ISSN 0142-7229

electronics today

INTERNATIONAL AUGUST 1982 75p

ETI MOBILE – To Be Built By Humans Run By Computer

ETI MICROTUTOR – Teach yourself To Handle Machine Code!

Configurations - a new "building block" approach to circuit design

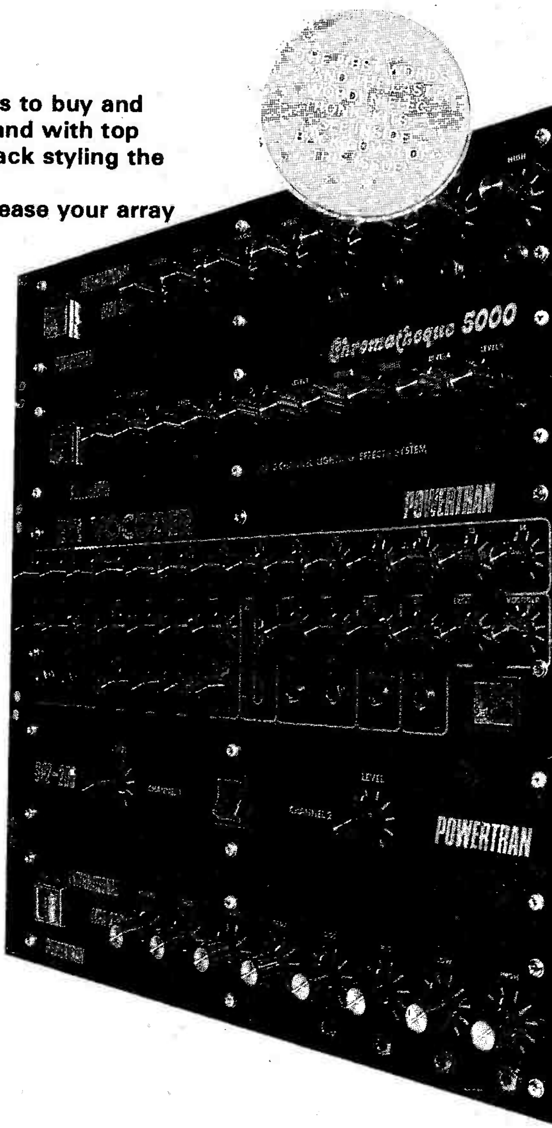
Build our new game project - novel design concept

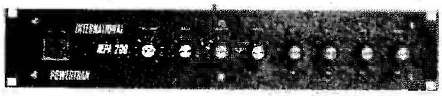
Playmate project for aspiring guitarists!

Major New Series! Designing Micro Systems – Computer Circuitry Made Easy

AUDIO....COMPUTING....MU ....ROBOTICS....

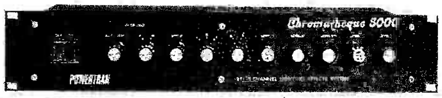
Powertran's black boxes are packed with punch. Not only are they superb kits to buy and build they really do the job! Imaginative and ingenious design goes hand in hand with top quality materials and outstanding performance capability. With their smart black styling the kits harmonise visually as well as musically.
Your can built each unit independantly for its set task and then gradually increase your array until you have a complete bank of formidable controllable power.





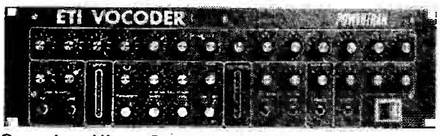
Complete Kit — **£49.90** + VAT

MPA 200 is a low price, high power 100W amplifier. Its smart styling, professional appearance and performance, make it one of our most popular designs. With adaptable inputs the mixer accepts a variety of sources yet straightforward construction makes it ideal for the first-time builder.



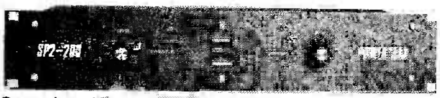
Complete Kit — **£49.50** + VAT

CHROMATHEQUE 5000 — a 5-channel lighting system powerful enough for professional discos yet controllable for home-effects. Sound to light, strobe to music level, random or sequential effects — each channel can handle up to 500W yet minimal wiring is needed with our unique single-board design.



Complete Kit — **£175.00** + VAT

ETI VOCODER — 14 channels, each with independent level control, for maximum versatility and intelligibility; Two input amplifiers — for speech/excitation — each with level control and tone control. The Vocoder is a powerful yet flexible machine that is interesting to build and thanks to our easy to follow construction manual, is within the capability of most enthusiasts.

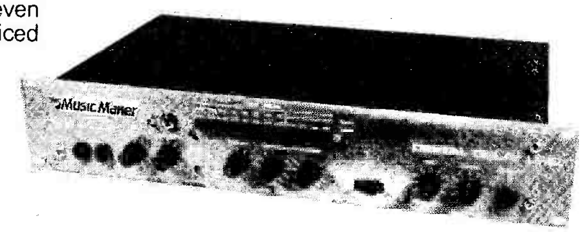


Complete Kit — **£64.90** + VAT

SP2 200 twice the power with two of the reliable, durable and economic amps from the MPA200; fed by separate power supplies from a common toroidal transformer. Superb finish and quality components throughout — up to (even over!) the standard of high priced factory-built units.

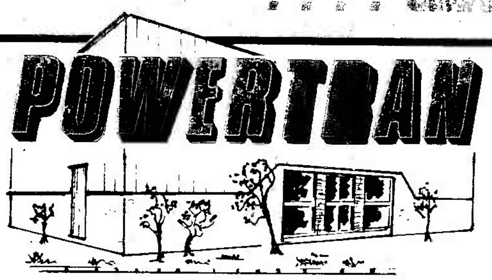
DJ90 Stereo Mixer — this is a really versatile new mixer that enables the constructor DJ to produce a professional performance every time. There are two stereo inputs for magnetic cartridges, a stereo auxiliary input and mike input. Other 'plus' features are auto-panning for fast or slow, slider controls, multi-mixing, ducking, interrupt, input modulation, in short everything. . .the whole works — AND — under £100 complete! (We have illustrated the DJ90 teamed in our own console with the Chromatheque and an SP2 200 and speakers.

Complete Kit — **£97.50** + VAT



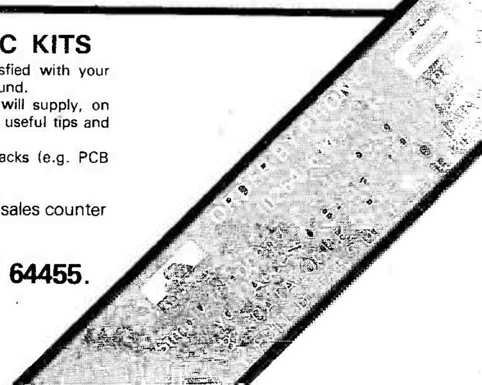
Digital Delay Line — our latest kit! With its ability to give delay times from 1.6 mSecs to up to 1.6 secs. Many powerful effects including phasing, flanging, A.D.T., chorus, echo & vibrato are obtained. The basic kit is extended in 400 mS steps up to 1.6 secs. Simply by adding more parts to the PCB. Compare with units costing over £1,000! Complete kit (400 mS delay) **£130** + VAT. Parts for extra 400 mS delay £9.50p.

. . . . Quite simply the best way to make music



WORLD LEADERS IN ELECTRONIC KITS

- **Money Back Guarantee** — If you are not completely satisfied with your Powertran Kit return it in original condition within 10 days for full refund.
- **Free Soldering Practice Kit** — To assist the beginner we will supply, on request with your first kit order, a free soldering practice kit with useful tips and illustrations.
- **Component Packs** — Most kits are available as separate packs (e.g. PCB component sets, hardware sets etc). Prices in our FREE catalogue.
- **Ordering** — Full ordering details, delivery service, and sales counter opening — inside back of this issue.



PORTWAY INDUSTRIAL ESTATE, ANDOVER, HANTS SP10 3NM. (0264) 64455.

electronics today INTERNATIONAL

AUGUST 1982 VOL 11 NO 8

PUBLISHED BY:
Argus Specialist Publications Ltd.,
145 Charing Cross Road, London WC2H 0EE.
DISTRIBUTED BY:
Argus Press Sales & Distribution Ltd.,
12-18 Paul Street, London EC2A 4JS
(British Isles)
PRINTED BY:
QB Limited, Colchester.
COVERS PRINTED BY:
Alabaster Passmore.

OVERSEAS EDITIONS and their EDITORS
AUSTRALIA — Roger Harrison
CANADA — Halvor Moorshead
GERMANY — Udo Wittig
HOLLAND — Anton Kriegsman

ABC **Member of the Audit Bureau of Circulation**

☐ Subscription Rates. UK £11.95 including postage. Airmail and other rates upon application to ETI Subscriptions Department, 513 London Road, Thornton Heath, Surrey CR4 6AR.

EDITORIAL AND ADVERTISEMENT OFFICE
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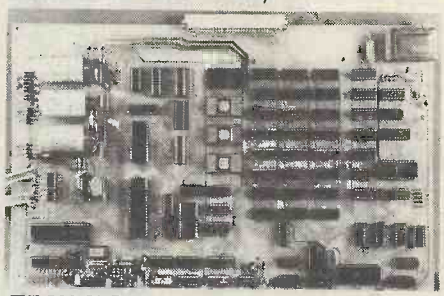
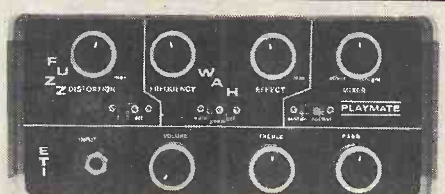
Telex 8811896.

FEATURES



PROJECTS



INFORMATION

SWITCHES

TOGGLE: 2A, 250V

SPST	33p
DPDT	44p

SUB-MIN TOGGLE

SPST on/off	54p
SPDT c/over	60p
SPDT centre off	85p
SPDT biased both ways	105p
DPDT 6 tags	75p
DPDT centre off	88p
DPDT biased both ways	145p
DPDT 3 positions on/on/on	185p
3-pole 2 way	205p

SLIDE 250V:

DPDT 1A	14p
DPDT 1A c/off	15p
DPDT 1/2A	13p

PUSHBUTTON 6A with 10mm Button

SPDT latching	99p
DPDT latching	145p
SPDT moment	99p
DPDT moment	145p
Mini Non Locking	
Push to Make	15p
Push to Break	25p

DIL SWITCHES

(SPST) 4 way 70p; 6 way 85p; 8 way 90p; 10 way 145p.
(SPDT) 4 way 190p.

ROTARY SWITCHES: (Adjustable Stop type) 1 pole/2 to 12 way; 2p/2 to 6 way; 3 pole/2 to 4 way; 4p/2 to 3 way 45p

ROTARY: Mains DP 250V 4 Amp on/off 56p

ROTARY: (Mak-a-switch) Make a multiway switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers (max. 6 pole/12 way + DP switch). Mechanism only 90p

WAFERS: (make before break) to fit the above switch mechanism. 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6p/2 way 56p
Mains DP 4A Switch to fit 45p
Spacers 4p. Screen 6p

ROCKER: 5A/250V SPST	28p
ROCKER: 10A/250V SPDT	38p
ROCKER: 10A/250V DPDT c/off	95p
ROCKER: 10A/250V DPST with neon	85p

VEROBOARD 0.1in

	clad	plain
2½ × 3¼	73p	52p
2½ × 5	83p	
3¾ × 3¾	83p	
3¾ × 5	95p	79p
3¾ × 17	326p	211p
4¾ × 17	426p	
Pkt. of 100 pins	50p	
Spot face cutter	118p	
Pin insertion tool	162p	

VQ Board	175
DIP Board	385
Vero Strip	144

PROTO DECs

Veroblock	375p
S-Dec	350p
Eurobreadboard	520p
Bimboard 1	575p
Superstrip SS2	1350p

VERO WIRING

PEN + Spool	310p
Spare Spool	75p
Combs	6p

DALO ETCH RESIST PEN + Spare tip 90p

FERRIC CHLORIDE 1 lb bag Anhydrous 195p + 50p P&P

ULTRASONIC TRANSDUCER 40KHz 325 pr

IDC CONNECTORS

	PCB Plugs with latch Pins Strt	pins Angle	Header Socket	PCB Pins Angled
2×5 way	90p	99p	85p	65p
2×8 way	130p	150p	110p	78p
2×10 way	145p	166p	125p	90p
2×13 way	175p	200p	150p	110p
2×17 way	205p	236p	169p	135p
2×20 way	220p	250p	190p	150p
2×25 way	235p	270p	200p	175p
2×30 way	–	–	230p	220p

EURO CONNECTORS

DIN	Socket Strt	Socket Angle	Plug Strt	Plug Angle
41617-31 way	200p	–	–	195p
41612 A+B 2×32 way	340p	345p	295p	325p
41612 A+C 2×32 way	350p	355p	300p	350p
41612 A+B+C 3×32 way	420p	425p	370p	400p

COPPER CLAD BOARDS

Fibre glass	Single-sided	Double-sided
6″ × 6″	90p	110p
6″ × 12″	150p	195p

S.R.B.P. 9.5″ × 8.5″ 95p

DIL SOCKETS (TEXAS)

	Low Prof.	Wire Wrap
8pin	8p	25p
14pin	10p	35p
16pin	10p	42p
18pin	16p	52p
20pin	22p	60p
22pin	25p	70p
24pin	25p	70p
28pin	28p	80p
40pin	30p	99p

EDGE CONNECTORS: (Double type)

	.1	.156
2×15 way	–	140p
2×18 way	180p	145p
2×22 way	199p	200p
2×23 way	210p	–
2×25 way	225p	220p
2×30 way	245p	–
2×36 way	295p	–
2×40 way	315p	–
2×43 way	395p	–
2×75 way	550p	–

RIBBON CABLE 12crGrey Color

	Grey	Color
10 way	12p	22p
16 way	18p	32p
20 way	25p	40p
24 way	36p	50p
34 way	48p	60p
40 way	55p	75p
50 way	65p	90p
64 way	85p	110p

DIL PLUG Headers)

	Solder	IDC
14 pin	44p	99p
16 pin	49p	105p
24 pin	88p	178p
40 pin	250p	255p

ZIF DIL SOCKETS

24 pin	575p
28 pin	820
40 pin	975p

PANEL METERS

FSD 60 × 46 × 35mm
0-50μA; 0-100μA; 0-500μA; 0-1mA; 0-5mA; 0-10mA; 0-50mA; 0-100mA; 0-500mA; 0-1A; 0-2A; 0-25V; 0-50V AC; 0-300V AC; "S"; "VU"
496p each

RELAYS

Miniature, enclosed, PCB mount. Our RL6 series.
S.P.C.O.
RL6-91 170Ω coil, 7V5 to 12V DC; 380V/6A AC; 1300VA/50W 210p
D.P.C.O.
43Ω coil, 4V2-7V DC; 250V AC; 5A; 1100VA/150W 218p
RL6-111 170Ω coil, 8V-14V; 250V AC 5A 220p
RL6-114 740Ω coil, 17V5-29V 250V 5A AC 222p

'WEMON' WATFORD'S Ultimate Monitor IC

A 4K Monitor chip specially designed to produce the best from your: Superboard Series I & II, Enhanced Superboard & UK101. As reviewed by Dr A. A. Berk in Practical Electronics, June 1981.
Price only £12 + 50p P&P

PIEZO TRANSDUCERS
Type PB-2720 75p

ETI PROJECTS We stock most of the parts

JUMPER LEADS (Ribbon Cable Assembly)

Length	14 pin	16 pin	24 pin	40 pin
Single ended DIP Jumper				
24 inches	145p	165p	240p	380p
Double ended DIP Jumper				
6 inches	185p	205p	300p	465p
12 inches	198p	215p	315p	490p
24 inches	210p	235p	345p	540p
36 inches	230p	250	375p	595p

AMPHENOL PLUGS IEEE (24 way) 575p; Centronic parallel (36 way) 550p

ANTEX SOLDERING IRON

C-15W	450p	CX17W	475p
CCN-15W	495p	CX25W	500p
Spare tips, assorted sizes	65p		
Spare Elements	210p		
Iron stand with sponge	165p		

Soldercon Pins: 100 pins 70p; 500 pins 325p

BUZZERS, miniature, solid-state 6V; 9V & 12V 70p

LOUDSPEAKERS Miniature, 0.3W; 8Ω.
2in, 3¼in, 2½in, 3in 80p
2½in 40Ω, 64Ω or 80Ω 80p

ASTEC UHF MODULATORS
Standard 6MHz 280p
Wideband 8MHz 425p

CRYSTALS

32.768KHz	100
100KHz	350
200KHz	295
455KH	370
1MHz	295
1.008M	275
1.28MHz	392
1.6MHz	395
1.8NHz	395
1.8432M	200
2.0MHz	225
2.4576M	220
3.278M	150
3.5794M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.80MHz	200
4.194304M	200
4.433619M	120
5.0MHz	160
5.185MHz	300
5.24288M	390
6.144MHz	225
6.5536MHz	226
7.168MHz	250
7.68MHz	200
8.0MHz	150
8.86723M	175
9.00MHz	150
10.0MHz	175
10.24MHz	200
10.7	150
12.0NHz	200
14.31814M	170
16.0MHz	290
18.0MHz	180
18.432M	150
19.968MHz	150
24.0MHz	170
261.69M	150
27.648M	170
27.145M	190
38.66667M	175
48.0MHz	170
100.0MHz	295
116.0MHz	250

TRANSFORMERS: Prim. 240V

6-0-6V; 9-0-9V; 12-0-12V 100mA 98p
pcb mounting, Miniature, Split Bobbin
3VA: 2x6V-0.25A; 2x9V-0.15A; 2x12V-0.12A; 2x15V-0.1A 200p
6VA: 2x6V-0.5A; 2x9V-0.3A; 2x12V-0.25A; 2x15V-0.2A 270p
Standard Split Bobbin type:
6VA: 2x6V-0.5A; 2x9V-0.4A; 2x12V-0.3A; 2x15V-0.25A 220p
12VA: 2x4.5V-1.3A; 2x6V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A 296p (35p p&p)
24VA: 2x6V-1.5A; 2x9V-1.2A; 2x12V-1A; 2x15V-0.8A; 2x20V-0.6A 330p (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-1A; 2x30V-0.8A 440p (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x25V-2A; 2x30V-1.5A; 2x50V-1A **920p** (75p p&p charge to be added over and above our normal postal charge).

VOLTAGE REGULATORS

	+ve		–ve	
1A	T03	Metal case		
5V	7805	145p	7905	220p
12V	7812	146p	7912	220p
15V	7815	145p	7915	220p
18V	7818	145p		
1A	TO220	Plastic casing		
5V	7805	40p	7905	45p
12V	7812	40p	7908	60p
15V	7815	40p	7912	45p
18V	7818	40p	7915	45p
24V	7824	40p	7918	45p
			7924	60p
100mA	TO92 casing	Plastic		
5V	78L05	30p	79L05	60p
6V	78L62	30p		–
8V	78L82	30p		–
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

CA3085	95p
LM300H	170p
LM304H	170p
LM305H	140p
LM309K	135p
LM317K	350p
LM317KP	99p
LM317H	280p
LM323K	500p
LM325N	240p
LM326N	240p
LM337	175p
LM723	35p
TAA550	50p
TBA625B	75p
TDA1412	150p
78HO5 + 5V/5A	550p
78HG +5V to +25V 5A	599p
79HG-2.25V to 24V 5A	785p

D CONNECTORS: Miniature

	9 way	15way	25way	37way
Plugs				
Solder	80p	110p	160p	250p
Angle	160p	210p	250p	355p
Pins	120p	130p	195p	295p
Sockets				
Solder	110p	160p	210p	350p
Angle	165p	215p	290p	440p
Pins	150p	180p	240p	420p
Covers	100p	95p	100p	110p

25 way 'D' CONNECTOR Jumper Lead Cable Assembly

18″ long, Single end, Male	560p
18″ long, Single end, Female	570p
36″ long, Double Ended, M/M	1025p
36″ long, Double Ended, F/F	1050p
36″ long, Double Ended, M/F	995p

ZX81 16K RAM PACK

Fully built & tested. Plugs straight into ZX81 Micro
Only
£17.35 + p&p 50p

BBC MICRO UPGRADE

(Our BBC Micro Upgrade Kits will save you £ s s s . . .)

16K Memory (8 × 4186AP)	£18
Printer User I/O Port Kit	£8.20
SK10 with 36″ Cable	£2
Complete Printer Cable 36″	£13
SK9 with 36″ Cable	£3
Disc Interface Kit	£41
Analogue I/O Kit	£6.75
Serial I/O Kit	£7.50
Expansion Bus Kit	£6.50
SK11 with Cable 36″	£3
SK12 with Cable 36″	£3.75
5 pin DIN Socket	£0.40

CMOS

4000	10	4075	15	4539	110
4001	10	4076	46	4541	140
4002	12	4077	18	4543	80
4006	50	4078	18	4544	150
4007	15	4081	16	4549	375
4008	48	4082	16	4553	246
4009	24	4085	50	4554	190
4010	24	4086	52	4555	35
4011	11	4909	125	4556	35
4012	16	4093	26	4557	320
4013	25	4094	120	4558	120
4014	50	4095	75	4560	180
4015	50	4096	70	4561	104
4016	20	4097	290	4562	495
4017	38	4098	75	4566	165
4018	45	4099	110	4568	250
4019	25	4160	95	4569	175
4020	50	4161	99	4572	30
4021	50	4162	99	4580	460
4022	50	4163	99	4581	250
4023	16	4174	99	4582	99
4024	32	4175	105	4583	99
4025	16	4194	105	4584	48
4026	80	4408	790	4585	99
4027	24	4409	790	4597	330
4028	50	4410	725	4598	290
4029	60	4411	675	4599	290
4030	30	4412	775	40085	90
4031	125	4415	480	40097	45
4032	80	4419	280	40098	193
4033	125	4422	770	40100	215
4034	140	4433	770	40101	130
4035	65	4433	770	40102	140
4036	275	4435	850	40103	175
4037	110	4440	999	40104	95
4038	110	4450	350	40105	110
4039	290	4451	350	40106	46
4040	50	4490	350	40107	60
4041	60	4500	675	40108	450
4042	45	4501	28	40109	100
4043	50	4502	60	40110	300
4044	50	4503	40	40114	240
4045	105	4504	75	40161	194
4046	650	4506	35	40163	65
4047	50	4507	35	40174	65
4048	40	4508	130	40175	75
4049	25	4510	46	40181	220
4050	25	4511	45	40182	90
4051	45	4512	50	40192	90
4052	60	4513	199	40193	68
4053	50	4514	115	40194	90
4054	85	4515	115	40195	72
4055	85	4516	55	40257	195
4056	86	4517	275	40244	195
4057	1915	4518	40	40245	186
4059	480	4519	30	40373	240
4060	60	4520	50	40374	245
4061	2295	4521	110		
4062	995	4522	125		
4063	85	4526	70		
4066	30	4527	65		
4067	245	4528	70		
4068	16	4529	150		
4069	16	4530	90		
4070	15	4531	130		
4071	15	4532	70		
4072	15	4534	455		
4073	15	4536	275		
		4538	90		

OPTO

LS400C	255
OCP71	120
ORP12	86
ORP61	85
2N5777	45

BARGRAPH
3914 500

OPTO ELECTRONICS

LEDs with Clips	
TIL209 Red	11
TIL211 Grn	14
TIL212 Yel.	14
TIL220 .2″ Red	12
.2″ Green, Yellow or Amber	14
0.2″ Bi colour	
Red/Green	65p
Green/Yellow	78p
0.2″ Tri colour	
Red/Green/Yellow	85p
Square LEDs, Red, Green, Yellow	30
Triangular LEDs	
Red	18
Green or yellow	22
LD271 Infra Red	46
SFH205 Detector	91
TIL32 Infra Red	58
TIL78 Detector	60
TIL38	45
TIL100	80
BARGRAPH. Red 10 segments	225
ISOLATORS	
IL74	55
ILD74	99
ILQ74	185
TIL111/2/4	90
TIL117	125
4N33 Photo Darlington	135
7 Segment Displays	
TIL307	675
TIL312 .3″ CA	105
TIL313 .3″ CC	105
TIL321 .5″ CA	115
TIL322 .5″ CC	115
DL704 .3″ CC	99
DL707 .3″ CA	99
DL747 .6″ CA	180
.8″ Orange CA	250
FND357 Red	120
FND500	115
.3″ Green CA	150
.6″ Green CA	215
.3″ ±1 Red CA	150
.3″ ±1 Green CA	150
DVM176	1885
LCD 3½ Digits	525
LCD 4 Digits	650
LCD 6 Digits	750
NEON with resistor, push fit.	
250V mains. Round. Red or amber	30p
Rectangular, nut giving Red, Amber, Green	30p
TIL139	170p
Reflective Optical Switch	296p

COMPUTER CORNER

- **VIC 20** Micro Computer. Connects directly to a colour TV. Still only........£165
- **VIC** Cassette Deck including a free 6 programme Cassette........£39
- **EPSON** MX80T 10″ Tractor Feed, 9 × 9 matrix, 80 column, Speed 80 cps, Bi-directional, Centronics interface, Baud rate 110-9600 (RS232)........£315
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- **VIDEO MONITOR** 9″, B&W, Attractively cased, Fully guaranteed. Value for money at........£75
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- **TEX EPROM ERASER** Erases up to 32 ICs in 15-30 minutes....£33
- **SPARE 'UV'** Lamb bulb........£9
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- **C12 CASSETTES** in library cases........40p

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Designed by Watford Electronics, this extremely versatile and economical Expansion System as published in E.T.I., starting from December 1981 issue, offers a low cost flexible expansion system for: ZX81, UK101, SUPERBOARD, Acorn ATOM, PET, TANGERINE, TRS80, VIC 20, etc.
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1/35V	17p
.22/35V	17p
.33/35V	17p
.47/35V	17p
.68/35V	17p
1.0/35V	17p
2.2/16V	17p
2.2/35V	22p
3.3/35V	22p
4.7/16V	22p
4.7/35V	24p
6.8/25V	26p
6.8/35V	25p
10/16V	25p
10/35V	34p
15/10V	22p
15/16V	30p
15/25V	32p
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10nF	12p
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22nF	18p
47nF	32p
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Fully enclosed Piher Pre-sets

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Veroboard 0.1" Copper Clad

2.5 x 3.75	72p
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4.7nF, 6.8nF	26p
10nF	28p
22nF, 33nF	37p
47nF	45p
100nF	48p
220nF	74p
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470p/6KV	30p
1n/2KV	28p
1n/6KV	32p
2n2/1KV	20p
2n2/4KV	32p
2n2/5KV	33p
3n3/2KV	31p
3n3/6KV	32p
4n7/4KV	33p

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100nF, 150nF	25p
220nF	38p
330nF	58p
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Prices per metre

Solid Hook up Wire Any colour	5p

Grade One Glass PCB Single Sided

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420 x 195mm	130p
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Ferric Chloride

60% Solution 250ml bottle	£1.60

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as used on professional studio equipment. All fit ¼" Standard spindles. Please specify grey or black

15mm	
Short	43p
With line	48p
Standard	44p
With line	49p
Short wing	58p
Standard wing	60p
21mm	
Short	53p
With line	58p
Standard	58p
With line	64p
Short wing	58p
Standard wing	60p

CAPS

Colours Blk, Red, Yel, Grn, Blu, Gry	5p
As above + line	8p
As above + dot	8p

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For 15mm only Colours as Caps	10p

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Black + Point	26p
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Clear 1 10	28p

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Warning Devices

6V mini buzzer	99p
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6 24V Piezo sounder	99p

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250V with Chrome Bezel	75p

Quality Electrolytics

By Matsushita or Siemens (other good makes may be sent only in the rare event of supply difficulty)

AXIALS

uFd	V	
.47	63	8p
.47	100	9p
.47	350	30p
1	63	8p
1	100	9p
1	500	40p
2.2	25	8p
2.2	63	9p
2.2	100	11p
2.2	350	30p
3.3	25	10p
3.3	40	11p
3.3	63	12p
4.7	16	8p
4.7	25	9p
4.7	40	10p
4.7	63	12p
4.7	100	14p
10	25	8p
10	40	12p
10	63	14p
10	100	16p
22	25	11p
22	40	14p
22	63	16p
22	100	21p
47	25	14p
47	40	17p
47	63	18p
47	100	28p
68	25	18p
68	63	25p
100	16	14p
100	25	16p
100	40	18p
100	63	25p
100	100	30p
220	10	16p
220	16	17p
220	25	22p
220	40	25p
220	63	30p
220	100	40p
330	16	19p
330	25	22p
330	63	38p
470	16	22p
470	25	28p
470	40	33p
470	63	43p
470	100	60p
1000	16	30p
1000	25	38p
1000	40	48p
1000	63	65p
2200	16	40p
2200	25	63p
2200	40	70p
2200	63	134p
4700	16	75p
4700	25	90p

Beautiful Mini Radial Low Voltage

Matsushita only

uFd	V	
10	16	6p
22	10	6p
22	16	7p
47	10	7p
47	16	8p
100	10	9p
100	16	10p
220	10	11p
220	16	12p
470	10	16p
470	16	18p
1000	10	20p
1000	16	24p
2200	10	34p
2200	16	44p

Mains/Speaker Cable (per metre)

Twin 1 amp	14p
Twin 2½ amp	16p
3 Core 2½ amp	18p
3 Core 6 amp	31p
3 Core 13 amp	56p

Solid Multicore

4 Core	33p
8 Core	39p
12 Core	46p
50 Core	1.37

Screened Cable

Single	14p
Stereo	27p
Mini Single	12p
Mini Stereo	15p
4 Core 4 Screens	44p
4 Core 1 Screen	54p
8 Core	61p
12 Core	80p

Aerial Cable

50Ω RG58A	36p
75Ω UHF	36p
75Ω VHF	28p
300Ω Flat	14p

Rainbow Ribbon Cable

10 Way	84p
24 Way	166p
40 Way	270p

TRANSISTORS

Probably the largest retail variety in UK. If you don't see what you want please phone or write as this is not a full list

2N404	1.50
2N914	20p
2N916	39p
2N917	65p
2N918	33p
2N929	36p
2N929A	45p
2N930	20p
2N930A	30p
2N1131	25p
2N1132	25p
2N1302	65p
2N1303	65p
2N1304	60p
2N1306	75p
2N1308	75p
2N1370	58p
2N1420	66p
2N1483	2.95
2N1485	3.47
2N1507	42p
2N1524	58p
2N1702	3.20
2N1711	35p
2N1889	50p
2N1890	50p
2N1893	30p
2N1974	1.50
2N2060	7.14
2N2102	39p
2N2217	39p
2N2218	33p
2N2218A	38p
2N2219	27p
2N2219A	28p
2N2220	22p
2N2221	22p
2N2221A	23p
2N2222	25p
2N2222A	31p
2N2223	2.60
2N2223A	4.15
2N2303	1.10
2N2368	30p
2N2369	19p
2N2369A	20p
2N2405	88p
2N2410	1.15
2N2411	3.60
2N2412	80p
2N2477	95p
2N2483	25p
2N2484	26p
2N2491	8.00
2N2646	49p
2N2647	98p

2N2714	12p
2N2848	60p
2N2875	2.20
2N2890	1.10
2N2891	2.28
2N2892	3.00
2N2904A	27p
2N2905	28p
2N2905A	29p
2N2906	25p
2N2906A	30p
2N2907	25p
2N2907A	26p
2N2920	3.47
2N2923	25p
2N2924	15p
2N2925	15p
2N2926	10p
2N3010	75p
2N3011	25p
2N3019	50p
2N3053	27p
2N3054	56p
2N3055 CSF	60p
2N3055RCA	80p
2N3107	46p
2N3108	42p
2N3109	48p
2N3232	1.50
2N3250	36p
2N3251	36p
2N3300	60p
2N3301	68p
2N3302	80p
2N3390	38p
2N3391	30p
2N3391A	34p
2N3392	27p
2N2393	24p
2N3394	20p
2N3395	26p
2N3396	26p
2N3397	27p
2N3402	35p
2N3403	50p
2N3404	50p
2N3405	50p
2N3416	24p
2N3417	23p
2N3420	2.50
2N3439	98p
2N3440	80p
2N3441	1.25
2N3442	1.35
2N3442MOT	2.40
2N3444	1.70
2N3445	4.80
2N3446	6.09
2N3447	5.72
2N3448	6.56
2N3468	1.00
2N3512	1.06
2N3553	2.30
2N3563	20p
2N3564	25p
2N3565	20p
2N3566	50p
2N3567	55p
2N3568	50p
2N3569	60p
2N3570	2.54
2N3571	2.19
2N3572	2.06
2N3584	2.76
2N3585	2.99
2N3605	36p
2N3606	28p
2N3607	28p
2N3632	9.88
2N3638	35p
2N3638A	37p
2N3639	36p
2N3641	39p
2N3642	25p
2N3643	15p
2N3644	28p
2N3645	33p
2N3646	28p
2N3662	15p
2N3663	16p
2N3691	18p
2N3692	20p
2N3693	25p
2N3694	30p
2N3702	10p
2N3703	10p
2N3704	10p
2N3705	10p
2N3706	10p
2N3707	10p
2N3708	10p
2N3709	10p
2N3710	10p
2N3711	10p
2N3712	2.00
2N3713	2.86
2N3714	2.98
2N3715	3.31
2N3716	3.60
2N3724	75p
2N3725	85p
2N3730	4.65
2N3732	2.88
2N3734	1.30
2N3725	2.45
2N3738	2.00
2N3740	2.38
2N3741	2.76
2N3766	2.90
2N3767	3.19
2N3771	1.75
2N3772	1.83
2N3773	2.55
2N3779	1.70
2N3789	3.27
2N3790	2.73
2N3791	2.47
2N3792	2.68
2N3794	25p
2N3819	21p
2N3820	42p
2N3821	1.84
2N3822	90p
2N3823	1.30
2N3824	1.70
2N3826	78p
2N3827	78p
2N3854	44p
2N3855	30p
2N3855A	40p
2N3856	45p
2N3858	31p
2N3858A	37p
2N3859A	31p
2N3860	31p
2N3866	90p
2N3877A	35p

2N3900	25p
2N3901	30p
2N3902	6.65
2N3903	15p
2N3904	15p
2N3905	15p
2N3906	15p
2N3945	85p
2N3962	30p
2N3964	1.42
2N4030	66p
2N4031	55p
2N4032	65p
2N4036	58p
2N4037	43p
2N4058	10p
2N4059	17p
2N4060	12p
2N4061	10p
2N4062	10p
2N4064	1.50
2N4069	1.00
2N4074	75p
2N4092	98p
2N4093	1.20
2N4121	45p
2N4122	45p
2N4123	21p
2N4124	35p
2N4125	37p
2N4126	27p
2N4220	1.77
2N4221	3.95
2N4222	3.95
2N4223	3.95
2N4224	3.95
2N4234	1.30
2N4236	45p
2N4237	1.21
2N4238	95p
2N4239	1.00
2N4240	3.00
2N4248	15p
2N4249	17p
2N4250	17p
2N4258	75p
2N4266	45p
2N4275	48p
2N4284	32p
2N4285	35p
2N4287	45p
2N4288	22p
2N4289	22p
2N4290	45p
2N4291	46p
2N4292	45p
2N4294	45p
2N4297	2.50
2N4302	39p
2N4303	40p
2N4304	41p
2N4314	60p
2N4342	68p
2N4347	2.26
2N4351	1.16
2N4400	15p
2N4401	27p
2N4402	30p
2N4403	30p
2N4409	36p
2N4410	42p
2N4427	1.87
2N4440	12.58
2N4870	80p
2N4871	55p
2N4888	92p
2N4898	1.71
2N4901	3.26
2N4902	3.52
2N4903	3.24
2N4904	2.75
2N4905	3.25
2N4906	3.42
2N4907	3.20
2N4908	3.70
2N4909	2.90
2N4910	1.95
2N4913	2.59
2N4914	2.69
2N4915	2.95
2N4916	48p
2N4917	47p
2N4918	95p
2N4919	1.28
2N4920	1.34
2N4921	1.09
2N4922	1.29
2N4923	1.34
2N4924	92p
2N4926	95p
2N4927	95p
2N4928	1.59
2N4964	27p
2N4965	25p
2N4966	25p
2N4967	25p
2N4968	25p
2N4969	31p
2N5010	8.50
2N5011	9.37
2N5030	44p
2N5033	48p
2N5035	1.60
2N5036	1.95
2N5039	3.90
2N5086	36p
2N5087	39p
2N5088	37p
2N5089	37p
2N5126	48p
2N5127	38p
2N5128	38p
2N5129	30p
2N5130	37p
2N5131	22p
2N5133	22p
2N5135	38p
2N5136	38p
2N5137	23p
2N5138	30p
2N5139	48p
2N5140	25p
2N5141	25p
2N5143	25p
2N5172	15p
2N5175	58p
2N5179	46p
2N5180	43p
2N5183	1.00
2N5184	1.10
2N5188	1.15
2N5189	1.00
2N5190	68p
2N5191	70p
2N5193	90p
2N5194	1.34
2N5209	24p

2N5210	25p
2N5219	25p
2N5220	15p
2N5221	25p
2N5222	28p
2N5223	15p
2N5224	38p
2N5225	25p
2N5226	25p
2N5227	25p
2N5232	30p
2N5232A	32p
2N5245	37p
2N5246	40p
2N5247	45p
2N5248	46p
2N5249	48p
2N5266	2.88
2N5293	98p
2N5294	1.28
2N5295	1.37
2N5296	1.28
2N5298	1.37
2N5302	3.20
2N5303	3.80
2N5305	25p
2N5306	37p
2N5307	40p
2N5308	25p
2N5354	19p
2N5355	19p
2N5358	73p
2N5366	25p
2N5367	28p
2N5401	35p
2N5415	1.10
2N5416	1.54
2N5447	16p
2N5448	19p
2N5449	21p
2N5450	23p
2N5451	25p
2N5457	35p
2N5458	35p
2N5459	35p
2N5460	72p
2N5461	60p
2N5462	80p
2N5484	40p
2N5485	40p
2N5490	1.37
2N5492	1.56
2N5494	1.37
2N5496	1.59
2N5543	5.00
2N5551	37p
2N5640	45p
2N5654	35p
2N5786	80p
2N5813	23p
2N6027	30p
2N6030	6.60
2N6082	18.00
2N6099	1.20
2N6101	1.30
2N6109	1.15
2N6111	1.00
2N6121	54p
2N6122	56p
2N6123	59p
2N6124	56p
2N6125	59p
2N6126	71p
2N6129	79p
2N6130	93p
2N6131	98p
2N6132	83p
2N6133	1.14
2N6134	1.36
2N6253	1.45
2N6254	1.55
2SC1306	95p
2SC1444	2.50
2SC2078	1.70
2SJ49	3.98
2SK134	3.98
3N128	1.98
3N138	3.50
3N139	3.30
3N140	2.37
3N143	2.85
3N152	3.00
3N153	2.47
3N154	2.56
3N200	6.93
3N201	2.98
40250	2.42
40251	2.77
40254	2.75
40264	2.63
40280	2.00
40290	2.00
40309	1.80
40311	97p
40312	1.64
40313	1.89
40315	1.94
40316	1.63
40324	1.86
40325	2.46
40326	1.98
40346	1.30
40347	1.40
40348	1.95
40360	1.70
40361	50p
40362	50p
40363	2.22
40364	2.90
40372	1.80
40373	2.60
40374	2.84
40389	1.24
40390	2.72
40392	1.20
40394	1.10
40394	1.70
40406	1.39
40407	1.10
40408	1.59
40410	1.80
40411	3.00
40412	1.50
40422	2.96
40467A	1.72
40513	1.75
40537	96p
49543	1.60
40594	1.15
40595	1.20
40600	2.58
40601	2.36
40602	1.68
40603	2.06
40604	1.85
40608	2.44
40622	1.46

40625	1.60
40626	3.20
40631	1.90
40632	2.12
40635	1.35
40637	2.00
40643	1.80
40673	95p
40822	1.80
40871	1.00
40872	1.00
AC125	35p
AC126	25p
AC127	25p
AC128	25p
AC132	39p
AC151	51p
AC152	45p
AC153	55p
AC153K	64p
AC176	27p
AC176K	37p
AC187	25p
AC187K	28p
AC188	25p
AC188K	40p
ACY17	70p
ACY18	90p
ACY20	75p
ACY21	75p
ACY22	75p
ACY28	75p
ACY44	98p
AD136	7.90
AD145	1.65
AD149	1.10
AD150	1.31
AD161	52p
AD162	52p
AF106	75p
AF109	75p
AF114	65p
AF117	70p
AF118	89p
AF124	72p
AF126	72p
AF126	72p
AF139	53p
AF170	88p
AF172	88p
AF178	88p
AF200	65p
AF201	75p
AF239	1.24
AF240	1.00
AF279B	75p
AF279G	75p
AL102	3.49
AU110	2.20
AU113	2.30
BC107	13p
BC107A	14p
BC107B	14p
BC108	12p
BC108A	13p
BC108B	14p
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BC123	82p
BC125	37p
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BC143	34p
BC147	11p
BC147A	12p
BC147B	13p
BC147C	18p
BC148	11p
BC148A	12p
BC148B	13p
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BC149	11p
BC149B	12p
BC149C	13p
BC152	35p
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BC170C	18p
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BC171B	15p
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BC172A	15p
BC172B	15p
BC172C	16p
BC173	15p
BC173B	16p
BC173C	16p
BC174	21p
BC174A	24p
BC174B	24p
BC175	75p
BC177	23p
BC177A	25p
BC177B	26p

