devotes the initial 43 pages of the main body of the text to the structure and mode of operation of the basic one-transistor MOSFET cell. This invention was first claimed by R. H. Dennard of I.B.M. in 1967, though it was to be a further ten years before mass-storage memory chips became widely available in the U.K. The authors trace the evolution of single-cell structures in chronological order, pointing out the limitations of each proposed improvement, as well as the advantages. The graphs and illustrations are as comprehensive as the text, though the diagrams are neither simple nor simplified.

The following two chapters, which comprise the bulk of this work, detail proposed improvements both to the standard one-transistor cell, and to other basic cells. In every case, the authors are meticulous in their discussion of the implications; they are not offering opinions, but presenting (and clarifying) a portfolio of ideas from the research laboratories of the world.

Soft-error prevention, an increasingly important consideration as chip density increases, is discussed at length, as is non-volatile backup for RAMs. Finally there is an excellent review of alternative technologies for dynamic cells, including bipolar circuits.

The claim that this book is "uniquely authoritative . . . compiled by specialists in the subject disciplines concerned" is fully justified, and it seems destined to become the standard reference for some time to come.

D.A.B.

SERVICING PERSONAL COMPUTERS

Author Michael Tooley
Price £17.95 limp
Size 235 x 165mm
Publisher Butterworth & Co.
ISBN 0-408-01502-0

The personal computer market continues to be one of the largest growth areas of this decade and there must be thousands of books available which relate in some way to this subject. Despite this, there seems to be little information available on computer servicing techniques and procedures, which generally means servicing is left to the manufacturers or appointed agents.

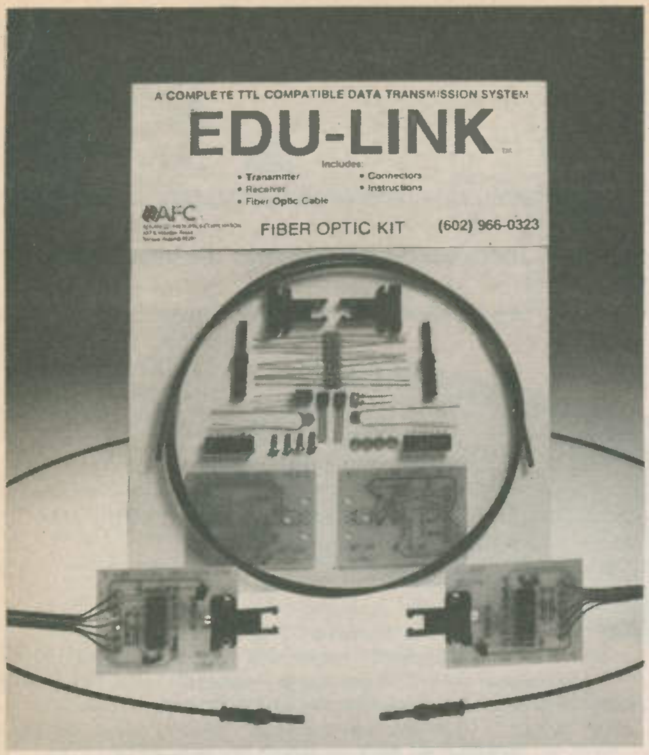
This book may go some way towards changing this situation by providing a fairly comprehensive guide to computer and peripheral servicing. It starts with a wealth of background information on computer hardware, numbering systems, software and firmware, which is essential to any engineer or technician not already familiar with these products and concepts. A second chapter gives a useful guide to organising and setting up a servicing workshop, as well as providing a detailed list of the necessary test equipment and their uses.

The nitty-gritty of servicing micro computers is a very difficult subject to deal with, but Michael Tooley has managed to cover this vast and complicated topic precisely and succinctly within one chapter. This chapter is split into several key areas including: fault diagnosis, testing the memory and CPU and a guide to miscellaneous faults. It is all backed up by a number of software diagnostic programs which make up a large part of micro servicing techniques.

The last two chapters go into detail about peripherals such as: cassette and disk drives, monitors and printers. Without this information, no book on micro servicing would be complete.

With all these subjects combined in one book, you have an indispensable reference manual for computer service engineers and technicians. However, for the hobbyist, it might be a little extravagant at £17.95, unless regularly engaged in computer servicing.

R.M.B.



WHY FIBRE OPTICS?

ERIC HOFFMAN

Including a Review of the EDU-LINK Kit

IN FIBRE-OPTIC cables, the signals are transmitted in the form of energy packets (photons) which have no electrical charge. Consequently, it is physically impossible for high electric fields (lightning, high-voltage, etc.) or large magnetic fields (heavy electrical machinery, transformers, cyclotrons, etc.) to affect the transmission. Although there can be a slight leakage of flux from an optical-fibre, shielding is easily done with an opaque jacket, so signal-bearing fibres cannot interfere with each other or with the most sensitive electric circuits, and the optically-transmitted information is, therefore, secure from external detection.

Jacketed fibre-optic cables can tolerate more mechanical abuse (crush, impact, flexing) than electrical cables of comparable size; moreover, fibre-optic cables have an enormous weight and size advantage for equivalent information capacity. Properly cabled optical-fibres can tolerate any kind of weather and can without ill-effect, be immersed in most fluids, or used in polluted air. The higher the carrier frequency in a communication system, the greater its potential signal bandwidth. Since fibre-optics work with carrier frequencies in the order of 10^{13} to 10^{14} Hz as compared with radio frequencies of 10^6 to 10^8 Hz, signal bandwidths are theoretically 10^6 times greater.

A single fibre is capable of replacing a very large bundle of individual copper wire. For example, a typical telephone cable may contain over 1000 pairs of copper wires and have a cross sectional diameter of 70 to 100mm. A single optical-fibre cable capable of handling the same amount of signal might be only 5mm in diameter. The actual fibre is a great deal smaller. The additional size is the jacket and strength element, and the weight reduction in this example should be obvious. Length for length, optical-fibre exhibits less attenuation than does twisted wire or coaxial cable. Also, the attenuation of optical-fibres unlike that of wire, is not signal frequency dependent.

In many wired systems, the potential hazard of short circuits between wires or from wires to ground, requires special precautionary designs. The dielectric nature of fibre-optics eliminates this requirement and the concern for hazardous sparks occasioning short circuits. Optical-fibre costs are continuing to decline while the cost of wire is increasing. In many applications today, the total system cost for a fibre-optic design is lower than for a comparable wired design. As time passes, more and more systems will be decidedly less expensive using optical-fibres.

EDU-LINK REVIEWED

The EDU-LINK kit is designed to give hands-on experience in the design and assembly of a fibre-optic transmitter and receiver. The package contains two pre-designed p.c.b.s and all the necessary components. The l.e.d. is a Siemens 665nm red emitter with a 5ns rise/fall time whilst the detector is a newly designed photo PIN diode with a 0·2μA/μW responsivity and 1ns rise time.