BC178	22p
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BC178B	25p
BC179	23p
BC179A	25p
BC179B	25p
BC179C	27p
BC182	11p
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BC182B	13p
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BC239C	18p
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BC253C	24p
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BC413	25p
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BC559B	16p
BC559C	17p
BC560	32p
BC560C	34p
BC727	44p
BC737	44p
BCW32R	60p
BCY30	1.15
BCY30A	1.30
BCY31	1.15
BCY31A	1.30
BCY32	1.15
BCY32A	1.30
BCY33	80p
BCY33A	1.00
BCY34	80p
BCY34A	80p
BCY54	1.91
BCY58	32p
BCY59	33p
BCY66	1.80
BYC67	2.00
BCY70	17p
BCY71	17p
BCY72	36p
BCY77	34p
BCY78	22p
BCY79	22p
BCY87	6.60
BCY88	4.90
BCY89	4.10
BCZ10	4.60
BCZ11	4.60
BD115	58p
BD116	2.50
BD121	2.25
BD124	1.50
BD131	44p
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BD135	40p
BD136	40p
BD137	42p
BD138	42p
BD139	44p
BD140	44p
BD142	2.40
BD153	1.25
BD155	1.20
BD157	1.20
BD158	1.40
BD160	3.80
BD181	1.75
BD182	2.50
BD183	2.70
BD187	1.09
BD201	1.30
BD202	1.39
BD204	1.44
BD220	1.00
BD221	95p
BD223	1.00
BD224	95p
BD232	1.11
BD233	70p
BD234	72p
BD237	98p
BD238	98p
BD239A	57p
BD239C	64p
BD240A	59p
BD240C	73p
BD241A	61p
BD241C	67p
BD242A	65p
BD242C	70p
BD243A	72p
BD243C	85p
BD244A	82p
BD244C	1.00
BD245A	1.14
BD245C	1.30
BD246A	1.20
BD246C	1.50
BD249A	2.00
BD249C	2.31
BD250A	2.11
BD250C	2.46
BD433	79p
BD434	79p
BD435	81p
BD436	81p
BD437	88p
BD438	88p
BD439	90p
BD440	91p
BD441	91p
BD442	93p
BD529	1.20
BD530	1.30
BD535	75p
BD536	75p
BD537	80p
BD538	80p
BD539	80p
BD539C	1.10
BD540	85p
BD540C	1.20
BD675	72p
BD676	77p
BD677	78p
BD678	83p
BD711	1.32
BD712	1.32
BDX14	1.30
BDX18	1.59
BDX32	3.47

BDY10	2.00
BDY11	2.50
BDY17	2.89
BDY23	3.40
BDY25	3.75
BDY38	1.74
BDY54	1.98
BDY55	2.09
BDY56	2.35
BDY57	5.25
BDY58	6.15
BDY60	2.80
BDY61	2.80
BDY62	2.34
BDY92	3.76
BF115	38p
BF119	1.00
BF121	75p
BF123	70p
BF127	80p
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BF163	50p
BF166	67p
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BF170	79p
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BF256C	45p
BF257	30p
BF258	32p
BF259	35p
BF262	80p
BF263	90p
BF270	65p
BF271	68p
BF273	40p
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BF324	38p
BF336	36p
BF337	38p
BF338	48p
BF355	60p
BF362	85p
BF363	85p
BF457	46p
BF458	56p
BF459	62p
BF469	85p
BF470	85p
BFR39	25p
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BFR79	25p
BFR80	25p
BFR81	25p
BFR90	2.11
BFS28	2.95
BFS61	1.00
BFS98	1.10
BFT19	1.65
BFT19B	1.88
BFT66	2.48
BFW10	1.48
BFW10	1.48
BFW11	1.48
BFW43	2.47
BFW59	1.08
BFW87	1.53
BFW90	1.53
BFX12	1.00
BFX13	91p
BFX19	50p
BFX20	80p
BFX29	30p
BFX30	35p
BFX34	1.00
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BFX86	40p
BFX87	32p
BFX88	33p
BFX89	1.08
BFY18	1.15
BFY19	1.10
BFY37	1.20
BFY39	50p
BFY41	1.16
BFY50	25p
BFY51	25p
BFY52	25p
BFY53	45p
BFY56	70p
BFY56A	65p
BFY75	75p
BFY76	50p
BFY77	80p
BFY78	80p
BFY90	95p
BSV81	1.87
BSW41	95p
BSW67	1.00
BSW70	1.00
BSX19	25p
BSX20	25p
BSX21	40p

BSX26	60p
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BSX28	66p
BSX29	80p
BSX39	80p
BSX60	75p
BSX61	80p
BSX76	50p
BSX77	55p
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BSY54	40p
BSY65	58p
BSY95A	25p
BU104	3.00
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BU109	3.00
BU126	1.66
BU204	2.25
BU205	1.75
BU206	2.00
BU208	2.00
BU326S	2.25
BU406	1.45
BU407	1.45
BU408	1.35
BU409	1.25
BU500	2.80
BUV20	11.00
BUV21	10.90
BUV23	13.60
BUV24	12.10
BUV25	15.00
BUX20	17.00
BUY18S	3.95
J300	48p
J310	53p
MA8001	45p
MA8002	62p
MA8003	39p
MD7000	2.60
ME0401	25p
ME0402	30p
ME0404	25p
ME0411	35p
ME0412	35p
ME0413	35p
ME0414	48p
ME0461	45p
ME0462	45p
ME1001	45p
ME1002	45p
ME1075	45p
ME1100	45p
ME1120	48p
ME3002	25p
ME4001	45p
ME4002	45p
ME4003	45p
ME4101	25p
ME4101	25p
ME4103	25p
ME4104	25p
ME6001	25p
ME6002	25p
ME6003	25p
ME6101	29p
ME6102	28p
ME8001	47p
ME8002	62p
ME8003	50p
ME9001	56p
ME9002	56p
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MJ1001	3.00
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MJ4502	4.46
MJE340	55p
MJE370	72p
MJE371	79p
MJE520	58p
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MJE1100	3.65
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MP8111	1.00
MP8112	1.39
MP8121	1.35
MP8122	1.40
MP8123	1.16
MP8512	1.59
MPF102	45p
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MPF104	40p
MPF105	40p
MPF112	50p
MPF121	1.21
MPS3638	27p
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MPS4356	60p
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MPS6518	47p
MPS6530	37p
MPS6560	32p
MPS6562	32p
MPSA05	20p
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MPSA12	28p
MPSA13	28p
MPSA14	48p
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MPSA18	65p
MPSA20	50p
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MPSA66	47p
MPSA70	45p
MPSA92	65p
MPSA93	66p
MPSL01	42p
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MPSU06	56p
MPSU07	75p
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MSPU55	84p
MPSU56	86p
MPSU57	1.20
MRF421	poa
MFR450A	poa
MRF453	poa
MRF454	poa
MRF475	7.55
MRF477	poa
MRF479	poa
MRF604	poa
NKT124	63p
NKT125	48p
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NKT135	40p
NKT137	42p
NKT210	42p
NKT215	40p
NKT216	65p
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NKT240	42p
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NKT281	47p
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NKT773	40p
NKT781	43p
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NKT12429	87p
NKT13329	50p
NKT13429	54p
NKT16229	50p
NKT20329	38p
OC20	2.30
OC22	2.00
OC23	2.00
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OC29	2.36
OC35	2.36
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R2008B	2.14
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SC107	27p
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SC109	27p
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TIP31A	44p
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TIP32A	44p
TIP32C	50p
TIP33A	75p
TIP33C	80p
TIP34A	95p
TIP34C	1.25
TIP35A	1.25
TIP35C	1.58
TIP36A	1.80
TIP36C	1.79
TIP41A	54p
TIP41C	78p
TIP42A	58p
TIP42C	80p
TIP49	1.20
TIP50	1.40
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TIP54	2.00
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TIP112	90p
TIP115	81p
TIP117	90p
TIP120	88p
TIP122	1.00
TIP125	1.20
TIP127	1.27
TIP130	1.80
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TIP135	1.80
TIP137	1.88
TIP140	1.96
TIP142	1.40
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TIP147	1.40
TIP2955	77p
TIP3055	70p
TIS37	62p
TIS43	40p
TIS45	60p
TIS46	60p
TIS47	40p
TIS48	65p
TIS49	60p
TIS50	60p
TIS51	60p
TIS52	70p
TIS53	97p
TIS54	60p
TIS55	60p
TIS58	52p

GET A GOOD DEAL FROM CRICKLEWOOD: OVER 300 PRICE CUTS NOW EFFECTED

Cricklewood is the shop in London with the largest variety of brand new, full-spec, guaranteed electronic components. Just look at our range and thats only part of it! Items not covered on this list include soldering equipment, tools, meters, tri-colour LEDS, D-connectors, fuses, knobs switches, plugs and sockets, transformers cases etc. etc., all at competitive prices, all under one roof. We have a 95% stock situation with all in stock items posted the same day. OFFICIAL ORDERS FROM SCHOOLS, GOVT. DEPTS, ACCEPTED. OVERSEAS ORDERS WELCOME (CWO) PLUS ADEQUATE POSTAGE. QUANTITY DISCOUNTS BY NEGOTIATION.

TELEX NO 914977 CRIKEL G.

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TIS60 42p
TIS62 44p
TIS64 67p
TIS87 60p
TIS88A 62p
TIS90 28p
TIS91 30p
TIS92 30p
TIS93 54p
VN10KM 80p
VN46AF 84p
VN66AF 85p
ZTX107 10p
ZTX108 10p
ZTX109 10p
ZTX300 13p
ZTX301 15p
ZTX302 15p
ZTX303 23p
ZTX304 15p
ZTX310 35p
ZTX311 32p
ZTX312 35p
ZTX313 36p
ZTX314 24p
ZTX320 35p
ZTX330 35p
ZTX341 28p
ZTX500 14p
ZTX501 14p
ZTX502 14p
ZTX503 17p
ZTX504 24p
ZTX510 34p
ZTX530 24p
ZTX531 25p

DIACS
BR100 40p
ST2 29p

THYRISTORS
Sensitive Gate Small Signal
2N5060 30p
2N5061 32p
2N5062 35p
2N5063 37p
2N5064 40p
BR101 75p
BRY39 60p
BRY56-100 60p
BRY55-300 67p
BRY56 50p
TIC44 35p
TIC47 50p

4, 8 & 12 Amps Texas TO220
Suffix: A = 100V, B = 200V, C = 300V, D = 400V, M = 600V
4A TIC106A 48p
TIC106B 47p
TIC106C 48p
TIC106D 59p
TIC106M 68p
8A TIC116A 66p
TIC116B 68p
TIC116C 71p
TIC116D 73p
TIC116M 80p
12A TIC126A 72p
TIC126B 72p
TIC126C 73p
TIC126D 77p
TIC126M 96p

SIEMENS THRISTORS
1.2 amp plastic
Bst B0106 (100V) 60p
Bst B0113 (200V) 70p
Bst B0146 (700V) 1.12
4.7 amp plastic
Bst B0206 (100V) 80p
Bst B0213 (200V) 1.10
Bst B0246 (700V) 2.00

TV Thyristors
2N4444 1.80
BT101-500R 1.40
BT106 1.50
BT116 Use TIC116M
BT119 1.70
BT120 1.50
BT121 1.30

TRIACS
Texas 400V TO220 Case
TIC206D(4A) 66p
TIC225D(6A) 74p
TIC226D(8A) 88p
TIC236D(12A) 1.16
TIC246D(16A) 1.22
TIC253D(20A) 1.90
TIC263D(25A) 2.11

Other Triacs
2N5756 (TO5) 1.44
2N6155 (TO127) 3.39
40432 (Quadrac) 2.23
40486 (TO5) 1.65
40512 2.70
40576 (TO66) 3.33
40842 1.92

DIODES
1N34A 30p
1N821 70p
1N823 92p
1N914 08p
1N916 10p
1N1190 1.47
1N1192 1.75
1N1194 1.65
1N1194A 1.80
1N1196A 2.41
1N1198A 2.65
1N1201A 97p
1N1204A 1.00
1N1206 1.20
1N3063 36p
1N3065 48p
1N3492 1.86
1N3493 2.20
1N3493R 2.20
1N3602 36p
1N3604 45p
1N3766 3.00
1N3768 4.50
1N3768R 4.50
1N4001 4p
1N4002 5p
1N4003 6p
1N4004 7p
1N4005 8p
1N4006 9p
1N4007 10p
1N4009 20p
1N4148 6p
1N4150 18p
1N4448 22p
1N4517 22p
1N5172 30p
1N5176 94p
1N5400 12p
1N5401 13p
1N5402 14p
1N5403 15p
1N5404 16p
1N5405 17p
1N5406 18p
1N5407 19p
1N5408 20p
1N5024 52p
1N5625 60p
1N5626 62p
1N5627 68p
1S44 10p
1S131 40p
1S134 56p
1S421 1.00
1S421R 1.00
1S940 10p
1S941 11p
1S961 22p
AA118 28p
AA129 57p
AA144 25p
AAY30 44p
AAY33 48p
AAZ17 27p
BA100 22p
BA102 25p
BA115 25p
BA133 40p
BA138 30p
BA142 20p
BA144 15p
BA155 15p
BA156 38p
BA182 40p
BA201 18p
BA202 26p
BA316 25p
BA317 25p
BA318 30p
BAV10 16p
BAV19 15p
BAV20 15p
BAV49 15p
BAX13 10p
BAX16 11p
BY38 20p
BAY44 15p
BAY93 10p
BB103B 70p
BB103G 70p
BB104B 80p
BB104G 80p
BB105 62p
BB105A 67
BB105B 58p
BB109G 65p
BY126 20p
BY127 22p
BY134 52p
BY182 1.26
BY188A 65p
BY206 36p
BY207 36p
BY223 1.56
BY297 48p
BY299 55p
BYW11-800 1.40
BYW11-1000 2.00
BYW12-100 1.30
BYW12-200 1.40
BYW12-400 2.00
BYX10 36p
BYX50-200R 2.00
BYX55-350 62p
BYX71-350 1.10
BYX71-600 1.52
ITT33 15p
ITT44 10p
ITT921 10p
ITT923 15p
ITT2002 27p
MZ2361 1.80
OA10 70p
OA47 20p
OA90 10p
OA91 10p
OA95 20p
OA200 20p
OA202 20p
RAS508AF 75p
SPD9000 75p
SPD9002 95p

6 amp type Square with hole
PW01 (100) 50p
PW02 (200) 78p
PW04 (400) 85p
PW06 (800) 90p

25 amp type Metal clad with hole
K01 (100) 2.20
K02 (200) 2.30
K04 (400) 2.80
K06 (600) 3.40

Proprietory Bridges
B40C1500 1.20
B80C3700 1.80
BY164 55p
BY179 92p

ZENER DIODES
400-500mW E24 Series 2.4-47V 10p
1.3 Watt E24 Series 3.3-82V 20p
2.5 Watt E24 Series 7.5-75V 1.10
5W wire ended following voltages only 3V3, 3V6, 4V3, 4V7, 5V6, 7V5, 8V2, 8V7, 9V1, 10V, 12V, 20V, 33V, 51V, 62V, 68V 1.25
10W Pos. Stud Following voltages only 7V5, 13, 18, 20, 24, 27, 30, 33, 68, 82, 91, 100, 110 1.25
20W Pos. Stud (BZY93 series) E24 values 7V5-75V 2.00

OPTO ELECTRONICS
2N5777 78p
2N5778 88p
2N5779 1.09
4N25 1.10
BP100 1.40
BP104 1.00
BPX25 2.47
BPX29 2.47
BPX48 6.76
BPX60 4.75
BPX61 3.48
BPX63 2.93
BPX79 4.60
BPX86 4.15
CQX13 40p
CQX23 53p
CQX33 48p
LD30A 10p
LD36A 12p
LD37A 12p
LD52A 12p
LD56A 15p
LD57A 15p
LD52C 30p
LD56C 30p
LD57C 30p
LD80A 18p
LD86A 22p
LD87A 22p
LD242 75p
LD271 40p
LD461 25p
LD466 1.45
LD468 1.65
LD471 27p
LD476 1.20
LD478 1.45
LD479 1.65
LD481 27p
LD486 1.25
LD488 1.70
LD489 1.89
LD599 81p
ORP12 1.20
RPY60 2.65
RPY63 2.65
TIL32 71p
TIL63 1.95
TIL64 1.95
TIL65 2.25
TIL66 2.30
TIL67 2.35
TIL78 60p
TIL81 1.60
TIL99 1.35
TIL116 1.10
TIL138 2.40
TIL139 2.40
TIL209 15p
TIL211 19p
TIL212 19p
TIL224 32p
TIL228 42p
TIL312 1.65
TIL313 1.65
TIL401 3.50
TIL403 3.80
TIL406 4.10

BRIDGE RECTIFIERS
(PIV shown in brackets)
1 amp type
W01 (100) 20p
W02 (200) 26p
W04 (400) 28p
W08 (800) 40p
2 amp type Square with hole
S01 (100) 37p
S02 (200) 40p
S04 (400) 48p
S08 (800) 56p

VA1053 40p
VA1055 40p
VA1056 40p
VA1065 40p
VA1067 40p
VA1074 40p
VA1086 40p
VA1091 40p
VA1098 40p
VA1100 40p
VA1103 40p
VA1104 90p
VA1108 40p
VA1109 40p
VA1110 40p
VA1191 40p
VA3705 4.15
GD25 1.25
Many other Thermistors in stock please phone

VOLTAGE DEPENDENT RESISTORS

New LEDs Now in stock
R = red, G = green, Y = yellow

	1+	50+
Large diffused		
R5D	9p	7p
G5D	15p	12p
Y5D	15p	12p
Small diffused		
R2D	8p	6p
G2D	12p	10p
Y2D	12p	10p
Micro 0.1"		
R1D	25p	22p
G1D	27p	25p
Y1D	27p	25p
Large clear		
R5C	12p	10p
G5C	17p	13p
Y5C	17p	13p
Super bright Large (100 times brighter)		
R5U	38p	29p
G5U	42p	34p
Y5U	42p	34p
Tri-colour flat		
RGY8	83p	78p

LINEAR ICs
AN103 2.20
AY1-0212 6.60
AY3-0215 7.95
AY1-1320 3.20
AY1-5050 1.40
AY1-1270 8.70
AY3-8910 5.95
AY3-8912 6.15
AY5-2376 10.50
CA3000 4.80
CA3001 4.95
CA3002 4.60
CA3005 3.15
CA3007 4.92
CA3010 1.30
CA3012 1.75
CA3013 4.12
CA3014 2.36
CA3015 2.62
CA3018 75p
CA3018A 2.00
CA3020 2.00
CA3020A 3.90
CA3021 3.20
CA3022 3.12
CA3026 1.52
CA3028A 1.21
CA3028B 2.53
CA3029 1.44
CA3030A 2.97
CA3033 5.44
CA3034 5.18
CA3035 2.75
CA3036 1.50
CA3039 3.47
CA3041 3.47
CA3042 3.92
CA3043 2.89
CA3046 69p
CA3047 4.80
CA3048 2.99
CA3049 3.21
CA3050 4.11
CA3051 3.80
CA3052 2.92
CA3053 1.00
CA3054 1.66
CA3059 2.80
CA3060 4.09
CA3062 13.84
CA3065E 4.62
CA3068 4.23
CA3070 3.30
CA3071 3.30
CA3075 2.25
CA3076 3.42
CA3078T 2.25
CA3080 1.89
CA3080A 3.95
CA3080E 70p
CA3081 1.90
CA3085 1.35
CA3086 56p
CA3088E 2.35
CA3089E 1.95
CA3090AQ 3.70
CA3130E 87p
CA3130T 1.80
CA3140E 46p
CA3140T 86p
HA1366W 2.40
HA1388 2.40
ICL7106 7.40
ICL7107 9.50
ICL8038 3.20
ICM7555 90p
LC7120 3.20
LC7130 3.20
LF351 47p
LF353 92p
LF355 83p
LF356 92p
LF357 1.09
LF13201 2.99
LF13331 3.30
LF13741H 68p
LF13741N 59p

NEW OPTO DEVICES
To be brought into stock please phone

THERMISTORS
VA1010 40p
VA1026 40p
VA1033 40p
VA1034 40p
VA1035 40p
VA1037 40p
VA1039 40p
VA1040 40p

LM10CH 4.25
LM11CH 4.50
LM114 6.75
LM137K 11.52
LM301AH 1.00
LM301AN 25p
LM305AH 2.90
LM305H 88p
LM307H 1.05
LM307N 55p
LM308AH 3.15
LM308AN 2.14
LM308H 95p
LM308N 88p
LM309K 2.80
LM310H 1.95
LM310N 1.89
LM311H 1.04
LM311N 70p
LM317K 2.80
LM317MP 1.04
LM317T 1.50
LM318H 2.40
LM318N 1.95
LM319H 2.48
LM319N 2.10
LM320 — See 79XX Series Volt. Regulators
LM324N 40p
LM337K 4.75
LM337MP 1.65
LM337T 1.99
LM339AN 1.60
LM339N 51p
LM340 — See 78XX Series Volt. Regulators
LM345K 3.60
LM348N 62p
LM349N 1.16
LM350K 4.60
LM359N 1.44
LM360N 3.88
LM376N 65p
LM377N 1.55
LM378N 3.40
LM379S 6.60
LM380N14 75p
LM380N8 1.50
LM381AN 2.26
LM381N 1.40
LM382N 1.25
LM383T 3.40
LM384N 1.40
LM386N1 88p
LM386N4 1.20
LM388N 1.32
LM391N60 1.70
LM391N80 1.93
LM392N 76p
LM393N 96p
LM394H 3.80
LM396K 13.52
LM709N8 64p
LM709CH 1.00
LM710CH 89p
LM710CN 52p
LM711CH 1.38
LM711CN 70p
LM723CH 1.21
LM723CN 40p
LM725CH 3.30
LM725CN 3.30
LM733CN 77p
LM741CH 96p
LM741CN 15p
LM741CN14 80p
LM747CN 70p
LM748CH 39p
LM748CN 1.30
LM1303N 1.20
LM1304N 2.50
LM1305N 3.10
LM1307N 2.75
LM1310N 1.45
LM1330N 2.25
LM1458 44p
LM1496 1.08
LM1800 3.24
LM1801 3.47
LM1812 8.00
LM1818 2.99
LM1820 2.15
LM1828 4.79
LM1830 2.75
LM1845 4.12
LM1848 2.89
LM1850 2.75
LM1871 4.75
LM1872 4.75
LM1886 7.44
LM1889 3.77
LM2907N 2.75
LM2907N8 2.60
LM2917N 1.90
LM2917N8 1.90
LM3524 6.77
LM3301 1.60
LM3302 96p
LM3401 65p
LM3403 85p
LM3405 1.46
LM3900 48p
LM3905 1.25
LM3909 75p
LM3911 1.20
LM3914 2.00
LM3916 2.20
LM4250CH 2.63
LM4250N 2.39
LM13600 1.25
MB3712 2.36
MB3756 3.80
MB8719 7.95
M53200 8.64
MC1303 = LM1303N
MC1304 = LM1304N
MC1305 = LM1305N
MC1307 = LM1307N
MC1310 = LM1310N
MC1330 = LM1330N
MC1352 1.75
MC1456 1.80
MC1458 = LM1458
MC1466L 6.77
MC1495L 3.75
MC1496 = LM1496
MC3340 1.45
MC3401 = LM3401
MC3403 = LM3403
MC3405 = LM3405
NE531N 1.36
NE543N 2.50
NE544N 1.80
NE555 16p
NE556 45p
NE558 1.43
NE560 3.25
NE562 3.97
NE565 1.18
NE566 1.50
NE567 1.37
NE570 4.22
NE571 4.12
NE5534A 1.25
PLL02A 4.95
PLL03A 12.75
RC4136 65p
S566B 2.50
SAD1024A 12.95
SAS560 1.65
SAS570 1.65
SAS580 2.20
SAS590 2.20
SFF96364 8.28
SL610C 4.00
SL611C 4.00
SL612C 4.00
SL620C 6.00
SL621C 6.00
SL623C 10.00
SL630C 6.00
SL640C 6.00
SL641C 6.00
SN76001N 2.80
SN76008 3.90
SN76018 3.90
SN76003N 2.95
SN76013N 2.95
SN7023N = SN76033N
SN7603N 2.95
SN76110 2.25
SN76115 2.65
SN76116 2.75
SN76226 3.45
SN76228 2.90
SN76477 1.70
SN76530 1.80
SN76550 80p
SN76666 2.90
SO41P 1.60
SO42P 1.60
TA7210 1.62
TA7204 1.95
TA7205 1.20
TA7222 1.60
TA7310 1.60
TAA263 1.50
TAA300 3.95
TAA320 2.05
TAA350 3.60
TAA521 1.60
TAA522 2.47
TAA550 73p
TAA560 2.35
TAA570 2.35
TAA621AX1 2.75
TAA661A 1.50
TAA661B 1.70
TAA700 2.60
TAA930 2.50
TAA930B 2.63
TAA970 2.45
TAA991D 2.45
TAD100 2.00
TBA120AS 75p
TBA331 1.50
TBA341 2.05
TBA395 1.65
TBA396 1.50
TBA450 1.95
TBA460 1.63
TBA500 2.97
TBA500Q 3.11
TBA510 2.95
TBA510Q 3.05
TBA520 2.57
TBA520Q 2.75
TBA530 2.55
TBA530Q 2.76
TBA540 2.72
TBA540Q 2.74
TBA550 3.25
TBA550Q 3.27
TBA560C 2.87
TBA570 2.37
TBA570Q 2.48
TBA581 3.11
TBA641 3.00
TBA651 1.90
TBA673 4.15
TBA700 2.38
TBA700Q 2.47
TBA720AQ 2.60
TBA750 2.25
TBA750Q 2.46
TBA790A 2.11
TBA800 78p
TBA810 95p
TBA810P 95p
TBA820M 75p
TBA920 2.70
TBA920Q 2.82
TBA950 2.95
TBA990 2.65
TBA990Q 2.74
TCA105 3.00
TCA160C 2.87
TCA220 3.44
TCA270 2.44
TCA440 2.20
TCA450 2.65
TCA640 4.15
TCA650 4.15
TCA660B 4.15
TCA730 4.80
TCA740 4.80
TCA750 4.85
TCA760 2.85
TCA800 3.50
TCA800Q 3.60
TCA830S 1.90
TCA910 2.00
TCA940 1.70
TDA1002 3.00
TDA1003 3.60
TDA1004 2.87
TDA1005 3.60
TDA1010A 2.25
TDA1022 5.20
TDA1024 1.00
TDA1034 3.20
TDA2020 3.20
TDA2030 3.20
TDA2522 4.20
TDA2530 3.30
TDA2540 4.10
TDA2541 4.10
TDA2560 4.10
TDA2571 4.40
TDA2581 3.75
TDA2590 5.20
TDA2591 4.73
TDA2600 6.15
TDA2610 3.90
TDA2611A 2.50
TDA2640 3.64
TDA3000 2.76
TL061 40p
TL062 60p
TL064 1.10
TL071 36p
TL072 50p
TL074 1.30
TL081 30p
TL082 75p
TL083 85p
TL084 1.10
TL170 50p
TL430 70p
UAA170 1.97
UAA180 1.97
ULN2003 1.00
UPC575C2 2.65
UPC1156 2.75
XR2206 2.92
ZN414 86p
ZN419 2.25
ZN1034 2.00
ZN1040 6.96
ZTK22 89p
ZTK33 89p

TTL
7400 11p
7401 11p
7402 11p
7403 12p
7404 12p
7405 15p
7406 20p
7407 20p
7408 14p
7409 15p
7410 14p
7411 16p
7412 20p
7413 18p
7414 26p
7416 24p
7417 22p
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7422 20p
7423 20p
7425 26p
7426 24p
7427 25p
7428 28p
7430 15p
7432 22p
7433 25p
7437 26p
7438 26p
7440 15p
7441 60p
7442 32p
7443 90p
7444 90p
7445 50p
7446 60p
7447 60p
7448 44p
7450 15p
7451 15p
7453 15p
7454 14p
7460 15p
7470 34p
7472 26p
7473 25p
7474 20p
7475 28p
7476 28p
7480 49p
7481 1.08
7482 68p
7483 40p
7484 79p
7485 60p
7486 20p
7489 2.20
7490 26p
7491 35p
7492 35p
7493 26p
7494 36p
7495 36p
7496 39p
7497 90p
74100 80p
74104 54p
74105 56p
74107 22p
74109 26p
74110 40p
74111 70p
74116 80p
74118 65p
74119 89p
74120 80p
74121 25p
74122 40p
74123 40p
74125 36p
74126 36p
74128 40p
74132 38p
74136 30p
74141 55p
74142 1.99
74143 2.48
74144 2.48
74145 50p
74147 1.28
74148 1.00
74150 60p
74151 40p
74153 40p
74154 49p
74155 40p
74156 49p
74157 30p
74159 75p
74160 60p
74161 49p
74162 49p
74163 49p
74164 49p
74165 49p
74166 69p
74170 1.25
74172 2.90
74173 60p
74174 55p
74175 50p
74176 40p
74177 45p
74178 80p
74180 40p
74181 80p
74182 40p
74184 90p
74185 90p
74186 4.99
74188 2.50
74190 48p
74191 48p
74192 48p
74193 48p
74194 50p
74195 48p
74196 63p
74197 48p
74198 85p
74199 85p
74221 55p

74LS TTL
74LS00 11p
74LS01 11p
74LS02 11p
74LS03 12p
74LS04 14p
74LS05 12p
74LS08 12p
74LS10 12p
74LS11 15p
74LS12 15p
74LS13 18p
74LS14 36p
74LS15 15p
74LS20 13p
74LS21 15p
74LS22 15p
74LS27 15p
74LS28 22p
74LS30 15p
74LS32 13p
74LS33 16p
74LS37 16p
74LS38 16p
74LS40 25p
74LS42 30p
74LS47 40p
74LS51 16p
74LS54 14p
74LS55 14p
74LS73 20p
74LS74 20p
74LS75 20p
74LS76 20p
74LS78 20p
74LS80 1.20
74LS83 40p
74LS85 65p
74LS86 20p
74LS90 27p
74LS92 33p
74LS93 30p
74LS95 38p
74LS96 96p
74LS107 45p
74LS109 29p
74LS112 28p
74LS113 23p
74LS114 23p
74LS122 36p
74LS123 36p
74LS124 99p
74LS125 29p
74LS126 29p
74LS132 43p
74LS136 29p
74LS138 32p
74LS139 36p
74LS145 75p
74LS147 1.57
74LS148 75p
74LS151 39p
74LS153 39p
74LS154 90p
74LS155 40p
74LS156 40p
74LS157 27p
74LS158 29p
74LS160 38p
74LS161 36p
74LS162 36p
74LS163 36p
74LS164 39p
74LS165 59p
74LS166 86p
74LS168 2.42
74LS169 76p
74LS170 69p
74LS173 46p
74LS174 50p
74LS175 99p
74LS181 1.79
74LS183 48p
74LS190 48p
74LS191 51p
74LS192 47p
74LS193 36p
74LS194 45p
74LS195 36p
74LS196 64p
74LS197 59p
74LS221 66p
74LS240 66p
74LS241 80p
74LS242 80p
74LS243 64p
74LS244 85p
74LS245 54p
74LS247 65p
74LS248 59p
74LS249 40p
74LS251 36p
74LS253 36p
74LS257 36p
74LS258 59p
74LS259 1.49
74LS261 24p
74LS266 68p
74LS273 1.19
74LS275 47p
74LS279 1.86
74LS280
74LS283 45p
74LS289 4.70
74LS290 46p
74LS293 45p
74LS295 89p
74LS298 89p
74LS299 2.66
74LS323 1.78
74LS324 1.46
74LS325 2.96
74LS326 2.38
74LS327 2.39
74LS347 99p
74LS348 1.45
74LS352 79p
74LS353 79p
74LS362 7.50
74LS365 29p
74LS366 29p
74LS367 29p
74LS368 29p
74LS373 59p
74LS374 58p
74LS378 58p
74LS386 33p
74LS390 52p
74LS393 60p
74LS395 89p
74LS396 1.90
74LS398 2.70
74LS399 1.59
74LS445 99p
74LS490 2.40
74LS540 77p
74LS541 99p
74LS640 1.69
74LS641 1.69
74LS643 2.25
74LS644 2.75
74LS668 1.19
74LS669 1.50
74LS670 1.65
74LS673 5.50
74LS674 7.50

74S TTL
74S00 60p
74S02 60p
74S04 60p
74S08 75p
74S20 60p
74S30 60p
74S32 1.00
74S40 1.45
74S64 60p
74S65 1.45
74S74 1.00
74S85 3.25
74S86 2.05
74S112 90p
74S113 1.00
74S124 3.50
74S132 1.80
74S133 1.00
74S138 2.35
74S139 2.35
74S140 2.50
74S153 7.95
74S157 2.75
74S163 3.00
74S174 2.60
74S175 3.20
74S188 3.50
74S189 3.50
74S194 3.50
74S200 4.75
74S201 4.00
74S225 5.60
74S261 3.00
74S262 10.00
74S287 3.71
74S288 3.71
74S289 2.81
74S301 3.99
74S470 6.75
74S471 6.75
74S473 12.50
74S474 4.25
74S475 13.10
74S571 9.00
74S573 9.00

74H TTL
74H00 1.45
74H01 1.45
74H04 1.55
74H05 1.55
74H10 1.45
74H11 1.45
74H20 1.45
74H21 1.45
74H30 1.45
74H40 1.65
74H51 1.75
74H53 1.65
74H54 1.45
74H55 1.40
74H60 1.70
74H62 1.75

[illegible]

74C CMOS/TTL
74C00 27p
74C04 29p
74C10 28p
74C14 89p
74C20 28p
74C30 36p
74C42 96p
74C48 1.40
74C73 54p
74C76 57p
74C83 1.74
74C85 1.34
74C86 1.10
74C89 5.95
74C90 1.05
74C93 1.44
74C95 1.00
74C107 1.20
74C151 2.55
74C154 4.95
74C157 2.20
74C160 1.54
74C161 1.15
74C162 1.16
74C163 1.15
74C164 1.15
74C165 2.00
74C173 98p
74C174 1.22
74C175 1.00
74C192 1.15
74C193 1.13
74C194 1.20
74C195 1.00
74C200 10.00
74C221 1.20
74C901 1.91
74C902 71p
74C903 2.30
74C904 1.84
74C905 10.88
74C907 1.91
74C908 1.87
74C911 9.59
74C912 8.00
74C914 2.88
74C915 1.99
74C918 2.50
74C920D 8.50
74C922 4.50
74C923 5.00
74C925 6.00
74C926 6.58
74C928 6.00
74C929 5.20
74C930J 7.80
74C932 3.12

40 CMOS
4000 10p
4001 11p
4002 11p
4006 49p
4007 15p
4008 49p
4009 25p
4010 25p
4011 11p
4012 15p
4013 30p
4014 50p
4015 58p
4016 20p
4017 39p
4018 46p
4019 26p
4020 44p
4021 48p
4022 48p
4023 15p
4024 32p
4025 15p
4026 79p
4027 24p
4028 49p
4029 56p
4030 75p
4031 1.19
4032 1.60
4033 1.20
4034 1.55
4035 59p
4036 2.49
4037 1.30
4038 99p
4039 2.90
4040 46p
4041 59p
4042 46p
4043 46p
4044 41p
4045 1.20
4046 56p
4047 58p
4048 40p
4049 25p
4050 23p
4051 44p
4052 49p
4053 49p
4054 88p
4055 89p
4056 89p
4059 4.80
4060 57p
4063 85p
4066 34p
4067 2.49
4068 17p
4069 16p
4070 17p
4071 17p
4072 17p
4073 16p
4075 16p
4076 46p
4077 17p
4078 17p
4081 17p
4082 16p
4085 65p
4086 72p
4089 1.50
4093 27p
4094 97p
4095 90p
4096 90p
4097 3.20
4098 87p
4099 90p
For higher numbers in 40 Series, substitute 74C for 40 prefix. eg 40107 = 74C107

45 CMOS
4502 59p
4503 50p
4507 39p
4508 1.19
4510 49p
4511 48p
4512 49p
4514 1.17
4515 1.17
4516 89p
4518 47p
4519 43p
4520 56p
4521 1.17
4526 63p
4527 79p
4528 59p
4532 79p
4534 4.29
4536 2.98
4538 99p
4539 99p
4543 89p

[illegible]

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74S288 2.50

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ADC0817 10.06
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MC4044 3.25
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MM67161 9.00
MM58174 11.80
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RO2513UC 7.50
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SAA5010 7.10
SAA5012 7.10
SAA5020 5.50
SAA5030 10.00
SAA5040 15.00
SAA5041 15.00
SAA5050 8.50
SAA5052 8.50
TMS6011 3.65
ULN2003A 99p
8T26 1.35
8T28 1.35
8T95 1.35
8T97 1.35
81LS95 90p
81LS96 1.20
81LS97 90p
81LS98 1.20
6522 4.70
6532 6.95
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6845 10.00
6847 10.00
6850 1.40
6852 2.49
6875 5.98
8131 3.75
8154 9.42
8155 8.00
8212 1.80
8216 1.50
8223 1.80
8224 2.50
8226 2.50
8228 2.50
8238 5.75
8243 4.68
8250 8.65
8251 3.39
8253 7.95
8254 10.00
8255 2.90
8257 8.00
8259 8.00
8279 9.46
8304 4.50
8544 1.50
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8678CABN 19.50
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8833 2.35
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9601 5.50
9602 2.50
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Z80ADART 8.00
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Z80APIO 3.39
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ZN426E8 3.39
ZN427E8 6.38
ZN428E8 4.87

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78L05A 30p
78L12A 30p
78L15A 30p
78L24A 30p
100mA To5
78L05CH 80p
78L12CH 80p
78L15CH 80p
78L24CH 80p
500mA T0202
7805M 47p
7812M 47p
7815M 47p
7824M 47p
1 Amp T0220
7805T 50p
7812T 50p
7815T 50p
7824T 50p
1.5 Amp T03
7805K 1.40
7812K 1.40
7815K 1.40
7824K 1.40
Negative
100mA T092
79L05 70p
79L12 70p
79L15 70p
500mA T0202
7905M 55p
7912M 55p
7915M 55p
7924M 55p
1 Amp T0220
7905T 60p
7912T 60p
7915T 60p
7924T 60p
1.5 Amp T03
7905K 2.20
7912K 2.20
7915K 2.69
7924K 2.69
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L200 (2A Pos) 2.50
LM137K 12.00
LM309K 1.50
LM317K 3.42
LM317MP 1.64
LM317T 2.00
LM337K 4.80
LM337MP 1.73
LM337T 2.25
LM345K 3.60
LM350K 4.50
LM396K 13.52

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4.00MHz 3.00
4.194304MHz 3.00
4.433619MHz 1.45
5.00MHz 3.50
6.00MHz 2.76
6.9375MHz 3.50
8.00MHz 2.75
10.00MHz 2.75
18.00MHz 2.75
20.00MHz 3.25
27.648MHz 2.60
48.00MHz 3.00
100.00MHz 5.50
5.5 MHz Ceramic filter 90p

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DY86/87/802 1.32
ECC82 1.22
ECC83 1.22
ECC84 1.22
EF86 1.80
EL34 2.89
EL84 2.50
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KT88 12.50
PC900 1.76
PCC84 3.00
PCC85 3.40
PCC89 1.89
PCF86 2.30
PCF201 3.00
PCF801 2.57
PCF802 2.11
PCL82 1.80
PCL85 2.20
PCL86 2.10
PCL805 2.20
PD510 4.95
PFL200 2.99
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PL508 2.36
PL509 4.75
PL802 4.17
PY88 1.62
PY500A 2.63
6L6 2.59

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¼" Stereo 25p
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3½mm Mono 15p
Line
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¼" Stereo 30p
¼" Stereo Metal 40p
3½mm Mono 15p
3½mm Mono Line 20p

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Plug 25p
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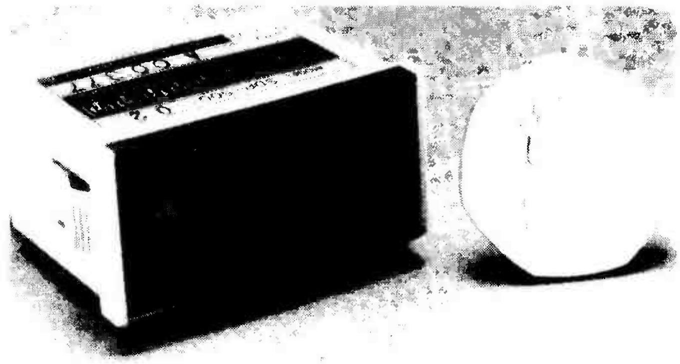
3½ DIGIT LCD MULTIMETER
2 amps AC DC 1KV (DC) 750V (AC) Incredible at £34.50 (SAE brings specs)

DIGEST

Beeb's Loss of Memory

If you're stuck in the waiting list for a BBC Microcomputer, we've done some simple arithmetic that may persuade you to cancel your order and choose an alternative. One of the major selling points of the Beeb machine has always been the high resolution graphics, but it isn't until you let high-res loose on your memory that you find out the snag. For example, the Model A is advertised as being a 16K machine. In fact it's only 16K if it's turned off. As soon as you switch on, the operating system automatically reserves 3328 bytes as its workspace, and a further 1K goes to the memory-mapped screen if you're in mode 7 (40 x 25 teletext). In any other graphics mode you lose a whopping 8-10K, so a '16K' machine actually has a maximum of 11.75K of user memory for programs, and a minimum of 2.75K! In the '32K' Model B, the screen can steal up to 20K in highest-res graphics mode, giving 27.75K maximum, 8.75K minimum. These figures have been available since the specs were published over a year ago, but how many people have actually put two and two together and come up with 2.75? Not many, we suspect. The most charitable comment we can make is that there could be a lot of disappointed customers when deliveries are finally made. On the other hand, you do get one of the best BASIC interpreters around—but stick to mode 7 if you want enough memory to use it properly.