Mode	OSE	TXD	Operation state
1	X	0	L.e.d. off
2	0	1	L.e.d. on
3	1	1	Built-in oscillator enabled
3	1	Open	Built-in oscillator enabled
3	Open	1	Built-in oscillator enabled
4	0	Data in	L.e.d. follows TXD input
Key: 0 & 1 = TTL logic levels; X = Doesn't care; TXD = Transmit data			

Table 1. Transmitter truth table

TRANSMITTER

The transmitter contains a built-in oscillator so that link operation can be observed without the need for an external signal source. EDU-LINK is also capable of being driven from an external TTL level signal source, should one be available. The transmitter has four primary modes of operation as described in the transmitter truth table (Table 1.). Modes one, two and three are used in the exercise described later. Mode four is the data transmission mode which responds to external signals applied to the TXD input.

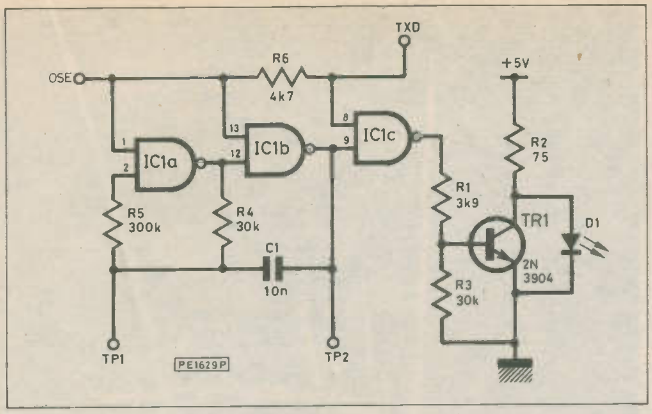


Fig. 1. The transmitter circuit diagram

OSCILLATOR OPERATION

Referring to Fig. 1, the transmitter schematic IC1a and IC1b make up a two-gate relaxation oscillator. To understand its operation, one needs to understand the relationship between the various time constants in the circuit. The shortest time constant is the propagation delay time of the gates themselves. This is the time it takes the gates outputs to respond to changes to their inputs and is typically about 10ns. The next longest time constant is about 2 microseconds and is associated with input (pin 2) of IC1a. It is determined by the value of R2 and the input capacitance (5pF) of the gate. The longest time constant is that of the network of R4 and C1 which is 0·3ms.

As you will discover, the relative size of these time constants is necessary for proper operation of the oscillator. For example, input pin 2 should track the voltage at TP1 (Test Point) with a small time delay (Fig. 2). This delay is provided by R5 and the input capacitance of gate IC1a.

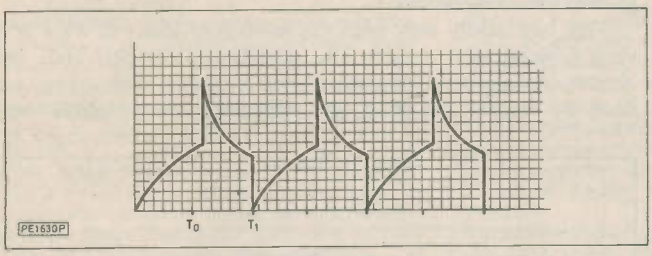


Fig. 2. TP1 waveform

When OSE is low, the output of both gates are high, preventing oscillation. In this state the l.e.d., D1, will respond to TTL level signals applied to TXD input. Assume now that OSE is switched to a high state at time=t(0). Due to the input capacitance associated with input of pin 2 of IC1a instantaneous voltage changes cannot occur on input pin 2. With both inputs now high, the output of IC1a goes low. Note that before the change in the state of OSE, one of the inputs of IC1b was low the other high. Such is the case now also, except reversed. Therefore the output of IC1b remains high. With IC1a output low and IC1b output high, the voltage developed across R1, and appearing at TP1 is high at t(0+), and holds the output of IC1a output low, forcing completion of the charging half cycle of C1. The charging cycle is complete when the voltage at TP1 decays below the threshold value representative of a logic 1 at time t1. At t1, the oscillator changes states, ie IC1b output goes low and the discharge of C1 begins.

OUTPUT GATE AND LED DRIVER

When the transmitter is in mode four the l.e.d. is turned on and off in response to TXD logic levels 1 and 0 respectively. Nand gate, IC1c acts as an inverter, which cancels the inverting action of driver transistor TR1. When TXD is driven high the output of IC1 goes low, turning of TR1 and allowing the l.e.d. to be forward biased through R2.

When TXD is driven to a logic low the output of IC1c goes high, turning on and saturating TR1, consequently the l.e.d. is switched off. The advantage of this type of transmitter design is that the power supply drain current remains constant whether the l.e.d. is on or off, reducing supply transient generation. Its disadvantage is its constant power drain.

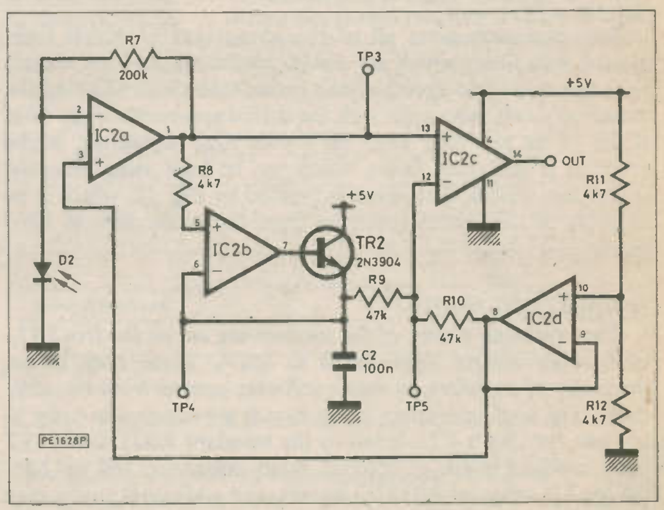
RECEIVER

Referring to the receiver schematic in Fig. 3. IC2a, PIN diode, D2 and R7 form a wide bandwidth current to voltage converter commonly referred to as a transimpedance amplifier (XZA). Its function is to convert the output current of the PIN detector to a voltage for further processing and level detection. The PIN diode can be modelled as a high quality (high resistance and low capacitance) current source, and responds linearly to optical flux incident upon it.

The output voltage of the ZXA is also a linear function of the received optical power. Receiver band width and sensitivity is most effectively determined in the first stage of amplification, the ZXA, and the effective input time constant determined using the relationship: $B=A_0/2R_fC_i$ where A_0 is open loop gain, R_f is the feedback resistor (R1), and C_i is the input capacitance. The smaller the effective input capacitance for a given bandwidth, the larger R can be, resulting in greater XZA gain (sensitivity) and higher signal-to-noise ratios for a given input flux level.

IC2b of the receiver is a peak signal detector. Its purpose is to hold a sample of the peak signal for reference purposes during extended periods of time between signal peaks. This stored reference signal allows one to sample the incoming signal at its point of minimum distortion, thereby reducing pulse width distortion. In particular, note that the voltage divider of R9 and R10 divides the detected peak signal by two relative to a common reference voltage for presentation to the input of output comparator IC2c. The reference voltage is generated by R11 and R12 which is buffered by IC1d to provide a low impedance source. As a result, incoming optical flux generates a signal current in D2 which is amplified by the XZA and used to drive output comparator IC1c.