SDP Shrinks Drastically

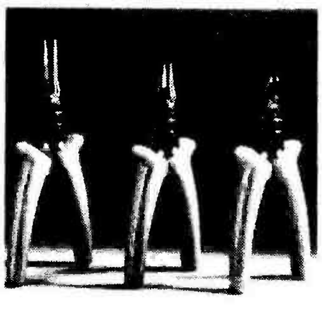
Hot on the heels of the BICC-Vero Speedwire prototyping system, reviewed exclusively in the June ETI, comes the SDP-500 range of digital panel meters. The SDP range (do we detect political overtones?) is into miniaturisation in a big way, if that's not a contradiction — they measure only 48 x 24 x 48 mm. Packed into this tiny case we have the latest LSI dual-integration A-to-D technology for high stability and excellent noise rejection (40dB at 50 Hz), bright 9.2 mm LED display with anti-glare filter, externally programmable decimal points and external hold. The eight models cover DC voltage or current measurement from ± 199.9 mV to ± 199.9 V and ± 199.9 uA to ± 199.9 mA. The supply is 5 V at 100 mA maximum. For a comprehensive application guide contact Verospeed, Stansted Road, Boyatt Wood, Eastleigh, Hants SO5 4ZY.

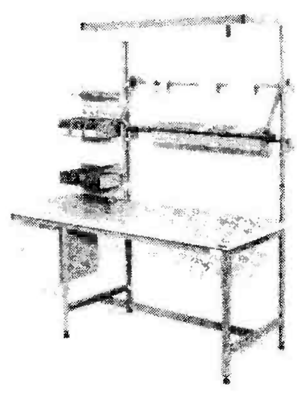
Plug-in Power

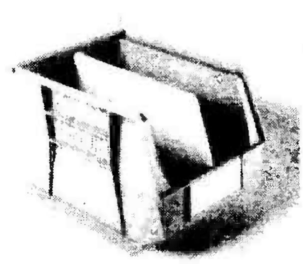
These smart cases have been added to the West Hyde range and are designed to house power supplies for low-voltage equipment such as calculators, radios and TV games. Two sizes are available, both able to accommodate PSU components including the transformer, and the case may be plugged directly into a 13 A socket. You can have any colour so long as it's black or white, and the case is moulded in impact-resistant ABS. More details from West Hyde Developments Ltd, Unit 9, Park Street Industrial Estate, Aylesbury, Bucks, HP20 1ET.

Cut With Comfort

Now hands that do cutting can feel soft as your face...with these self-opening, cushion-grip hand tools. The three tools each weigh about 80 grams and comprise an angle side cutter, short fine nosed and long fine nosed pliers. Each tool costs £2.90 plus 45p P&P and VAT, and is available by mail order from Electronic Hobbies Ltd, 17 Roxwell Road, Chelmsford, Essex, CM1 2LY.





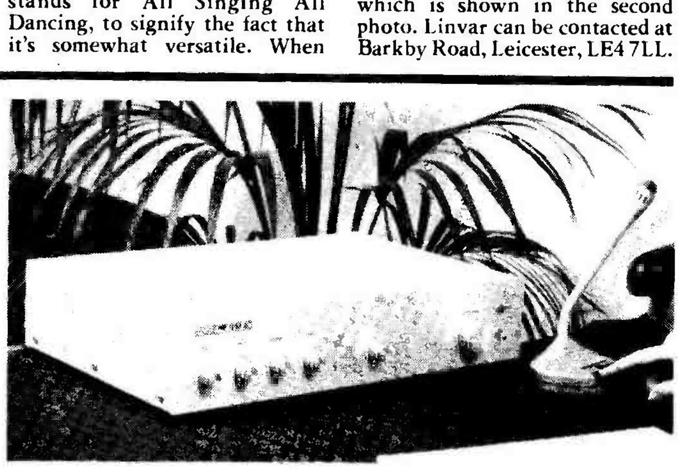


That's Entertainment?

It seems there's at least one jolly wag at Linvar Ltd; they've sent us details of the ASAD Work Centre. ASAD? — well, that stands for All Singing All Dancing, to signify the fact that it's somewhat versatile. When assembled the Work Centre is 5' by 2'6", but it can be packed up into its tailor-made carton for storage. The total cost is £89.90. Drawers, cupboards, shelves and a host of other accessories are available, including a paper cutting unit. This features in the Linvar Packing Bench, built from ASAD components. This more specialised work centre is designed to be the basis of a cost-effective packing department. Another aspect of Linvar's involvement in small parts storage is the 'Linbin' range of polypropylene containers, one of which is shown in the second photo. Linvar can be contacted at Barkby Road, Leicester, LE4 7LL.

Flock Of Eagles

Eagle International, the industrial electronics company, have introduced three new professional public address mixer/amplifiers. These are the TPM 40, TPM 80 and TPM 120 models which offer — surprise, surprise — 40, 80 and 120 W RMS output power. All three are suitable for both four-eight ohm or 100 V line speaker systems. General spec is 30 Hz-15 kHz frequency response, priority paging over background music, master volume controls etc, and two year guarantee. Individually, the TPM 40 has battery backup for mains failure, three mike and two auxiliary inputs, plus a tone control; the TPM 80 is mains-only with a tone control, four mike, one record deck and two auxiliary inputs; and the TPM 120 has the same inputs as the 80 but with independent bass and treble controls and more versatile input controls. Further information from Eagle International, Precision Centre, Heather Park Drive, Wembley, Middlesex HA0 1SU.



Rapid Electronics

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Essex CO4 5RD

BARCLAYCARD VISA · Access

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20 metre pack single core connecting cable ten different colours 65p

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0-50mA	0-25V
0-100mA	0-30V DC

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Cermet precision multiturn, 0.75W ¾in 100 ohms to 100K 88p each

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5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	12p	13p	4mm	18p	17p

UHF (CB) Connectors
PL250 Plug 40p Reducer 14p
SO239 square chassis skt 38p
SO239S round chassis socket 40p
IEC 3 pin 250V/6A

Plug chassis mounting	38p
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6A 400V	95
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Polyester. Radial leads. 250V. C280 type.
0.01, 0.015, 0.022, 0.033 6p; 0.047, 0.068, 0.1 7p; 0.15, 0.22 9p; 0.33, 0.47 13p; 0.68, 20p; 1u 23p
Electrolytic. Radial or axial leads.
0.47/63V, 1/63V, 2.2/63V, 4.7/63V, 10/25V 7p; 22/25V, 47/25V 8p; 100/25V 9p; 220/25V 14p; 470/25V 22p; 1000/25V 30p; 2200/25V 50p.
Tag end Power Supply Electrolytics.
2200/40V 110p; 4700/40V 160p; 2200/63V 140p; 4700/63V 230p
Polyester. Miniature Siemens PCB
1n, 2n2, 3n3, 4n7, 6n6, 10n, 15n 7p; 22n, 33n, 47n, 68n 8p; 100n 9p; 150n 11p; 220n 13p; 330n 20p; 470n 26p; 680n 29p; 1u 33p; 2u2 50p
Tantalum bead
0.1, 0.22, 0.33, 0.47, 1.0 @ 35V 12p; 2.2, 4.7, 10 @ 25V 20p; 15/16V 30p; 22/16V 27p; 33/16V 45p; 47/6V 27p; 47/16V 70p; 68/6V 40p; 100/10V 90p
Ceramic disc. 22p-0.01u 50V 3p each
Mullard miniature ceramic plate
1.8pF to 100pF 6p each
Polystyrene. 5% tolerance
10p-1000p 6p; 1500-4700p 8p; 6800-0.012u 10p
Trimmers. Mullard 808 Series
2-10pF 22p; 2-22pF 30p; 5.5-65pF 35p

DIODES

BY127	12	★1N4001	3
OA47	10	1N4002	5
OA90	8	1N4006	7
OA91	7	1N4007	7
OA200	8	1N5401	15
OA202	8	1N5404	16
1N914	4	1N5406	17
★1N4148	2	400mW zen	6

BZX61 Series zeners 1.3W 4V7-39V 15p each

SOLDERING IRONS

Antex CS 17W Soldering iron	450p
2.3 and 4.7mm bits to suit	65p
CS 17W element	210p
Antex XS 25W Soldering iron	480p
3.3mm and 4.7mm bits to suit	65p
Solder pump desoldering tool	480p
Spare nozzle for above	70p
10 metres 22swg solder	100p
Soldering iron stand for above	190p

REGULATORS

78L05	25	79L05	65
78L12	25	79L12	65
78L15	25	79L15	65
7805	40	7095	45
7812	40	7912	45
7815	40	7915	55
LM309K	130	LM723	40
LM317K	350	LM338K	475
LM317T	120	78H05	
LM323K	350	5A 5V	550

SWITCHES

Submin toggle
SPST 55p SPDT 60p ★DPDT 50p
Miniature toggle
SPDT 80p SPDT centre off 90p DPDT 90p DPDT centre off 100p
Standard toggle SPST 35p DPDT 48p
★Miniature DPDT slide 12p
★Push to make 12p Push to break 22p
Rotary type adjustable stop 1P12W 2P6W 3P4W all 55p each
DIL switches
4 SPST 80p 6 SPST 80p 8 SPST 100p

SOCKETS

	Low profile	Wire-wrap
★8 pin	7p	25p
★14 pin	9p	35p
★16 pin	10p	42p
18 pin	15p	52p
20 pin	18p	60p
22 pin	20p	70p
24 pin	22p	70p
28 pin	26p	80p
40 pin	32p	98p
Soldercon pins		60p/100

RESISTORS

¼W 5% Carbon film E12 series 4.7Ω-10M 1p each
½W 5% Carbon film E12 series 4.7Ω to 4M7 2p each
¼W 1% Metal film E24 series 10Ω-1M 6p each

OPTO

★3mm red	8	★5mm red	8
★3mm green	12	★5mm green	12
★3mm yellow	12	★5mm yellow	12

Clips to suit 3p each

★red	12	TIL32	40
green	17	TIL78	40
yellow	17	TIL111	60
TIL38	40	ORP12	85
2N5777	45	TIL100	90
		Dual color	60

Seven segment displays

Com cathode		Com anode	
DL704 0.3"	95	DL707 0.3"	95
★FND500 0.5"	80	FND507 0.5"	90
DL704	80	TIL312 0.3"	105
TIL313 0.3"	105	TIL321 0.5"	115
TIL322 0.5"	115		

LCD: 3½ digit 580p 4 digit 620p

TRANSFORMERS

Please add carriage charges to our normal post charges

Miniature mains
606V, 909V, 12012V all @ 100mA 100p each
PCB mounting. Miniature
3VA 0-6, 0-6 @ 0.25A; 0-9, 0-9 @ 0.15A; 0-12, 0-12 @ 0.12A 200p each
6VA 0-6, 0-6 @ 0.5A; 0-9, 0-9 @ 0.4A; 0-12, 0-12 @ 0.25A 270p each
High quality. Split bobbin construction
6VA 0-6, 0-6 @ 0.5A; 0-9, 0-9 @ 0.4A; 0-12, 0-12V @ 0.3A 220p each
12VA 0-6, 0-6 @ 1A; 0-9, 0-9 @ 0.8A, 0-12, 0-12 @ 0.5A; 0-15, 0-15 @ 0.4A 295p (plus 40p carriage)
25VA 0-6, 0-6 @ 1.5A; 0-9 @ 1.2A; 0-12, 0-12 @ 1A; 0-15, 0-15 @ 0.8A 330p each (plus 60p carriage)
50VA 0-12, 0-12 @ 2A, 0-15, 0-15 @ 1.5A 440p each (plus 75p carriage)

VERO

★ Verobloc 350p ★

Size 0.1 matrix

2.5 × 1	22p
2.5 × 3.75	75p
2.5 × 5	85p
3.75 × 5	95p
VQ board	160p
Veropins per 100	
Single sided	50p
Double sided	60p
Spot face cutter	105p
Pin insertion tool	162p

COMPONENT KITS

An ideal opportunity for the beginner or the experienced constructor to obtain a wide range of components at greatly reduced prices.
¼W 5% Resistor kit. Contains 10 of each value from 4.7Ω to 1M (650 resistors) 480p
Ceramic Capacity Kit. Contains 5 of each value from 22p to 0.01u (135 caps) 370p
Polyester Capacitor Kit. Contains 5 of each value from 0.01 to 1uF (65 caps) 575p each
Preset Kit. Contains 5 of each value from 100 ohms to 1M (total 65 presets) 425p each
Nut and Bolt Kit. Total 300 items 180p
25 6BA ¼" bolts
25 6BA ½" bolts
50 6BA nuts
50 6BA washers
25 4BA ¼" bolts
25 6BA ½" bolts
50 6BA nuts
50 6BA washers

VERO WIRING PEN

Pen + spool	310p	Pin Insertion Tool	162p
Spare spool	75p		
Combs	6p		

ORDERING INFO

All prices exclude VAT. Please add to total order.
Please add 50p carriage to all orders under £10 in value. Send cheque/PO or Access/Visa number with your order. Please note new address. Callers most welcome – we are just 10 minutes from the centre of Colchester. Telephone orders welcome with Access and Visa. Official orders welcome from colleges and schools etc. Export orders no VAT but please add carriage. All components brand new and full spec.

TRANSISTORS

				BC548	10	BFR80	25	TIP29C	60	ZTX300	14	★2N3702	6
				BC549	10	BFX29	25	TIP30A	45	ZTX301	16	2N3703	9
AC125	35	BC157	10	BC558	10	BFX84	25	TIP30B	50	ZTX302	15	★2N3704	6
AC126	25	BC158	10	BCY70	18	BFX85	25	TIP30C	60	ZTX304	17	2N3705	9
AC127	25	BC159	8	BCY71	18	BFX86	28	TIP31A	45	ZTX341	30	2N3706	9
★AC128	20	BC160	45	BCY72	18	BFX87	25	TIP31C	55	ZTX500	15	2N3707	10
AC176	25	BC168C	10	BD115	80	BFX88	25	TIP32A	45	ZTX501	15	2N3708	10
AC187	22	BC169C	10	BD131	35	BFY50	23	TIP32C	60	ZTX502	15	2N3709	10
AC188	22	BC170	8	BD132	35	BFY51	23	TIP33A	50	ZTX503	18	2N3772	190
AD142	120	BC171	10	BD133	50	BFY52	23	TIP33C	75	ZTX504	25	2N3773	210
AD149	80	BC172	8	BD135	50	BFY53	32	TIP34A	60	2N697	20	★2N3819	18
AD161	40	BC177	18	BD136	30	BFY55	32	TIP34C	85	2N698	40	2N3820	40
AD162	40	BC178	18	BD137	30	BFY56	32	TIP35A	160	2N706A	20	2N3823	65
AF124	60	BC179	18	BD138	30	BRY39	40	TIP35C	180	2N708	20	2N3866	90
AF126	50	BC182	10	BD139	35	BSX20	20	TIP36A	170	2N918	35	2N3903	10
AF139	40	★BC182L	8	BD140	35	BSX29	35	TIP36C	195	2N1132	22	2N3904	10
AF186	70	BC183	10	BD204	110	BSY95A	25	TIP41A	60	2N1613	30	2N3905	6
AF239	75	BC183L	10	BD206	110	BU205	160	TIP42A	60	2N2218A	45	2N3906	10
BC107	10	BC184	10	BD222	85	BU206	200	TIP120	90	2N2219A	25	2N4037	45
BC107B	12	★BC184L	7	BF180	35	BU208	170	TIP121	90	2N2221A	25	2N4058	10
★BC108	9	BC212	10	BF182	35	MJ2955	99	TIP122	90	2N2222A	20	2N4060	10
BC108B	12	BC212L	10	BF184	25	MJE340	50	TIP141	120	2N2368	25	2N4061	10
BC108C	12	BC213	10	BF185	25	MJE520	65	TIP142	120	2N2369	16	2N4062	10
★BC109	9	BC213L	10	BF194	12	MJE521	95	TIP147	120	2N2484	25	2N5457	36
BC109C	12	BC214	10	BF195	12	MJE3055	70	TIP2955	60	★2N2646	45	2N5458	36
BC114	22	★BC214L	8	BF196	12	MPF102	40	TIP3055	55	2N2904	20	2N5459	30
BC115	22	BC237	8	BF197	12	MPF104	40	TIS43	40	2N2904A	20	2N5485	36
BC117	22	BC238	14	BF198	10	MPSA05	22	TIS44	45	2N2905	22	2N5777	45
BC1119	35	BC308	15	BF199	18	MPSA06	25	TIS45	45	2N2905A	22	2N6027	30
BC137	40	BC327	14	BF200	30	MPSA12	30	TIS90	30	2N2906	25	40360	40
BC139	40	BC328	14	★BF244B	22	MPSA55	30	TIS91	30	2N2906A	25	40361	50
BC140	30	BC337	14	BF245	30	MPSA56	30	★VN10KM	45	2N2907	25	40362	50
BC141	30	BC338	14	BF256B	45	MPSU05	55	VN46AF	75	2N2907A	25	40408	70
BC142	25	BC477	30	BF257	32	MPSU06	55	VN66AF	85	2N2926	9		
BC143	25	BC478	30	BF258	25	MPSU55	60	VN88AF	95	2N3053	23		
BC147	8	BC479	30	BF259	35	MPSU56	60	★ZTX107	8	2N3054	55		
BC148	8	BC517	40	BF337	40	TIP29A	40	★ZTX108	8	2N3055	50		
BC149	9	BC547	7	BFR40	23	TIP29B	55	ZTX109	12	2N3442	120		

LINEAR

										TL064	96
		ICL7106	790	LM358	50	LM3914	200	NE567	100	TL071	30
		ICL7611	95	LM377	150	LM3915	220	NE570	400	TL072	50
★555CMOS	80	ICL7621	180	★LM380	65	LM13600	120	NE571	400	TL074	95
★556CMOS	150	ICL7622	180	LM381	120	MC1310	150	★RC4136	68	★TL081	25
709	25	ICL8038	320	LM382	130	MC1496	68	★RC4558	60	★TL082	45
★741	14	ICL8211A	200	LM384	130	ML922	400	SL480	170	★TL084	95
748	35	ICM7224	785	LM386	65	ML924	195	SL490	250	TL170	50
9400CJ	350	ICM7555	80	LM387	120	ML925	210	SL76018	150	★UA2240	120
AY-3-1270	840	LF351	45	LM393	100	ML926	140	SN76477	250	ULN2003	86
AY-3-8910	600	LF353	85	LM709	25	ML927	140	SP8629	250	ULN2004	90
AY-3-8912	625	LF356	90	LM711	60	ML928	140	TBA120S	70	★XR2206	300
CA3046	60	LM10	360	LM725	350	ML929	140	TBA800	80	ZN414	100
CA3080	65	LM301A	25	LM733	75	MM5387A	465	TBA810	96	ZN423	136
CA3089	215	LM311	70	LM741	14	NE529	225	TBA820	80	ZN424	136
CA3090AQ	375	LM318	120	LM747	75	NE531	150	TBA950	290	ZN425E	360
CA3130E	90	LM324	40	LM1458	40	NE544	205	TDA1008	320	ZN426E	330
★CA3140E	45	LM334Z	100	LM2917	200	★NE555	16	★TDA1022	525	ZN427E	650
CA3161E	100	LM335Z	125	LM3900	50	★NE556	45	TDA1024	125	ZN428E	480
CA3189	230	LM339	50	★LM3909	70	NE565	120	TL061	40	ZN459	285
★CA3240E	110	LM348	65	LM3911	120	NE566	150	TL062	60	ZN1034E	200

CMOS

		★4017	38	4036	275	4055	95	4082	16	4502	60	4529	150
		4018	45	4039	290	4059	480	4085	65	4503	40	4532	80
4000	10	4019	25	4040	50	4060	65	4086	50	4507	38	4534	485
★4001	10	4020	50	4041	60	4063	85	4089	125	4508	150	4538	110
4002	12	4021	50	4042	45	★4066	30	★4093	30	4510	50	4563	100
4006	50	4022	50	4043	50	4067	295	4094	120	★4511	50	4549	360
4007	15	4023	15	4044	50	4068	16	4095	75	4512	50	4553	275
4008	48	4024	33	★4046	60	4069	16	4097	290	4514	120	4555	35
4009	24	4025	24	4047	50	4070	15	4098	75	4515	120	4556	35
4010	24	★4026	80	4048	40	4071	15	4099	90	4516	65	4559	390
★4011	11	4027	24	★4049	25	4072	15	40106	50	★4518	40	4560	175
4012	15	4028	50	★4050	25	4073	15	40109	110	4520	70	4584	45
★4013	25	4029	60	4051	45	4075	15	40163	100	4521	130	4585	80
4014	50	4030	30	4052	60	4076	50	40173	100	4526	70	4724	140
4015	50	4031	125	4053	50	4077	18	40175	100	4527	80		
4016	20	4034	140	4054	95	4081	14	40193	95	4528	70		

LS TTL

		LS21	12	LS76	18	LS125	26	LS161	37	LS221	54	LS365	30
		LS22	12	LS78	18	LS126	25	LS162	37	LS240	69	LS366	30
★LS00	11	LS26	14	LS83	40	LS132	42	LS163	37	LS241	69	LS367	30
LS01	11	LS27	12	LS85	52	LS136	26	LS164	43	LS242	75	LS368	35
LS02	11	LS30	12	LS86	19	★LS138	32	LS165	75	LS243	75	★LS373	65
LS03	12	LS32	12	★LS90	28	★LS139	32	LS166	75	★LS244	60	LS374	65
LS04	12	LS37	15	LS92	32	LS145	70	LS170	85	★LS245	70	LS375	45
LS05	13	LS38	15	★LS93	28	LS147	150	LS173	65	LS247	50	LS377	70
LS08	12	LS40	13	LS95	40	LS148	85	LS174	45	LS251	35	LS378	60
LS09	12	★LS42	32	LS96	95	LS151	38	LS175	45	LS257	35	LS390	55
LS10	12	★LS47	38	LS107	40	LS153	40	LS190	45	LS258	35	LS393	55
LS11	12	LS48	45	LS109	21	LS154	90	LS191	45	LS259	75	LS399	175
LS12	12	LS51	14	LS112	21	LS155	35	LS192	45	LS266	22	LS541	120
★LS13	22	LS55	14	LS113	23	LS156	36	LS193	45	LS273	68	LS670	150
LS14	38	LS73	18	LS114	22	★LS157	30	LS195	36	★LS279	35		
LS15	12	★LS74	18	LS122	38	LS158	30	LS196	50	LS283	40		
LS20	12	LS75	22	LS123	38	LS160	37	LS197	60	LS353	88		

TTL

		7413	18	7442	32	7480	48	74107	25	74155	40	74177	46
		7414	28	7444	90	7482	65	74109	25	74156	40	74179	80
★7400	11	7416	24	7446	65	7483	40	★74121	25	74157	40	74180	40
7401	11	7417	24	7447	40	7485	60	74122	40	74160	60	74181	115
7402	11	7420	15	7448	45	7486	20	74123	40	74161	50	74182	60
7403	12	7421	20	7450	16	7489	180	74125	35	74162	50	74190	50
7404	13	7422	20	7451	16	★7490	21	74126	36	74163	50	74191	50
7405	15	7427	22	7453	16	7491	45	74132	30	74164	50	74192	50
7406	24	7428	28	7454	16	7492	25	74141	60	74165	50	74193	45
7407	25	7430	14	7460	16	★7493	25	74145	60	74167	150	74194	50
7408	14	7432	20	7472	26	7494	38	74147	90	74170	125	74195	50
7409	14	7433	25	7473	26	7495	35	74148	70	74173	60	74196	50
7410	14	7438	25	★7474	20	7496	40	74150	55	74174	66	74197	50
7411	16	7437	25	7475	26	7497	90	74153	40	74175	56	74198	90
7412	18	7440	15	7476	30	74100	80	74154	55	74176	40	74199	90

TRIACS

400V 4A	50
400V 8A	65
400V 16A	96
BR100	25

SCRs

TIC45	28
C106D	30
400V 8A	70
400V 12A	99

BOXES

Aluminium		Plastic with lid + screws	
3 × 2 × 1in	70p	3 × 2 × 1in	55p
4 × 3 × 1½in	85p	4½ × 3 × 1½	88p
4 × 3 × 2in	100p	7 × 4 × 2in	160p
6 × 4 × 2in	120p		
6 × 4 × 3in	180p		

PCB MATERIALS

Alfac transfer sheets – please state type (e.g. DIL pads etc) 45p
Dalo etch resist pen 100p
Fibre glass board 3.75" × 8" 75p
Ferric Chloride 250ml bottle 100p

CRYSTALS

100KHz	290	6.0M	200
200KHz	370	6.144M	180
1MHz	300	7.0M	250
1.008M	370	8.0M	170
1.8432	300	10.0M	180
2.0M	270	12.0M	290
2.4576M	220	16.0M	240
3.276M	240	18.0M	240
3.579M	120	18.432	220
4.0M	150	19.968	300
4.194M	150	38.667	320
4.43M	125	48.0M	220
5.0M	240	116M	300

The Rapid Guarantee ★ Same day despatch ★ Competitive prices ★ Top quality components ★ In-depth stock

Shorts

● A lot of hot air from Hellermann Electric of Plymouth; their new heat-guns, the GHM Mite and GHW-Triac are ideal for use with the "Helashrink" range of heatshrink sleeving.

● The ZN435 from Ferranti is a new multifunction eight-bit data converter. The standard 18-pin DIL IC contains a fast DAC, an up/down counter, a precision voltage reference and a clock generator. Uses include ramp-and-compare and tracking ADCs, low-frequency waveform generators, fader controls and radio channel selectors.

● Thorn EMI and JVC have postponed the launch of the VHD videodisc system in Japan for economic and marketing reasons. The same decision was recently taken in the USA. To achieve a co-ordinated launch, VHD won't now appear in the UK until 1983.

● Gulf Oil have donated an out-of-date IBM computer to the Science Museum in London. The machine was originally bought in 1978 for a quarter of a million pounds; the Science Museum hope to have it in running order eventually.

● The first edition of the Electroware catalogue is now available and contains too much to list here; we'll just say it's good, it's free (30p P&P, though) and it's available from Electroware, Dutton Lane, Eastleigh, Hants, SO5 4AA.

● Stuck when it comes to metric conversion sums? The LC950 from Casio can switch from one system of weights and measures to another and has a split level display showing both sets of figures. RRP is £18.95.

● It seems there are people in the electronics industry who can think up even worse puns than us (is this possible, you gasp). MC Computers Ltd, of Newbury has launched a repackaged version of the Apple II personal computer, so naturally they've called it the Apple Pi.

● The 1982 edition of the IC Master (which contains details of more than 55,000 ICs) is now available in two hardback volumes from Paterson, Steadman and Partners of Saffron Walden. Price is £59.00 inclusive, which is one tenth of a penny per IC.

Fax You Should Know

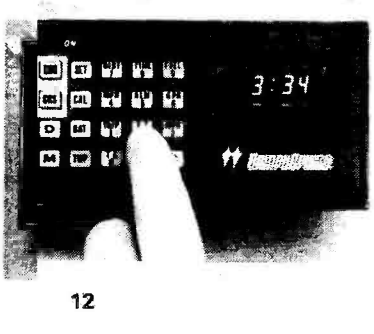
For a special three-month evaluation period, ITT Business Systems will allow customers to rent a Telefax facsimile unit at virtually half-price. At the end of the three months, they have the option to buy the unit or return it. Facsimile transmission, as if you didn't know, is an electronic method of sending test, pictures, or graphics: the document is scanned, coded and send down a telephone line to be printed out as hard copy on a receiver anywhere in the world — all very clever, although the young lady looks quite bored by it all. If you're interested, ITT Business Systems live at Diversey House, Chalk Lane, Cockfosters, Barnet, Herts EN4 0BU.

Lithium Cell Clicks

Kodak's new disc camera is revolutionary in more ways than one — it will be using a high performance lithium battery from Matsushita. The disc camera does not use conventional film — pictures are taken on a flat disc of film and the camera includes automatic film advance exposure control and electronic flash. The lithium battery was chosen to power all this lot because of its high-rate pulse discharge capability (greater than 1 A), wide operating temperature range, 10-year shelf life and high reliability and safety. The lithium cell is expected to find increasing use in consumer products including cameras, flashguns, radios, transceivers, and telephone pocket pagers, as well as security and emergency equipment.

More For Less

Zemco's latest car computer, the CompuCruise, has several new features but costs £20 less than the previous model. For £130 you get on-line fuel consumption; clock with stopwatch facility, cruising speed control, distance/time/fuel-to-arrive calculations, battery voltage indicators, inside and outside temperatures and about 15 other functions. The car freak who has everything (except a computer) can contact Zemco at 66 Earlsdon Street, Coventry, CV5 6EJ.



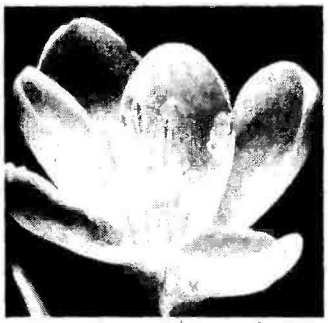
Candid Cameras

Could this be a prototype TV of the future, once satellite TV brings us a bewildering choice of channels? Nope — it's JUPITER, a CCTV control system from Photo-Scan Ltd for multi-camera configurations. The microprocessor-based system allows cameras to be incorporated in multiples of 32, with up to 10 monitors, video recorders, remote camera controls, controls for up to four alarms per camera, and a lot of other stuff for security with a vengeance. Because the system is software-based the surveillance system can be modified to meet the needs of any customer. Photo-Scan are at Dolphin Estate, Windmill Road, Sunbury-on-Thames, TW16 7HG, if you want to know more — what we want to know is, why we never see security guards that look like this.

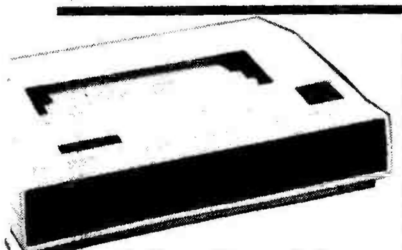
Orient On Air

Here's a novel story — Pye Telecommunications have won an order to supply mobile radio equipment for Chinese transport vehicles. It would have been nice to report that the rickshaw in the picture was being fitted with the equipment, but not such luck; it's the Kew Kwan Motor Road Co. buses that are getting the two-way treatment. It'll be the first time that China has had radio-controlled vehicles, and Kee Kwan, who hold the exclusive bus tour franchise for Macau, expect that the system will improve route supervision, efficiency and safety.

The Light Fantastic



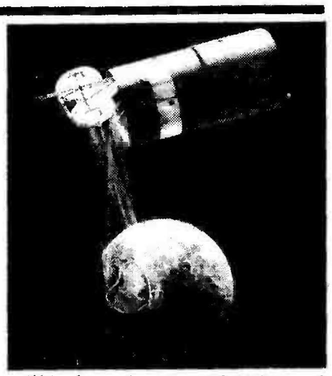
This bizarre pic arrived at the office with an announcement that General Instrument Lamps of Bury St. Edmunds will be marketing Tokyo Minilite Ltd products in Europe. Assuming they haven't cheated with a fake flower, then Minilite definitely lives up to its name. For further information contact General Instrument Lamps Ltd, Beetons Way, Bury St. Edmunds, Suffolk IP32 6RA. Note to ad agencies: it's ingenious pix like this one that make it worthwhile ploughing through the hundreds of boring press releases we get each week.



At The Zenith

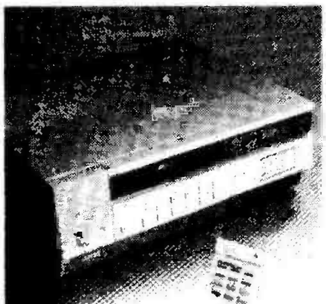
Regular readers of the mag will know the high regard we have for Heath Electronics and the quality of their kits, so a new printer from Zenith Data Systems (a Heath division) has to be good news. The Z-25 is a bi-directional printer with quad tractor feed which provides accurate forms registration, and a 9 × 9 dot matrix head for high quality print. The character set includes all 95 ASCII characters (upper and lower case) as well as 33 graphics characters. The high print rate (greater than 150 characters per second) results in a print speed of about 300 lines per minute for 10 column lines, and 65 lines per minute for 132 column lines. The operator can select from 10, 12, 13.2 or 16.5 characters per inch, while the completely enclosed cabinet results in quiet operation. The printer interfaces to microcomputers via an RS-232C serial interface or 20 mA current loop. The printer (and other Zenith products) are marketed in the UK through Zenith Data Systems outlets.

AUSSAT — Owzat?



Hughes Aircraft Company have signed an agreement to build Australia's first communication satellite system. The three satellites, to be known as AUSSAT, will provide a variety of communication services including the first TV transmissions to many of the communities and homesteads in the remote outback regions. Other services include digital data transmissions, telephony, air traffic control and maritime radio coverage. The first of the satellites will be launched in mid-1985, and each satellite is warranted for seven years; one hell of a trip for the service engineer, though!

Stereo VHS



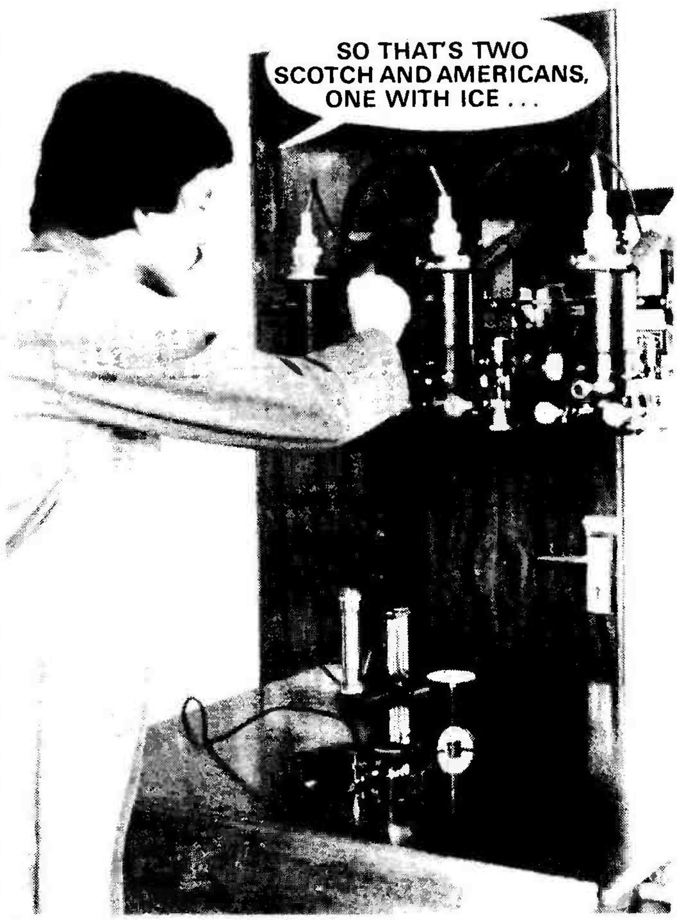
Sound quality continues to improve in the video recorder field; the new top-of-the-line HR7650 EK from JVC features stereo sound amongst a host of other goodies. This means that the inceasingly frequent simultaneous broadcasts on TV and FM radio can be recorded, as well as allowing playback of the fast-growing number of prerecorded stereo video tapes. Sound quality is further improved by the inclusion of a Dolby noise reduction system. There are some pretty good extras on the video side too, such as insert and assemble editing, a special effects playback for fast or slow picture search, double speed play, still frame and frame advance. A full function IR remote control unit is also provided. Please can I have one for my birthday?

Change Of Key

This is a gorgeous young lady and that's her hotel key in her hand. Well, no-one would dispute the first statement, but the second probably requires a bit of explanation. The card is part of a new programmable electronic door lock system developed by the Yale Security Group for better hotel security; the system is known as Yaletronics. Each lock uses a Yale mortice lock and a microprocessor synchronised to the central computer — the locks are each battery-powered to avoid any costly hard-wiring. The present "credit-card" keys are presently made from plastic , but anything could be used; they have the advantage of being small, light and able to have the hotel's logo, room number and other information printed on them.

Each successive guest at the hotel is assigned a different code combination from the millions stored in the computer on a floppy disc with a 5000-room capacity. The system has a printer to record such information as who made each key, the security level and the date. There are six security levels, from guest keys through maid's keys to master keys and emergency keys. The receptionist uses the system to punch a new key for a guest when he checks in, the microprocessor in the lock cancelling the previous card. Hotel owners with security problems can obtain further information from Yale Security Products Ltd, Wood Street, Willenhall, East Midlands, W13 1EA.

Of course, it was only a matter of time before a security company caught up with the private detectives on TV, who've been opening doors with credit cards for years...



NEXT MONTH

electronics today INTERNATIONAL

ACTIVE SPEAKER

A long time ago in a magazine far, far away (well, ETI December '75 to be exact), we published a design for an active crossover. The idea was to avoid the need for bulky, high current coils along with all the problems involved in high-power crossover design, and perform the filtering on the low-level signal. Each audio band was then fed to its driver via its own power amp, removing the need for any conventional crossover altogether. For some time now we've been planning to go one better by presenting a complete active speaker system, with the electronics built right into the speaker cabinet. When we tell you it's a joint design with the speakers by Badger Sound Systems and the power amplifiers by Crimson Elektrik, you'll appreciate how good it is. Don't miss the September issue of ETI if you know what's good for your ears.

AUTO VOLUME CONTROL

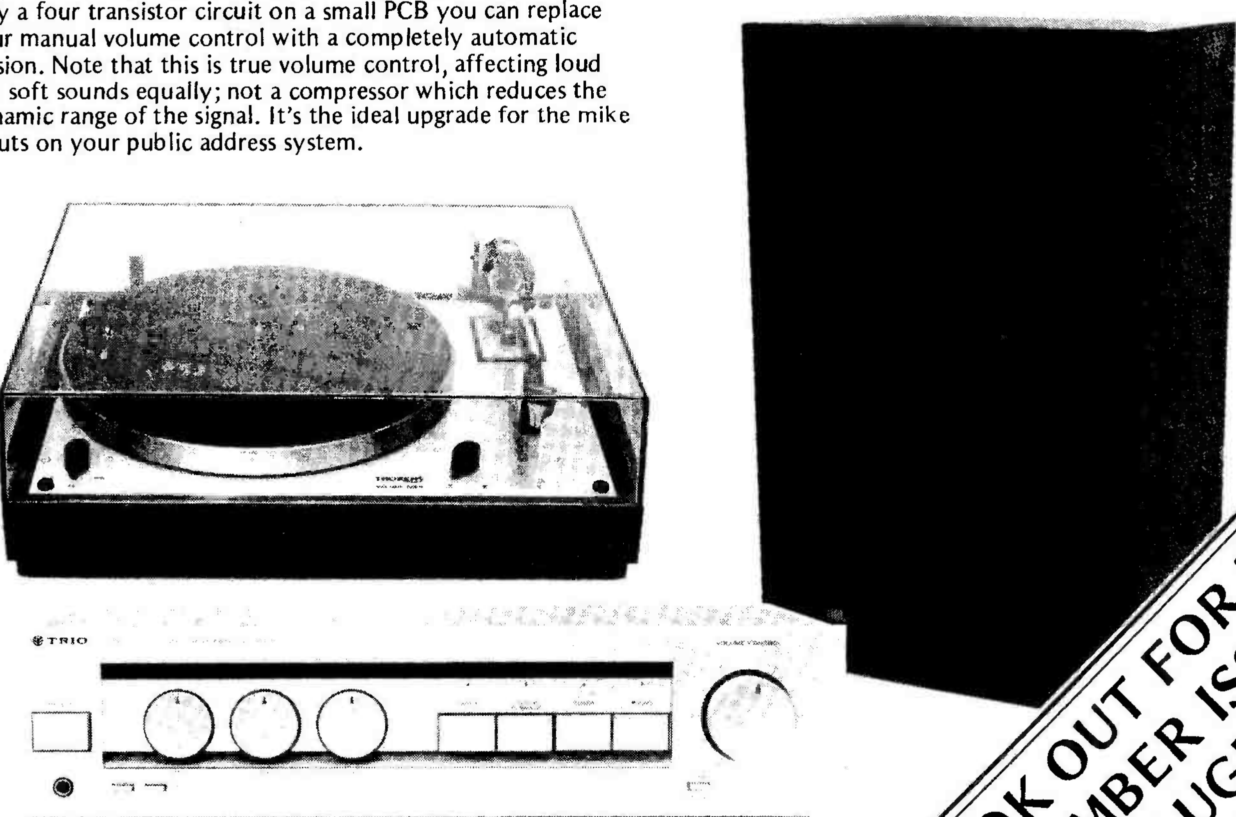
We had hoped to bring you this project in the issue you're holding but lack of space at the last moment meant it had to be held over. The best laid plans of mice and men etc (you can decide for yourself which category editorial staff are part of . . .). Anyway, it's well worth waiting for, because with only a four transistor circuit on a small PCB you can replace your manual volume control with a completely automatic version. Note that this is true volume control, affecting loud and soft sounds equally; not a compressor which reduces the dynamic range of the signal. It's the ideal upgrade for the mike inputs on your public address system.

SIGNAL MEASUREMENT

Tim Orr, our man of many parts (most of them integrated circuits), is usually to be found within the pages of ETI expounding on the subject of electronic music in one form or another. Next month we have something a little different from him — an article about audio from the point of view of test gear. This is an in-depth feature about several aspects of electronic measurement techniques, including true RMS conversion, noise measurement, and an explanation of the decibel, a unit many people find a trifle confusing. Naturally there's also the usual helpful tables and circuits you've come to expect from us.

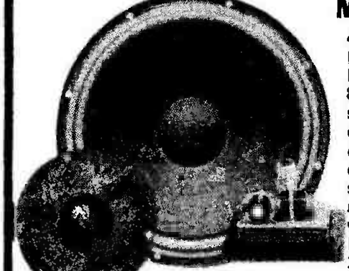
AUDIOPHILE

Something for the (relatively) hard of wallet is the subject of our (relatively) tame hi-fi expert. The September Audiophile will contain a review of the system shown here, which will provide you with excellent sound quality for an outlay of £500. Deck by Thorens, amplifier by Trio, loudspeakers by JBL — we're not sure if it's built by robots too, but it certainly delivers as far as performance is concerned.



LOOK OUT FOR THE SEPTEMBER ISSUE ON SALE AUGUST 6th

Articles described here are in an advanced state of preparation. However, circumstances may dictate changes to the final contents.



MULLARD SPEAKER KIT

40 watt R.M.S. 8ohm DESIGNED BY MULLARD SPECIALIST TEAM IN BELGIUM comprising a Mullard 8" woofer with foam rolled surround, Mullard 3" high power dome tweeter and a cleverly designed B.K. Electronics crossover combining spring loaded loudspeaker terminals and recessed mounting panel. Supplied complete with assembly and cabinet details. Recommended cabinet size 240 × 216 × 445mm.

PRICE £13.90 + £1.50 P&P per kit

OMP

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A superb **fully built and tested** mixer/pre-amp with integral power supply. 4 **Inputs** 2 turntables (ceramic cartridge). Aux. for tape deck etc., plus Mic. with override switch, all with individual level controls. Two sets of active tone controls (bass and treble) for Mic. and main inputs. Master volume control. Monitor output with select switch and volune control.

Outputs Main 750 mV Monitor 500 mW into 8 ohms **Supply** 220/240V AC50/60Hz
Size 22½" × 4⅞" × 2½" **zprice £39.99 + £2.50 P&P**

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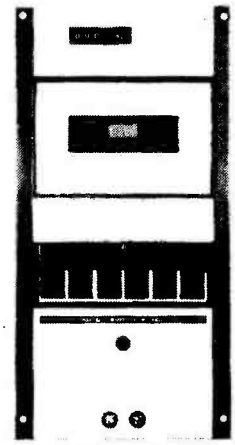

6 piano type keys

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Features: Three digit tape counter. Auto stop. Six piano type keys, record, rewind, fast forward, play, stop and eject. Automatic record level control. Main inputs plus secondary inputs for stereo microphones. **Input Sensitivity:** 100mV to 2V **Input Impedance:** 68K. **Output level:** 400mV to both left and right hand channels. **Output Impedance:** 10K. **Signal to noise ratio:** 45dB. **Wow and flutter:** 0.1%. **Power Supply requirements:** 18V DC at 300mA. **Connections:** The left and right hand stereo inputs and outputs are via individual screened leads, all terminated with phono plugs (phono sockets provided). **Dimensions:** Top panel 5½in x 11¼in. Clearance required under top panel 2¼in. Supplied complete with circuit diagram and connecting diagram. Attractive black and silver finish.

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Supplementary parts for 18V D.C. power supply (transformer, bridge rectifier and smoothing capacitor) **£3.50.**

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BSR P256 TURNTABLE

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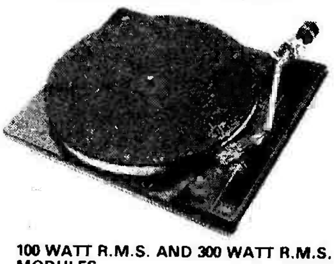
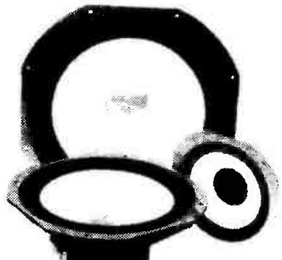
Price: **£28.50** + £2.50 P&P



NEW RANGE QUALITY POWER LOUDSPEAKERS (15", 12" and 8"). These loudspeakers are ideal for both hi-fi and disco applications. Both the 12" and 15" units have heavy duty die-cast chassis and aluminium centre domes. All three units have white speaker cones and are fitted with attractive cast aluminium (ground finish) fixing escutcheons. Specification and Price:

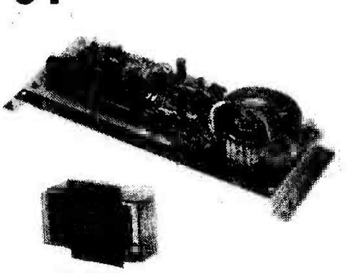


15" 100 watt R.M.S. Impedance 8ohm 59 oz. magnet, 2" aluminium voice coil. Resonant Frequency 20Hz. Frequency Response to 2.5KHz. Sensitivity 97dB. **Price £32 each.** £2.50 Packing and Carriage each.

12" 100 watt R.M.S. Impedance 8 ohm, 50 oz magnet. 2" aluminium voice coil. Resonant Frequency 25Hz Frequency Response to 4KHz. Sensitivity 95dB. **Price £23.70 each.** £2.50 Packing and Carriage each.

8" 50 watt R.M.S. Impedance 8 ohms, 20 oz. 1½" aluminium voice coil, Resonant Frequency 40Hz, Frequency Response to 6KHz. Sensitivity 92dB. Also available with black cone fitted with black metal protective grill. **Price: White cone £8.90 each. Black cone/grill £9.50 each.** P & P £1.25 each.

OMP **POWER AMPLIFIER MODULES**



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Power Amplifier Modules with integral toroidal transformer power supply, and heat sink. Supplied as **one complete** built and tested unit. Can be fitted in an L.E.D. Vu meter available as an optional extra.

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310 watts R.M.S. (OMP 300)
Loads: Open and short circuit proof. 4-16 ohms.
Frequency Response: 20Hz — 25KHz ±3dB.
Sensitivity for Max. Output:
500mV at 10K (OMP 100) 1V at 10K (OMP 300)
T.H.D.: Less than 0.1%
Supply: 240V 50Hz
Sizes: OMP 100 360 × 115 × 72mm
OMP 300 460 × 153 × 66mm
Prices: OMP 100 **£29.99 each + £2.00 P&P**
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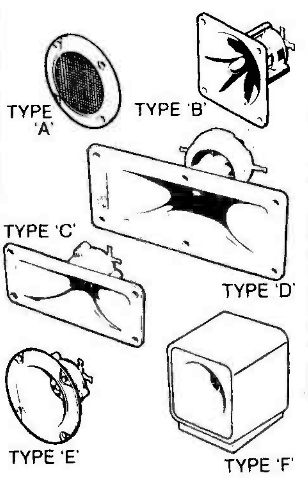
Vu Meter **£6.50 each + 50p P&P**

PIEZO ELECTRIC TWEETERS MOTOROLA

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



TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. **Price £3.45 each.**

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TYPE 'F' (KSN1057A) Cased version of type 'E'. Free standing satellite tweeter. Perfect add on tweeter for conventional loudspeaker systems. **Price £10.75 each.**

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Build a quality 60 watt R.M.S. system

★ 10" Woofer 35Hz-4.5KHz
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★ 5" Mid Range 600Hz-8KHz
★ 3-way crossover 6dB/oct 1.3 and 6KHz
Recommended Cab-size 26" × 13" × 13"

Fitted with attractive cast aluminium fixing escutcheons and mesh protective grills which are removable enabling a unique choice of cabinet styling. Can be mounted directly on to baffle with or without conventional speaker fabrics. All three units have aluminium centre domes and rolled foam surround. Crossover combines spring loaded loudspeaker terminals and recessed mounting panel.

Price £22.00 per kit + £2.50 postage and packing. Available separately, prices on request

12" 80 watt R.M.S. loudspeaker.
A superb general purpose **twin cone** loudspeaker. 50 oz. magnet. 2" aluminium voice coil. Rolled surround. Resonant frequency 25Hz. Frequency response to 13KHz. Sensitivity 95dB. Impedance 8ohm. **Attractive blue cone with aluminium centre dome.**

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DESIGNING MICRO SYSTEMS

When the chips are down, ETI delivers the goods. In this major new series, Owen Bishop takes the lid off computers and the ICs that go into them. This is the definitive treatise on hardware.

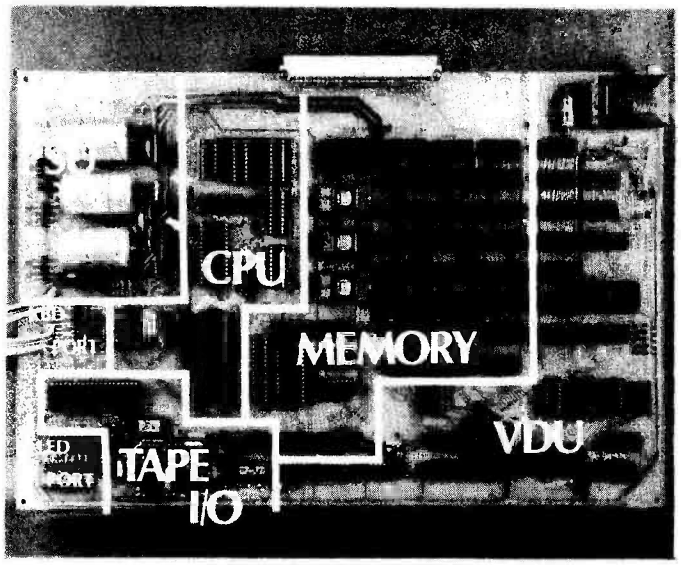
This series is aimed at those readers who already know something about electronics, but who would like to know how electronics is being used today in perhaps its most important application of all — the computer. The series will be concerned with only one of the two types of electronic computer, the digital computer. The other type, the analogue computer, has several important applications but in the main its work has been taken over by digital computers.

We still owe something to the analogue computer, for our trusty work-horse, the op-amp, was originally designed as its building block. Whereas the analogue computer operates with precisely determined voltages which are allowed to vary continuously over their range and are analogues of continuous physical quantities, the digital computer operates with only two discrete voltage levels. The analogue computer depends on the high precision of its op-amps, and needs an op-amp for every step in its computations.

As we shall see, the electronic requirements for the digital computer are much simpler, allowing designers to concentrate on obtaining high speeds of action. The units of the circuit are simple logic gates, thousands of which can be manufactured on a single slice of silicon, already connected to form the complex logic circuits of the computer. This allows the digital computer to have great computing power combined with flexibility of function. It also allows the computer to be mass-produced cheaply so that, today, anyone with a few tens of pounds to spend can buy one.

The Heart Of The Matter

Figure 1 shows the heart of the computer to be its central **processing unit** (CPU). It is connected to a number of other devices — the peripheral devices. Input devices usually include a keyboard, so that the operator can send information to the CPU. Information may consist of instructions and data. Input devices might include sensors (eg circuits to measure temperature) so that the CPU can obtain its data directly without need for intervention by a human operator. One essential part of this would be an analogue-to-digital converter sub-circuit, to convert the analogue quantity (in this case temperature), to its digital coded equivalent.



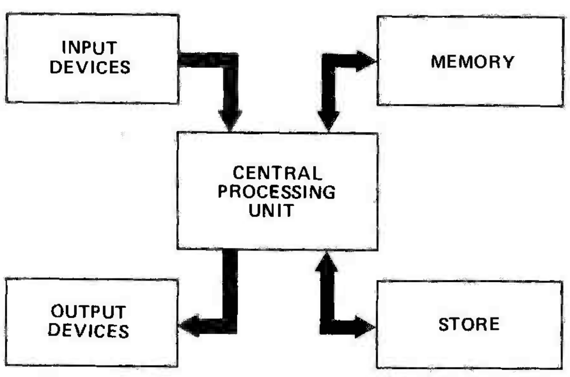


Fig. 1 Block diagram of a computer.

Output devices allow the CPU to communicate the results of its computations to the world outside. There is usually a monitor screen on which messages and the results of calculations are displayed. There may also be a printer or a chart plotter. Alternatively there may be direct control of a robot arm or similar device.

The memory is one place where information is stored. The instructions tell the CPU what to do (its program), and it is provided with data to work on. The computer is able to use part of the memory for storing other data which arises from its computations. Information can be transferred between CPU and memory very rapidly and in either direction. Memory is where the currently-used information is held. The store is for information that is not required urgently. The store may consist of a tape deck or disk drive, by means of which information is stored in magnetic form. Blocks of information can be transferred between CPU and store in either direction, but only relatively slowly. The amount of information which can be held in store is much greater than the amount held in memory.

The CPU

This has the job of receiving instructions and data, either from input, memory or store, processing the data according to the instructions, and then sending the results of its computation to an output device, memory, store, or possibly to more than one of these. In a main-frame computer, the CPU occupies several circuit boards, but in the personal computer the whole CPU is replaced by a single integrated circuit, the **microprocessor.** This article and the remainder of the series will concentrate on the personal computer, or microcomputer, using a microprocessor as its CPU.

We have been able to use very large scale integration (VLSI) to put all the logical parts of the CPU on to one slice of silicon. The CPU must include an oscillator, or **clock**, by means of which all its actions and the actions of other peripheral devices are synchronised. It is not possible to reduce the physical size of the components required for this, in particular the quartz crystal, so a least part of the clock circuit is external to the microprocessor. The clock circuit and microprocessor (MPU) together constitute the CPU of the microcomputer.

We Want Information

Before we look at what goes on inside the MPU we must consider the concept of information in more detail. The unit of information is the bit. The term 'bit' is a shortened version of 'binary digit'. A bit can have one of two values, '0' or '1' but not any other value. This binary concept is widespread in thought, in logic and also in electronics. Table 1 shows pairs of opposite and mutually exclusive states. A binary digit is '0' or '1'; it cannot be anything else. A statement is true or false; truth is by definition the *whole* truth, for half-truth is meaningless. A switch is either on or it is off; it cannot be partly on. If the circuits are made so that only two voltages (low and high) produce definite results and so that intermediate voltages give indeterminate results, then voltages are either high or low. Transistors are either fully off, or fully on (saturated). Given these binary states, the state of any one pair in Table 1 can be used to represent the state of any other pair. For example, we can stipulate that the digit '0' is represented in a computer circuit by a low voltage, and the digit '1' is represented by a high voltage; falsity by '0' or a low voltage, truth by '1'. Here we have a system which allows numerical values and logical statements to be represented in terms of electrical signals. This is the basis of the digital computer.

TABLE 1

0	1
No	Yes
False	True
Absent	Present
Switch off	Switch on
Transistor off	Transistor on
Open circuit	Closed circuit
Low voltage	High voltage

Grab A Byte

In this system, the bit is the minimum quantity of information to be dealt with. Normally a computer deals with far more information than this. Bits are usually handled in groups. Some of the earlier MPUs handled bits in groups of four, but the majority of micros handle them in groups of eight. A group of eight digits is called a **byte**. In the computer, a byte is represented by a set of eight lines (eg tracks on the PCB), each at high (= 1) or low (= 0) voltage. Or it might be represented by a set of eight flips-flops or bistables, each one either set (= 1) or reset (= 0). According to the interpretation placed on it, the byte could represent:

- A binary value, ranging from 0000 0000 (= 0 decimal) to 1111 1111 (= 255 decimal)
- The truth or falsity of eight different logical statements.
- A coded instruction to the computer.

There is more to be said on this subject next month, but for the moment we will rest with the fact that the computer has to handle binary information represented in electronic form.

On The Level

For most MPUs the low and high voltages are standardised at 0 V and + 5 V respectively. These are the same levels as are used in the 7400 TTL series of ICs. These values are nominal; a Z80 MPU, for example, interprets any voltage between — 0V3 and 0V8 as 'low'. Any voltage between 2 V and 5 V is interpreted as 'high'. Voltages between 0V8 and 2 V produce indeterminate results and must not be allowed to occur. The lack of insistence on precise voltage levels allows computer circuits to remain relatively simple in electronic terms, yet be highly reliable in action.

Those Important Little Places

If the CPU is the heart of the computer, the heart of the CPU is its **arithmetic logic unit.** The ALU is where data is manipulated according to the instructions stored in memory; we shall describe some of its operations next month. The ALU is able to operate on all eight bits of a byte in a single operation. We say that the **word length** is eight bits, or one byte. Some MPUs, such as the Texas 9980A, have a 16-bit word, but the general principles of its operation are the same as described below.

As an example of a well-known MPU we shall first consider the 6502 (Fig. 2). This successful but relatively simple MPU is used in the Apple, the PET, the BBC Microcomputer, and several other popular microcomputers. The ALU operates in close conjunction with the **Accumulator.** This is a set of eight flip-flops which temporarily hold a byte which is to be operated on by the ALU, or is the result of an operation performed by the ALU. The two registers known as X and Y may also be used to store one byte of data each. Data can be transferred between these registers and the Accumulator in either direction. These registers are therefore useful for storing values obtained in one stage of a calculation, ready for use at a later stage. They are also used as index registers, in which the values held in X or Y are the base addresses of selected blocks of memory. This makes it simpler to access blocks of memory; when storing a table of data, for example.

Since data has to be transferred from one register to another, or from a register to the ALU, it speeds the operation of the MPU if a whole byte is transferred in one operation, rather than bit-by-bit. This requires a set of eight lines connecting all the registers and the ALU. This is called the data bus. To distinguish it from a similar set of lines which connect the MPU with the peripheral devices, it is more precisely known as the **internal data bus.**

It's Under Control

The **control bus** consists of several lines along which signals are sent to coordinate the actions of the various parts of the MPU. For example, if the data held in register X is to be sent to the ALU, a signal must be sent along a control line to register X, making it place the data on the data bus. Register X makes the lines go 'high' or 'low' according to the pattern of 0s and 1s held in its eight flip-flops. At the same time a signal must be sent along another control line to the ALU, making it accept the data now present on the data bus. The control lines emanate from a special part of the MPU called the **Control.**

Despite its impressive name, the Control is no more than a slave. It knows how to carry out the tasks it is allotted, but does not remember what it has just done, and does not know

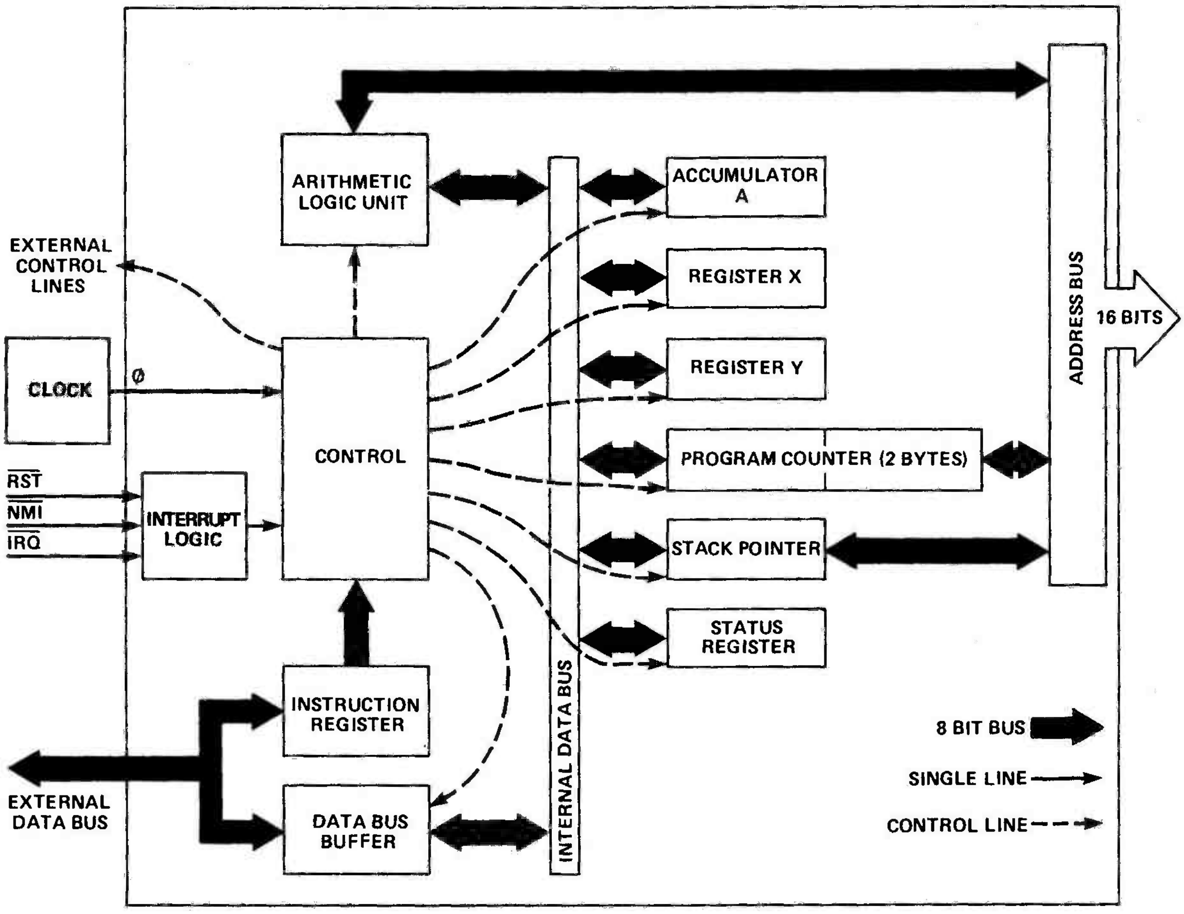


Fig. 2 The internal structure of the popular 6502 microprocessor.

what task it must perform next. The list of tasks (the program) is stored in memory at a sequence of locations. The control simply fetches these instructions from memory, a byte at a time, and acts on each immediately it is received. For this purpose it needs the **Program Counter**, a register in which it records how far it has reached in the program — a sort of 'bookmark'. Since a single byte cannot store numbers greater than 255 (decimal), and since most programs have far more bytes than this, the Program Counter is a double-byte register. Its 16 bits allow any number up to 1111 1111 1111 1111 (binary) to be stored, equivalent to 65535 (decimal).

During its calculations, the MPU often has to store data in the **Stack**, a special section of memory set aside for this purpose. As data is added to or removed from the Stack, the position in memory of the first item in the Stack (the Top of Stack) changes. The **Stack Pointer** register records the current position of Top of Stack, so that the MPU knows where to go to retrieve the stacked data.

Status Symbols

The **status register** should be considered as eight individual bits, arranged together for convenience as a byte. Each bit is **set** (made equal to 1), or **reset** (made equal to 0) individually as the result of a particular operation. For example, bit 7 is set whenever the result of an operation results in a negative value. Bit 1 is set when the result of an operation is zero. These bits, which indicate whether a particular event has occurred or not, are often known as **flags**. Bit 0 holds the 'carry' digit from additions or subtractions in the accumulator.

The remaining sections of the MPU are concerned with communicating with the peripheral circuitry. There is the **data bus buffer** which detects voltage levels on the external data bus and copies these on to the internal data bus. Or it

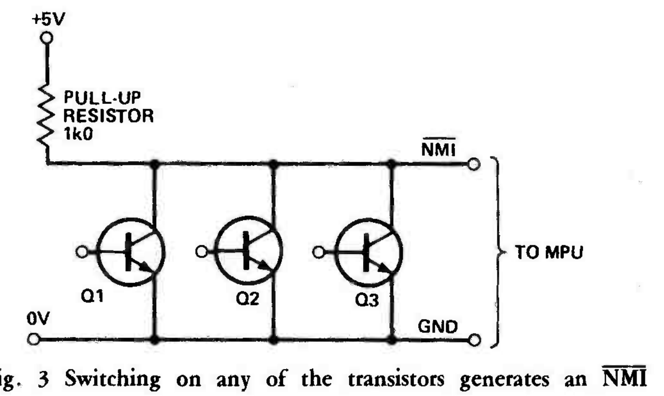


Fig. 3 Switching on any of the transistors generates an NMI

can operate in the reverse direction. If the data bus is carrying an instruction, this is accepted by the **instruction register**. From there it goes to the control which decodes it and then acts upon it. The **address bus** receives outputs from certain registers putting voltage levels on the 16 address lines, a subject which will be dealt with later.

Dealing With Interruptions

The **interrupt logic** receives signals along any of three lines. All three lines are normally held high by pull-up resistors. The lines are thus described as 'active-low'. In other words, it requires a low level on the line to make the MPU respond. Most control lines in the computer are active-low. This makes it simple for any number of devices to bring the line to its low state. If the line is connected to open-collector transistors, for example (Fig. 3) this is equivalent to a wired-OR configuration. Then if any one of these transistors is turned on, the voltage level on the line is made low. If a line is active-low, this fact is indicated by a line above its abbreviation (eg $\overline{RST}$ for active-low 'reset').

The **reset** line is used to initialize the MPU, either when the computer is first switched on or if it gets into a 'latched-up' condition, in which normal methods of controlling it do not work. There is generally a pull-up resistor holding the voltage high, with a 'Reset' press-button hidden in a fairly inaccessible place at the rear of the computer. Pressing this button temporarily grounds the reset line.

When the computer is first switched on, resetting is usually done automatically, by having a large-value capacitor to hold the line low for a short period while the rest of the system reaches its full voltage levels (Fig. 4). There is no reset button in the Sinclair ZX-81. To reset, you simply turn off the power, wait a moment or two and then reapply power. Resetting the MPU resets the program counter to zero, so that it returns to the beginning of the program stored in memory and starts again.

On receiving a low signal on one of the interrupt lines ($\overline{NMI}$ or $\overline{IRQ}$) the MPU finishes whatever operation it is engaged in, then stores away (on the stack) any data relating to that operation. This takes only a few microseconds, after

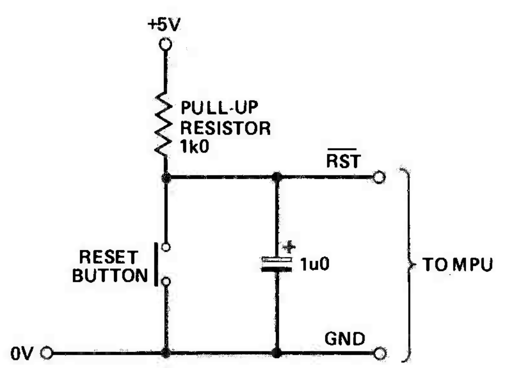


Fig. 4 A suitable circuit for generating a power-on reset pulse. A manual reset button is also provided.

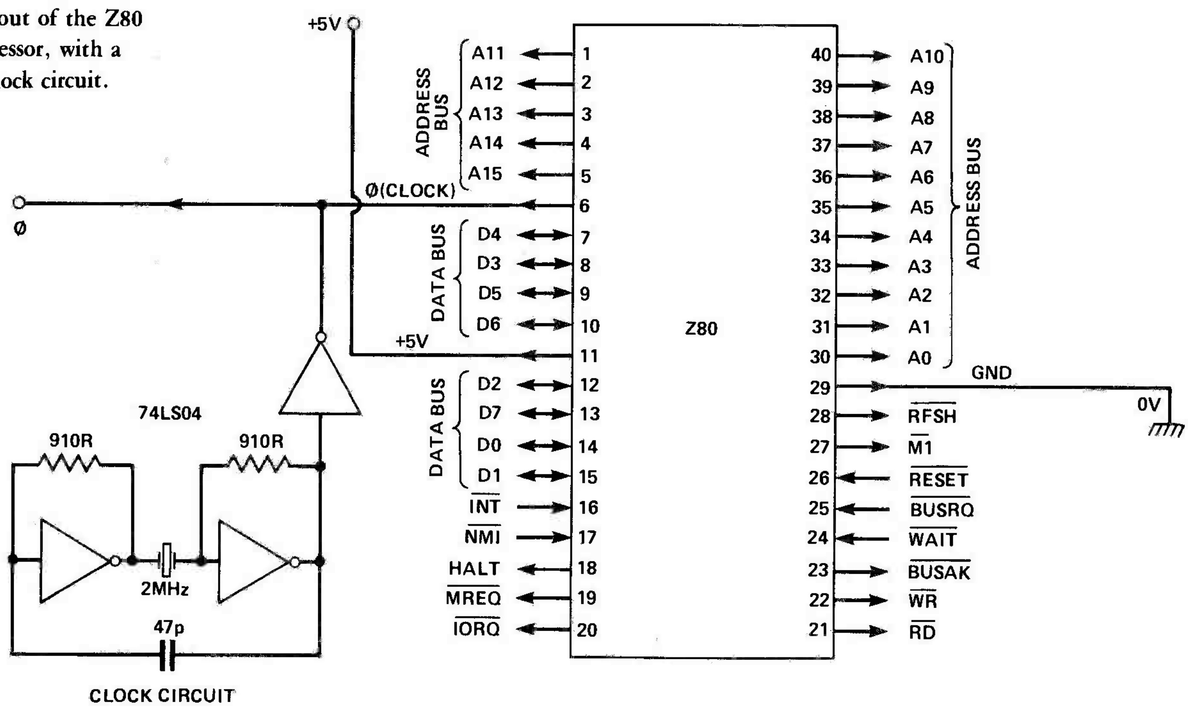
which the program counter is sent to the address in memory of a special interrupt service program. It performs whatever this program requires, then returns to its original program, recovers the data from the stack and continues with the original program as if nothing had happened. Interrupts are used by peripheral devices to gain the attention of the MPU when it is urgently required. The non-maskable interrupt ($\overline{NMI}$) takes priority. It cannot be ignored by the MPU, and, while the MPU is performing the $\overline{NMI}$ task, it cannot be interrupted again. The Interrupt Request ($\overline{IRQ}$) has second priority. The MPU can be pre-programmed to ignore an $\overline{IRQ}$ altogether. In the 6502, this is done by setting digit 2 of the Status Register to '1'. An $\overline{IRQ}$ task can be interrupted by an $\overline{NMI}$. After completing the $\overline{NMI}$ task, the MPU continues with the interrupted $\overline{IRQ}$ task. When this is completed (assuming there is no further $\overline{NMI}$) it returns to its original program.

Z80 Anatomy

Most MPUs have the same kind of organization, or architecture, as the 6502. The Z80 MPU, which is the processor for a wide range of computers including the TRS-80 Models I and II, the Research Machines 380Z, and the Sinclair ZX-81, has a rather more elaborate set of registers. The main set comprises the accumulator (A), the flag register (F, corresponding to the status register of the 6502), and registers B, C, D, E, H, and L, which are general-purpose registers. There is also an alternate set of registers, A', F', B', C', D', E', H', and L'. The MPU normally begins operations by using the main set, but can be switched over to use the alternate set instead, leaving the main set unaffected. It can be switched back to the main set again later.

In addition there are two index registers (IX, IY corresponding to X and Y in the 6502), a stack pointer, and a program counter. In the Z80, IX, IY, SP and PC are double-byte registers (16 bits). Finally there's the interrupt vector register (I) in which instructions for a complex series of vectored interrupts can be stored, and the memory refresh register (R) which is used in connection with refreshing the dynamic memory of the system. This topic will be dealt with in a later article.

Fig. 5 Pinout of the Z80 microprocessor, with a suitable clock circuit.



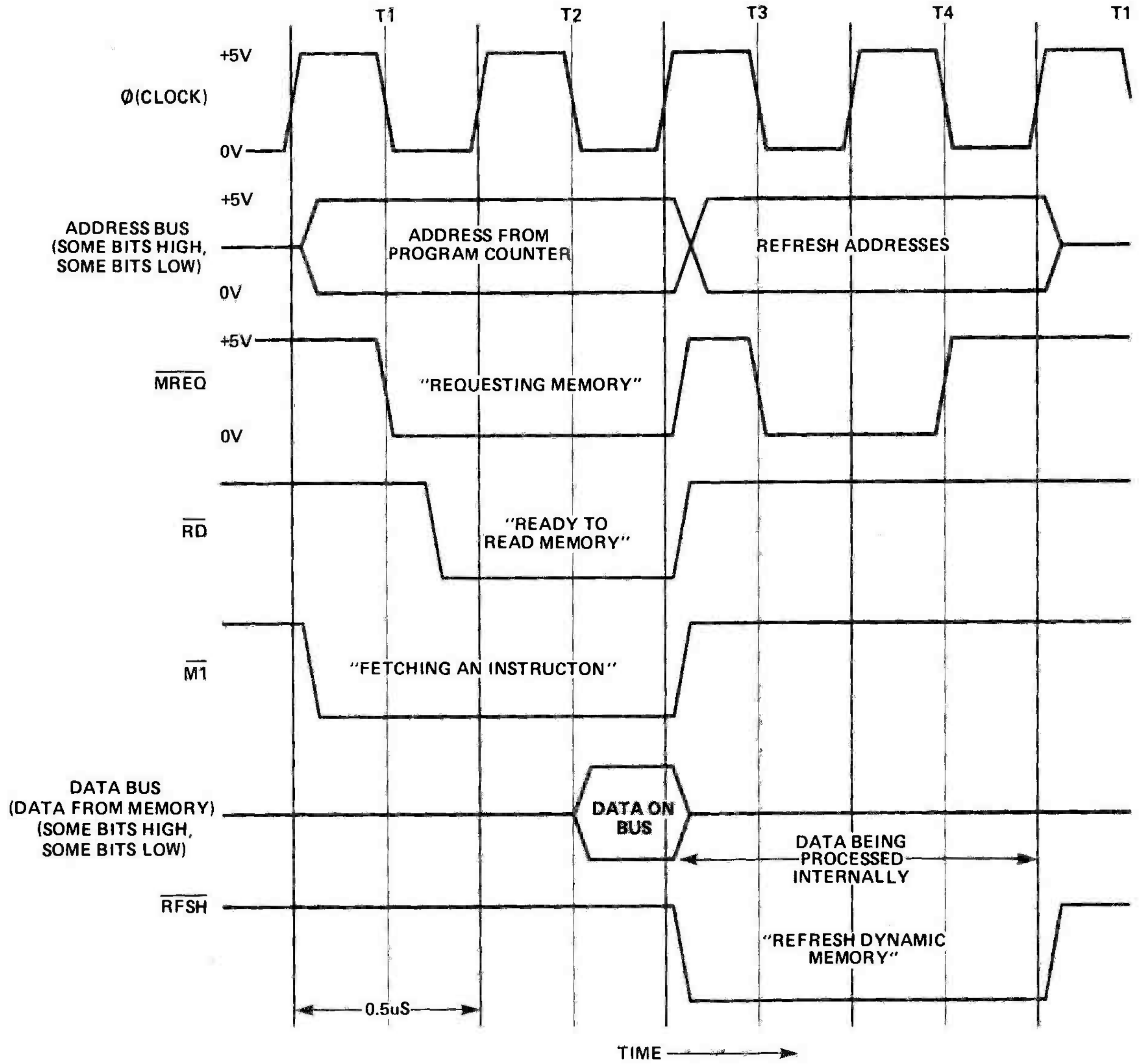


Fig. 6 The clock and control signals for the Z80.

Making The Connection

The typical MPU is contained in a 40-pin DIL package as shown in Fig. 5, which uses the Z80 as an example. It requires a regulated 5 V DC supply, which is applied between pins 29 (system ground) and 11 (+ 5 V). The clock circuit supplies pulses at 2 MHz in the case of the original Z80 MPU. The newer Z80A can operate with a clock rate up to 4 MHz. The clock signal may also be taken to peripherals; for example, the circuits which control the monitor.

The eight data lines, D0 to D7, come direct from the data buffer (Fig. 2). These may act as inputs or outputs, though not in both capacities at the same time. The data bus is taken to the peripherals, to allow for transfer of data between these and the MPU. In order that the peripherals will know which one (and *only* one) of them is to receive or transmit data, each peripheral is also connected to the address bus. This is a set of 16 lines, A0 to A15. Address lines are outputs from the MPU. By putting various combinations of highs and lows on these lines the MPU can indicate which peripheral it is addressing. The peripheral may be a printer or a relay on a control board. It may be a single location in memory. Since there are 16 lines, there are 65536 possible combinations of highs and lows, this being the maximum number of locations which can be directly addressed. This figure is usually written in its shorter form, 64K, where one 'K' is not 1000, but 1024 (= 2^{10}).

Peripheral Procedures

The remaining pins of the IC are connected to control lines which connect the MPU to certain of the peripherals. We will consider the input control lines first. The functions of $\overline{RST}$, $\overline{NMI}$ and $\overline{INT}$ (= $\overline{IRQ}$) have already been dealt with. A low level on $\overline{WAIT}$ causes the MPU to halt its operations. It may have asked a peripheral to send data to it but the peripheral is not ready to put the data on the bus. Instead the peripheral sends the $\overline{WAIT}$ signal, and the MPU suspends action until the peripheral has had time to put the required data on the bus and let the $\overline{WAIT}$ line go high again. The bus request signal ($\overline{BUSRQ}$) is used by certain peripherals to force the MPU to hand over control of the address bus, the data bus and certain control lines. This is used during an operation known as **Direct Memory Access** (DMA) in which blocks of data are transferred between memory and other peripheral devices without the intervention of the MPU. This is not usually implemented on the smaller microcomputers.

There are eight outputs in the control bus of which we shall mention only three now, dealing with the rest later as part of specific examples. The Machine Cycle One output ($\overline{M1}$, pin 27) indicates when the MPU is fetching an instruction from memory. Two outputs of special importance are read ($\overline{RD}$) and write ($\overline{WR}$). When the MPU is to receive data from a peripheral it puts the address of the peripheral on the address bus and make the $\overline{RD}$ line low. This indicates to the peripheral, which is also wired to the $\overline{RD}$ line, that it is to transmit data and not to receive it. When the MPU wants to transmit data to a peripheral, it puts the address on the address bus and makes the $\overline{WR}$ line low.

Clocking On

With so many signals being passed in several directions, and with the data bus being required for transmissions into or out of the MPU, it is essential that all these activities take place to a clearly defined schedule. Although micros and their peripherals act at fantastic speeds, these are only fast according to our human scale of appreciation. To an MPU a memory which responds in a microsecond is not particularly speedy. The MPU even has to wait a while to give it time to put the data on the bus, and for the voltages to settle to their intended levels. To keep all sections of the system operating in an orderly way, and to allow the circuits a finite (even if infinitesimal) time to react, the clock is of major importance.

As an example of the way the various parts of the system interact, let us consider what happens when the MPU goes to memory to find the instruction which it is to execute next. Figure 6 shows the voltage levels on the lines concerned. The top curve shows the regular pulsing of the system clock at, say, 2 MHz. At this frequency, each of the periods T_1 to T_4 is 0.5 microseconds (uS). The MPU begins by making $\overline{M1}$ low, indicating that it is about to fetch an instruction from memory. At the same time it puts on the address bus the address of the memory location in which this instruction is stored. It has obtained this address from its program counter, which has just been incremented following the execution of the previous instruction. The addressed location does not know at this stage whether it is to be read or written to.