Fig. 3. The receiver circuit diagram



CONSTRUCTION AND USAGE

From the photo it can be seen that very few components are needed to construct this interesting kit. The p.c.b.s are of a professional quality and the full kit can be assembled in a reasonably short time. The l.e.d. and the PIN diode fit neatly in their special connectors and only then should they be soldered to the board and finally secured with the screws supplied. Care must be taken when the actual fibre-optic cable is to be terminated as this is the key to optimum optical transmission. A *sharp* knife should be used to trim the edge to ensure a smooth surface otherwise some loss of transmission is inevitable.

The manual supplied with the kit gives full detailed descriptions accompanied by easy to follow diagrams of how to terminate the fibre-optic cable to the connectors.

Once the kit is completed and working it can be used first with the supplied exercises to give the constructor some hands-on experience of how a fibre-optic link operates. These will include some transmit/receive power calculations, pulse width distortion measurements, and finally how light through the fibre-optic cable can be affected by wrong use of the hardware.

Now that we understand how fibre-optic transmission works, the kit can be used to replace any means of ordinary wire transmission, whether connecting your computer to a remote printer or observing your software coming from your tape recorder. The use of the link is, of course, unlimited and as we can see in the fast growing technical industry the hard wiring is being replaced by fibre-optic alternatives in greater numbers every day.

CONCLUSION

The EDU-LINK is a well designed kit, easy to construct and by using the inclusive exercise sheet, will provide an in-depth understanding of fibre-optic data transmission. ★

Typical example of an industrial multi-strand fibre-optic cable

The EDU-LINK kit is available for £22.57 (inc VAT and p&p) from **G. A. Stanley Palmer Ltd., Elmbridge Works, Island Farm Avenue, West Molesey Trading Estate, Surrey, KT8 0UR (01-979 7254).**

modems

CONTINUED FROM PAGE 36

and 1·3k of RAM allow it to perform digital filtering, modulation and demodulation; even the carrier used for the transmitter is digitally synthesised in this section. Other functions included in the chip are auto-answer and analogue/digital loopback testing.

This approach gives all of the advantages of digital techniques, with filters which are stable, predictable and not subject to temperature and ageing effects (other than those affecting the master crystal). Also gone with the digital approach, to the relief of all of us not over keen on 6-pole filter equations, is the problem of designing filters which can be built using 'sensible' component values. The result is typified by Fig. 12, which is an example of the output spectrum from the transmitter at 1200 baud.

OPERATING MODE

The operating modes of the modem are set by the five TTL-compatible control lines, MC0 to MC4. These may be set manually by switches, or under software control from the computer. The level converters in the circuit are required in order to convert the chip's TTL levels to the standard RS232C/CCITT V.24 interface levels. In practice, many computers will not handle the full range of RS232C signals, and additional gating may be necessary. The phone line interface, which completes the picture, provides any additional filtering and protection necessary to meet local regulations.

This has clearly only been the briefest of looks at what is a very sophisticated device. The possibilities for this chip are almost endless, especially when it is combined with other i.c.s from the World-Chip series, and other computer peripheral support chips. Although the Am7910 has been discussed, it is but one example of the latest in LSI modem technology.

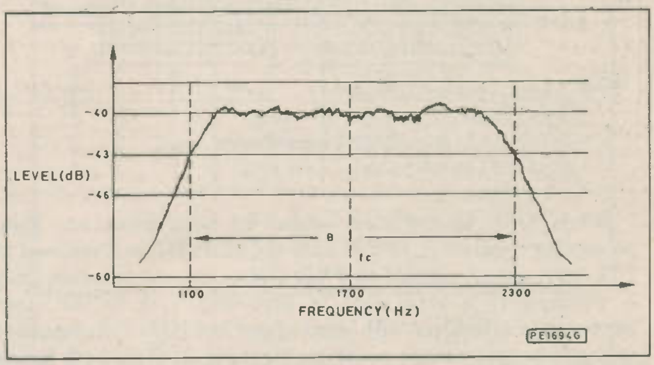


Fig. 12. V.23 spectrum at 1200 Baud

NEXT MONTH

This completes our brief look at modem design techniques. Next month we conclude this short series with a buyer's guide and a brief look at modem applications.

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DELAY SELECTION

In many digital delay units that are available the selection of the delay factor is controlled by varying the rate at which data is sampled and retrieved. In those cases, the write and read addresses always have a fixed relationship, and the fine tuning of the delay selection is controlled by varying the master clock oscillator rate, and coarse selection made by switching between either more or less memory blocks.

Up to a point this is a good way of doing it and with analogue delay units it is probably the only way available. It is also partly available here but another, and probably a better way is also used. It takes full advantage of the random access nature of the memory address and data relationships. Normally the sampling clock is maintained at a constant frequency, and in theory a delay range of zero through to 65536 separate steps is possible. Such resolution of delay factors is not necessary in practice, and here, it is limited to a choice of 255 discrete delay steps. In this way the wow normally associated with varying clocking frequencies is avoided.

The principle is very simple. Say for example you put data into address 1. Step forward to address 2 and put in more data, you can now read back the data already at address 1. If it has taken 1 ms to put data into address 1 before you read it back, that is the delay time. Having read back address 1, both the Write and Read addresses are stepped forward one place. You write into 3 and read back 2. Still the same delay of 1ms applies. Taking it further, suppose the memory is full of data, and you read back not the previous location but the one 65535 steps earlier, the delay then becomes 65535 x 1ms, over 65 seconds.

Of course if you read back the 65536th step earlier, that is the same as reading back the data just this instant fed in, so no delay occurs, apart from that required in shifting from write to read mode. The same clock signal applies to both the read and write addresses, and only the displacement factor varies. When the clock counter reaches the final address number, it automatically resets to the first address so that a constant loop is maintained.

S6	VR20	S5	VR14	VR15	MASTER CLOCK	SAMPLE RATE	DELAY	NOMINAL BANDWITH	DISPLACEMENT STEP
↑	↖	X	↖	↖	1·34MHz	67kHz	3·83ms	22·3kHz	3·83ms
↓					400kHz	20kHz	12·88ms	6·66kHz	12·88ms
↑	↖	X	↗	↖	1·34MHz	67kHz	100ms	22·3kHz	3·83ms
↓					400kHz	20kHz	335ms	6·66kHz	12·88ms
↑	↖	X	X	↗	1·34MHz	67kHz	1s	22·3kHz	3·83ms
↓					400kHz	20kHz	3·28s	6·66kHz	12·88ms
↑	↗	↑	↖	↖	142kHz	7100Hz	36ms	2·36kHz	36ms
↓					37kHz	1850Hz	138ms	616Hz	138ms
↑	↗	↑	↗	↖	142kHz	7100Hz	937ms	2·36kHz	36ms
↓					37kHz	1850Hz	3·56s	616Hz	138ms
↑	↗	↑	X	↗	142kHz	7100Hz	9·37s	2·36kHz	36ms
↓					37kHz	1850Hz	35·28s	616Hz	138ms
↑	↗	↓	↖	↖	59·4kHz	2970Hz	86ms	990Hz	86ms
↓					15kHz	750Hz	341ms	250Hz	341ms
↑	↗	↓	↗	↖	59·4kHz	2970Hz	2·24s	990Hz	86ms
↓					15kHz	750Hz	8·87s	250Hz	341ms
↑	↗	↓	X	↗	59·4kHz	2970Hz	22·4s	990Hz	86ms
↓					15kHz	750Hz	87s	250Hz	341ms

X = Don't Care

Table 2. Delay control settings

MASTER CLOCK OSCILLATOR

In Fig. 7, IC26 is a voltage controlled oscillator, where the frequency is determined by the timing capacitor, the control voltage at pin 9, the current at pin 11, and the line voltage. The latter is derived directly from the nominal 8V rail, for although most of the logic requires a 5V line, IC26 has a frequency range too low if only 5V is used to supply it.