On the next low-going edge of clock, the Memory Request line ($\overline{MREQ}$) indicates that this is an operation involving memory (as opposed to a printer, or monitor peripheral, for example). Immediately after this, the $\overline{RD}$ line is taken low by the MPU, indicating that this is a read operation. The $\overline{MREQ}$ signal is used to enable (or 'turn on') the memory IC so that it is ready to put its data on the bus. Since many such ICs are permanently wired to the bus and since only one can be allowed to put data on to any line at any one time, memories have **tri-state outputs**. These can be high, low or 'high impedance'. The high impedance state means that the output is virtually isolated from the bus and not able to communicate with it. Outputs are in this state until a $\overline{RD}$ signal is received by the IC. The $\overline{RD}$ signal can be fed to the memory IC so as to make its outputs change to low impedance and take the lines of the bus to high or low states.

As soon as the data has appeared on the bus the CPU reads it into its instruction register. It has until the next rising edge of the clock to do this. Then $\overline{M1}$, $\overline{MREQ}$ and $\overline{RD}$ are made high, indicating that the operation has been completed. The total time for the whole operation is 1 uS. During the next 1 uS the CPU passes the data along its internal bus to its control, where the data is decoded as an instruction and then acted upon. While this is happending there is no need to take in further data and, since the instruction is still being decoded, the time for acting upon it has not yet arrived. In the Z80, this period is used for refreshing dynamic memories, as will be explained in a future issue.

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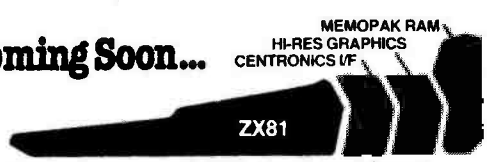

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PLAYMATE GUITAR EFFECTS/AMP

The sounds of the superstar in your own room — or in the middle of a field! The PLAYMATE will help you on your way. Design and development by Phil Walker

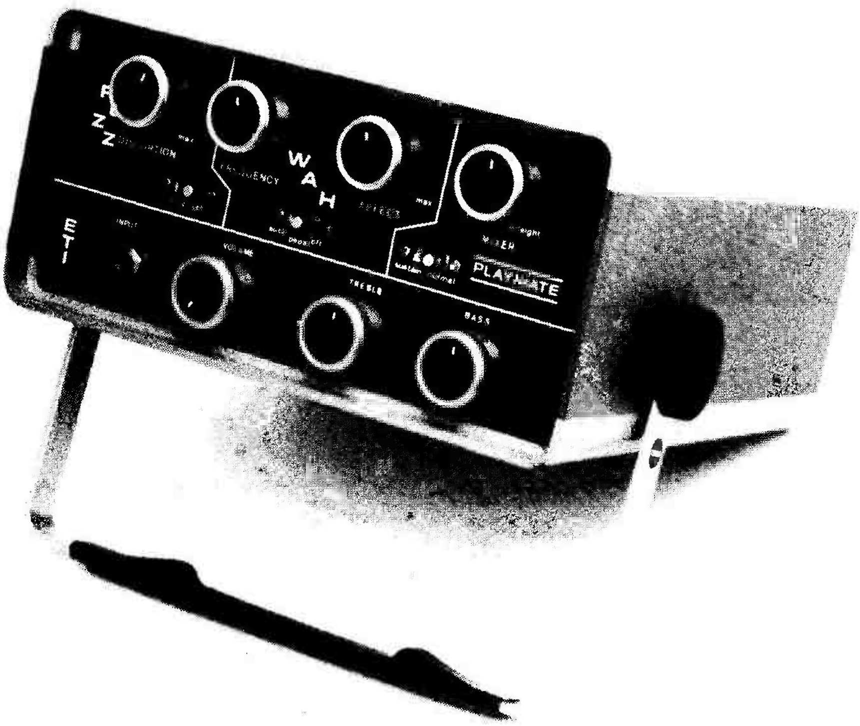
The Playmate is a small practice amplifier for use with a guitar giving a few watts output for easy listening while also providing some of the basic effects used by many musicians. It is ideally suited to those who do not carry all the various effects units around in their guitar case but would like to be able to practice at odd moments or in out-of-the-way places.

In addition to the amplifier and standard tone controls etc, various distortion and wah-wah effects are possible. As a by-product of the circuitry a sustain effect is also possible.

The sound output is provided by a small internal loudspeaker and the whole module is powered from a small mains unit or batteries. An external foot pedal could be used with the wah effect if required. This consists of a variable resistor and a couple of other resistors to provide the necessary control current. The internal control is still active at this time and can be used to set an operating range.

The Circuit

The circuit is in general straightforward. It consists of an input buffer with a gain of about 50 followed by a signal compression stage which reduces the dynamic range greatly in order to feed the effects circuitry at a constant level. The effects consist of a distortion-inducing stage for fuzz and a variable band-pass filter for the wah wah. After the effects stages, the dynamic range of the signal is restored to normal before being fed to the mixer, tone controls and power output stages.



The input buffer consists of a single 3140 CMOS op-amp whose gain is set at 48 by R2, R3. The following dynamic range compressor consists of one part of a LM13600 dual transconductance amplifier. The gain of this device is a function of the amplifier bias current, the input diode current and the load resistor. The output buffer of the device is used here as a peak detecting rectifier which charges a capacitor (C3) to the peak value of the output signal less two base-emitter drops (about 1V4). If this voltage is greater than about 0V7 the resulting current flowing through the input linearising diodes causes the effective stage gain to decrease and keep the output level constant.

Distorting The Facts

Distortion effects in this project are of two types. The first is mainly even harmonic generated by half-wave-rectifying the input, inverting it and then mixing it with the original signal to get from no distortion to complete frequency doubling. In addition to this, overload type distortion is provided by a high gain clipping amplifier using non-linear feedback (IC3a,3b).

Wah wah sound effects are produced by a current-controlled state variable filter. The control current determines the centre frequency of the pass band while a two-gang variable resistor sets the bandwidth and compensates for inevitable gain changes.

Tone controls are of a standard type and use frequency-selective feedback networks around an op-amp. The following power amplifier has been designed to have a low quiescent

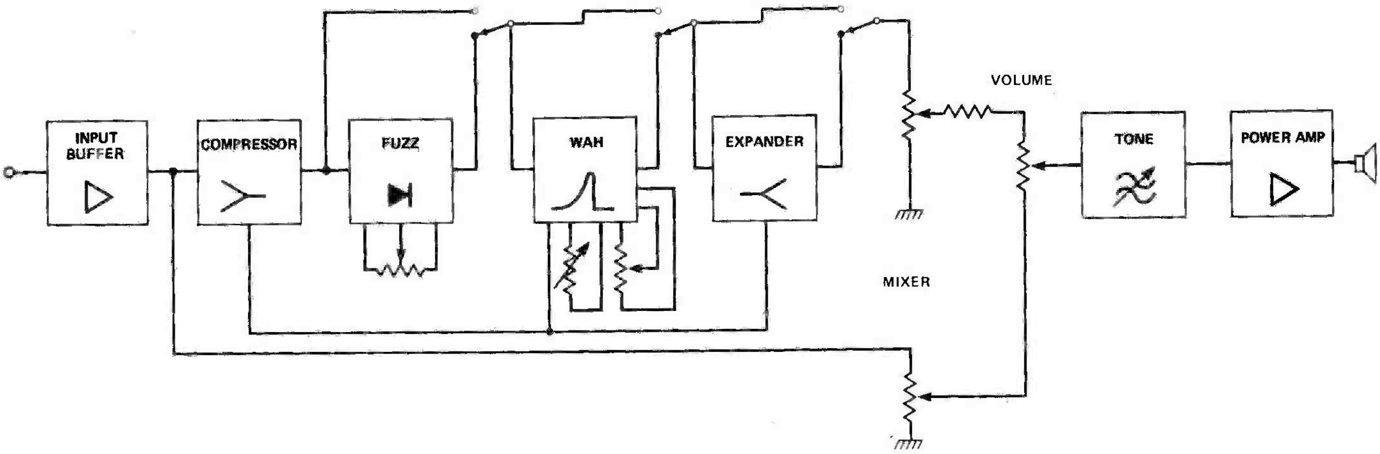


Fig. 1 Block diagram of the Playmate.

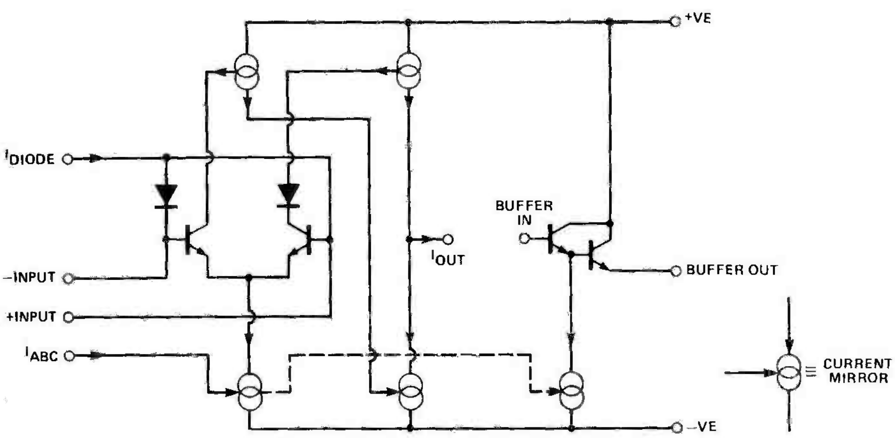


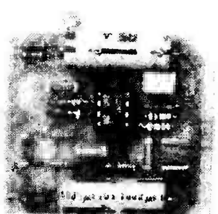
Fig. 2 Internal circuitry of the LM13600 — an operational transconductance amplifier!

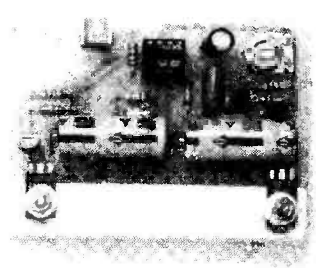
$$I_{out} = \frac{I_{abc} \times q}{2KT} \times V_{in} = \frac{I_{abc}}{26 \times 10^{-3}} \times V_{in}$$

If the diode current is not zero and the signal current is less than $I_{D/2}$ then the transfer function is:—

$$I_{out} = \frac{2 \times I_{abc} \times I_s}{I_D}$$

where
I_s = signal current
I_{abc} = amp. bias current
I_D = lin. diode current
I_{out} = output current





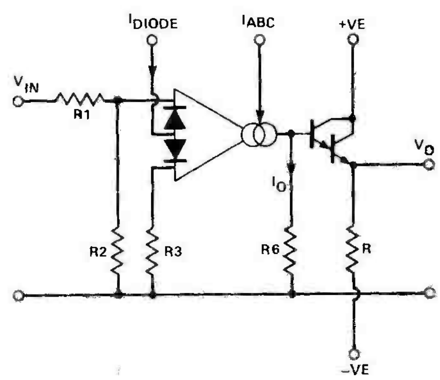


Fig. 3 Basic voltage amplifier circuit.

current. This is important if batteries are to be used as many amps of the IC variety take 30 mA or more, or are designed for single rail working.

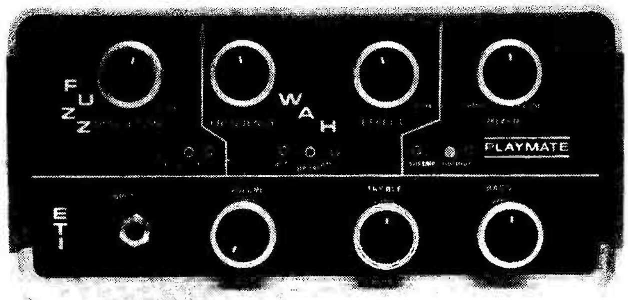
The LM13600

This device is used for two functions in this project. One of these is the compressor/expander while the other is the wah wah. In both of these, use is made of the fact that the gain of the device is dependent on the amplifier bias current and the linearising diode current (provided that the input current is less than half the diode current). In fact the output resistor also determines the gain but is not so easily varied.

If the diode current is zero then the manufacturers' data sheet shows that the transfer function of the device is:—

If we use resistors for input and output, it can be seen that the voltage gain of a stage using this device can be controlled easily by use of the bias and linearising diode currents.

Figure 3 shows the basic circuit for a voltage amplifier and from it we can show that the output voltage V_o is dependent on the bias and diode currents.



$$V_o = \frac{V_{in} \times 2 \times I_{abc} \times R_L}{R1 \times I_D}$$

$I_{in} = V_{in}/R_{in}$ Therefore

and the gain $\dfrac{V_o}{V_{in}} = 2 \times \dfrac{I_{abc}}{I_D} \times \dfrac{R_L}{R1}$

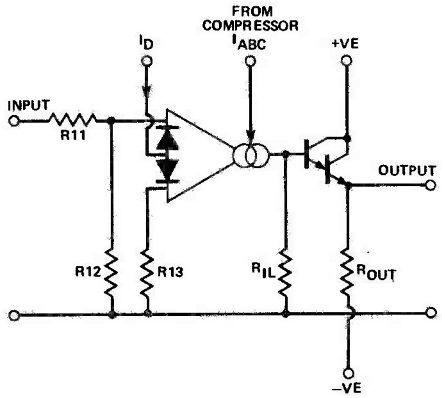


Fig. 4 The LM13600 as an expander.

HOW IT WORKS

The gain of the input buffer IC1 is set by R2 and R3 at 48. R1 determines the input impedance while C1 provides DC blocking. The output from this device goes to the dynamic range compressor IC2a and its buffer IC3a. This part of the circuit also provides control signals for the expander circuit and, if required, for the wah wah effect. The buffered output from the compressor then goes via C4 to the first part of the fuzz effect circuitry constructed around around IC3b. Here an inverted half-wave-rectified version of the input signal is produced by the action of D1 and D2 in the feedback network of IC3b. This is applied to RV1 from which a portion is selected and mixed with a little of the original signal. As the half-wave-rectified signal at this point of the circuit is twice as great as the straight-through signal, by varying the setting of RV1, amounts of distortion varying from none to virtual frequency doubling can be selected.

The mixture of signals obtained above is now applied to IC3c where they are amplified. The amount of amplification is determined by the setting of SW1. In position 3 minimum gain is provided and in fact the whole fuzz section is bypassed. Position 2 gives the same gain, allowing the first distortion stage to be effective. The final position connects D3 and D4 via C5 and R19 into the feedback circuit of IC3c instead of R18. This has the effect of greatly increasing the small signal gain but causing the output to limit sharply, thus clipping and squaring the output. This facility is available on whatever output is coming from IC3b.

The output from the fuzz stages now passes to the wah wah. This effect is produced by the current controlled state variable filter used in a band-pass mode. The filter is realised by using a LM13600 device with a controlled bias current providing the variable centre frequency. The 'Q' factor is controlled by a dual gang potentiometer, half of which is used to control the 'Q' factor while the other half compensates for the effective gain change as this is altered. In this type of circuit the frequency range is determined by the values of C7, C8, R24 and R26, while the actual centre frequency is controlled by the amplifier bias current. If the bias current is allowed to become too small it is sometimes found that a thump is heard at the output; in order to prevent this R34, R35, D5 and R33 are used in the control circuitry to keep the current above this threshold.

SW2 selects between the control options for the wah wah circuit. The 'off' position bypasses the circuit altogether, the 'pedal' position makes access to an external foot pedal if fitted, while the 'auto' position connects to an output from the compressor stage. This control signal is a current which is proportional to the amount of signal compression being applied to the input signal. The magnitude of this current increases as the input signal increases. The result of this is that when the input signal is loud, the wah wah centre frequency is high and as the input decays, the wah wah frequency decreases with it. The effect of this is to make a wah sound automatically whenever a string or chord is played.

The output from this section is buffered and adjusted in level by IC3d. After this the signal passes to the signal expansion stage built around IC2b. C23 provides DC isolation and R36 converts the input voltage to a suitable drive current for the IC. For this application the linearising diode current is held constant while the amplifier bias current is varied. Q1 in the compressor circuit provides the control current for this stage allowing a good match in the attenuation/gain characteristics of the two stages. SW3 selects either the output from the expander or bypasses it as required to give normal or sustain on the effects channel.

A dual gang potentiometer RV4 allows mixing between the original signal and the effect-modified signal. This is followed by a volume control RV5 to set the output sound level.

After the volume control, IC5a buffers the signal before applying it to the tone control circuit around IC5b. The configuration used here is a very common type of feedback arrangement. As an approximation, the gain of an op-amp with feedback is taken as —(feedback resistor value)/(input resistor value). If we replace the feedback and input resistors with variable impedances, we find that when the feedback impedance is greater than the input impedance then the overall gain is greater than unity, and vice versa. As impedances vary with frequency, the gain at each frequency will tend to be different. The only time the gain does not vary is when the input and feedback impedances are equal whatever their magnitude. This is the general principle on which the tone control networks operate.

The final section to be considered is the power amplifier stage. Voltage amplification is provided by IC6 and the output from it drives two complementary compound Darlington pairs, Q4/Q6 and Q5/Q7. Quiescent current through the output devices is set by RV8 in conjunction with Q3, R54 and C19. R59 and R60 aid in maintaining bias stability and provide some protection to the output transistors in the event of a fault. R61 and C20 compensate for load impedance variations at high frequency and C18 reduces the high frequency gain of the power amplifier to reduce the possibility of RF oscillation. The large capacitors C21-25 are to reduce the effects of aging batteries and prevent low frequency oscillation or intermodulation distortion.

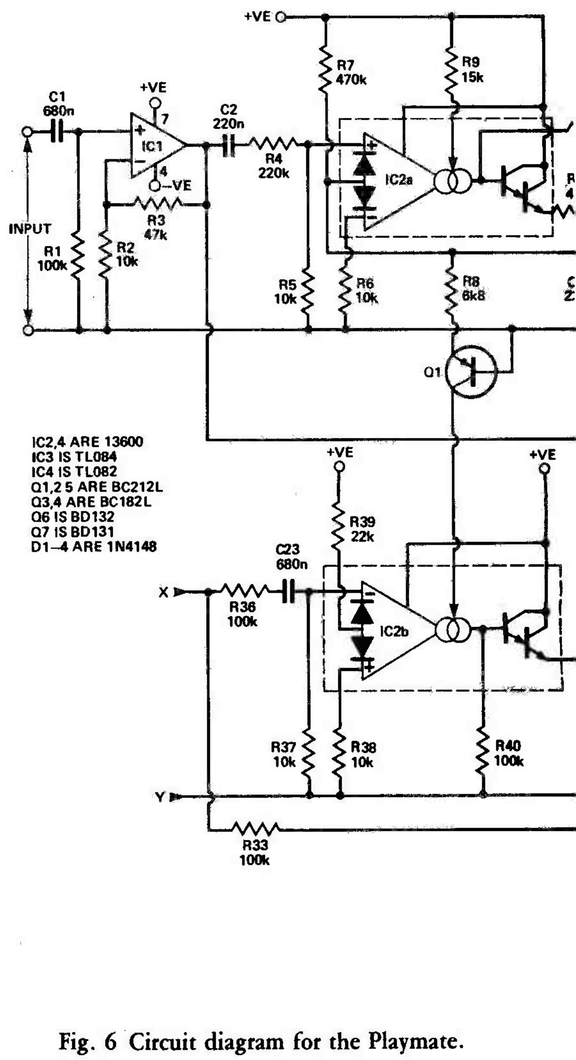


Fig. 6 Circuit diagram for the Playmate.

Compressing With The LM13600

Figure 5 shows the circuit used in this project to compress the dynamic range of the signal input. For very small signals I_D is virtually zero and the amplifier operates with a very high gain. As the signal increases, the output peak voltage will reach a level sufficient to charge the capacitor C to about one diode drop. If the input signal tries to increase further the resulting current into the input diodes will cause their impedence to fall, thus increasing the attenuation of the input and maintaining a constant output level.

At any time the current flowing into the diodes is:—

$$I_D = \frac{2 \times (V_o - 3 \times 0.7)}{R2}$$

The 3 × 0.7 represents the voltage drops associated with the base-emitter junctions of the output buffer transistors and the voltage drop of the linearising diodes. This voltage does vary with temperature and current so since another control current is required for the expander function, this is derived by using a resistor and common base transistor. The configuration gives a current output which tracks the compressor control current very closely as it has the same number of junctions in series.

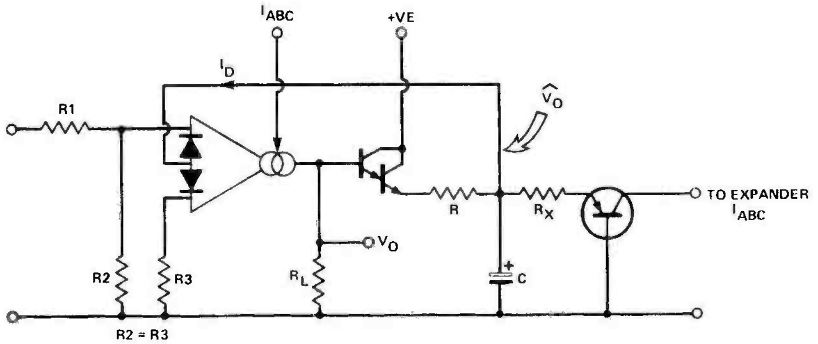
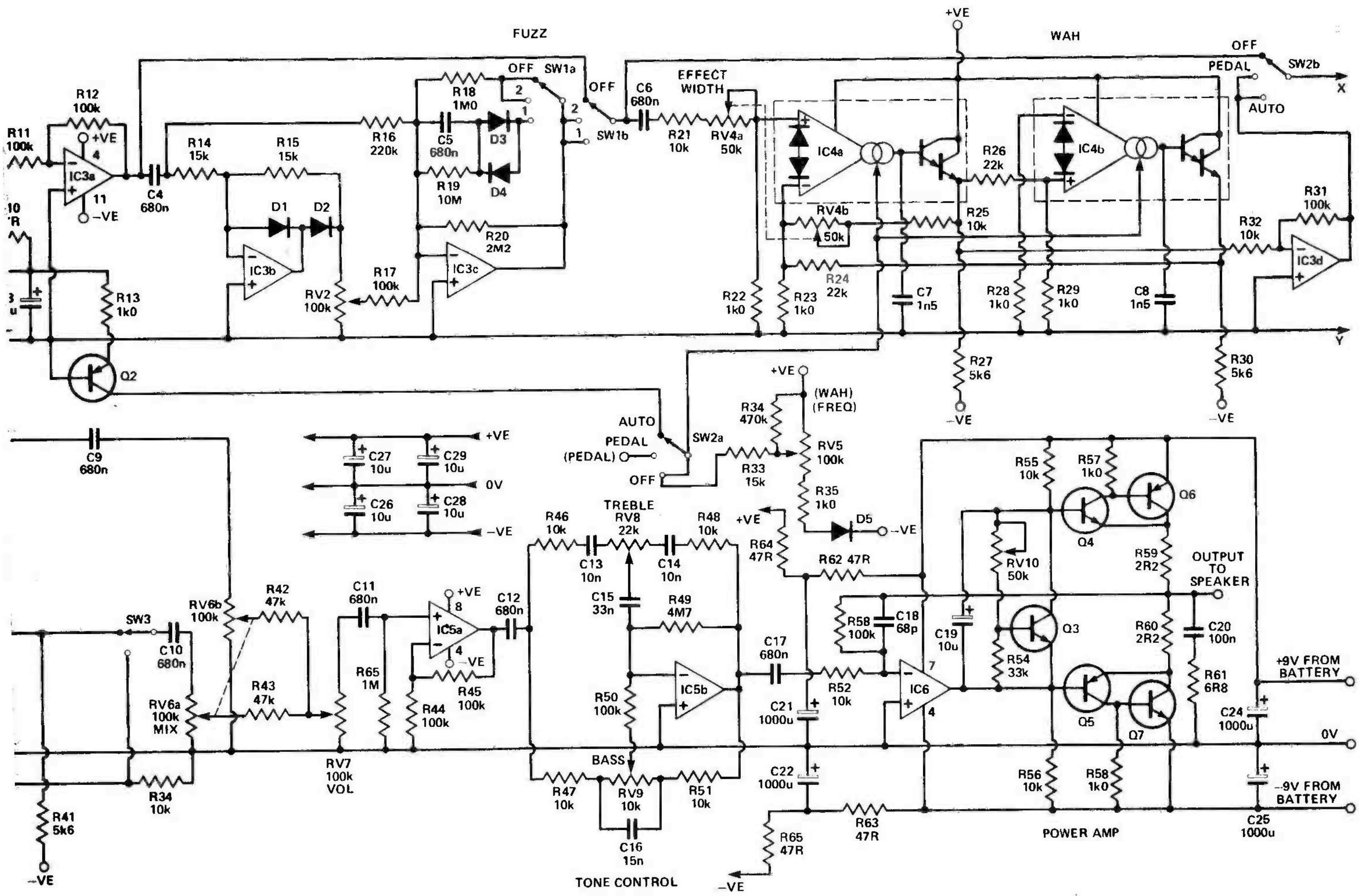


Fig. 5 Here the LM13600 is configured as a compressor.

The LM13600 As An Expander

If the current produced by the above circuit is fed into the bias current input of a virtually identical stage while the diode current is held a constant then the voltage gain equation above shows that the gain of the circuit will be increased as the current increases. Moreover the product of the two gains will be constant giving an invariant overall signal transfer function.



The construction details, parts list and overlays will appear next month. **ETI**

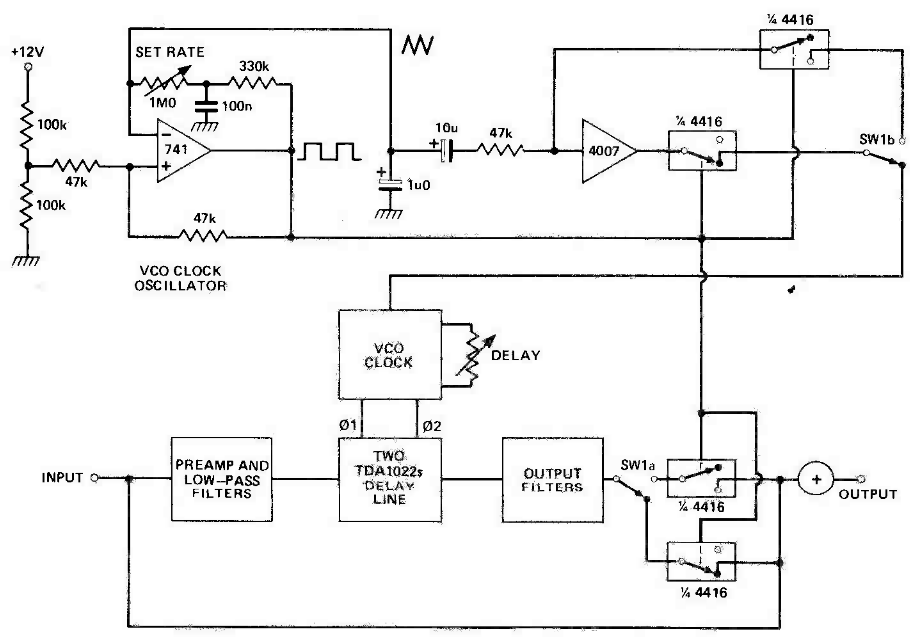
TECH TIPS

CMOS Phaser

S.P. Giles, Edmonton

This is an extension of the usual op-amp phaser, which uses CMOS inverters instead. IC1a amplifies the input signal to compensate for some of the loss in gain through the four-stage allpass network formed by IC1b-1f and IC2a-2c. The resistance of the four resistors marked R_X is altered by the enhancement FETs in IC3 and the changing voltage applied to their gates by slow oscillator IC2d,e as in the ETI audio phaser.

To set up, adjust RV2 for approximately the same level as at X, then adjust PR2 until the familiar phasing sound is heard with a smooth sweep. RV2 can then be adjusted for the best effect. These adjustments should be made with RV1 at a minimum; this is a feedback control which gives a deeper phasing effect. PR1 should be adjusted so that with RV1 full on, the feedback whistle just disappears.



Guitar Harmoniser

S.P. Giles, Edmonton

This is one for guitarists who cannot afford commercial units which cost at least £1000 at the moment. Constructors who have built the CCD phaser will be familiar with the pitch-changing effect when it is set up in the vibrato mode, and must have noticed that the longer the delay, the greater the pitch change above and below the frequency of the input.

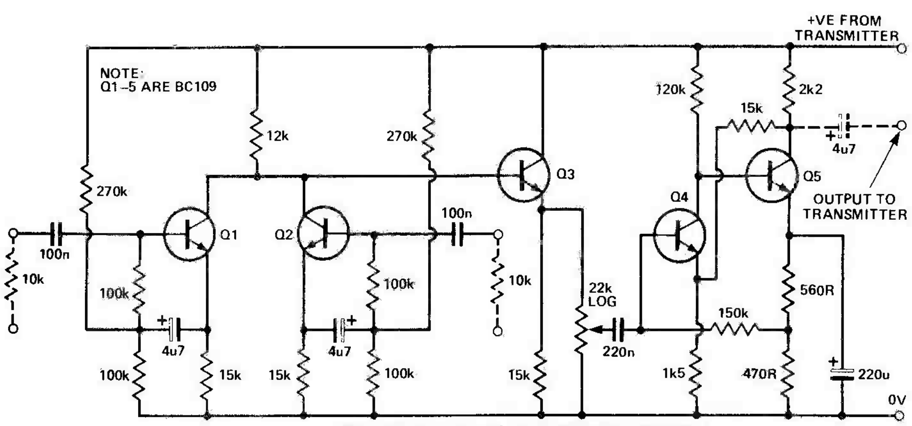
All that this circuit does is to silence the output for one half of the clock modulation oscillator's cycle. This is achieved using a 4416 quad CMOS switch, which is controlled by the square wave output of the clock modulation oscillator. This IC differs from the 4016 in that two switches will be on and two will be off even when the same control signal is applied to each switch. Depending on which way SW1 is connected, either the raised or the lowered frequency of the input will appear at the output, which can be adjusted by the rate control or by altering the delay of the TDA1022s.

There are many circuits available for TDA1022 clocks and filters so I have not bothered to include them here. Constructors must remember that there will be a slight tremulant effect as the signal in harmony with the input will only be present for the time that the clock modulation oscillator is high or low.

Mains Remote Speaker

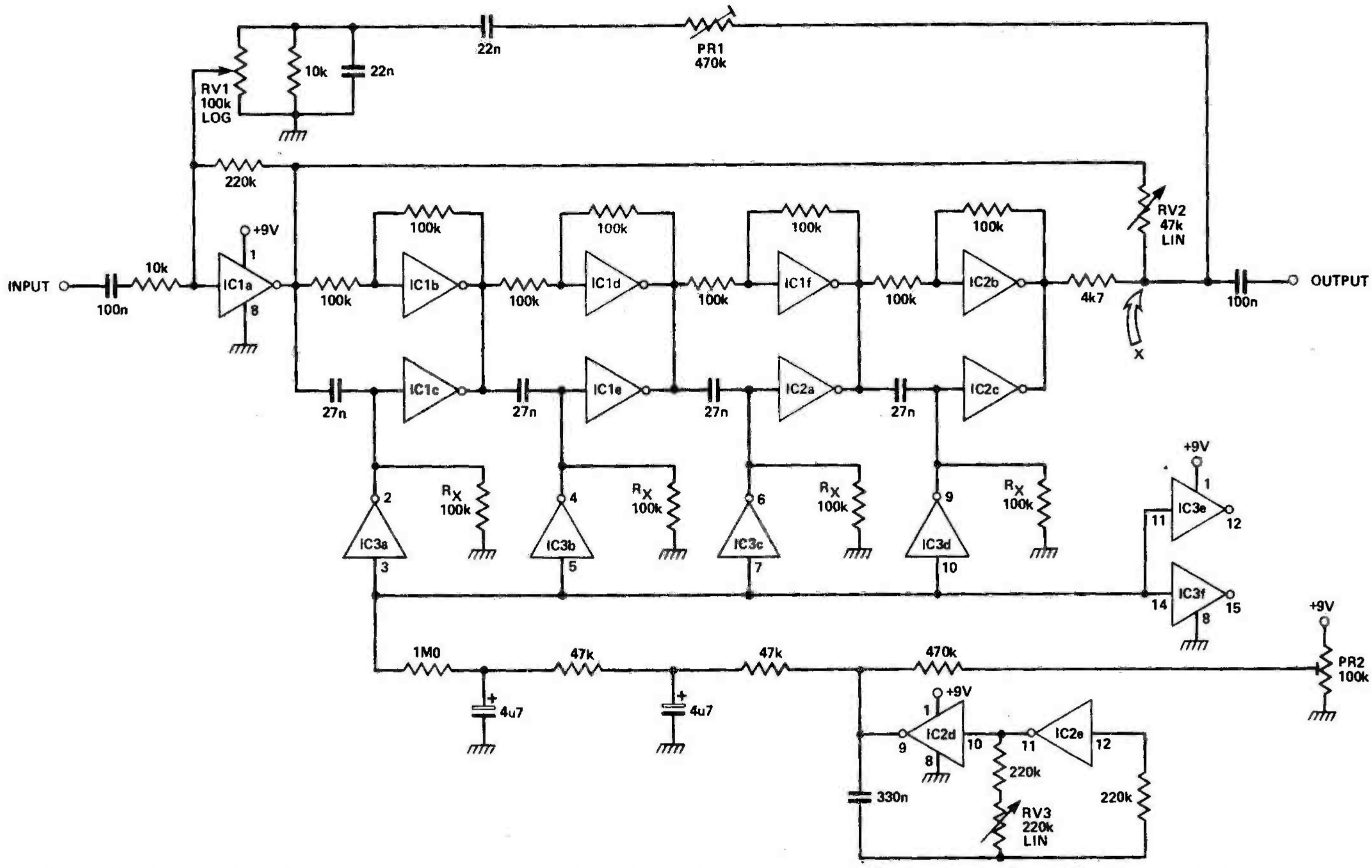
G.M. Perry, West Kilbride

I have used the idea you recently published as the 'Ear-stretcher' communication system to produce an extension speaker. The receiver unit (slightly modified) has been built into a small speaker/cabinet unit, while the transmitter is connected to the hi-fi via a 20 dB amp and mixer. (This combines the stereo channels into a mono signal). The result is a portable speaker which can be plugged into any mains socket in the neighbourhood and produce an acceptable audio quality from the hi-fi system. In three weeks I've been asked to build four units!



DOTTED COMPONENTS USED DURING SETTING UP

The modifications are as follows. The receiver is built as in the Ear-stretcher except for the following; the mains input is switched and RV1 is a 220k log pot (not a switched pot); the 'mute' is wired off; C13, 14 are 100n; C15 is omitted; C19 is 3n3. In the transmitter, C6, 7, IC3 and RV1 are not used and the circuit shown here is used to provide the signal input (instead of the microphone unit). This is a mixer with a high impedance input followed by a 20 dB amp. It is important to connect the positive supply of the mixer amp to the regulated side of the transmitter power supply. Screened cable has been used for all audio connections and an operating frequency of 250 kHz was chosen to minimise mains-borne RFI on Radio 4.



Number-guessing On The FX-501P

David Kenyon, Knaresborough

I wrote this program for the Casio FX-501P and FX-502P, but it could easily be adapted for other programmables. The object is to guess a three-digit number generated by the calculator. To start the gane, press INV P8. The display will show the number 15, which is the number of attempts you have. To make a guess, enter the number followed by EXE. One of two numbers will come up on the display; —1 means the guess was too low, while 2 means the guess was too high. If you succeed in guessing the number the number of attempts you made will displayed. The numbers in the program marked with an asterisk may be changed to give a different number of attempts.

CODE	LOC
INV P9	
INV RAN	1
x	2
1	3
0	4
0	5
0	6
=	7
MIN F	8
AC	9
INV P8	
GSB INV P9	1
1*	2
5*	3
MIN 0	4
LBL 5	5
HLT	6
INV X ≥F	7
GOTO 3	8
INV X F	9
GOTO 2	10
GOTO 1	11
LBL3	12
0	13
=	14
INV DSZ	15
1*	16
5*	17
—	18
MR 0	19
=	20
MIN 3	21
HLT	22
LBL 2	23
2	24
=	25
INV PAUSE	26
INV DSZ	27
GOTO 5	28
LBL 1	29
1	30
+ /—	31
=	32
INV PAUSE	33
INV DSZ	34
GOTO 5	35

TOTAL IS 44

MINIMUM PAYMENT £20

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items. ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for at a competitive rate.
Drawings should be as clear as possible and the text should be typed. Text and drawings must be on separate sheets. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International,
145 Charing Cross Road, London WC2H 0EE.

Intelligent Alarm Switch

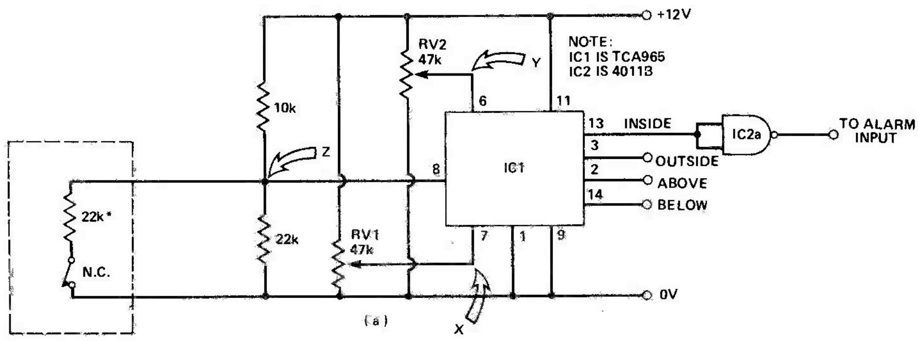
S. S. Norman, Sunbury-On-Thames

This simple circuit is built around a TCA965 window discriminator. It is a device which is given a predefined "voltage window" set by RV1 (lower limit) and RV2 (upper limit). The four outputs, which are normally high, indicate whether the input voltage (pin 8) is inside, outside, above or below the "window". Figures 1 and 2 show two possible circuits for normally open or normally closed switches.

The resistors marked * are mounted inside or fixed with epoxy to the switch to be "defended". RV1 and RV2 are set to form a window around the voltage at point Z. Once set, any attempt to cut the wires to the switch or short the switch out in an attempt to bypass it will pull the voltage at point Z out past the window and the output to the alarm will go high. Needless to say the switch will also activate the alarm in the normal way.

The smaller the window about point Z the more sensitive the circuit becomes. To set up the circuit, measure the voltage at point Z (with the circuit in its standby condition). Then adjust RV1 to set the voltage at point X to be 0V5 lower than point Z. Now adjust RV2 to set voltage at point Y to be 0V5 higher than point Z.

Fig. 1



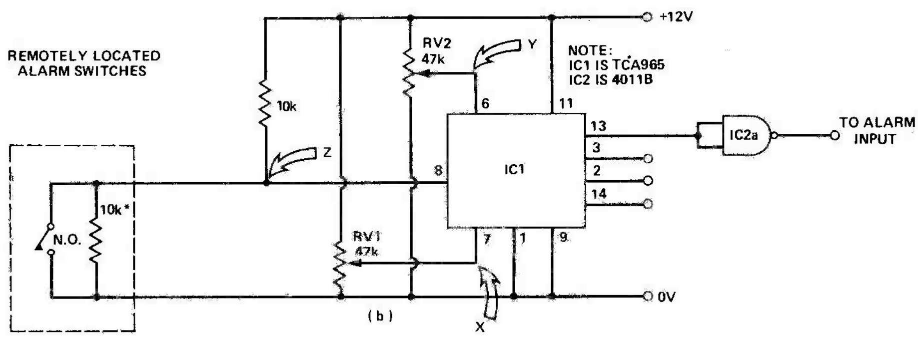


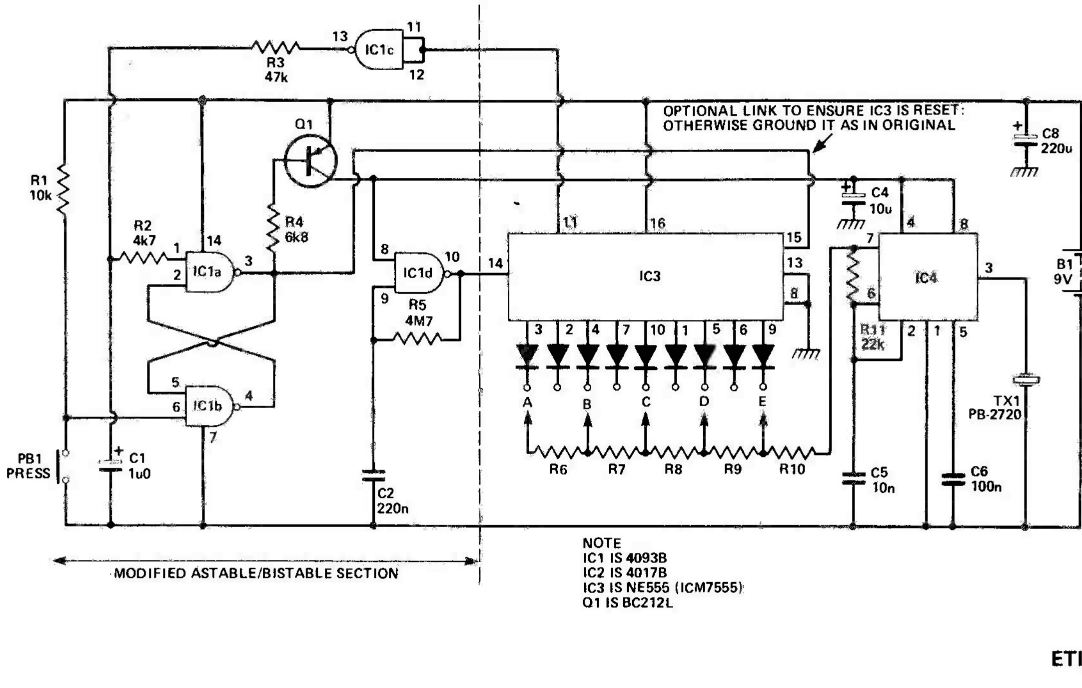
Fig. 2

Current Saving Modifications For The Musical Doorbell

William Leung, Harlow

In the original Musical Doorbell circuit (ETI December '80) IC1 and IC2 can be replaced by a single CMOS IC. This chip has four NAND Schmitt triggers. The bistable formed around IC1a,b is different from that of the original, in that it requires a negative trigger pulse. This explains why R1 and PB1 are transposed, the presence of IC1c as an inverter, and R4 being connected to the output of IC1a rather than IC1b. Next comes the astable; this is only gated into operation when IC1 pin 8 goes high.

One further current-saving modification which I have yet to try out is to replace C7, R13 and the speaker with a piezo-electric transducer (the PB-2720). To go even further, IC4 can be an ICM7555 when using TX1, although it must be stressed that TX1 only has a range between 1 kHz and 7 kHz, so R6-R10 will need some adjustment ie they should be reduced.



KITCHEN SCALES PART 2

The final part of this out-of-the-ordinary, state-of-the-art, nifty little gadget describes the construction and calibration procedures. Design and development by Rory Holmes.

Assemble the PCB in the usual fashion, noting the IC orientation, and the polarity of ZD1 and the tantalum capacitors. Also check the BC184L pinouts; these often cause confusion. Twelve Veropins should be inserted at the points marked for external connections. Another point to watch is the hole marked beneath preset PR1; this should be drilled out to 3 mm diameter before mounting the preset, thus allowing its adjustment from either side of the board. Likewise, a 3 mm hole drilled on the other centre allows a secure 6BA mounting bolt for the board.

When complete, the board may be initially tested by inserting all the ICs into their sockets and connecting a 9 V PP7 battery to the supply terminals as indicated. If a scope is available, the digital sine wave approximation should be observed at the junction of R14 and C6; it could also be checked with a crystal earpiece, when a high pitched tone of 10 kHz should be heard. The reference supply voltage can be measured with a multi-meter across the wire link and a 0 V terminal. It should be in the region of 5 V if all is well, the exact value being unimportant. At this stage the transducer should be built and wired up before further testing of the PCB.

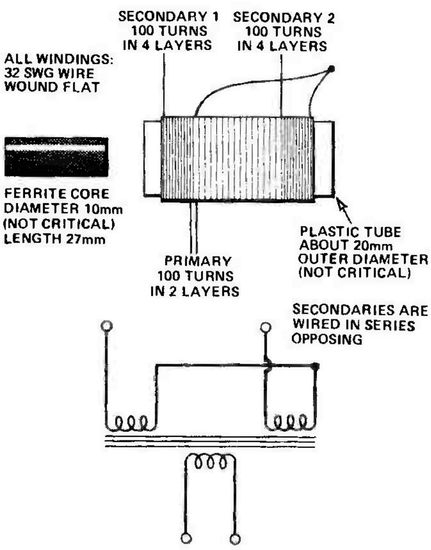


Fig. 1 Coil winding details.

Winding You Up

The LVDT is wound using 32 swg enamelled copper wire on a piece of 20 mm diameter plastic tubing of the type used for electrical conduit, and available from DIY shops. Any similar piece of tubing will suffice since the dimensions are not critical. Figure 1 shows the winding arrangements. Two separate secondaries are wound either side of the central primary winding. All the windings consist of 100 turns wound in the same direction in flat layers; four layers of 25 turns for each secondary, and two layers for the primary. The accuracy and linearity of the LDVT transducer depends upon the two secondaries being as similar as possible and symmetrically positioned about the primary winding. Care should thus be take to ensure the layers are evenly wound and tightly packed. Superglue may be used to retain each layer as it is wound. After completing the windings and finishing with a liberal coat of glue the two secondaries are then wired in series opposition to form one coil by connecting together the end of each winding.

The LVDT should now be wired up to the PCB using screened leads as illustrated on the overlay diagram. On our prototype assembly we used a four way 'Molex' PCB plug and socket for this connection since the transducer assembly could then be conveniently plugged in.

Figure 2 shows how the LVDT is mounted to measure displacement. As described last month the mechanics of an ordinary pointer scale are utilised to provide the linear displacement with weight via the in-built spring and pivot.

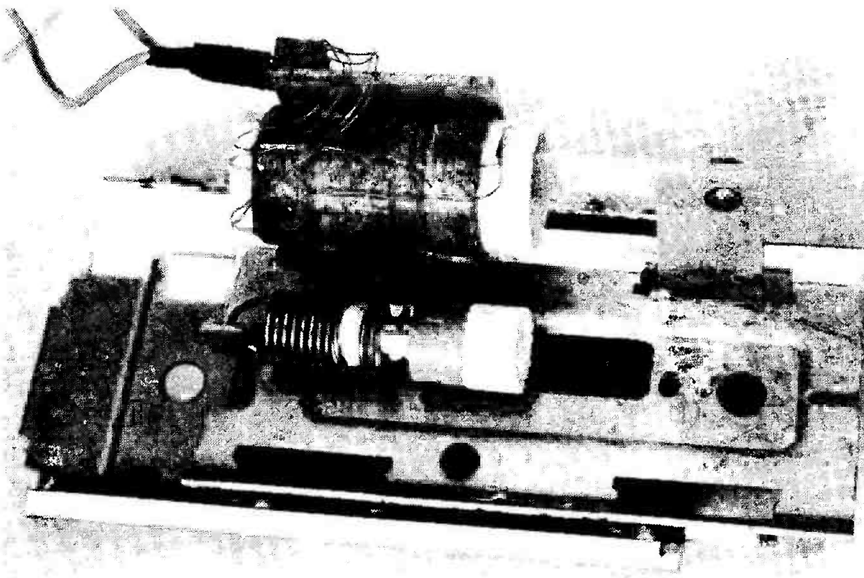
For our prototype we used a small low cost Salter scale which incorporated a ball-race slide mechanism to support the weighing pan. Practically any type of scales could be converted to a digital readout, provided these is room to mount the LVDT and its associated driver electronics.

Scaling The Heights

Obviously, the more precise the mechanics of the original scale, the greater the degree of accuracy that can finally be achieved with the electronic transducer. The principle is to attach the main coil to a fixed part of the scale while the ferrite core is attached via some rigid element to the weighing pan movement, such that as weight is put on the scale the core moves linearly along its axis into the coil former.

In our prototype the two steel plates of the slide were used to support the transducer as represented in the diagram. Two pieces of PCB material fixed with epoxy act as brackets for the coil former and ferrite core.

The mounting arrangement is not too critical but the following points should be observed. The coil must not be too close to steel or other magnetic material and likewise the ferrite core mounting should be non-magnetic and non-conductive. Remember to allow sufficient leeway on the ferrite mounting ▶



The scale mechanics with the LVDT added. Compare with Fig. 2.

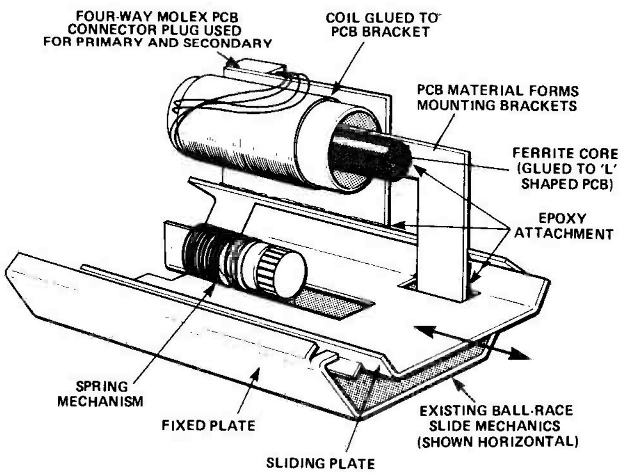


Fig. 2 An artist's impression of the sensor to help with construction.

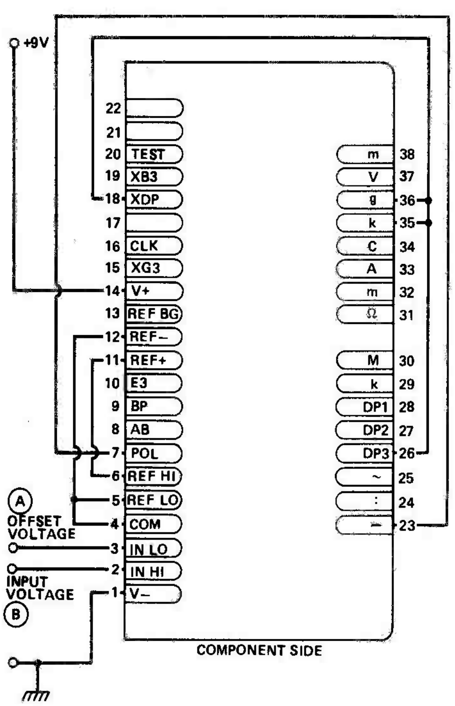


Fig. 3 The (corrected) wiring diagram.

for the full displacement (about 1 cm). The ferrite core must be central in the tube, with the axis of both coil and core parallel to the direction of weight displacement. Sufficient rigidity can be achieved using epoxy glue on the transducer, but initially the ferrite core should only be secured to its bracket with tight rubber bands until the calibration procedure.

Having completed the transducer the entire unit can now be tested by wiring up to the LCD meter-module. Wire up the module according to the connections shown in Fig 3 (this has been reprinted due to an error in last month's diagram).

The input voltage at point B should then be connected to the corresponding point on the PCB; point A temporarily connects to the 2V5 reference terminal. After connecting the DVM supply rails to the 9 V terminals on the PCB, power can be switched on. When the ferrite core is near the middle of the coil the meter should be close to 0 V and will indicate + or — readings as the core is moved to either side of the null position. The 100 mV sine wave across the primary coil can be observed on a scope along with the other waveforms illustrated last month. If all is well, the electronics can be assembled inside the scale. Figure 5 shows how we arranged the various components to fit into the existing scale box. The back of the case has now become the front to allow room for the LCD display! The 10 turn potentiometer, RV1, should also be connected up at this stage, along with the on/off switch, so completing the interwiring.

BUYLINES

The bandgap reference diode ZN423 is available from most semiconductor suppliers as are all the other more familiar semiconductors. Ferrite rods and copper wire can be supplied by Watford Electronics and 10 turn wirewound potentiometers are available from Henry's Radio.

The most expensive item in this project is the very neat LCD panel meter, a state-of-the-art CMOS module available from Verospeed Ltd (known as the DPM200, order ref. 89-25453C).

Suitable mechanical scales are available from most large department stores from about £5 upwards. The type used on our prototype conversion was a small Salter scale with a ball-race slide mechanism (around £6). The PCB Service advert is on page 69.

Alternatively, for the mechanically ingenious with a bent to experiment, a large selection of springs can be obtained from Proops of Tottenham Court Road for about £1!

Calibration

Once you are satisfied with your mechanical arrangement for mounting the transducer and associated electronics, the scale should be calibrated using standard or known weights. First, the offset voltage input to the DVM module, marked as 'A' on the wiring diagram, should be temporarily connected to the 2V5 reference terminal shown on the PCB overlay. The preset PR1 should be set at roughly half travel, and the scale loaded up with about 1 kg. After switching on the supply, the ferrite core should be adjusted relative to the coil until it's approximately in the middle at the null output position (this corresponds to half scale deflection). As the null position is approached the DVM will accordingly decrease to zero reading. The ferrite core should now be fixed permanently to its mounting plate using epoxy and allowed to set. When set, the DVM reading must be brought exactly to zero by the addition of small increments of weight, sugar or salt being ideal. The known weight, which can be anywhere between ½ and 1 kg, should be added to the scale pan, and PR1 adjusted until this weight is shown on the LCD display

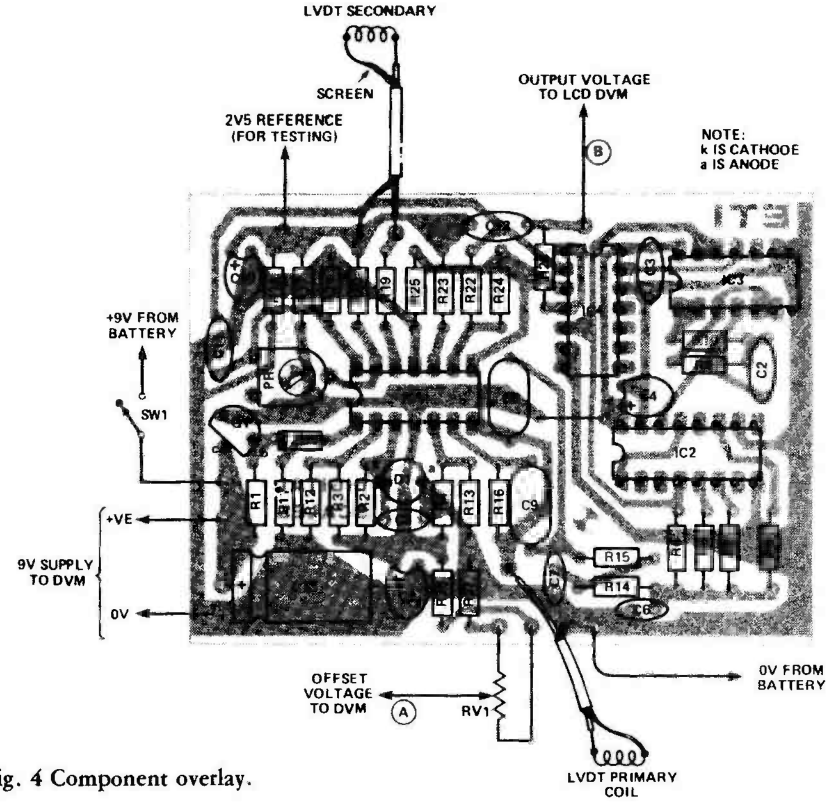
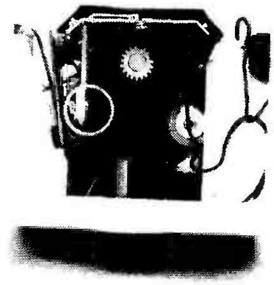


Fig. 4 Component overlay.

(turning PR1 clockwise increases the reading).

Now remove the weight to check that the reading returns to zero, and adjust PR1 accordingly (a few adjustments to PR1 may be necessary to set the correct reading for the known weight).

Finally, the offset input 'A' can be disconnected from the 2V5 reference and wired to the slider of RV1. Rotating RV1 will alter the reading and the meter can now be easily zeroed for any weight measured, including the empty scale pan. You may now proceed to calibrate the larder.


The mechanics, seen from above.

PARTS LIST

Resistors (all ¼W, 5%)

R1, 11, 13	1k0
R2	2k7
R3	27k
R4,28	100k
R5,8	33k
R6,7,16	22k
R9,12,17,18, 19,20,22,24	10k
R10	220k
R14	68k
R15	5k6
R21,25	1k5
R23	4k7
R26,27	270k

Potentiometers

RV1	47k 10 turn wirewound potentiometer
PR1	470k miniature horizontal preset

Capacitors

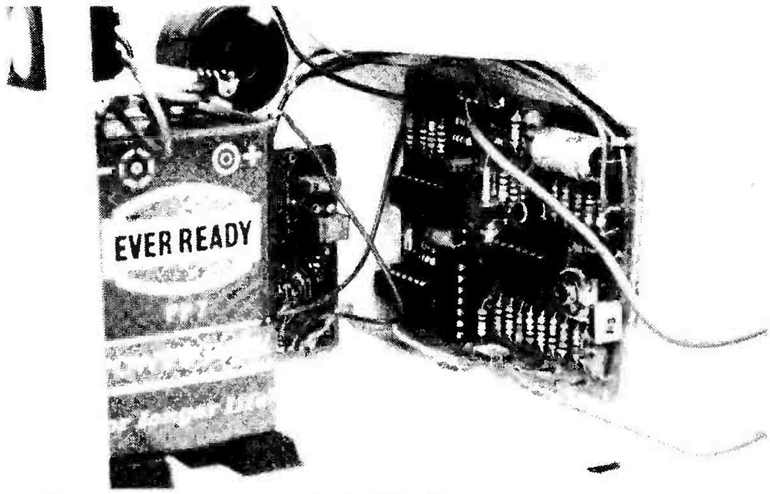
C1,4,10	22u 16 V tantalum
C2	220p polystyrene
C3,7	10n ceramic
C5	68n ceramic
C6	2n2 ceramic
C8,9	1n5 polystyrene
C11,12	100n polycarbonate
C13	220u 16V electrolytic

Semiconductors

IC1	LM324
IC2	4018B
IC3	4093B
IC4	4066B
Q1	BC184L
D1	ZN423
ZD1	2V7 400 mW zener diode

Miscellaneous

LVDT (see text); PCB (see Buylines); scales (see Buylines); 3½ digit LCD panel meter type DPM 200 (see Buylines)



An internal view showing the arrangement of the boards.

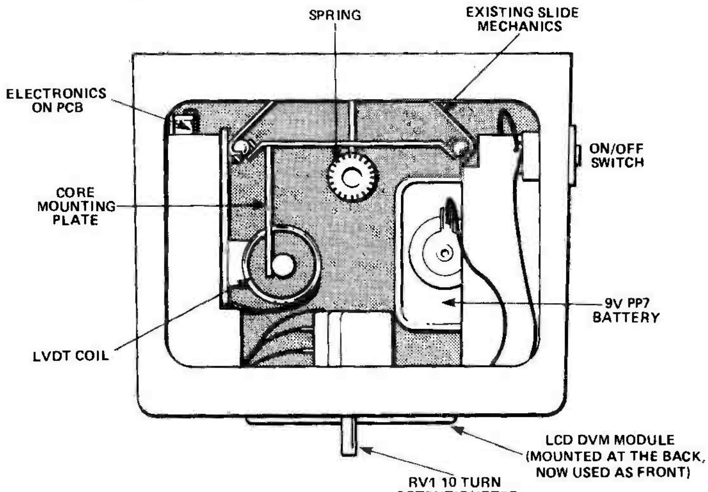


Fig. 5 Artist's impression of the 'view from the top'.

ETI

Greenbank

Greenbank Electronics
(Dept. T8E), 92 New Chester Rd., New Ferry,
Wirral, Merseyside L62 5AG
(Tel: 051-645 3391)

INTERAK 1 COMPUTER SYSTEM

INTERAK 1 Computer System: International Size Cards. Rack mounting, 4 MHz Z80A, 16K RAM expandable to 48K. Single card VDU suits standard 625 line television sets (VDU special features: "no snow", no "wait" states; character set held in EPROM permits user-defined graphics characters etc — effective resolution 256 × 240 dots). 2K ZYMON 1 monitor in 2716 EPROM £14.95, includes manual with listing. Easy to interface with International size cards from various manufacturers, e.g. "Kemitron" EPROM Programmer cards, Dual RS-232 Interface, Relay output, Optoisolated input, etc. Cards plug into 13-slot ISBUS motherboard (any card in any slot), price £11.50, suits 19" × 3U rack. Typical bare-board prices: MZB-3 CPU Card £11.50, MXD-2 16K Dynamic RAM card £11.50, VDU-K single board VDU £15.95.

INTERAK 1 is also useful in Industrial environments e.g. programs can be developed on the complete system, then the "target" system can be constructed on a few cheap cards, using e.g. ROM and RAM cards (mixed 2716 and 2114 devices). In the event of more work being needed on the "target" system, the cards can be brought back to the main INTERAK 1 system and simply plugged into the standard ISBUS.

Note: INTERAK 1 uses no ULA or other "funny" chips; the majority of components used are simple 74LS series gates, buffers, etc., and popular (i.e. low cost!) memories such as 4116, 2114, 2716 etc. Almost any ASCII encoded keyboard is suitable for input. Programs and data (Kansas City standard) are stored on your unmodified domestic tape cassette recorder; a special feature of ZYMON 1 is that check-sums are embedded throughout the data stream for increased data confidence. We have already sold several thousand boards from this range, which has been established since prehistoric times (1978), i.e. pre-Sinclair, pre-Acorn, pre-Tangerine etc.

Come to us if you want a system which is sold by people who know and care about the system they offer, rather than by advertising and media-marketing men. We are a small, and we hope, friendly company (established 12 years), and we would be happy to tell you more if you were to telephone or arrange to call and see us, or if you prefer, you can write in for a free descriptive leaflet, which includes a price list.

FEATURED CARD THIS MONTH — VDUK

* International Size Card (114 × 204mm)
* Fast Z80A CPU runs at full 4MHz.
* Quartz crystal controlled.
* Address and data lines fully buffered (four buffer chips).
* Power on reset, and manual reset.
* Reset line pulsed to maintain Dynamic RAM data when reset is active.
* Z80A Refreshed Dynamic RAMs transparently.
* On-board 4-bit address latch included for easy interface to Dynamic RAMs.
* On-board "boot" EPROM socket, addressable at any 4K boundary.
* Boot EPROM can be disabled under software control.
* Power-on jump circuit to any 4K boundary.
* Epoxy-glass PCB.
* Double-sided board, tinned copper tracks.
* Gold-plated edge connector on A side.
* Needs only single 5V rail (if 5V on-board EPROM is used).

DESCRIPTION
The MZB-3 is a "Kemitron" card which has been selected for use in the INTERAK 1 computer, as it is ideally suited for this purpose.

Bus Allocations
The "Kemitron" allocation for the NWAIT line on the card is position A30, and this needs re-routing to position A34 to suit ISBUS-A and INTERAK 1.
The CPU card is the heart of a computer system (or perhaps more correctly the "brains"). The Z80A is an ideal choice since it is rapidly becoming the standard 8-bit microprocessor. (This is proved by observing that many 6502-based computers now provide "add-on" Z80A adaptors; you never see an add-on 6502 for a Z80A-based computer.)

Crystal Controlled
The Z80A is a specially selected fast version of the standard Z80, it is used on this card at its full 4 MHz operating speed. No "Wait" states are included to slow the CPU down, but the NWAIT line on the bus is available for use with slow memories. Note that the VDU-K and the MXD-2 Dynamic RAM cards do not require any wait states, and so the CPU card in an INTERAK 1 system can operate at its full speed.
The "Clock" signal required for the Z80A is not a normal LSTTL level, but is required to swing right up to +5V. At full speed an "active pull-up" is needed to meet this requirement, and is included on the MZB-3 card. A spearate clock of the same frequency is output to the bus for those cards which require it.

Reset
A power-on reset circuit is included as standard, so that the system starts to operate in an orderly manner. A push-button switch is provided so that the user can reset the system at any time, without the need to sacrifice the contents of memory by switching the computer off. The reset signal is taken to the bus, so that any other cards which require resetting can be reset at the same time.

Dynamic RAM
As the user can reset the CPU at any time special circuitry is needed, and is included on the card, to ensure that the reset pulse does not occur in the middle of a Dynamic RAM access, and so corrupt any data stored. As Dynamic RAM needs "refreshing" several hundred times a second, and this is carried out by the CPU, it is important that the reset pulse is not maintained for too long a time. The reset circuitry on the MZB-3 card ensures that this requirement is met also.
Although the Z80A has been chosen primarily because it is the best and most well-known microprocessor, a very useful built in feature it possesses, which is not available to the users of say the 6502, is its ability to refresh Dynamic RAM "transparently". More will be said on the subject of refreshing, why it is needed and so on, on the MXD-2 card data sheet, but there are some aspects which are most conveniently covered here.

The built in Z80A refresh is described as "transparent" because it is carried out at a time when the Z80A is not using the bus, and so does not slow the Z80A down in any way. The particular time used is available after each "op-code fetch"; this is when the next instruction of the program has been fetched and is being decoded by the Z80A. Special hardware within the Z80A chip outputs the necessary refresh signal at this time, without the rest of the CPU being involved at all.
A special 4-bit latch has to be added to the CPU circuit, to feed the top four address lines when Dynamic RAMs are being used, and of course this is included on the standard MZB-3 card.

Buffers
Buffers are needed in a computer system to allow each card to drive the bus with sufficient power so that neither corruption of data nor damage to expensive integrated circuits will occur. It becomes doubly important when the CPU is being run at topo speed, so that the signals can reach their full voltage levels in the short times available.
Beware of systems where the buffering is omitted simply to give a low price "starter kit", or to cram too much circuitry on the introductory card in the system.

Power on Jump
An important feature of INTERAK 1 is that it has RAM starting at location zero. There are many technical reasons why this apparent complexity is a good thing, and these are discussed in the various INTERAK 1 leaflets. Suffice it to say that the technique of having RAM at zero solves more problems than it causes. There is in fact very little benefit in a simple minimum system, but an expandable system like INTERAK 1 should have as few limits as possible placed on the future needs of the more advanced user (for example note that the well known disk operating system CP/M just will not work unless RAM is present from zero upwards).
At power-on, the RAM at zero will not usually contain any useful program and it is necessary to force the Z80A to "jump" to get its first instructions from some other address (usually one at which an EPROM is to be found). This address can be set by wire links to any 4K boundary, and in the INTERAK 1 system it has been chosen to be E000 (hexadecimal). One of the first tasks of the program at E000 is to disable the power-on jump circuitry.

74LS

74LS00	11	74LS73	18	74LS157	30	74LS257	35	74LS375	45
74LS01	11	74LS74	18	74LS158	30	74LS258	35	74LS377	70
74LS02	11	74LS75	20	74LS160	37	74LS259	75	74LS378	60
74LS03	12	74LS76	18	74LS161	37	74LS260	22	74LS379	65
74LS04	12	74LS78	18	74LS162	37	74LS261	£1.38	74LS384	£3.95
74LS05	13	74LS83	40	74LS163	37	74LS266	20	74LS385	£2.50
74LS08	12	74LS85	52	74LS164	43	74LS273	68	74LS386	86
74LS09	12	74LS86	24	74LS165	75	74LS275	£2.25	74LS390	55
74LS10	13	74LS90	28	74LS166	75	74LS279	35	74LS393	55
74LS11	13	74LS91	60	74LS168	84	74LS280	£1.80	74LS395	£1.25
74LS12	13	74LS92	32	74LS170	85	74LS283	40	74LS396	£1.90
74LS13	21	74LS93	28	74LS173	65	74LS290	45	74LS398	£2.75
74LS14	38	74LS95	40	74LS174	50	74LS293	40	74LS399	£1.75
74LS15	13	74LS96	95	74LS175	45	74LS295	£1.50	74LS445	£1.00
74LS20	13	74LS107	40	74LS181	£1.30	74LS298	95	74LS447	£1.44
74LS21	13	74LS109	28	74LS183	£1.80	74LS299	£2.70	74LS471	£6.20
74LS22	13	74LS112	28	74LS180	45	74LS300	£1.75	74LS490	£2.00
74LS26	14	74LS113	22	74LS191	45	74LS302	£1.75	74LS541	£1.20
74LS27	13	74LS114	22	74KS192	45	74LS320	£2.70	74LS640	£1.80
74LS28	14	74LS122	38	74LS193	45	74LS323	£1.95	74LS641	£1.80
74LS30	13	74LS123	38	74LS194	36	74LS324	£1.68	74LS645	£1.80
74LS32	15	74LS124	95	74LS195	36	74LS325	£2.90	74LS668	£1.25
74LS33	15	74LS125	26	74LS196	50	74LS326	£2.40	74LS669	£1.20
74LS37	15	74LS126	25	74LS197	65	74LS327	£2.40	74LS670	£1.50
74LS38	15	74LS132	42	74LS200	£2.75	74LS347	95	74LS673	£5.50
74LS40	15	74LS133	30	74LS202	£2.75	74LS348	£1.25		
74LS42	32	74LS136	26	74LS221	55	74LS352	88		
74LS47	38	74LS138	32	74LS240	75	74LS353	88		
74LS48	45	74LS139	32	74LS241	75	74LS362	£7.50		
74LS49	50	74LS145	70	74LS243	75	74LS363	£1.50		
74LS51	14	74LS147	£1.50	74LS244	75	74LS364	£1.50		
74LS54	14	74LS148	85	74LS245	70	74LS365	30		
74LS55	14	74LS151	40	74LS247	50	74LS366	30		
74LS63	£1.20	74LS153	40	74LS248	55	74LS367	30		
		74LS154	£1.70	74LS249	55	74LS368	40		
		74LS155	35	74LS251	35	74LS373	65		
		74LS156	36	74LS253	35	74LS374	65		

74S

74S04	73p

74C

74C00	28p	74C14	30p	74C901	57p
74C02	28p	74C20	28p	74C902	79p
74C04	28p	74C30	28p	74C903	57p
74C08	28p	74C32	28p	74C904	57p
74C10	28p	74C42	95p	74C905	£7.53
		74C48	£1.43	74C905	57p
		74C73	57p	74C907	57p
		74C74	50p	74C908	£1.00
		74C76	57p	74C909	£1.69
		74C83	£1.34	74C909	£1.69
		74C85	£1.34	74C910	£7.45
		74C86	67p	74C911	£7.39
		74C89	£4.62	74C912	£7.39
		74C90	89p	74C914	£1.45
		74C93	90p	74C915	£1.15
		74C99	£1.06	74C918	£1.10
		74C107	£1.27	74C921	£17.07
		74C150	£3.81	74C922	£3.78
		74C151	£2.56	74C923	£5.49
		74C154	£3.81	74C925	£5.99
		74C157	£2.29	74C926	£5.99
		74C160	£1.40	74C927	£5.99
		74C161	£1.15	74C928	£5.99
		74C162	£1.15	74C929	£17.90
		74C163	£1.15	74C930	£17.90
		74C164	£1.60	80C95	85p
		74C165	£1.08	80C96	92p
		74C173	93p	80C97	85p
		74C174	93p	80C98	92p
		74C175	93p	82C19	£6.20
		74C192	£1.15	88C29	£2.90
		74C193	£1.15	88C30	£2.90
		74C195	£1.00		
		74C200	£7.45		
		74C221	£1.41		
		74C373	£1.79		
		74C374	£1.79		

CMOS

4000	14p	4002	14p	4043	70p	4093	43p	4409	£7.90	4530	70p
4001	14p	4006	66p	4044	65p	4094	£1.68	4410	£7.20	4531	£1.30
		4007	18p	4045	£1.70	4095	90p	4411	£6.95	4532	£1.10
		4008	62p	4046	75p	4096	90p	4412VP	£8.00	4534	£5.00
		4009	35p	4047	75p	4098	88p	4415V	£4.80	4536	£2.95
		4010	40p	4097	£3.20	4099	95p	4422	£5.66	4537L	£26.10
		4011	15p	4048	55p	40100	£1.92	4433	£7.70	4538	£1.15
		4012	18p	4049	50p	40101	£1.30	4435V	£5.40	4539	£1.15
		4013	34p	4050	30p	40102	£1.80	4450	£3.50	4541	£1.19
		4014	75p	4051	78p	40103	£1.75	4451	£3.93	4543	£1.35
		4015	66p	4052	78p	40104	95p	4461	£4.41	4549	£3.95
		4016	32p	4053	78p	40105	£1.15	4490PP	£3.50	4552	£14.85
		4017	48p	4054	£1.25	40106	75p	4490VP	£3.14	4553	£2.99
		4018	68p	4055	£1.25	40107	60p	4501	29p	4554	£1.38
		4019	42p	4056	£1.20	40108	£4.50	4502	£1.20	4555	50p
		4020	61p	4059	£4.80	40109	£1.00	4503	70p	4556	55p
		4021	70p	4060	90p	40110	£3.00	4505	£5.71	4557	£3.20
		4022	66p	4062T	£9.95	40114	£1.77	4506	50p	4558	£1.20
		4023	20p	4063	99p	40160	£1.54	4507	40p	4559	£3.95
		4024	45p	4066	36p	40161	£1.54	4508	£2.65	4560	£1.80
		4025	19p	4067	£3.99	40162	£1.54	4510	68p	4561	81p
		4026	£1.30	4068	22p	40163	£1.54	4511	68p	4562	£4.95
		4027	38p	4069	20p	40174	£1.54	4512	75p	4566	£1.59
		4028	58p	4070	26p	40181	£5.03	4513	£1.99	4568	£2.38
		4029	77p	4071	20p	40182	£1.90	4514	£1.99	4569	£1.75
		4030	50p	4072	20p	40192	£2.41	4515	£1.98	4572	36p
		4031	£1.70	4073	20p	40193	£2.41	4516	75p	4580	£4.60
		4032	£1.25	4075	20p	40194	£1.05	4517	£4.15	4581	£2.50
		4033	£1.65	4076	60p	40208	£7.54	4518	42p	4582	99p
		4034	£1.95	4077	26p	40257	£2.31	4519	29p	4583	90p
		4035	95p	4078	26p	4160	95p	4529	78p	4584	48p
		4037	£1.15	4081	26p	4161	99p	4521	£2.00	4597	£2.44
		4038	£1.10	4082	26p	4162	99p	4522	£1.11	4598	£2.90
		4039	£2.79	4085	65p	4163	99p	4526	95p	4599	£5.95
		4040	59p	4086	65p	4174	99p	4527	£1.15	4700	£1.75
		4041	78p	4086	70p	4175	£1.05	4528	80p	ICM7038A	£4.25
		4042	60p	4089	£1.40	4194	£1.05	4529	£1.30		

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3.2768 MHz	£2.70	14.0 MHz	£3.92
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4.194304 MHz	£1.99	20.000 MHz	£2.80
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5.120 MHz	£3.23	38.6666 MHz	£3.50
5.185 MHz	£3.23	48.000 MHz	£2.70
		100.000 MHz	£2.90
		116.000 MHz	£3.00

MICROPROCESSORS

Z80

Z80A CPU	£3.30
Z80A P10	£2.90
Z80A CTC	£2.90
Z80A-S10/10	£13.95

6502

6502	£4.25
6520/21	£2.99
6522	£3.50
6532	£6.95

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6800 MPU	£2.95
6802 MPU	£3.99
6809	£8.75
6810 (128 × 8 RAM)	£1.20
68A10 (128 × 8 RAM)	£1.30
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6840	£4.20
6845	£9.50
6850 ACIA	£1.50
MC6880	£1.20

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SC/MP II (4MHz)	£10.47
INS 8070	£22.37
INS 8154 RAM I/O	£9.62
INS 8255 I/O	£3.50

CMOS

COSMAC CDP 1802CE	£6.50
COSMAC CDP 1802E	£10.85
CDP 1864	£6.45

STATICS

2114L 200nS	84p
2114L 300nS	83p
6116 CMOS 2K RAM 200nS	£4.75
4118 — 1K × 8	£3.25

DYNAMICS

4116 16K 200nS	74p
4164	£7.96

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2708 1K × 8	£1.98
2716/2516 2K × 8 single 5v	£1.98
2532 K4 × 8 (5v)	£4.05
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EPROMPT	£33.00

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81LS 95	90p
81LS 96/97	90p
81LS 98	90p
1488	59p
1489	59p
75491	70p
75492	92p
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1.74	48p
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FD 1771	£17.12
8131	£2.50
8136	£2.50
ICM 7209 IPA	£2.69
COM 8116 (Baud Rate)	£8.00
SAA5050	£8.51
SAA5020	£6.33

CRT CONTROLLER: Uarts

AY-5-1013	£3.45
AY-3-1014A	£5.50
AY-3-1015	£3.00
6402	£3.92
1402	£4.50
96364E	£5.94

CHAR. GEN. KEYBOARD ENCODER

MK 2302	£15.29
RO 3 2513 (5v Uppercase)	£5.75
AY 5 2376	£5.80

FIRMWARE

2K ZYMON for Z80 (1 × 2516) includes commented listing	£14.95
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2K Tiny Basic for Z80 (1 × 2516)	£14.95
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4K NIBL-MM for SC/MP (4 × 2708)	£49.95
(Description leaflet available)	
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1½K ELBUG (3 × 5204)	£35.00
ETIBUG (1 × 5204)	£35.00
ETIBUG (1 × 5204)	£14.95
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7912	55p

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Spot face cutter	£1.30
Pin insertion tool	£1.78

Z80 DATA PACK
Comprehensive information on the Z80, CPU, P10, CTC etc., in the bound data books described below.
Mostek Z80 Programming Manual (approx 300 pages) fully detailed explanation of all the Z80 op-codes/assembly language.
Mostek Z80 Microcomputer Data Book (approx 475 pages) contains Z80 instruction set and technical information and specifications of the Z80 family I.C.'s
Mostek Micromputer Systems Data Book (approx 220 pages) contains details of the Mostek range of microcomputer circuit boards and software etc.
The weight of the data pack is approximately 1.9 kilos.
Price: £14.95 (There is no VAT on this item, but please add an extra £1.00 towards the cost of the postage).

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IN 4003/4/5	6p
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15nF, 22nF, 47nF at 5p each
100nF at 7p

WIRING SYSTEM

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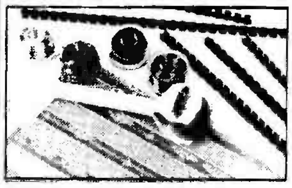

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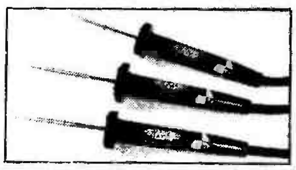

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GREEN COLOUR	2.12
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28 WAY 25p 40 WAY 35p
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20 WAY 27p 22 WAY 28p
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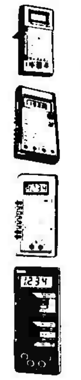

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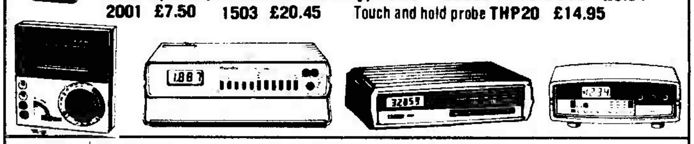

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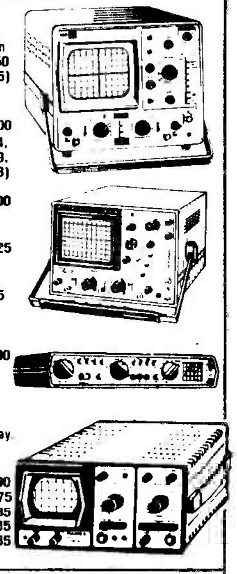
Scope probes all models - see below.



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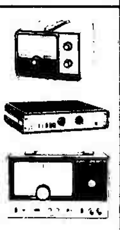

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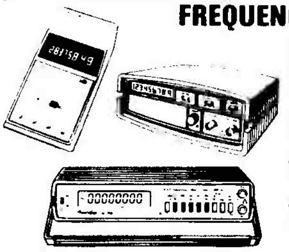

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- **8000B** 9 digit LED 3 range 1000 MHZ Bench (SABTRONICS) — £178.00
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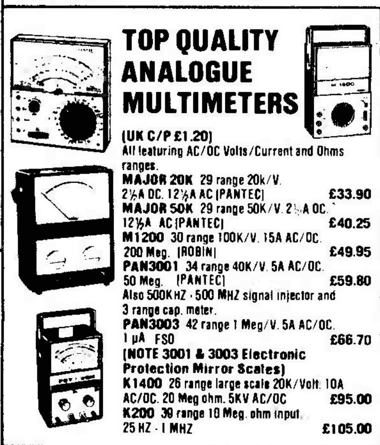

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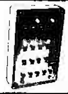

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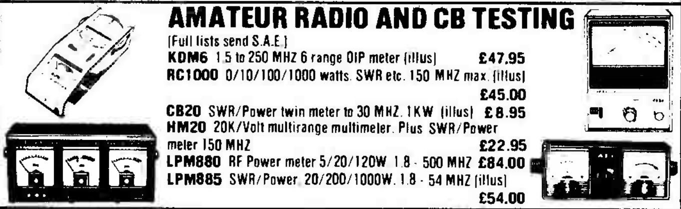

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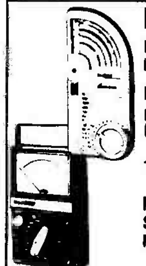

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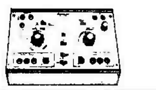

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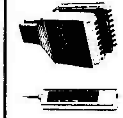

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CONFIGURATIONS

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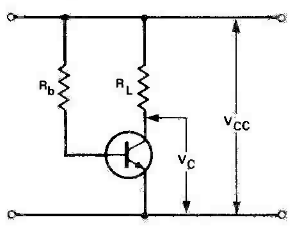
Configurations is a new series which aims to provide you with fundamental circuit design data for a number of the most commonly used circuit blocks. A very large amount of circuit work concerns these standard arrangements, so that by gathering your pages of Configurations each month, you will be able to build up a complete designer's handbook of circuits and their design data. We're starting this month with the most fundamental of all — biasing and calculating gain and bandwidth of the single-stage common-emitter amplifier, using a silicon transistor with a resistive load.