With S4 open, pin 9 is held at 5V. VR20 controls the fine

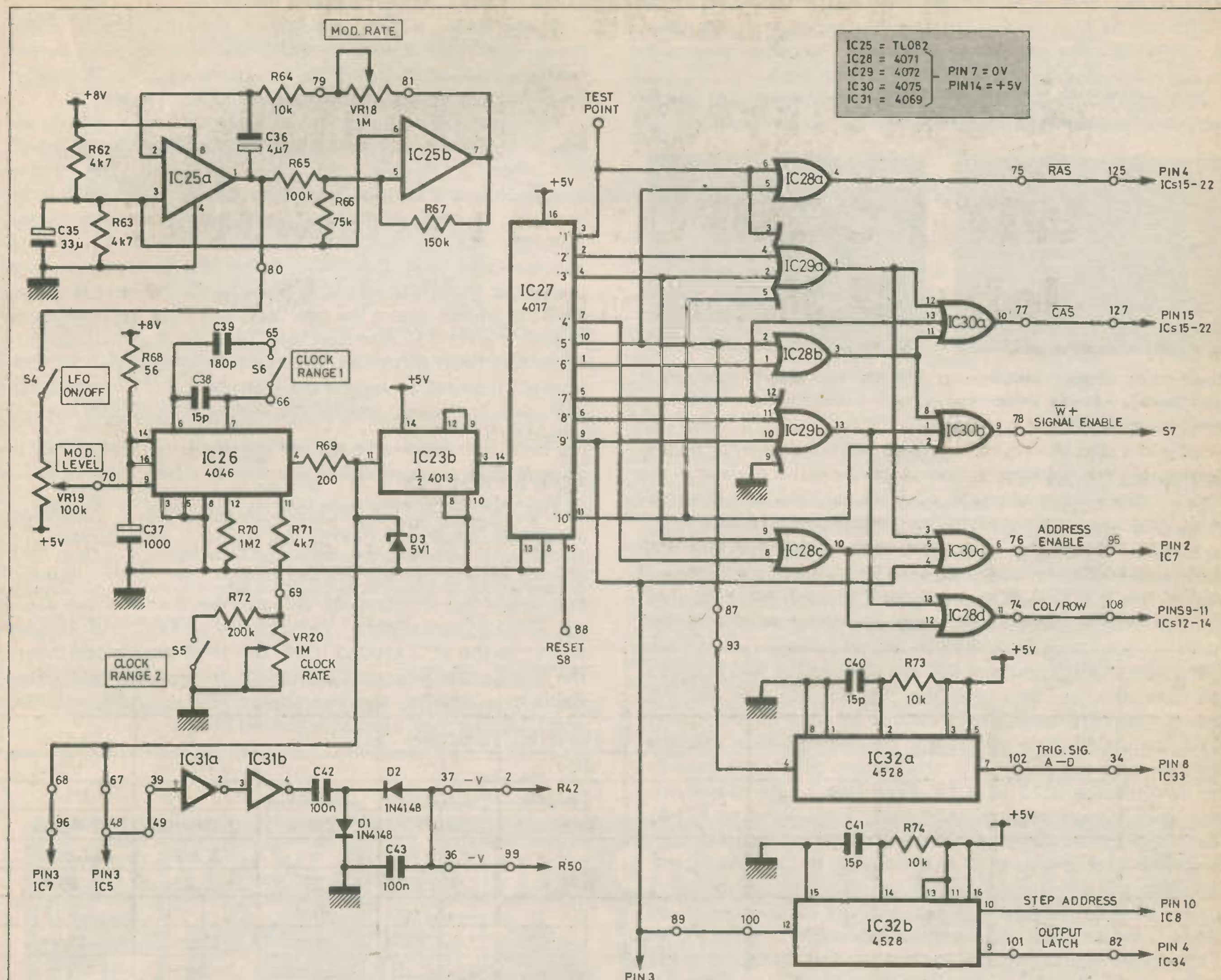

Fig. 7. Timing components and trigger interfaces

selection of oscillation, and at minimum resistance with only C38 in circuit, a frequency of around 1MHz is generated. Switch in C39 and the minimum frequency reduces to around 400kHz. With S5 open and VR20 at maximum resistance the lowest clock rates then become about 60kHz and 15kHz respectively. With S5 closed, the resistance range of VR20 is reduced by R72. For normal musical use S5 remains closed and S6 open, so keeping the sampling rate sufficiently high to maintain a respectable signal bandwidth. R69 and D3 restrict the output voltage to 5V maximum, as required by the other controlled circuits.

Modulation of the clock frequency for phasing, flanging, vibrato, chorus etc, is effected by the standard triangle wave oscillator around IC25a and IC25b. The modulation rate is determined by C36 and the resistance of the panel control VR18. With S4 closed the modulation depth is controlled by VR19. Photos 11 and 12 show some effects of modulating the oscillator.

The output of IC26 is the controlling clock for the two A to D converters. These also need a negative line voltage of around −3V for correct operation. This is derived by buffering the high frequency by IC31a and IC31b, and using a diode pump around C42, C43, D1 and D2. In order to enable the A to D converters to perform their conversions within a given period of the timing sequence, they are driven by a higher frequency than the rest of the control network. Remember from earlier these need eight clock cycles to perform their task.

IC23b divides the original high frequency by two, which is a sufficiently reduced rate to maintain the remaining synchronisation factors. By matrixing the outputs of the decade counter, IC27, through the various OR gates IC28 to IC30, the required polarity and duration of the control pulses is easily achieved. Take $\overline{CAS}$ for example, the line needs to be high for three clock cycles, down for one, up for three, down for two and then up again on the 10th.

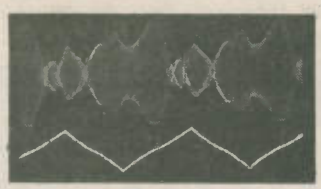

Photo 11. 660Hz

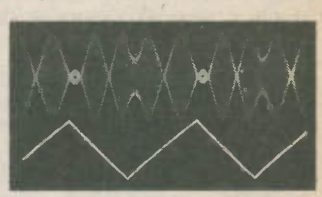

Photo 12. 1·2kHz

Upper trace—final audio output. Lower trace—modulated waveform

The output of IC29a will be high on the 1st, 2nd, 3rd and 10th cycles. This is fed to the gate IC30a. The output of IC28b will be high on the 5th and 6th cycles, and also goes to IC30a, as does the 7th cycle so that the output here will be high on cycles, 1, 2, 3, 5, 6, 7, 10 as required.

Photos 13 and 14 show practical oscillograms of some aspects of the timing sequence.

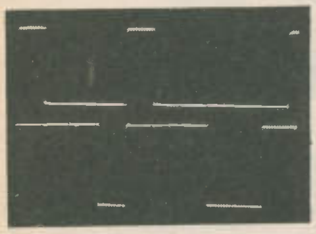

Photo 13. Upper trace—test point. Lower trace—clocking oscillator

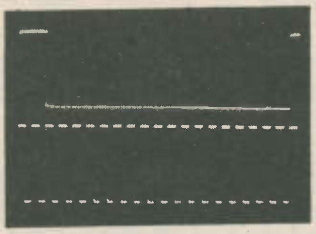

Photo 14. Upper trace—RAS. Lower trace—CAS

ADDRESS COUNTER

Every 9th output of IC27 steps the address counter IC8 on by one place (Fig. 3). This is a 12-stage ripple counter, each stage dividing by two. The 12th output triggers the next counter IC9 on every 4096th pulse from the address trigger. This is a 7-stage ripple counter, though only four outputs are used. Between them these two counters go through their full count once every 65536 trigger pulses.

The first eight outputs of IC8 are used as the row address selectors, the last four and the first four of IC9 are the Column address selectors. Assume for the moment that IC10 and IC11 just allow the column address straight through, then the set of row and column addresses pass to the multiplexers IC12 to IC14. Each has 3 sets of twin inputs, and 3 equivalent outputs (only 2 are used on IC14). These i.c.s act as gates and if their controlling signal is high then each gate will open to only one side of the twin inputs, and allow the data to pass to the output. If the control signal is low, then the first side closes, and the second opens, so allowing the other lot of data to pass through.

By constantly taking the control up and down, so these gates repeatedly switch between the row and column addresses. IC28d is the OR gate delivering these control voltages. As things stand the Write address is always the same as the Read address throughout all 65536 steps. We need to displace the Read address in relation to the Write address in order to achieve the desired time delay.

ADDRESS DISPLACEMENT

All we need is to add another number to the Write address in order to get the Read address. As stated earlier, it would be possible to have an address displacement available for each of 65536 delay factors, but this resolution is far too close to be of practical use. 255 separate delay factors controlled from the panel are quite enough.

IC7 is another A to D converter, and works in the same way as IC5, needing a clock, a convert trigger, and an output enable. These last two occur at different timing points to IC5, and the other difference is that the analogue voltage is a d.c. level set by VR14 and VR15. VR16 and VR17 are used to restrict the voltage seen by IC7 to within only the required limits of the 1 to 255 output range. IC7 samples the voltage programmed by VR15 and of course produces its binary equivalent. In practise on the prototype it was found that sampling this voltage too frequently was apt to produce a possibility of a high speed variation of the output number if the pot was set so that the voltage was really just between two numbers. Consequently the sampling rate is restricted to once every 8192 cycles (2^{13}).

At this point IC23a is triggered, then on receipt of the pulse from the timing network pin 9 IC27 the output changes state and triggers the monostable IC24a. Thereafter it will not trigger again until the next 8192nd pulse.

Although this sampling takes place so comparatively infrequently, the data of each sampling is held by IC7 which can allow it through any time instructed. The timing sequence tells it to do so each time the memory needs to be read for the delayed data. At this point the data passes through to the two adders IC10 and IC11. These automatically add this number to the column number presented from IC8 and IC9. If the actual answer is above 255 the adders ignore the overflow, and treat the number as though it were 255 numbers less. Thus the displacement address has been produced. R52 to R59 ensure that the adders IC10 and IC11 regard the input from IC7 as zero when that chip is closed, and so the write address has nothing added to it.

POWER SUPPLY

The power supply required is basically a 5V single stabilised line and is shown in Fig. 8. In the prototype the transformer used has two identical 6V windings each at 3VA and coupled in parallel to produce 6V with a 6VA capability. Full wave rectification of 6V a.c. produces about 8.5V d.c. This reduces slightly to roughly 8V on load, and supplies power to the LFO around IC25, the HFO around IC26, and the compander around IC2 and IC3. In the latter two cases ripple is rejected by the insertion of R68 and C37, and R80 and C14. The max. current is around 65mA.

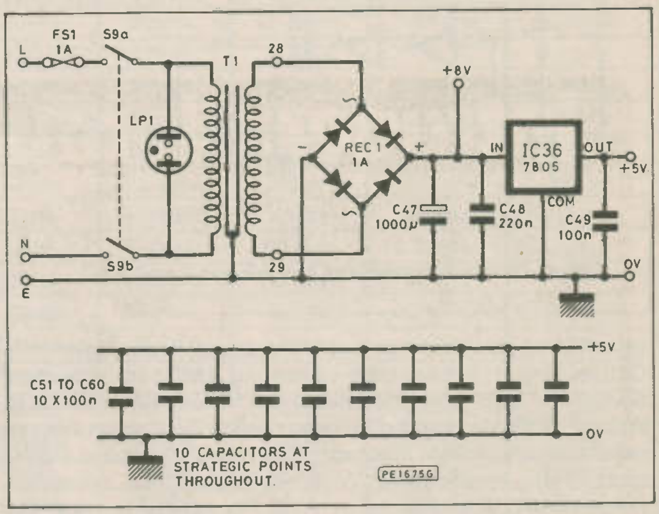

Fig. 8. Circuit diagram of the p.s.u

IC36 takes the 8V and produces a stabilised output of 5V. Despite the good regulation of this type of IC, it still takes time to correct for transient current changes, and so some HF spikes are still expected on the power lines. Various capacitors such as C51 to C60 are placed at strategic points throughout the printed circuit boards to minimise them. R25, R26 and C21 supply a split level reference to IC1 and IC4. R17, R18 and C13 do likewise for IC2 and IC3.

That then concludes the main circuit. We will leave the details of interfacing with a computer, and the associated circuitry until after the main unit assembly has been described. So for the moment ignore IC24b, IC35a and b, IC31c, and assume that IC33 and IC34 allow the control signals to pass straight through to their ultimate destination.

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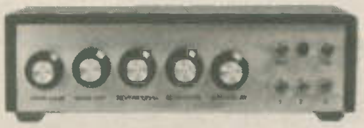

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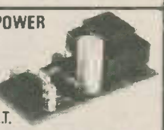