(a) TO FIND A VALUE FOR R_b, GIVEN A DESIRED VALUE OF V_C:

$$R_b = \frac{R_L h \ R_L . h_{fe} . (V_{CC} - 0.6)}{V_{CC} - V_C}$$

R_L AND R_b IN KILOHMS

(b) TO FIND WHAT VALUE OF V_C WILL BE CAUSED BY A GIVEN BIAS RESISTOR:

$$V_C = \frac{V_{CC} . R_b - R_L . h_{fe} . (V_{CC} - 0.6)}{R_b}$$

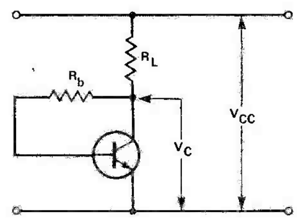
R_L AND R_b IN KILOHMS

Fig. 1 Simple single-resistor bias circuit. The value of resistance depends critically on the value of h_{fe} for the transistor.

The simplest bias circuit, of course, is that of Fig.1, using a single bias resistor connected between the base and the supply positive. We're not going to spend much time on this one, because it's not a very good bias method from any point of view. The reason is that the resistor value has to be spot on for this method to work, and you have to know the current gain (h_{fe}) value for that particular transistor (not just the average for the type) to a fair degree of accuracy. If you need to use that method and have a box of 1% tolerance resistors handy, then the design data is illustrated in Fig. 1. One of the few things that can be said for the circuit is that a high input resistance is attainable, but more on that subject later.

A Favourable Bias

A much more practical bias method is illustrated in Fig. 2. This makes use of DC shunt feedback between the collector and the base of the transistor, and is less likely to be upset by the changes that occur in the characteristics of the transistor as it heats up. You still have to know the h_{fe} value for the transistor, but the collector voltage won't be so far out if you just use an average value for the type and it happens that the one you're using is at one end of the range of values. The formula, like the previous one, assumes that the base-to-emitter voltage when the transistor is conducting will be 0V6 and since this is the quantity that changes most as a silicon transistor heats up, it's worth while taking a look at how this bias method is affected.



(a) TO FIND A VALUE FOR R_b, GIVEN A DESIRED VALUE OF V_C:

$$R_b = \frac{R_L . h_{fe} . (V_C - 0.6)}{V_{CC} - V_C}$$

R_L AND R_b IN KILOHMS

EXAMPLE: IF R_L = 2k2, h_{fe} = 100, V_{CC} = 9V, V_C = 3V, THEN

$$R_b = \frac{2.2 \times 100 \times 2.4}{6} = 88k$$

(b) TO FIND A VALUE FOR V_C, GIVEN R_b:

$$V_C = \frac{R_b . V_{CC} + 0.6 R_L . h_{fe}}{R_b + R_L . h_{fe}}$$

Fig. 2 Shunt-feedback bias. The value of collector voltage is less dependent on the h_{fe} value. Note the units, with all resistances in kilohms.

Figure 3 shows two calculations of collector voltage, both assuming a supply voltage (V_{cc}) of + 9 V, load resistor of 2k2, h_{fe} value of 100, and bias resistor R_b of 88k. However, one uses 0V6 as the V_{be} figure and the other uses 0V5. The difference in the collector voltage is negligible, which points to this method of bias as being a very useful one when you are worried about the effect of temperature changes on the performance of the transistor.

ASSUME IN BOTH CASES THAT R_b = 88k, h_{fe} = 100, V_{CC} = 9V, R_L = 2k2.

WHEN V_{be} = 0V6, $V_C = \frac{88 \times 9 + 0.6 \times 2.2 \times 100}{88 + 2.2 \times 100}$ = 3V

WHEN V_{be} = 0V5, $V_C = \frac{88 \times 9 + 0.5 \times 2.2 \times 100}{88 + 2.2 \times 100}$ = 2V93

DIFFERENCE IN V_C = 70 mV

Fig. 3 Effect of temperature. The V_{be} (assumed 0V6 for a silicon transistor) decreases as the temperature rises. The calculations show that the collector voltage value is hardly affected.

The circuit uses feedback, of course, and unless something is done to remove the feedback of AC, the gain of the stage and its input resistance will be reduced. The reduction in gain isn't serious for most circuits, but the input resistance problem can be more serious — it's detailed later in this article. Both can be tackled if AC is removed from the feedback path by splitting the bias resistor into two parts and decoupling it, as shown in Fig. 4.

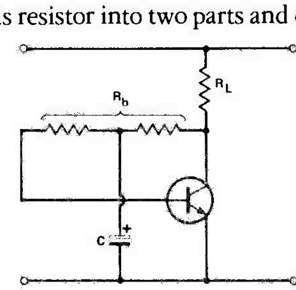
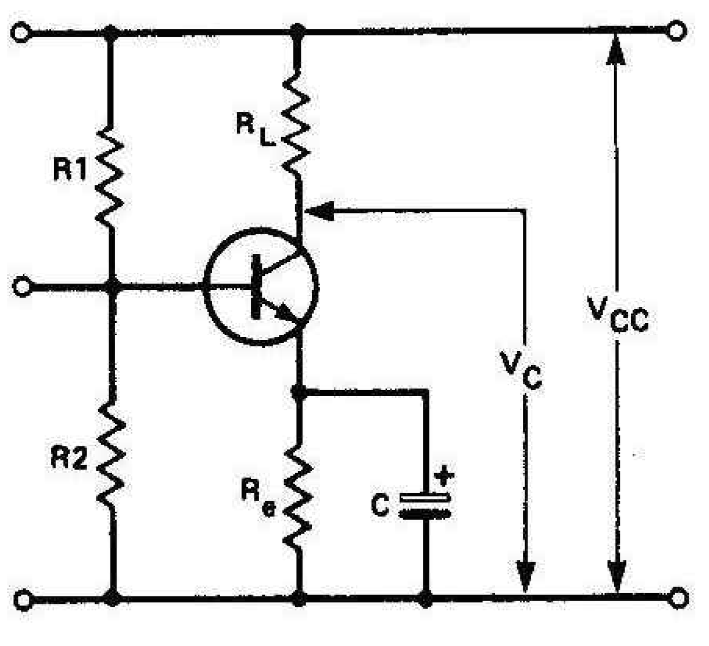


Fig. 4 Removing AC feedback by splitting the bias resistor into two sections and decoupling.

An Arrangement With Potential

The most-extensively used of all bias methods is our old friend in Fig. 5, which uses a potential divider to provide a constant voltage (we hope) at the base of the transistor, and DC feedback (series feedback this time) through the emitter resistor to stabilise the bias. The notable thing about the formula is that h_{fe} doesn't appear anywhere in it, so that the bias should not be affected by the value of h_{fe}. This means that the circuit is very tolerant of wide ranges of h_{fe} values, providing the base current of the transistor is not so large that it disturbs the base bias voltage set by the potential divider. As a rule of thumb, if the current flowing through R1 and R2 (equal to $V_{cc}/(R1 + R2)$) is something like 100 times the base current of the transistor, then the circuit will work exactly as per design, and any transistor whose base current is within limits can be used with the same bias components. If the base current of the transistor is far from negligible then complications arise, and it's easier just to use lower values of R1 and R2 — but for the effect on input resistance, see later. For voltage amplifier stages where the collector current is only about 1 mA, values like 6k8 and 1k5 on a 9 V supply will suit the circuit very nicely.



(a) TO FIND R_e FOR A DESIRED V_C:

$$R_e = \frac{R_L \cdot \left(\frac{V_{CC} \cdot R2}{R1 + R2}\right) - 0.6}{V_{CC} - V_C}$$

(b) TO FIND V_C FOR A GIVEN R_e:

$$V_C = V_{CC} - \frac{R_L \cdot \left(\frac{V_{CC} \cdot R2}{R1 + R2}\right) - 0.6}{R_e}$$

Fig. 5 The potential-divider bias method. This is particularly useful for mass-produced circuits, because bias does not depend on h_{fe} values.

Decoupling Is De Problem

One disadvantage of the circuit is that there's an emitter DC voltage so that the available voltage swing at the collector is correspondingly reduced. The other point, which is important where space is limited, is that decoupling of the emitter resistor is essential. Without decoupling the gain is low; it's given by R_L/R_e and will be around two to six times for the kind of values you are likely to end up with in a practical circuit. The decoupling capacitor operates at low voltage, so that a 3 V or 6 V type is normally adequate, but its value has to be large to avoid a noticeable loss of gain at low frequencies. It certainly isn't enough to have the reactance of the capacitor equal to the resistance value of R_e at the lowest frequency for which the amplifier is intended to be used, because if you make this assumption for each coupling and decoupling time constant, you'll end up with practically no gain at that frequency. Aim for a capacitor reactance of about one fifth of the emitter resistance value at the lowest frequency you intend to use and the results will be more acceptable. With C in microfarads and R_e in kilohms, this means a value given by the equation

$$C = \frac{5000}{2\pi f . R_e}$$

and for a 390 ohm emitter resistor, this indicates a capacitor value of around 50uF for a 40 Hz breakpoint. Even at 3 V working, this is going to be a component that will be larger than the resistors or the transistor.

IF h_{ie} = INPUT RESISTANCE IN KILOHMS, I_C = STEADY COLLECTOR CURRENT IN MILLIAMPS, AND h_{fe} = VALUE OF CURRENT GAIN, THEN

$$h_{ie} = \frac{h_{fe}}{40 I_C}$$

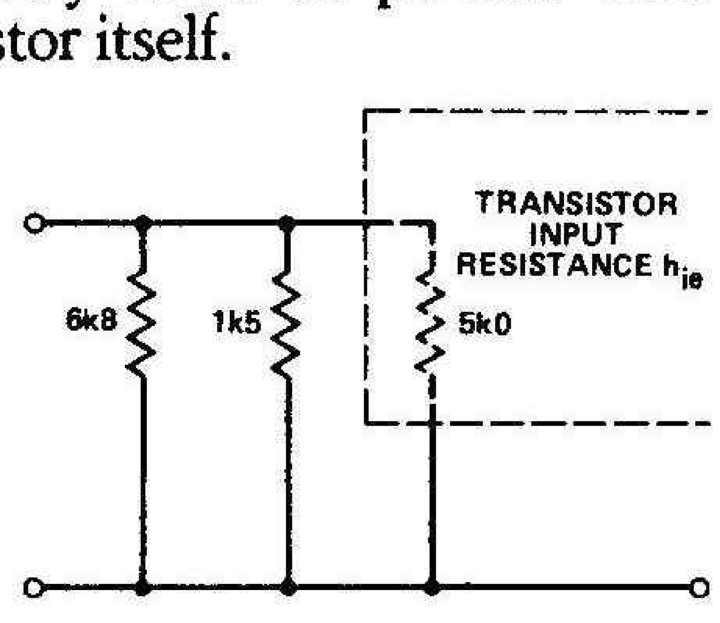
EXAMPLE: IF h_{fe} = 400 AND I_C = 1mA, THEN $h_{ie} = \frac{400}{40 \times 1} = 10k$

Fig. 6 Transistor input resistance, h_{ie}. Note this is for the transistor only, and assumes zero-signal conditions.

You Know My Resistance Is Low

The input resistance of an amplifying stage is, as the name suggests, the ratio of input voltage to input current for an AC signal at a frequency in the middle of the bandwidth. The input resistance of a transistor is not constant, but if we take the value which it has at the setting of the bias current, with no signal, than this is a reasonable average to take for small signal inputs — small meaning millivolts. The value is calculated as shown in Fig. 6, and it depends on the h_{fe} value and the bias current. In general, using transistors with high h_{fe} values operated at low collector currents will give the highest input resistance values for the transistor, but you can usually assume values in the region of 1k0 to 10k.

These are just input resistance figures for the transistor itself, however, and the total input resistance will be affected by the bias components. When we use the potential divider bias circuit, for example, both R1 and R2 (in Fig. 5) are connected between the base and a line which is at 0 V (AC). How so, you ask? Well, as far as AC voltage is concerned, the supply positive line is as much of an earth as the genuine earth line, since they are connected to each other by a whopping great electrolytic in the power supply circuit. Hence all of these bias resistors are in parallel across the base-to-earth path, considerably lowering the input resistance (Fig. 7). If you think that the shunt feedback circuit of Fig. 2 is better then think again, because the collector end of the bias resistor is connected to a voltage which is in antiphase to (and of much greater amplitude than) the base voltage, so it behaves as if its value were R_b/G connected to earth. G is the voltage gain of the stage, so that if R_b = 88k and G = 50, then the bias resistor is effectively 1k76 in parallel with the input resistance of the transistor itself.



$1/R_{IN}$ = 1/5 + 1/1.5 + 1/6.8 (ALL RESISTANCES IN KILOHMS), SO R_{IN} = 0.986k = 986R WHERE R_{IN} IS TOTAL INPUT RESISTANCE

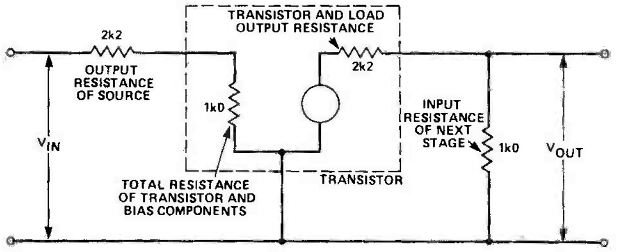
Fig. 7 The effect of bias components and h_{ie} on total input resistance.

Gainful Employment

The output resistance of a single transistor amplifier consists of the output resistance of the transistor itself, usually around 30k, in parallel with the load resistor. Since load resistor values are usually of the order of 1k0 to 10k, this in practice means that we can use the load resistor value as the value for output resistance when we are dealing with resistor-capacitor coupled stages.

The crunch comes when we want to find what the gain of an amplifying stage will be. For a silicon transistor which has enough h_{fe} to class it as being in the land of the living, the maximum voltage gain is given by 40 x V_{RL}, where V_{RL} is the voltage across the load resistor when no signal is applied — the bias voltage in other words across R_L. For example, if you are using a transistor with 4V5 across the load resistor, then the maximum gain is 40 x 4.5, which is 180 times (we showed how to derive this figure in 'Gm Revisited'', April 79), and that's the value which can be measured if you use a low impedance signal generator, a very small signal amplitude, and a high-impedance oscilloscope to measure the output.

Practical circuits, however, use higher-resistance devices as signal sources and lower resistance devices as signal loads, so that the gain when we take into account the potential-dividing effect of all these loss-makers is a lot less. For example, if we imagine our transistor stage to be fed with a signal from another stage with an output resistance of 2k2 and feeding into a stage with input resistance of 1k0 (and with these same values itself) then its gain (Fig. 8) will be a miserable 17.5 times. It's not the gain of the transistor which has fallen, notice; it's the attenuation caused by the potential dividers which is dissipating the signal. The moral is that input and output resistances are important when you are aiming for maximum gain, and that everything you can do to raise input resistance and reduce output resistance can be useful.

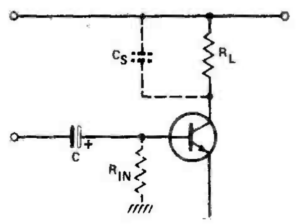


IF TRANSISTOR GAIN IS 180, THEN SIGNAL INTO TRANSISTOR = $\frac{V_{IN} \times 1k0}{3k3}$

AND SIGNAL OUT = $180 \times \frac{V_{IN} \times 1k0}{3k3}$ SO THAT $V_{OUT} = 180 \times \frac{V_{IN} \times 1}{3.3} \times \frac{1}{3.3}$

$= 17.5 V_{IN}$

Fig. 8 The effect of input and output resistances in forming potential divider circuits with the internal resistances of source and load.



LOW-FREQUENCY GAIN IS 3dB DOWN ON MIDBAND GAIN WHEN

$\frac{1000}{2\pi.f.C} = R_{IN}$ (C IN MICROFARADS, R IN KILOHMS)

OR $f = \frac{1000}{2\pi.C.R_{IN}}$ (f IN HERTZ)

HIGH-FREQUENCY GAIN IS 3dB DOWN ON MIDBAND GAIN WHEN

$f = \frac{1000}{2\pi.R_L.C_S}$ (C_S IN PICOFARADS, R_L IN KILOHMS, f IN MEGAHERTZ)

Fig. 9 The time constants which affect bandwidth for a single stage. Note the different units for the two equations.

Strike Up The Bandwidth

The bandwidth of an amplifier stage is defined as the range of frequencies over which the gain does not drop 3 dB below its mid-band value. For a simple amplifier stage, the limits of bandwidth are set by the time constants of the coupling and emitter-decoupling capacitors at the low frequencies, and by the effects of stray capacitance at the high frequencies — Fig. 9 shows the details. Most modern transistors have good high-frequency gain and since stray capacitance can be made small with modern circuit layouts, frequencies into the many megahertz range can be expected. This is much more than is necessary (or desirable) in many cases, and it's a wise precaution to trim the bandwidth for the purpose you need. This can be done by introducing a time constant into the feedback network of a simple filter.

All of which brings us inexorably to the subject of feedback, and that's where we'll start next month, when we'll be looking at feedback pair circuits, their biasing and their gain. **ETI**

MICROTUTOR PART 1

BASIC, Pascal and the like are OK but if you want to get the most out of your micro then machine code is where it's at. This machine code tutor will help you throw off your chains; you have nothing to lose but your SYNTAX ERRORS. Design and development by Tangerine Computer Systems.

Real computing was able to escape from the lofty realms of the mainframe and into the hands of the layman because of two major developments. The first was when large-scale integration techniques enabled the production of small, versatile microprocessor chips which were adapted into small, relatively low-cost microcomputers. (The microprocessor was originally conceived for use in industrial machine control.) The second was the invention of the BASIC computing language, which allowed the complete beginner to write working computer programs easily and without any knowledge of the system hardware he was working on.

Unfortunately such ease of use can only be obtained by means of a compromise, and the major drawback of the average microcomputer is speed — or rather lack of it. BASIC is painfully slow when compared to the speed of operation of the microprocessor, because each BASIC statement requires a series of machine code subroutines to be executed. Obviously better use can be made of the system hardware if programs are written directly in the language of the microprocessor — machine code. Direct access to the processor means access to swift, versatile and efficient programming.

All Systems Go

Consequently some of the most popular micro systems haven't had BASIC as a language at all! Typical products include KIM, SYM, the late-lamented MK14 and the AIM 65, still a well-known 6502 machine code development system. And now there's the ETI Microtutor, a project we're hoping will coax more of our readers away from the security of BASIC and into machine code, the real stuff of microcomputing.

The Microtutor has been designed for us by Tangerine Computer Systems, who were responsible for the highly popular Space Invasion game we published in November 1980. The monitor program for the system is based on TANBUG, as used in the Microtan 65 computer from the same company; this is a remarkably powerful monitor with many useful programming commands available to make machine code easier to manipulate. The hardware is designed around the 6503, a member of the 6502 family with the same instruction set but an address range of only 4K as opposed to the more usual 64K. Thus the microprocessor is more compact (only 28 pins instead of 40), but any software written for it will also run on the Microtan 65. Furthermore, once you're familiar with the instruction set of the 6500 family you should be able to write machine code programs for home computers based on the 6502 such as the PET, Acorn System 1, Acorn Atom, Superboard, UK101, Apple, VIC and the BBC machine, which should give you plenty of scope! (Indeed, the PET is designed so that the entire system can be reconfigured from software, but you'll have to become pretty good to attempt that!)

Give Us The Tool

The Microtutor is a very sophisticated and professional-looking piece of equipment. The hex keypad is mounted directly on the PCB, as are the power supply regulator, cassette interface, and a VDU with UHF output on channel 36 for direct connection to a domestic TV set (one up on the AIM 65!). The PCB is incredibly compact and a masterpiece of design, as you can see from the photographs.

The only external equipment required is a battery charger type power supply (supplied with the kit from Tangerine), and a domestic TV and cassette recorder for storing your programs (not supplied with the kit!). In the interests of economy of design and cost, the Microtutor has no

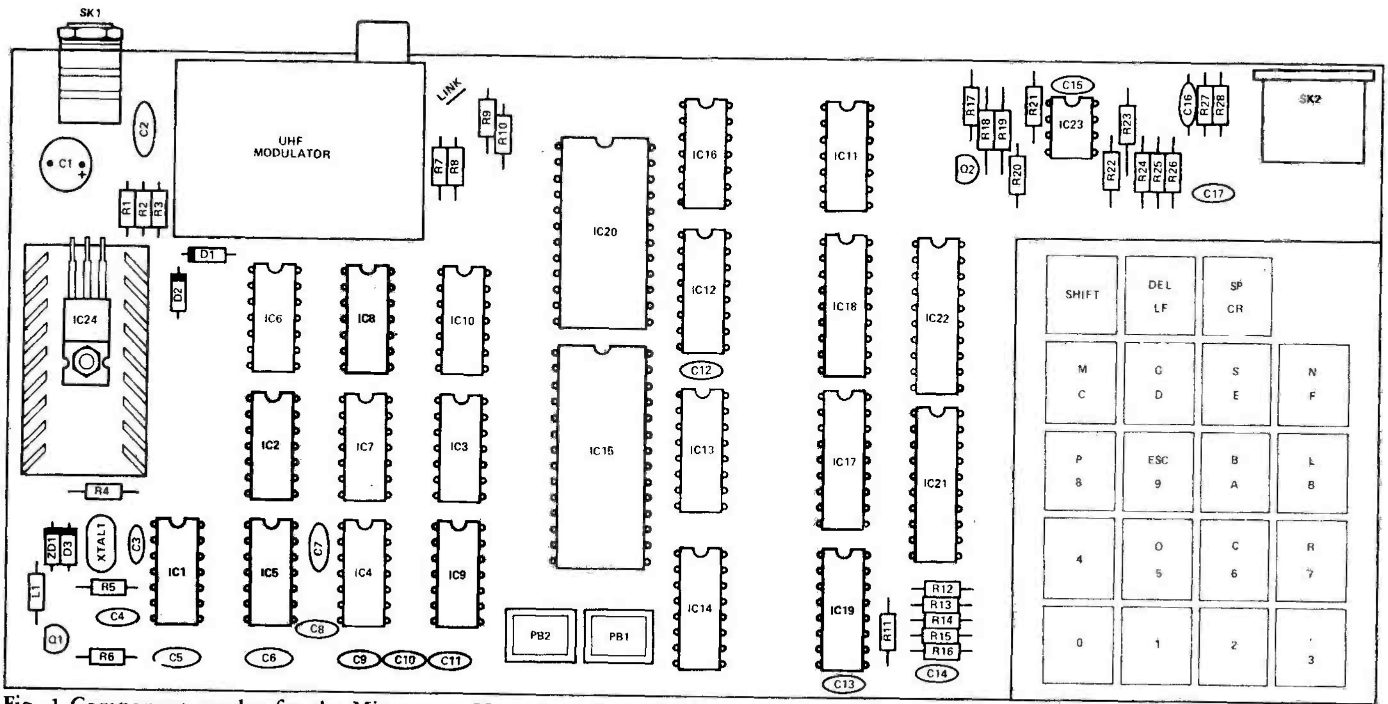
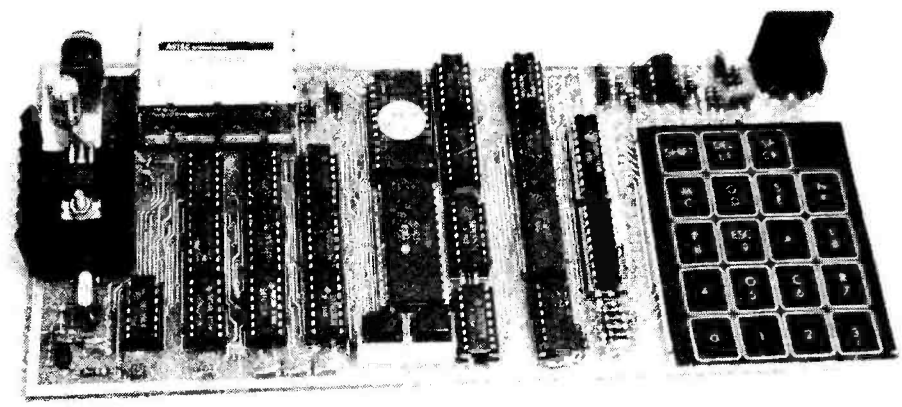


Fig. 1 Component overlay for the Microtutor. Note that all the ICs have pin 1 pointing upwards.

graphics and the ASCII set repeats through the entire range of 256 character codes. Only upper case is available (see Table 1).

Apart from a teaching aid for machine code programming, the Microtutor is also intended to be used for I/O experiments; thus all the bus lines and control signals are brought out to pads on the PCB so that external circuitry can be connected.

The only thing to remember about machine code is that it is very unforgiving of errors. Unlike BASIC, a programming blunder won't produce a polite message on the screen and a chance to try again; more often than not your program and data may be corrupted, or the thing gets locked into an endless loop until it disappears up its own data bus. When developing software for a home computer there is often little choice at this point but to switch off the machine to cure things, causing loss of program and laborious re-entry. We've had some nasty experiences in the office with the PET this way! On the Microtutor things are more civilised; two buttons are



The PCB is very compact and uses thin tracks, so a fine bit is essential on your soldering iron.

PARTS LIST

Resistor (all ¼W, 5%)

R1	75R
R2	470R
R3	220R
R4-17 22 27	1k0
R18, 24	10k
R19, 23	120k
R20, 21	2k2
R25, 26, 28	22k

Capacitors

C1	100u 10 V PCB electrolytic
C2, 5, 6, 9-17	100n ceramic
C3, 8	10n ceramic
C4, 7	100p ceramic

Semiconductors

IC1, 8	74LS04
IC2	74LS73
IC3, 9	74LS393
IC4	74LS21
IC5, 16	74LS74
IC6	74LS08
IC7	74LS11
IC10	74LS00
IC11	74LS32
IC12-14	74LS157
IC15	6503
IC17, 18	2114
IC19	86S64BWF
IC20	2716
IC21	74LS374
IC22	74LS244
IC 23	LM358
IC24	7805
Q1, 2	BC184L
D1-3	1N4148
ZD1	6V8 400mW zener

Miscellaneous

XTAL1	6 MHz crystal
L1	100uH choke
SK1	miniature charger socket (PCB-mounting)
SK2	5-pin DIN socket (PCB-mounting)
PB1, 2	push-buttons (PCB-mounting)

PCB (see Buylines); hex keypad; UHF modulator type UM1111E36; IC sockets; PCB-mounting heatsink for regulator.

SPECIFICATION

CPU:	6503 (addresses 4K)
ROM:	2K containing monitor program. EPROM is 2716 (5 V version)
RAM:	1K. Used for user program and memory-mapped VDU
I/O:	1K space available
Display:	16 rows by 32 characters, upper case only
UHF Output:	Channel 36

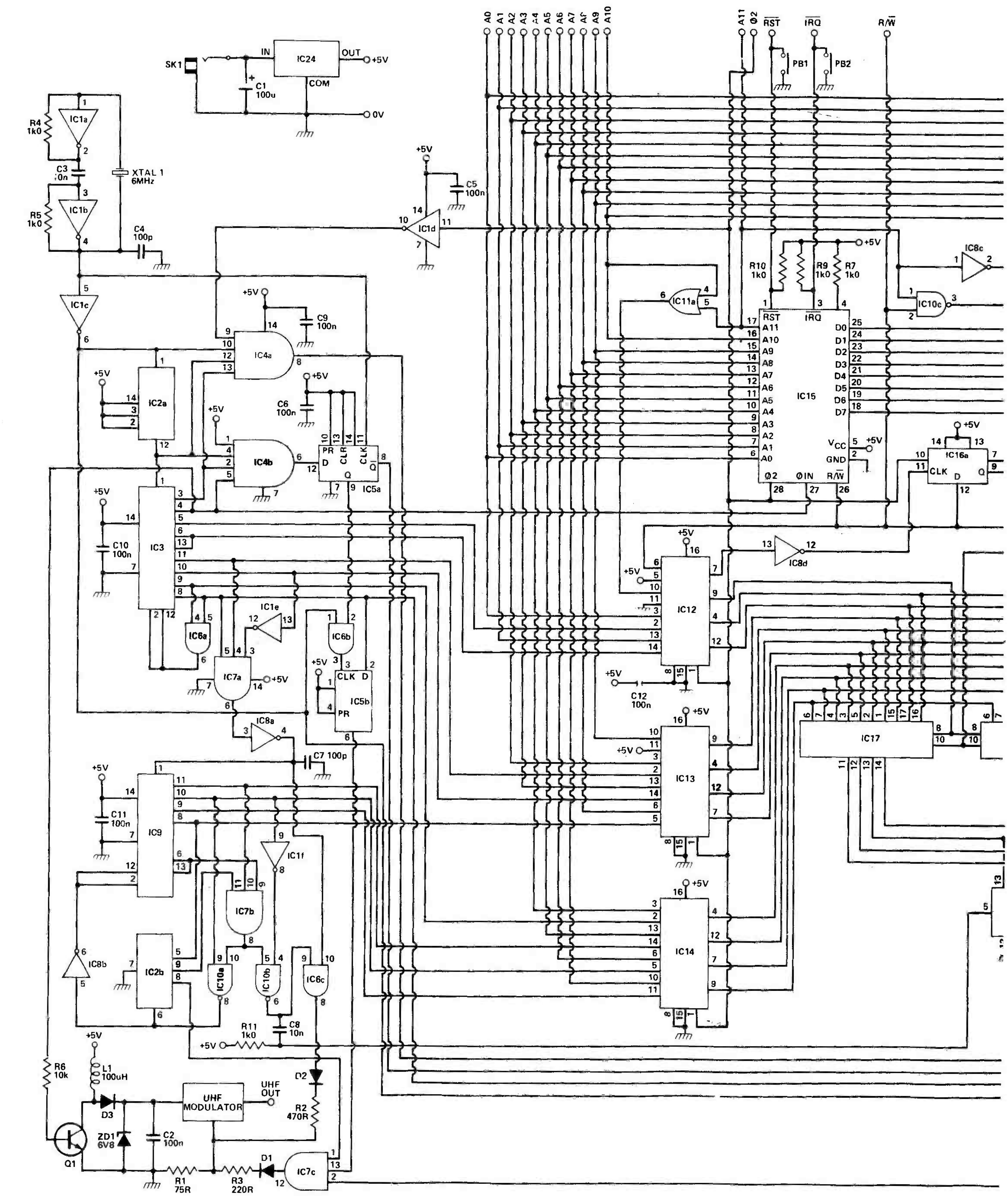
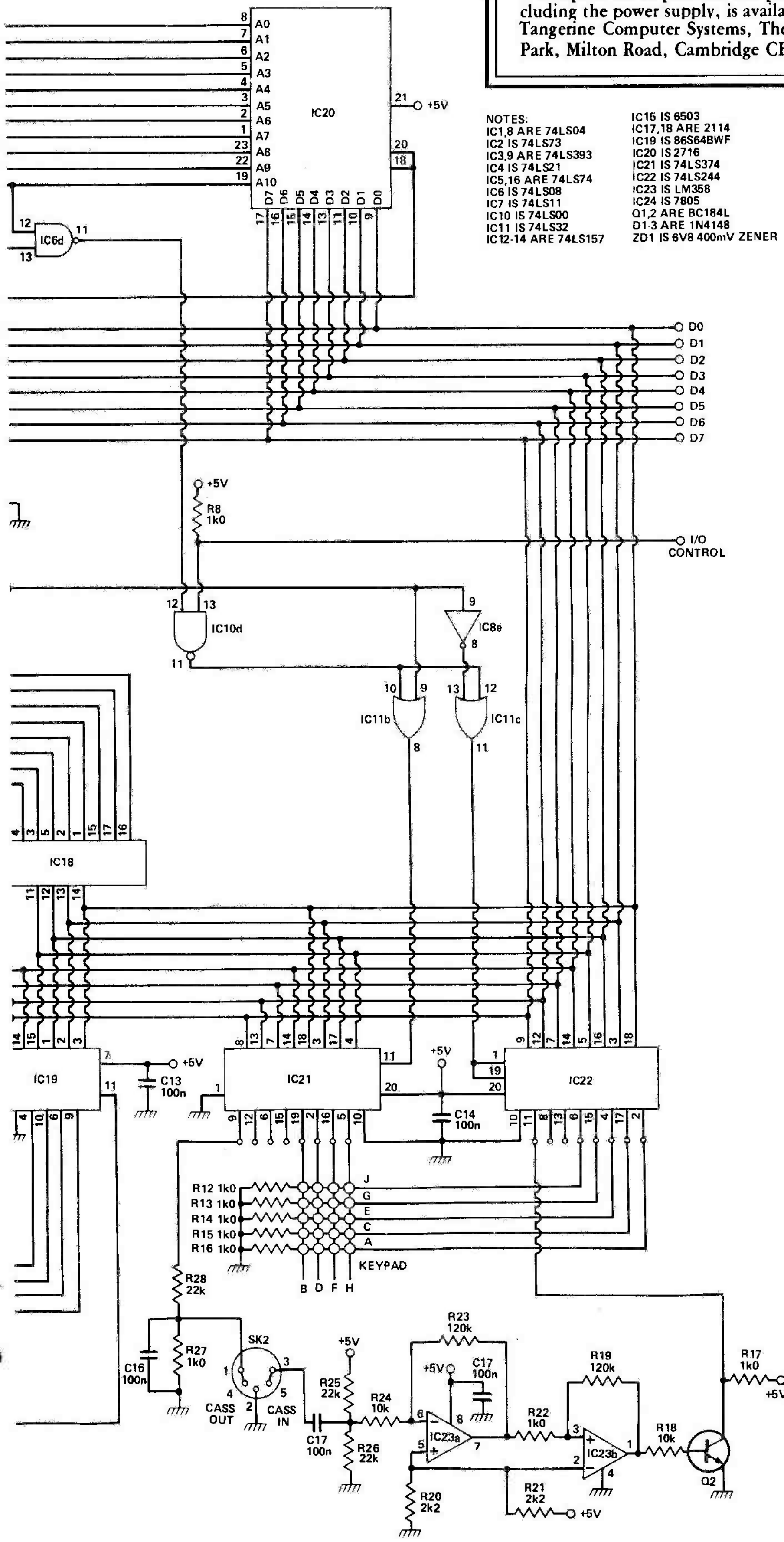


Fig. 2 Complete circuit diagram for the Microtutor.



BUYLINES

A complete kit of parts for this project, including the power supply, is available from Tangerine Computer Systems, The Science Park, Milton Road, Cambridge CB4 4BH.

HOW IT WORKS

The CPU (IC15) and the video display share the same memory. Access to the memory is switched at the processor's ø2 clock rate (as on the Microtan 65), using the address selector IC12-14. This alternately connects the CPU and CRT address onto the RAM chips IC17, IC18. IC16a is a R/W̄ synchroniser to ensure the RAM chips get proper set-up and hold times on the R/W line after it passes through the address selector IC12.

The master clock oscillator is built around three of the inverters in IC1; XTAL1 sets the operating frequency at 6 MHz. The clock signal enters the counter chain down the left of the circuit diagram at pin 1 of IC2a. IC3 generates all the character addresses along the video line for CRT refresh, with IC4a and IC4b/IC5a generating two of the timing signals required by the character generator IC19. The count length of IC3 is determined by the AND gate IC6a. IC7a generates the line sync pulses while IC5b/IC6b produce the line blanking. The line sync pulses also clock counter IC9, which together with IC2b generates all the line addresses. IC2b, IC7b and the associated logic controls the count length of the line counter and produces the frame sync. IC2b also produces the frame blanking directly.

IC19 is the character generator which receives data from the memory chips IC17, 18 during the time interval that the CRT refresh address is switched through. Data is latched and the character pattern is clocked out under the control of the various input signals to this chip. The character data is mixed with the line and frame blanking in IC7c, while the line sync and frame sync pulses are mixed in the AND gate IC6c to give a composite sync. The output of IC7c is mixed with the composite sync in the diode circuit (D1, D2 and associated resistors) to give an analogue video signal which is fed to the UHF modulator.

The modulator requires a supply of about 6V5. To avoid the need for a separate PSU, this is derived using the DC-DC converter based on L1 and Q1, which is driven via R6 from the CRT counter chain.

IC20 is the 2K EPROM containing the monitor program. For the EPROM to be enabled, A11 must be high and R/W̄ in the read mode; these lines drive NAND gate IC10c which provides the chip select signal to pins 18 and 20 of the EPROM. Gates IC8c, IC6d, IC10d, IC8e and IC11b,c enable the I/O port, controlling the hex keypad and the cassette interface. Any location between 400 and 7FF (Hex) will address the port provided the I/O control line has not been pulled low externally. When reading, IC22 is enabled; when writing, IC21 is enabled. IC23 and associated components form the input amplifer for the cassette interface.

The only expansion the Microtutor has is for I/O experiments; the address bus, data bus, R/W̄, ø2 and I/O control lines all come out to pads on the PCB. If the user builds an external I/O circuit then that circuit must operate the I/O control, which is active low, to disable the keypad circuits, otherwise bus contention will result. The monitor program assumes that they keypad is located at 7FF. Any location in the I/O address space will activate the keypad port if I/O control is not pulled low, however. For further I/O experiments, all eight bits from IC21, 22 are brought out to pads. This means that users can experiment with bigger keypads or utilise the unused bits. R̄S̄T̄ and ĪR̄Q̄ also come out to pads on the PCB.

provided, reset and interrupt. Both wil get you back into the monitor from a faulty program if it gets out of hand, without clearing the memory; interrupt will do so without losing any breakpoints you may have set (breakpoints are explained fully later).

Construction

The PCB is double-sided bur through-hole plated, so components only have to be soldered on the underside. Fit all the low profile components first, ie the link, resistors, diodes and choke, then the keypad. This is stuck to the component side of the board with double-sided sticky pads; insert the connecting wires through the holes in the PCB first first, secure the keypad in position with the pads and then solder the connections.

Now you can fit all the IC sockets and capacitors but don't insert the ICs until later. Solder the choke, crystal and transistors in place, then the UHF modulator. The voltage and its heatsink are bolted to the PCB and no insulating washers are required.

Finally mount the two sockets (power and cassette) and the large push-buttons, then insert all of the ICs paying great attention to the device type.

Ready To Go

Once you've double-checked everything, you're ready to connect the power supply and TV set. The modulator is connected to the TV using UHF coaxial cable with a phono plug at one end and the usual coax plug at the TV end. Switch on the set and tune the TV until you get a steady black-and-white picrure — at this point the screen will contain garbage. Press the RESET button and the screen should announce TANBUG. You may now use the keypad, as described below, to enter the wonderful world of machine code.

As an example of the sort of power you've got at your fingertips, here's a direct comparison. Some time ago it was necessary for someone in the office to check all four-digit numbers for certain combinations of digits. A BASIC program on the PET took about five minutes to write and about 15 minutes to run. The same problem, when solved by the Microtutor, took somewhat longer to write the program, but checked through all 10000 numbers in three seconds!

All About TANBUG

The TANBUG monitor program is located in 2K bytes of read only memory (ROM) at the top of the address space ie pages 8-15. It contains facilities to enter, modify, run and debug programs. TANBUG will only operate in the memory map of the Microtan system, it is not a general purpose 6502 software package and has been specifically written for Microtan/Microtutor.

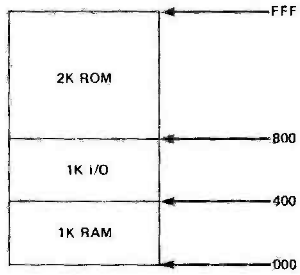


Fig. 3 Memory map.

Locations 2ØØ-3FF (pages 2 and 3) are the visual display memory — TANBUG writes to these locations whenever a command is typed to the monitor. Locations in pages 4 to 7 are the addresses of the peripheral attachments, eg keyboard. Locations 1ØØ-1FF (page 1) are used as the stack by the microprocessor. Since the stack is of the push-down variety it follows that the whole of this will not be used as stack storage in the majority of programs. TANBUG requires to use locations 1FØ-1FF as stack storage (only 16 locations). The rest of this area is free for user programs. Locations 4Ø-FF are also available as user RAM, the preceding locations Ø-3F being reserved for use by TANBUG. User programs which do not use the stack may therefore be loaded anywhere in the area 4Ø-1EF. For user programs which do use the stack, the user must calculate how many stack locations are required and reduce the upper limit accordingly.