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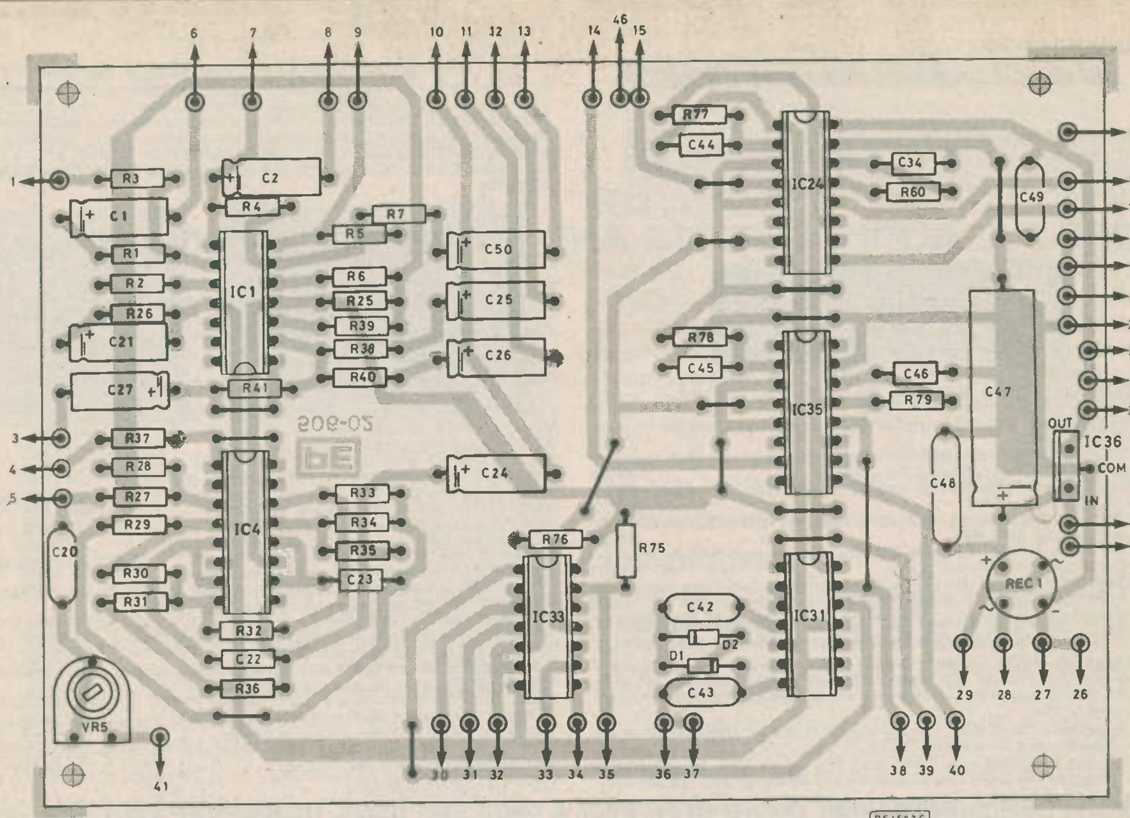


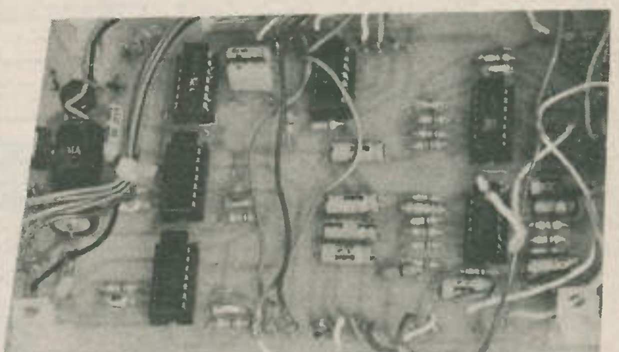
Fig. 9. Pre-amp, filter and external triggers p.c.b. layout

CONSTRUCTION

It is well worth while assembling and testing methodically and in easy stages. Assemble each board in the usual order of resistors, diodes, small capacitors, i.c. sockets, presets and then any larger components. Omit C31 unless the computer only version is being built (see later). Save all the long cut off wires as they can be used to make most of the short wire links on the p.c.b.s.

For the long matrixing topside wires on the memory board strip the covering off about 12 to 18 inches of ordinary stranded wire. Take one of the strands, insert one end through the top of the p.c.b. into the first hole in the series to be connected, and solder it on the other side. Feed the other end through the top of the 2nd hole, and pull fairly tight, then push the same end back through the same hole and pull until a short loop remains under the PCB. Solder the loop but don't cut it off yet. Repeat the process for each hole along the series. Now again go along each loop pulling it while the iron is applied, ensuring that the wire is taut enough on the top side of the board to prevent adjacent wires from touching, then the loops can be cut off and the next series wired likewise. It doesn't take long and is a simple low cost way of getting a double sided board for the price of a single.

In industrial circles a board using chips of this nature would probably be designed so that the matrixing tracks actually pass between the individual i.c. legs. This is superb if you then have industrial soldering equipment, such as a flow soldering bath. For most enthusiasts though the accurate soldering of such a board is probably beyond the capabilities of all but the most experienced. On the other boards where the resistor cut off leads may not be long enough, a similar linking method can also be used. As there are quite a few interconnecting wires, use 1mm terminal pins, to which the wire can be soldered on the top side. Now drill out the cabinet, apply control legends and mount all pots, switches and sockets, but at this stage do not attempt any interwiring between boards or controls and also leave out all i.c.s except for the regulator IC36. This should be mounted horizontally out from the p.c.b. to avoid touching the board to be stacked above it. Note that most i.c.s are MOS and so always discharge static from yourself by touching an item of earthed equipment before handling them. (The rest of the p.c.b. designs and wiring diagram will be shown next month).



NEXT MONTH: The remaining p.c.b. designs and the wiring diagram. Also complete testing procedures and setting up.

THE LEADING EDGE

WRONG NUMBER

Recently I discovered something so extraordinary about cellular radio, that I have to pass it on for the benefit of anyone who plans to use the system, or who plans to call a cell radio subscriber.

In America cell radio subscribers are charged computer time both for calls which they make from a mobile phone and for calls which they receive. As you can imagine this is highly unpopular, especially when someone with a mobile is pestered by junk calls, for instance trying to sell them life insurance which they don't want.

In Britain a decision was taken early on that subscribers would not be charged for incoming calls. They would pay only for calls keyed out from the mobile. The price varies up to 25p a minute depending on the time of day.

Originally (in a British Telecom price list issued in June 1984) the Cellnet service (run by British Telecom and Securicor) made no mention of how much would be charged per part minute. The rival service Vodafone, from Racal, then jumped in and promised to charge only in fractions of a minute. So Cellnet then switched to charging per half minute. Obviously this makes a lot of difference because on a minute charge basis you would pay for 2 minutes if you spoke for 61 seconds.

What no-one has made really clear is that this is a flat rate which applies across the whole of Britain. So you pay 25p a minute to call from a mobile to a house down the street, which is exhorbitant, and you pay 25p a minute to call from a mobile in London to a house in Scotland, which is cheap. At the time of writing, it costs 10p for a 3 minute local call, house to house.

But this is not the extraordinary discovery which I recently made. Both services, Cellnet and Racal, have assured me that they make no charge for incoming calls. BT's June price list says in black and white "Cellnet subscribers are not charged for incoming calls".

It's true. But what the services haven't publicized, and for very good reason I am sure, is that anyone who phones a cell radio mobile from a domestic or business phone, pays at the Irish Republic rate for that call! This means that you pay 43p a minute, instead of the local rate of around 3·3p a minute, to call someone on cell radio.

The awful truth of this will not emerge until the service has been running for at least six months, because people will not realise that their bills are high until they have received several quarterly charges. Perhaps the worst part is that mobile users may well make a one minute call at 25p, and ask the recipient to phone back, thinking it will be cheaper. It will be, but only for the mobile user. For the poor unfortunate caller, using a domestic or business telephone, the rate will be *13 times* the rate for a normal local call.

ORBITING COSTS

Why do direct broadcasting satellites (DBS) cost so much?

The British Government wants *Unisat*, a consortium of British Telecom, British Aerospace and GEC Marconi, to build the direct broadcasting satellite for Britain. For three years rumours have been flying around about the high prices Unisat want to charge and how it would be cheaper for Britain to shop abroad.

For three years Unisat have refused to talk about pricing. Now, under pressure from the consortium members, Unisat has talked to the press. And the talk is not particularly reassuring.

Originally the British DBS service was to be two channels, of 240W transmission power each. This high power should let people on the ground with small dish aerials get clear pictures.

The price being quoted to the BBC, three years ago, was £24·4 million per year over seven years. After the BBC realised it could not afford to run a DBS service, the ITV companies and several independent firms like Thorn-EMI and Granada joined in to make the so-called Group of 21. They planned a three channel service, still with 240W transmitters. The price was put at a staggering £80m a year.

At first Unisat refused to comment. Now Unisat says the cost of providing a three channel service could be anything between £40 million and £80 million a year, spread over 10 years. The highest price is for three satellites, two in orbit and one on the ground. That gives 95 per cent probability of service without interruption.

But how is probability measured? Not very accurately! If there are one hundred satellites in orbit for ten years, then 95 per cent probability means 95 of them will still be up there and transmitting after ten years.

This is a bizarre concept, because there is only one DBS satellite in orbit, and that is the Japanese craft which has three transmitters of only 100W each and two of them failed almost immediately. No-one has ever even tried to fly a craft with 240W transmitters. So how on earth can anyone even guess at how a hundred craft will perform over ten years?

The biggest question mark is over what happens when the satellites pass through eclipses. Inevitably any solar-powered craft in orbit will have to shut down its transmissions when the sun's rays are eclipsed. The orbital slots (31 deg. West for Britain) are chosen so that these eclipses will happen in the middle of the night, when no-one is watching television. But they happen 88 times a year, in two clusters of 44.

The eclipses vary in duration from between 2 minutes and 90 minutes. At these times, the travelling-wave tube (TWT) amplifiers which generate the microwave power, go from hot to cold to hot again. Just like an electric light bulb being switched on and off, that's when they are most likely to fail. It is what happened with the Japanese satellite. The tubes that failed in the Japanese satellite were made by Thomson-CSF of France.

Although Unisat has now talked to the press about costing, it has still not demonstrated any of the technology. This is because there aren't any 240W travelling wave tubes in Britain. For one demonstration, which was not opened to the press, Marconi borrowed a 240W TWT from the German company, Telefunken-ANT. This went back to Germany immediately afterwards.

If and when Marconi decides it is worth demonstrating to the press, I have a lot of questions to ask.

PAPER CHASE

If you run a computer with a printer you have a choice of either feeding in separate sheets one at a time, perhaps through a stack feed, or using a tractor feed and continuous paper from a fan-folded box. Here are a couple of tips that can save you time, money and frustration.

When buying continuous tractor feed paper with rows of feed holes down each edge, choose "microperf" type. On this paper the edge strips are secured to the main area of the paper by a continuous line of tiny perforations—rather like sheets of hi-tech toilet paper on a roll. In this way, after printing out text or graphics, you can strip off the paper edges.

The individual sheets are also joined together by microperfs so that these too are easily separated. Because the perfs are micro you end up with ordinary-looking individual sheets. But there's a snag.

Computer printers usually work on a basic format of six lines to the inch. Exotic printers can be set up by computer wizards to move the paper in smaller fractions. But movement is still on a fraction of an inch basis.

The metric standard for A4 size paper is a page length of 297mm. This does not convert accurately into fractions of an inch. It works out at 11.693 inches. And one-sixteenth will not divide neatly into 11.693.

Some paper firms sell pseudo A4 paper, which is $11\frac{2}{3}$ inches long. This matches an inch printer. But other firms sell genuine A4 metric paper for continuous tractor feed. If you use this paper on an inch printer the text will gradually get out of step with the page breaks so that the headers and footers gradually creep up or down the page and eventually onto and over the perforations.

The answer is to use 11in paper or 12in paper or pseudo A4 at $11\frac{2}{3}$. Don't be bullied into buying genuine metric A4 unless you are sure your printer can cope.

BARRY FOX

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Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not in the text.

INTELLIGENT LEVEL CROSSING WARNING LIGHTS CONTROLLER

MODEL railway enthusiasts have lots of tiny road signs available with built-in l.e.d.s. This circuit provides automatic control of level crossing lights, without affecting the railway circuitry. This is achieved with the use of two infra-red beams shone across the track.

The circuit is bi-directional, in as much that the direction of the train is irrelevant, because the circuit can 'remember' which detector was interrupted first. It will then concentrate on the second detector to establish when the train is clear of the roadway. Fig. 1 shows the general layout.

As the circuit consists of two identical parts, only one part is described. If the train breaks either beam, say from D1, then the output from TR1 will go low. VR3 and C1 allow a small delay before allowing IC7a to go low. This prevents the circuit from being affected by breaks in the train between carriages.

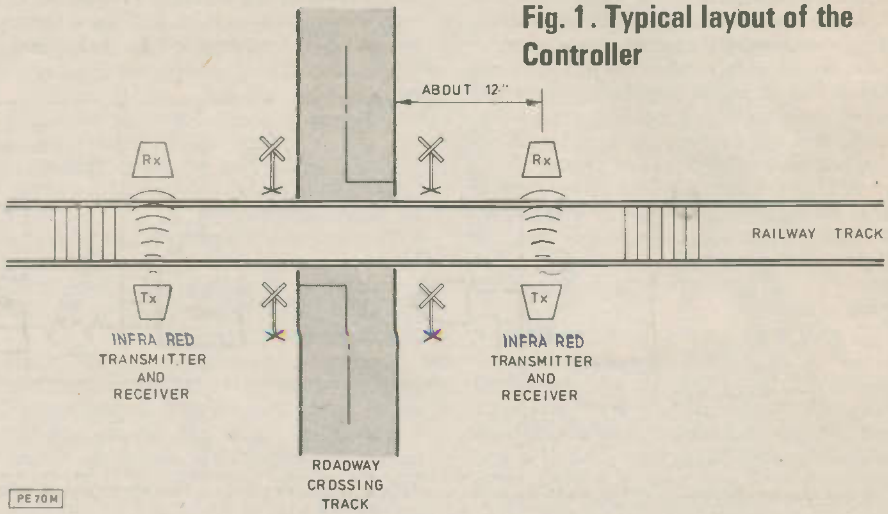


Fig. 1. Typical layout of the Controller

At this point the output of IC7b will set the latch IC1a; this in turn feeds an Ex-Or gate which sets the final latch. The output of this latch should be connected to a simple flasher unit.

When the train has cleared the first detector, the beam is re-established. The train will then break the second beam and the same action will occur, except that the Ex-Or gate will give a low output. This will reset the input to the final latch, IC3.

Re-establishment of the second beam will cause the output of IC2 to go high which will send a reset pulse to IC1a, IC1b and IC3. This will cause the final output to go low and the flasher circuit will be turned off. The infra-red beam works well on any track layouts, up to two N-Gauge tracks. If a wider gap is used, then an amplifier circuit will be required to pulse the transmitter.

R. S. Bacon,
Luton,
Beds.

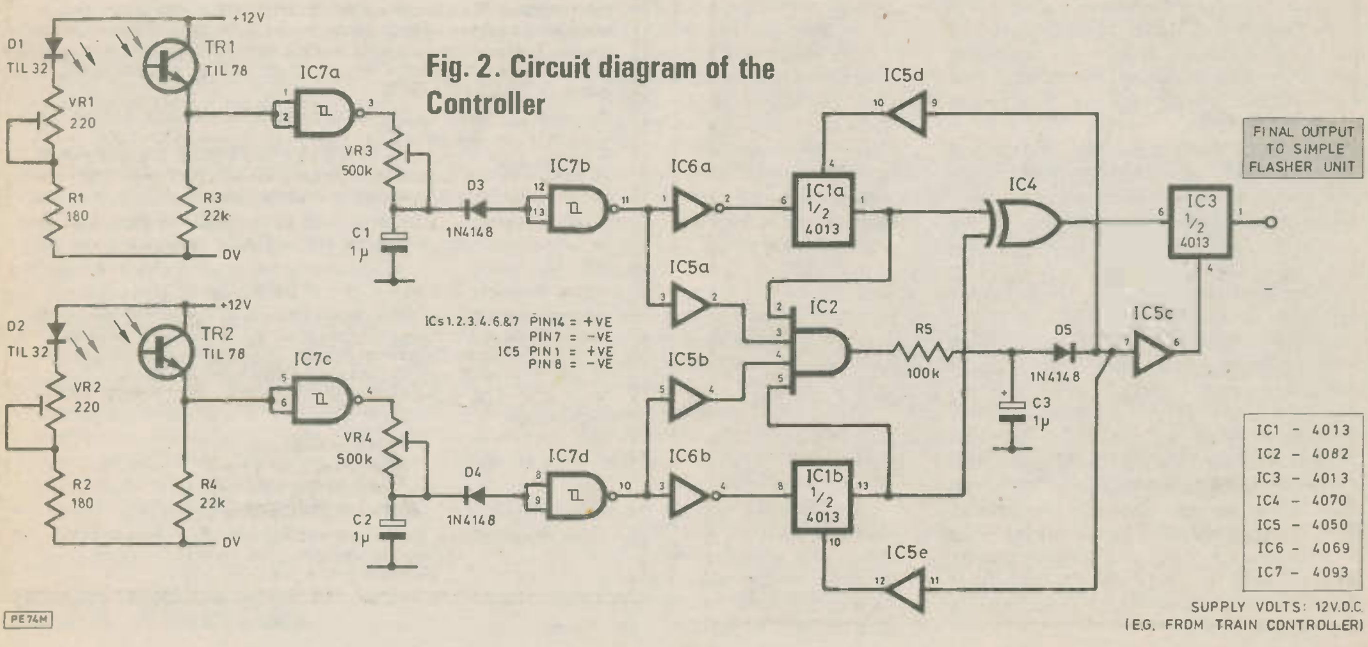


Fig. 2. Circuit diagram of the Controller

7-SEGMENT LOGIC PROBE

UNLIKE most logic probes, this design will indicate the state of the logic under test with a letter and decimal point on a seven-segment display. The decimal point is used to indicate an open circuit or a pulsing condition, and 'high' is indicated by 'H' and 'low', 'L'. From a 5 to 18V supply with a probe input resistance of about 15K it will draw only 20mA.

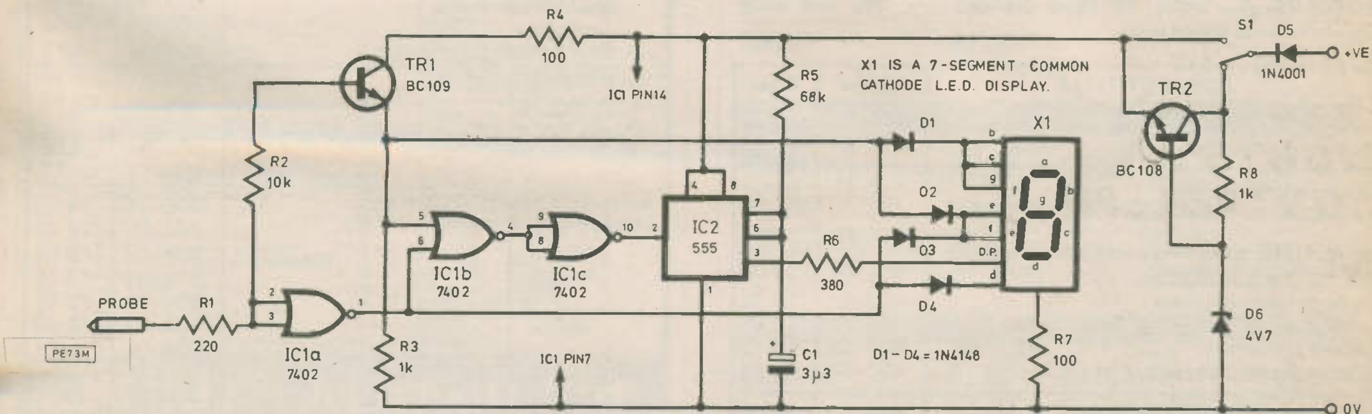
When pins 5 and 6 of IC1 are low, IC2 is triggered if the probe is in an open circuit condition. This is indicated by the decimal point being permanently lit.

If the probe is taken 'high', then IC1a does not change, but TR1 is switched on via R1 and R2. This causes the display to indicate a 'high' condition by lighting the appropriate segments. At the same time, pin 2 of IC2 is taken high and the decimal point is switched off after a short delay caused by the monostable.

When the probe is taken low, TR1 is switched off and the appropriate segments are lit to indicate this condition. If a pulse train is present there is a short time when the probe is effectively in an open circuit condition causing the monostable to be triggered. The delay is about $\frac{1}{4}$ second, causing a short pulse to be stretched. This will cause the pulse condition to be indicated by the decimal point, together with either the 'H' or 'L'.

D5 prevents damage due to supply reversal and TR2 together with R8 and D6 provide a 5V supply from any input voltage above 6V, enabling the probe to be used with CMOS circuits. If the supply is only 5V the switch should bypass TR2.

M. Pocook,
Taunton,
Somerset.



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Quality

To help us to process articles which are offered for publication, all subject matter should conform to the usual practices of this journal. Special attention should be paid to circuit symbols and abbreviations and all diagrams should be on separate sheets, not in the text. Also manuscripts should be typed with wide margins and double line spacing or neatly hand written in the same fashion.

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CELESTION	DISCO/Group	10in.	50	8/16	£21	£2
SEAS	WOOFER	10in	50	8	£19.50	£2
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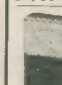

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8.	(11)	Syntom Drum Synth.	LW86T	£12.95	Best E&MM
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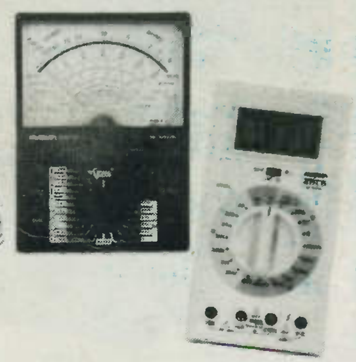

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