TABLE 1

Hex	Character	Hex	Character
20	Space	40	@
21	!	41	A
22	"	42	B
23	#	43	C
24	$	44	D
25	%	45	E
26	&	46	F
27	'	47	G
28	(	48	H
29	)	49	I
2A	*	4A	J
2B	+	4B	K
2C	,	4C	L
2D	—	4D	M
2E	.	4E	N
2F	/	4F	O
30	0	50	P
31	1	51	Q
32	2	52	R
33	3	53	S
34	4	54	T
35	5	55	U
36	6	56	V
37	7	57	W
38	8	58	X
39	9	59	Y
3A	:	5A	Z
3B	;	5B	[
3C	<	5C	\
3D	=	5D	]
3E	>	5E	^
3F	?	5F	_

The keypad is used as follows, its layout being shown in Fig. 1. TANBUG interrogates the keypad for a depressed key, then translates the matrix encoded signal into an ASCII character which it puts up on the visual display. Because of the limited number of keys it has been necessary to incorporate a shift function on the keypad. So, to obtain the character P for example, the user presses and releases SHIFT, then depresses and releases P. The SHIFT key contains a self-cancelling facility — if the user presses SHIFT twice in succession the pending shift operation is cancelled. So as an example, using the two keys SHIFT and 8 the operations SHIFT P yields P on the display. SHIFT SHIFT P yields 8 on the display. DEL deletes the last character typed. Repeated deletes erase characters back to the beginning of the line.

Having described some of the background to TANBUG it is now possible to describe the commands and syntax of TANBUG, ie how to use it. An example is shown later on. All numerical values of address, data and monitor command arguments are in hexadecimal. The symbol <CR> means on depression of the carriage return key, <SP> the space key, and <LF> line feed. In all examples, text to be typed by the user will be in bold type, while TANBUG responses will not. ■ indicates the cursor. <ADDR> means a hexadecimal address, <ARG> means hexadecimal data and <TERM> means one of the terminators <CR>, <SP>, or <LF>.

All commands are of the form
<COMMAND><TERM>
or
<COMMAND><ARG> TERM>
or <COMMAND><ARG>, <ARG><TERM>
or <COMMAND><ARG>, <ARG>, <ARG><TERM>
where <COMMAND> is one of the mnemonic commands and <ARG> is a hexadecimal argument applicable to the command. It should be noted at an early stage that the longest argument will contain four hexadecimal characters. If more are typed all but the last four are ignored. As an example consider the memory modify command M1234ØØ78 <CR>. In this case location ØØ78 will be modified or examined as all but the last four characters are ignored.

<TERM> is one of the terminating characters <CR>, <SP>, <LF> or <ESC>. In fact TANBUG accepts any of the "control" characters (HEX code ϕ-2ϕ) as terminator. TANBUG will reply with a ? if an illegal command is encountered.

Starting The Monitor

Press the reset button on the Microtutor. TANBUG will scroll the display and respond with

TANBUG
■

Note that on initial power-up the top part of the display will be filled with spurious characters. These will disappear as new commands are entered and the display scolls up. On subsequent resets the previous operations remain displayed to facilitate debugging.

Memory modify/examine command M

The M command allows the user to enter and modify programs by changing the RAM locations to the desired values. The command also allows the user to inspect ROM locations, modify registers and so on. To open a location type the following

M <ADDR> <TERM>

TANBUG then replies with the current contents of that location. For example, to examine the contents of RAM location 1ϕϕ type M1ϕϕ<CR> TANBUG then responds on the display with

M1ϕϕ,ϕE,■

assuming the current contents of the location were ϕE.

There are now several options open to the user. If any terminator is typed the location is closed and not altered and the cursor moves to the next line scrolling up the display by one row. If however, a value is typed followed by one of the terminators <CR>, <LF> or <ESC> the location is modified and then closed. For example, using <CR>

M1ϕϕ,ϕE,**FF**
■

location 1ϕϕ will now contain FF. If however <SP> is typed, the location is re-opened and unmodified.

M1ϕϕ,ϕE,**FF**
Mϕ1ϕϕ,ϕE,■

This facility is useful if an erroneous value has been typed. The terminators <LF> and <ESC> modify the current location being examined, then open the next and previous locations respectively ie using <LF>

M1ϕϕ,ϕE,**FF**
Mϕ1ϕ1,AB,■

and using <ESC>

M1ϕϕ,ϕE,
MϕϕFF,56,■

Using <LF> makes for very easy program entry, it only being necessary to type the initial address of the program followed by its data and <LF>, then responding to the cursor prompt for subsequent data words.

Note that locations 1FE and 1FF should not be modified. These are the stack locations which contain the monitor return addresses. If they are corrupted TANBUG will almost certainly "crash" and it will be necessary to issue a reset in order to recover.

List command L

The list command allows the user to list out sections of memory onto the display. It is possible to display the contents of a maximum of 120 consecutive memory locations simultaneously. To list a series of locations type

L <ADDR>, <NUMBER> <TERM>

where <ADDR> is the address of the first location to be printed and <NUMBER> is the number of lines of eight consecutive locations to be printed. TANBUG pauses briefly between each line to allow the user to scan them. For example, to list the first 16 locations of TANBUG (which resides at Cϕϕ-FFF) type LC00,2 <CR>.

The display will then be

LCϕϕ,2
Cϕϕ A2 FF 9A E8 86 17 20 B7
Cϕ8 FF 8D F3 BF A2 0E BD DF
■

If zero lines are requested (ie <NUMBER> = ϕ) then 256 lines will be given.

Go command G

Having entered a program using the M command and verified it using the L command, the user can use the G command to start running his own program. The command is of the format G <ADDR> <TERM>. For example, to start a program whose first instruction is at location 1ϕϕ type G1ϕϕ<CR>.When the user program is started the cursor disappears. On a return to the monitor it re-appears.

The G command automatically sets up two of the microprocessor's internal registers:

a) The program counter (PC) is set to the start address given in the G command.
b) The stack pointer (SP) is set to location 1FF.

The contents of the other four internal registers, namely the status word (PSW), index X (IX), index Y (IY) and accumulator (A), are taken from the monitor pseudo registers (described next). Thus the user can either set up the pseudo registers before typing the G command, or use instructions within his/her program to manipulate them directly.

Register modify/examine command R

Locations 15 to 1B within the RAM reserved for TANBUG are the user psuedo registers. The user can set these locations prior to issuing a G command; the values are then transferred to the microprocessor's internal registers immediately before the user program is started. The pseudo register locations are also used by the monitor to save the user internal register values when a breakpoint is encountered. These values are then transferred back into the microprocessor when a P command is issued, so that to all intents and purposes the user program appears to be uninterrupted.

The R command allows the user to modify these registers in conjunction with the M command. To modify/examine registers, type R <CR> and the following display will apppear (location 15 containing ϕϕ say).

TABLE 2

15	Low order byte of program counter	(PCL)
16	High order byte of program counter	(PCH)
17	Processor status word	(PSW)
18	Stack pointer	(SP)
19	Index X	(IX)
1A	Index Y	(IY)
1B	Accumulator	(A)

R
Mϕϕ15,ϕϕ,■

Now proceed as for the M command.

Naturally the M command could be used to modify/examine location 15 without using the R command — the R command merely saves the user the need to remember and type in the start location of the pseudo registers. Psuedo register locations are shown in Table 2. Two typical instances of the use of the R command are:—

a) Setting up PSW, IX, IY and A before starting a user program.
b) Modifying registers after a breakpoint but before proceeding with program execution (using the P command) for debugging purposes.

Note that when modifying registers in case (b) care must be taken if PCL, PCH or SP are modified, since the proceed command P uses these to determine the address of the next instructions to be executed (PCL, PCH) and the user stack pointer (SP). **ETI**

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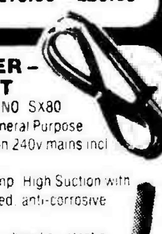

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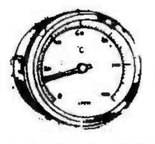

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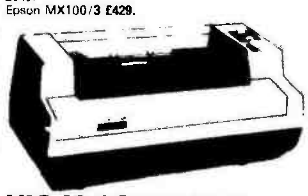

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READ/WRITE

Letters for this page should be addressed to Read/Write at 145 Charing Cross Road, London WC2H 0EE.

Dear Sir,

I am writing to enquire if your magazine or any of your readers have heard about or tested an electronic device for inducing dream consciousness (lucid dreams).

This bedside machine monitors the breathing rate of a sleeper by means of a sensitive thermistor attached to the nose. During a dream period, the breathing rate increases above normal; this is used to trigger a mild electric signal to the wrist of the dreamer telling him that he is dreaming and should become conscious in his dream.

Lucid dreams, being far more vivid than normal, are in full colour and three dimensional. The dreamer also has full control over his dream environment and can manipulate it at will. He can dream consciously about anything he chooses and total dream recall is normal.

This equipment was designed and developed by a Dr. Keith M. T. Hearne of Hull University and I believe manufactured and marketed by Campden Instruments (Incam Ltd) of London. But despite persistent enquiry, I have seen no test or reports on this equipment in electronic magazines. Have you or any of your readers seen anything?

I would be very grateful for any information you may have come across on this interesting device!

Yours faithfully,
Mark Botham,
Northumberland

Sorry, never heard of it. Sounds like it makes video games look a bit sick though. Control your dreams at will, eh? Interesting...very interesting...

Dear Mr. Harris,

I am enclosing my entry for your Prize Crossword No. 3. However, I am sorry to say that I do not find this feature up to the usual standards of the rest of the magazine.

May I draw your attention to Crossword No. 1 in the January issue. Clue 24 Down was "Radiation particles are certainly not passive." At first I chose "Active" as the answer. However, on reflection, a radiation particle may be an ion, so I changed the answer to "Action."

You can imagine my surprise when you published the answer as "Active." The problem really lay in the fact that the only letter crossed with this puzzle was the letter 'C', common to both possible answers.

Now, five months later, in Crossword No. 3, the same difficulty arises. Clue 22 Across is "Timely happening." The only letter crossed with is the second letter, which I make an 'E'. Hence the possible answers (all having some connection with time) are as follows: Decay, Death, Delay, Hence, Hertz, Leave, Merge, Peaky, Recur, Relay, Relic and Telex.

Many of these are also technical terms and therefore likely to be the correct answer. May I remind your Crossword compiler that the rule is: "If a clue is to be made wholly or partly vague, the answer must have sufficient letter crosses to enable it to be verified as the sole answer." The puzzle to be solved should involve ingenuity in word manipulation, not guesswork or thought transfer!

Yours sincerely,
Paul M. Richardson,
Tavistock

Comments received. Passed on to our compiler, who will no doubt have a few cross words to say in reply.

Dear Sir,

I was happy to read the article in your April Birthday supplement entitled, "Steering Wheel? – Wot Steering Wheel?". Enclosed is a copy of a letter I sent to the Prime Minister in February this year.

Robert W. Teasdale,
Newcastle-Upon-Tyne

Letter to Prime Minister,
February 1982

On giving some thought to future cars, I thought it would be a good idea if they had some form of electronic control.

The system of flashing lights on the motorways was a good idea, but motorists tend to ignore this system, and I though that futuristic systems could be devised to electronically control the speed of cars (to prevent them going too fast under certain conditions, eg fog), with a built-in safety device for the driver to ignore these signals in an emergency: electronically controlled to respond to certain speed limits; controlled to stop or slow at traffic lights (being able to override this signal if conditions desired it); controlled to slow at pedestrian crossings, crossroads and junctions; controlled to keep a safe distance from the car in front (with an override to overtake for a short period if necessary and an exterior signal to indicate when on override); controlled to slow at obstructions, again with an override.

Fast cars are dangerous and use a lot of energy. What is required is a safe, controlled car with power to get up hills and through adverse conditions.

I'm sure it would be better to have a safe, controlled system rather than fast dangerous cars, thus cutting down on accidents, death, disablements, and the work of all the services involved in accidents. I hope these suggestions can be put to future scientists and car manufacturers.

Dear Sir,

As so many of us are now using electronically operated quartz crystal controlled watches, may I suggest that an article giving a detailed description of their operation would be of considerable interest.

I am, yours sincerely,
H. Vernon Kirby (Regular Reader),
Hayling Island

Couldn't agree more. You wanna write it?

Dear Sir,

I know that you are busy men, but looking through recent ETIs, I came across two speaker systems – the ETI V3 (Oct 1981) and the Wharfedale E70 kit (April 1982). I would be interested in knowing your views on them.

Do you feel that it would be of interest to ETI's readership if you reviewed all the hi-fi projects and compared them to corresponding commercial units?

Yours faithfully,
M. G. Hill,
Harrow

The V3 and E70 are designed to meet different criteria. The V3 is an 'all-rounder' primarily intended for use with a wide range of music at 'normal' (if there is such a thing) volume levels. It is designed to be as neutral as possible in its portrayal of the signal.

The E70 is a high-efficiency speaker with an exciting 'lively' sound balance. It is most at home with the type of music best suited to this method of replay.

As to reviewing ETI projects, could you believe anything anyone says about their own product? Our objectivity would have to be suspect. ETI

RUGBY CLOCK

If you want to know the time, ask MSF Rugby. This accurate and versatile clock/calendar is packed with facilities and never needs resetting. Design and development by Stephen Makumbi.

Clock designs appear fairly regularly in hobbyist magazines, but they usually fall into one of two basic types. The first type derives clock pulses from the 50 Hz mains, and while these provide a highly accurate long-term performance, mains frequency variations in the short term can cause errors of several seconds in either direction. The second type relies on a built-in oscillator, usually crystal-controlled which gives excellent short-term precision but a steadily accumulating long-term error.

If only you could build your own atomic clock! This is a project slightly outside the scope of the magazine, but fortunately it isn't necessary to go quite that far. We can all get to share the atomic clock at the National Physical Laboratory because it's used to send coded time data, 24 hours a day, on a 60 kHz radio carrier from a transmitter at Rugby. The signal is transmitted at around 50 kW RF power and can be received over most of Western Europe. Of course, a specialised receiver is required to demodulate and decode the time signals, and *that's* the project we're offering; a clock that displays the correct time of day, date, day of week, and plenty more besides, with no need to ever correct it. Even when the signal completely disappears the clock senses this and automatically switches on to its own crystal timebase back-up clock.

All the information is checked thoroughly for parity and validity. As an example, February 29th 1983 will be rejected and dashes put into the display in place of the date.

We've included a comprehensive alarm system comprising no less than eight independent alarms. For each alarm setting there is a choice of a melody (author's 12 bar rock), altering the state of eight TTL-compatible lines, or both! The eight lines could, of course, be used

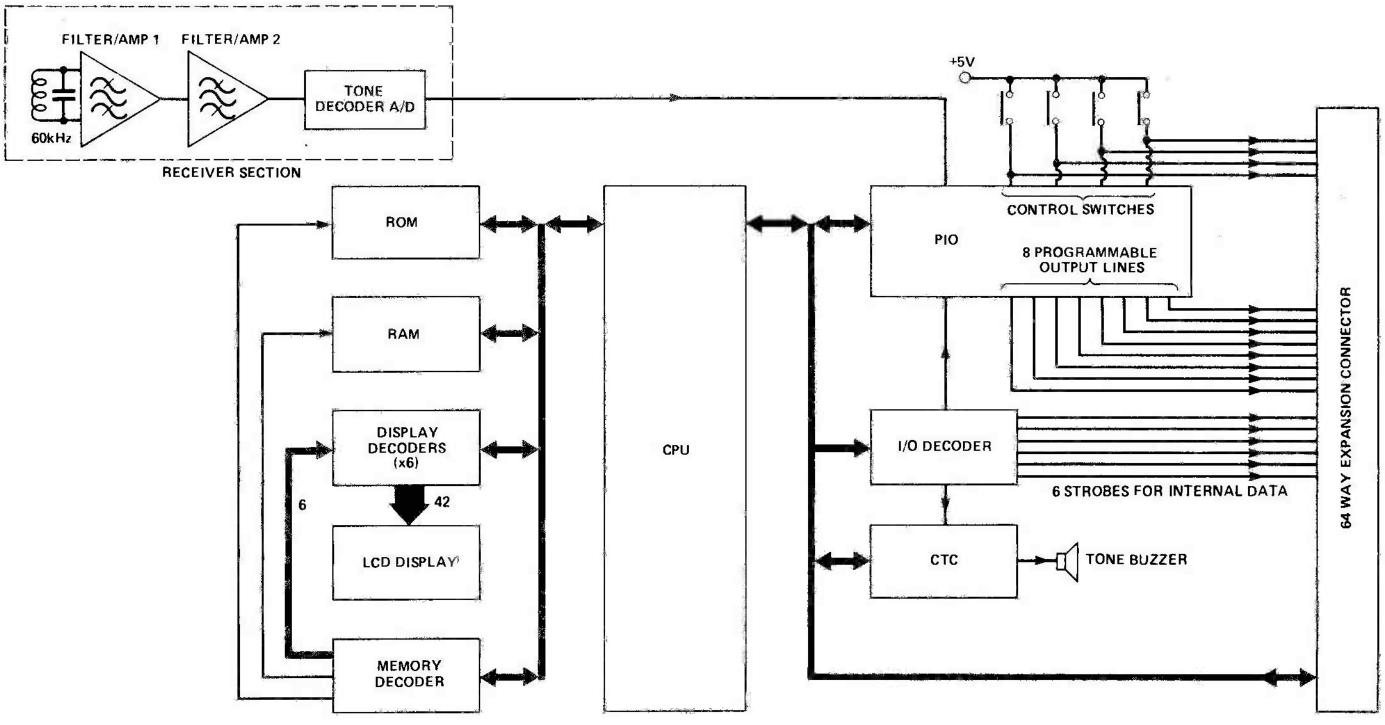
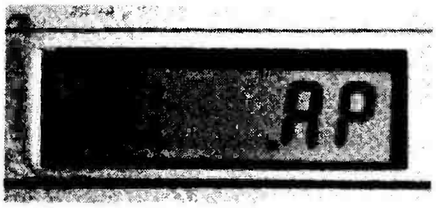


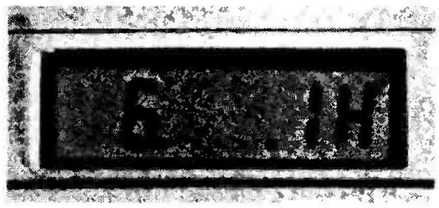
Fig. 1 Block diagram of the Rugby Clock.

Typical time display. Display format is set to 12 hour clock.

Mode 2, phase 1; the hours have been set at 12 for alarm number 2.



Mode 2, phase 2; alarm number 1 has been set for buzzer and port to function.



Mode 2, phase 3; bit 1 of alarm 6 will switch high when the alarm goes off.

to turn on and off eight different electrical appliances (through relays).

There is also a separate timer with a unique mode of operation capable of recording up to 240 lap times without interrupting the count! All this makes is simply the best clock available for home use — or anywhere!

General Description

There are three basic modes of operation designated 1, 2 and 3; clock, alarm, and timer respectively. On reset the clock automatically enters mode 1. Another switch would enter mode 2. In order to enter mode 3 (timer) you have to press reset while pressing one of the switches.

The emphasis in this system is ease of expansion and interfacing. To this end, all the important CPU lines are brought out to a dual 32-way connector. Also, all the information that is transmitted is output to six decoded port selects (including the timer). We intend to publish useful add-on units in the future. The entire unit can be controlled by an external computer, instead of by the push-buttons.

The Circuit

At the heart of the system is a Z80 microprocessor. Several other processors were considered including the RCA CPD 1802 for its low power consumption, Intel 8039 for its 'all-in-one' design, plus good BCD handling, and the Intel 8088 for its speed and overall superior processing power.

The Z80 was chosen because a good interrupt structure was of paramount importance in this application. IC4 decodes the lower 32K of the 64K address space into eight blocks each 4K long. These eight blocks are allocated to the PROM, RAM and six LCD displays. It might appear a waste for each digit in the display to take up an entire 4K of addressing space, but this simplifies decoding logic and reduces chip count. Furthermore, there is 32K of memory still free!

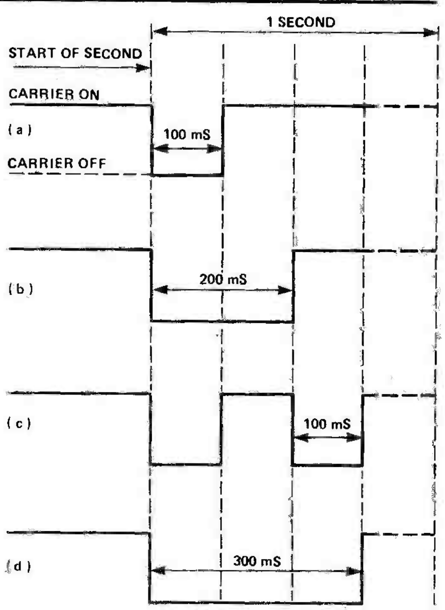


Fig. 2 (Above) Coding data into one second. (a) a 0; (b) a 1; (c) time difference; (d) a second containing odd parity.

As you may have gathered from the above text, the displays are 'memory mapped'; whenever the CPU wants to read or write to memory (in the lower 32K) pin 3 of IC6c goes high, $\overline{MREQ}$ goes low, and A15 is low, indicating to IC4 that a memory read or write is about to take place. If at this time the address bus contains 2XXX to 7XXX hex (X = don't care) then one of the six LCD displays will be selected. Similarly IC19 is used to decode the input/output section. This IC is active when A7, $\overline{IORQ}$ and one of $\overline{RD}$ or $\overline{WR}$ are low; the port selected depends on the binary value that is present on A2 to A4. This effectively divides the lower 128 port addresses (out of a possible 256) into eight separate ports each four addresses long and repeating 16 times.

The CPU clock signal is generated by XTAL1, IC5a, R1, C1, CV1. This is fed to IC5b and IC5c which are connected in parallel to provide a higher drive and isolation.

IC5d and IC5e together with R2, R3, R4, C2, SW5 form the manual and automatic power-on reset. The RESET signal is ANDed with $\overline{M1}$ by IC6a, IC6b to form a hardware reset for the PIO (Zilog ran out of pins and omitted a proper reset pin). Incidentally although Zilog don't mention it, it's possible to reset the PIO by software. This method is used in this application, but the hardware alternative is there in case another application using the board requires it. (Anyway, we had a couple of NAND gates spare!)

IC9 to 14 are LCD display latch-decoders. Information available at the

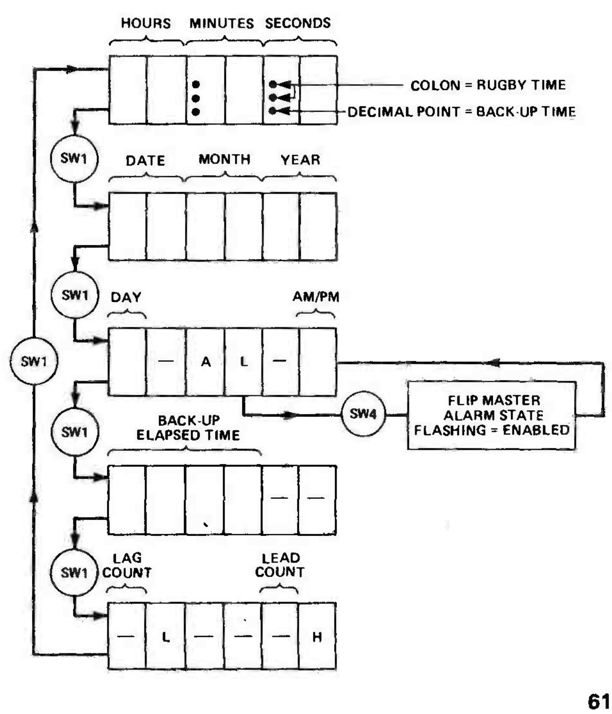


Fig. 3 (Right) The five clock faces available in Mode 1. From top to bottom they are time of day; date; day of week and master alarm indicator; time since clock switched to back-up; and BST/GMT time difference.

data pins (2-5) is latched internally when the latch input (pin 1) receives a positive-going pulse. Since this is of opposite polarity to the signals coming from IC4, a hex inverter is used.

LCD displays require a square wave drive signal on the segments in antiphase to that on the backplane. IC8c and IC8d provide such a signal with a frequency of approximately 50 Hz.

This is fed to the backplane input of the display and also to each display driver (IC9-14). These ICs perform the phase reversal, but unfortunately they don't have decimal point and colon outputs so these have to be generated externally using PIO A0 and A1. IC8a and IC8b perform the phase reversal on these.

IC15 performs several functions; serial input port (SIO), timer, tone generation for radio data, internal timing, user timer (mode 3) and alarm tune.

IC17 also performs several functions, including inputting the state of the switches SW1-SW4, inputting radio data, controlling the display decimal point and colon, inputting the default hour format (12/24); it's also a programmable output port in conjunction with mode 2!

The receiver follows an unusual design. For a start there are no cumbersome coils; instead the entire tuning section comprises two state variable filters in series (IC20, 21). They also provide the necessary gain to couple to IC22 via FET buffer Q1. The two filters provide very good selectivity which is required at these low frequencies due to interference, especially from TV timebase circuitry. When properly tuned by PR1-4 it is possible to have the receiver closer to a TV set than is possible with many current designs. IC22 is a tone decoder whose output pin goes low when a signal within its passband is present at its input (pin 3). Q2 inverts this signal to high for 'carrier on'. There are some spare inverters on the main board which could have been used instead, but the aim was to have a self-contained receiver.

Rugby Transmissions

The incoming radio carrier is switched off and on throughout the entire minute to convey the time information in binary-coded form. The carrier is switched off at the beginning of every second, and the point within the first half of the second that it comes on again determines whether the bit sent within that second is a logic 1 or 0, ie, if it switches on after 100 mS, then the bit is a 0. Otherwise it will switch on after 200 mS in which case the bit is a 1. Figure 2 should make this clear.

As each second transmits only one bit of a binary coded number more than one second may be needed to transmit a whole number. Each unit is allocated the minimum number of bits which will represent the maximum value of that unit; for instance. 'Day of Week' takes up three seconds (three bits) since these will contain binary combinations 0-8 (8 not used).

Seconds 7-16 contain information about the time difference between BST and GMT. An extra pulse (break in carrier) will indicate 1/100th second difference.

The total number of pulses within seconds 1-8 represent the number of hundredths of a second that BST lags behind GMT. Otherwise, those which occur in seconds 9-16 indicate BST leading GMT by their total multiplied by 10 milliseconds.

Seconds 17-51 contain the time, date, day of week, month and year. Seconds 51-59 contain a unique binary code which is used by detecting systems to synchronise; although the clock presented here uses a different system for synchronisation.

Seconds 52-58 also contain a parity checking code on the information that was received between seconds 17-51. That is to say a pulse 300 mS long indicates that the unit in question should have an odd number of 1 bits. A pulse of 200 mS indicates an even number of 1s.

The first second (0th) contains a fast serial code which also specifies the time, date and month.

Just before this code is a very short negative-going pulse (carrier off). It is the only pulse shorter than 3 mS in the entire minute. For this reason it is detected by its unique size and used for synchronisation. The fast code is then read immediately. Synchronizing on this code as opposed to the six second ident makes it possible to make another attempt within 10 mS of the previous attempt if the previous one was false. In the other case it would take at least six seconds to find out if the ident is valid or not before the subsequent trial is attempted.

More On Modes

As mentioned earlier, there are three basic modes which the clock could be in. In order to economise on front panel switches, SW1-4 are all multi-function and the function of each switch

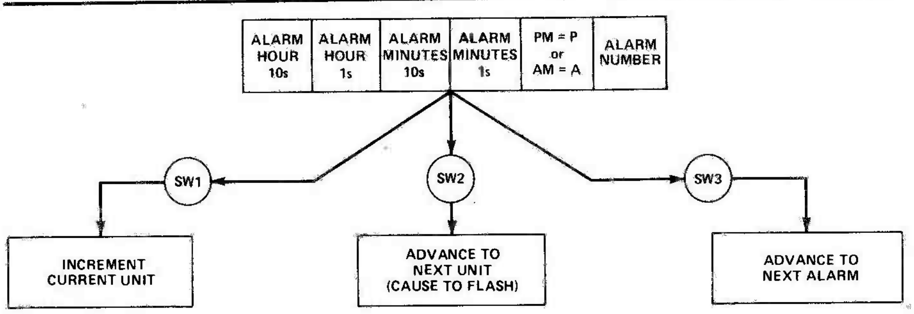


Fig. 4 Switch functions for Mode 2, phase 1.

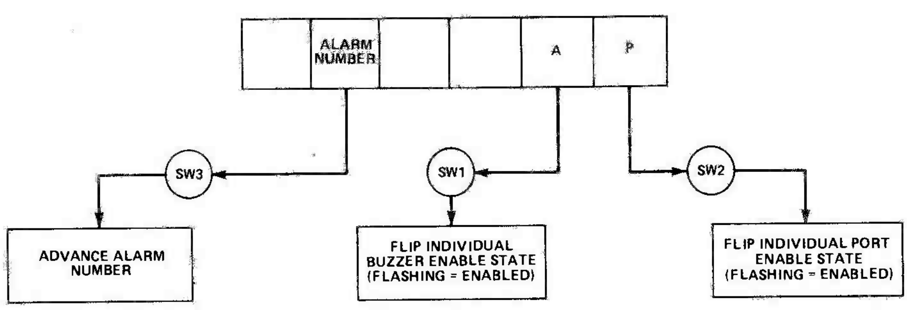


Fig. 5 Switch functions for Mode 2, phase 2.

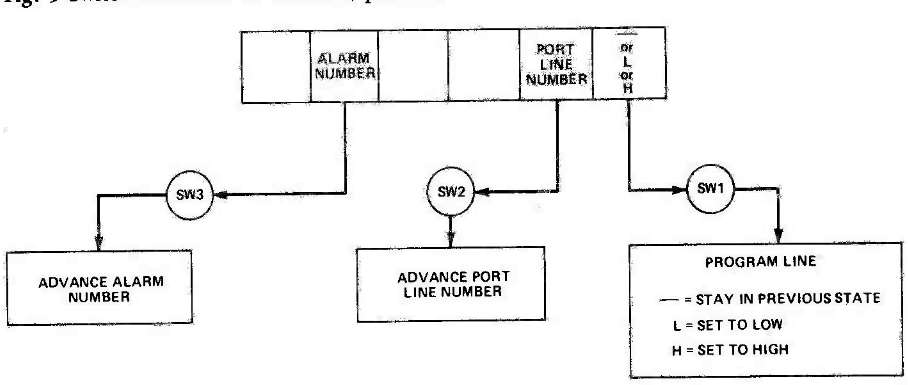
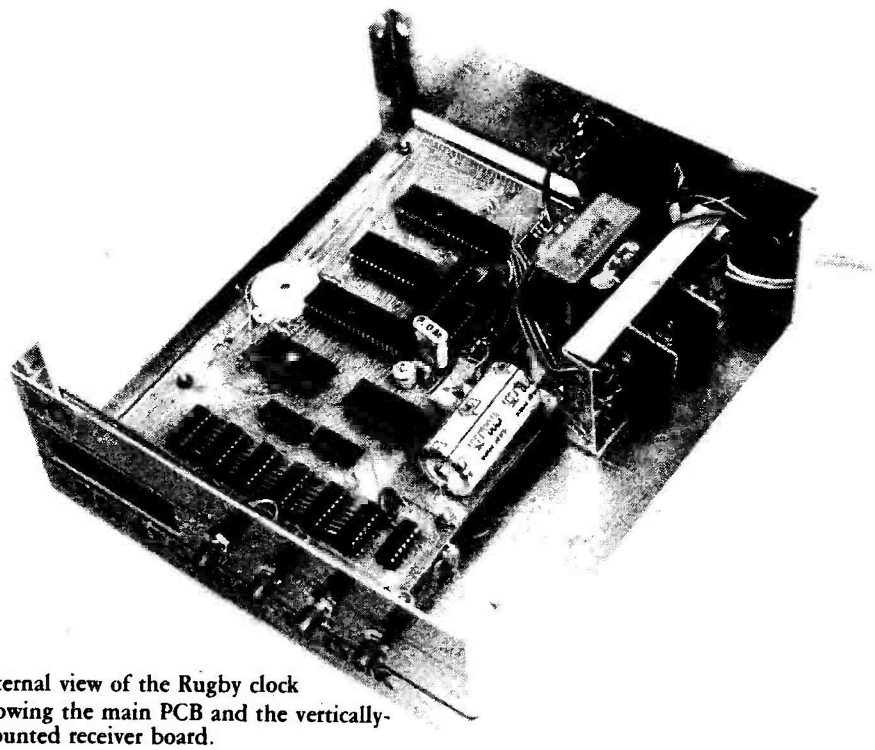


Fig. 6 Switch functions for Mode 2, phase 3.



Internal view of the Rugby clock showing the main PCB and the vertically-mounted receiver board.

depends on which mode, face or phase one is in.

Mode 1

Mode 1 is the default mode on power-on and displays the current time and related information. When the unit is first switched on a blip should be heard from the buzzer in sympathy with the incoming signal. This is useful for tuning purposes, as the receiver can be tuned until a clean blip (generally one a second) is heard.

After some time the blip will stop and the display will change from dashes to the correct time. The date information will take a further minute to appear. Now, assuming that you have waited this further minute, then pressing SW1 causes the display to change to date, month, and year. Press SW1 again and the day of week will appear on the left hand digit while the right hand digit will be either 'A' or 'P' (AM or PM). The middle two digits will contain letters 'AL'. This is the master buzzer enable/disable indicator. If while on this third face you press SW4 the letters 'AL' will begin to flash, indicating that the master alarm is enabled, ie any of the eight alarm settings will sound the buzzer of the preset time. With the master alarm disabled, none of the alarm settings will ever activate. Repeatedly pressing SW4 will toggle the master alarm between 'enabled' and 'disabled'.

Pressing SW1 once more will move on to face 4 which shows the amount of time in hours and minutes since the clock has switched to automatic back-up time. Normally this face will show "00.00--" meaning that the clock is running on Rugby Time.

Pressing SW1 once more will move on to face 5 which shows the BST/GMT time difference information. L indicates 'lagging' while 'H' indicates 'leading'

Finally, pressing SW1 again will wrap round to face 1 to display the time. It is possible to do a quick return to face 1 from any face except face 3 by pressing SW4 twice. Pressing SW2 while face 1 is displayed will change from 12 to 24 hour display and vice-versa.

Mode 2

In Mode 2 any one of eight alarms may be set to sound the buzzer and/or configure the state of the eight lines on port B. Each individual alarm can be enabled/disabled to sound the buzzer or alter the settings of the eight port lines.

From Mode 1, press SW4. The display will show 'AL', indicating the alarm mode. From here you can branch in any one of three directions depending on what you want to do. Let's call this point X. If you want to set an alarm time, from point X press SW3. The display will show a 1 on the right hand side indicating that the current alarm is alarm 1. The rest of the display will contain dashes, and the hour position will be flashing meaning that the hours will be the next unit to be set (like a digital watch). Pressing SW1 will advance the hours. Pressing SW2 will cause the minute 'tens' to flash. Similarly pressing SW1 will alter the minute tens. Pressing SW2 once more will advance to minute 'ones', and then wrap round to hours. SW3 will advance through the alarm numbers and is effective from whichever state the 'setting' procedure is in.

To exit 'alarm set' mode at any time press SW4 which will turn the display back to time display. Press SW4 again to go back to point X. This time we want to enable the alarm we have just set to sound, so press SW1 and then press SW3 to the desired alarm number. Now press SW1; the 'A' will start to flash. If you also want to enable the alarm to alter the port lines, press SW2; 'P' will start flashing. Press SW4 to go to mode 1.

For the third branch from point X, press SW4 again and this time follow it by SW2. Press SW3 to advance to the desired alarm number, then press SW2 to advance to the required bit number. Pressing SW1 will cycle through –, H, L; refer to Fig. 3 for the significance of these letters. Once, again, to exit, press SW4.

When any of the set alarm times come up the buzzer should play a tune and the port lines will take up the state that was programmed. Anyone who dislikes the tune can get it changed for one of their choice by sending a good quality tape or a manuscript to the designer via Technomatic. Details of the charge for this service will be available from Technomatic.

When the tune starts playing, pressing SW4 will stop it. Pressing SW3 will start a 10 minute snooze delay after which the tune will play again. When the tune is playing SW4 and SW3 will perform these two functions no matter what mode, phase or face you happen to be in; the current meaning of those switches will be postponed for one key depression.

Mode 3

This is the timer mode. It is entered by pressing SW5 (reset) and SW4 simultaneously, then releasing reset followed by SW4. The display will show both the colon and the decimal point. Presssing SW4 will start the count; pressing SW4 again will stop it. Pressing SW2 during the count will latch the current display. Repeated pressing of SW2 will latch (and store) up to 240 laps. Pressing SW1 will view the laps in store even while counting is in progress. Pressing SW3 will display the current count, if you happen to be viewing laps or have just latched a lap.

Expansion

The board was built with expansion in mind, hence the 64-way connector which carries all important signals. We hope to publish useful add-ons in the future.

Next month we continue this project with the circuit diagrams and How It Works.

ETI

DESIGNER'S NOTEBOOK

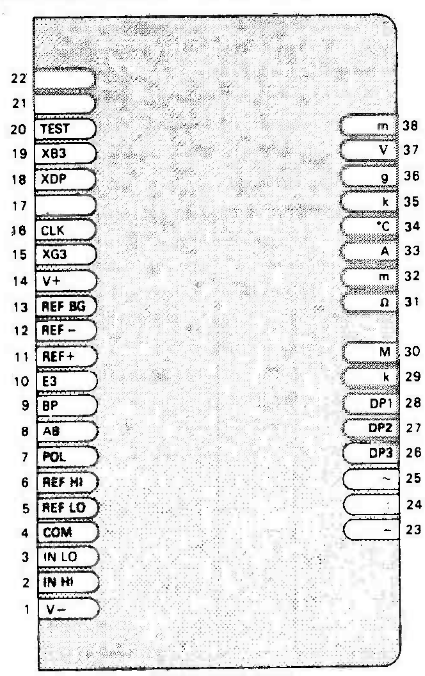
This month Rory Holmes provides you with all the design information you need to incorporate the DPM200 module into electronic measurement circuits. It requires few external components and is ideal for portable instruments.

A major role of electronic equipment is very often the measurement and display of some quantity, either from the 'real world' or an electronic parameter. The new generation of digital voltmeter modules allows the inherent readout accuracy of a digital system to be simply and conveniently implemented due to their low cost, low power and very small size. The price of moving coil meters is steadily increasing while the price of the solid-state ones is naturally falling.

Although digital meters lack an indication of analogue trends, this will soon cease to be a valid criticism. Medium resolution LCD bargraphs coupled with digital readouts will have all the advantages of both, with an increasingly attractive versatility.

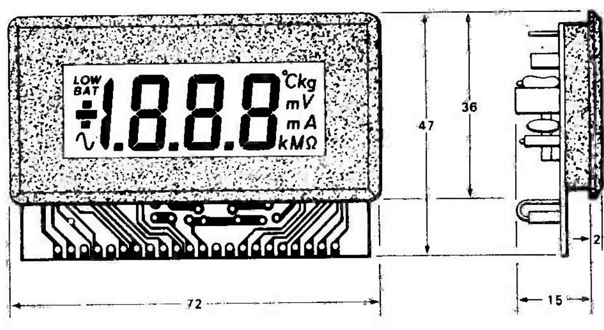
The DPM 200 module is described as a state-of-the-art 3½ digit LCD meter. Briefly, its features are:

- High contrast, wide angle display
- Wide range of programmable symbols
- Ultra-low current consumption
- Single rail supply (5-15 V)
- Auto-zero and auto-polarity
- 0.05% accuracy
- Built-in bandgap reference voltage
- Low battery indicator
- Programmable decimal points



COMPONENT SIDE
NOT TO SCALE

Fig. 1 PCB pin connection diagram for DPM200.



Dimensions in mm

Fig. 2 Physical dimensions of the module. Panel cut-out is 68 x 33 mm.

It is based around the latest dual-slope integration CMOS DVM chip, the 7126, and is certainly the best of its ilk available to the hobbiest.

Figure 3 shows the circuit diagram of the module. The great versatility of this device comes from the large number of user connections provided (38 in all) as shown on the connection overlay of Fig. 1.

When used in conjunction with other circuitry it offers a

TABLE 1

PIN	SYMBOL	FUNCTION
1	V –	Negative supply rail – always goes to negative
2	IN HI	Voltage input via attenuator and R/C filter (non-inverting)
3	IN LO	Voltage input via attenuator and R/C filter (inverting)
4	COM	Low impedance reference level approx. 2V8 below positive rail
5	REF LO	Direct connection from IC's internal reference (negative)
6	REF HI	Direct connection from IC's internal reference (positive)
7	POL	Liquid crystal display drive signal, active when analogue input is negative
8	AB	Auto-range output for ½ digit
9	BP	Backplane drive signal for LCD display
10	E3	Autorange output for E3 segment
11	REF +	100 mV bandgap reference output
12	REF –	Earthy side of bandgap reference for biasing
13	REF BG	1V2 main bandgap reference output
14	V +	Positive supply rail; + 5 to + 15 V
15	XG3	Autorange output segment G3 EXORed with backplane
16	CLK	48 kHz module clock output
17		No connection
18	XDP	Inverted backplane signal for driving annunciators
19	SB3	Autorange output segment B3 EXORed with backplane
20	TEST	Digital ground and "Lamp test" signal
21		No connection
22		No connection

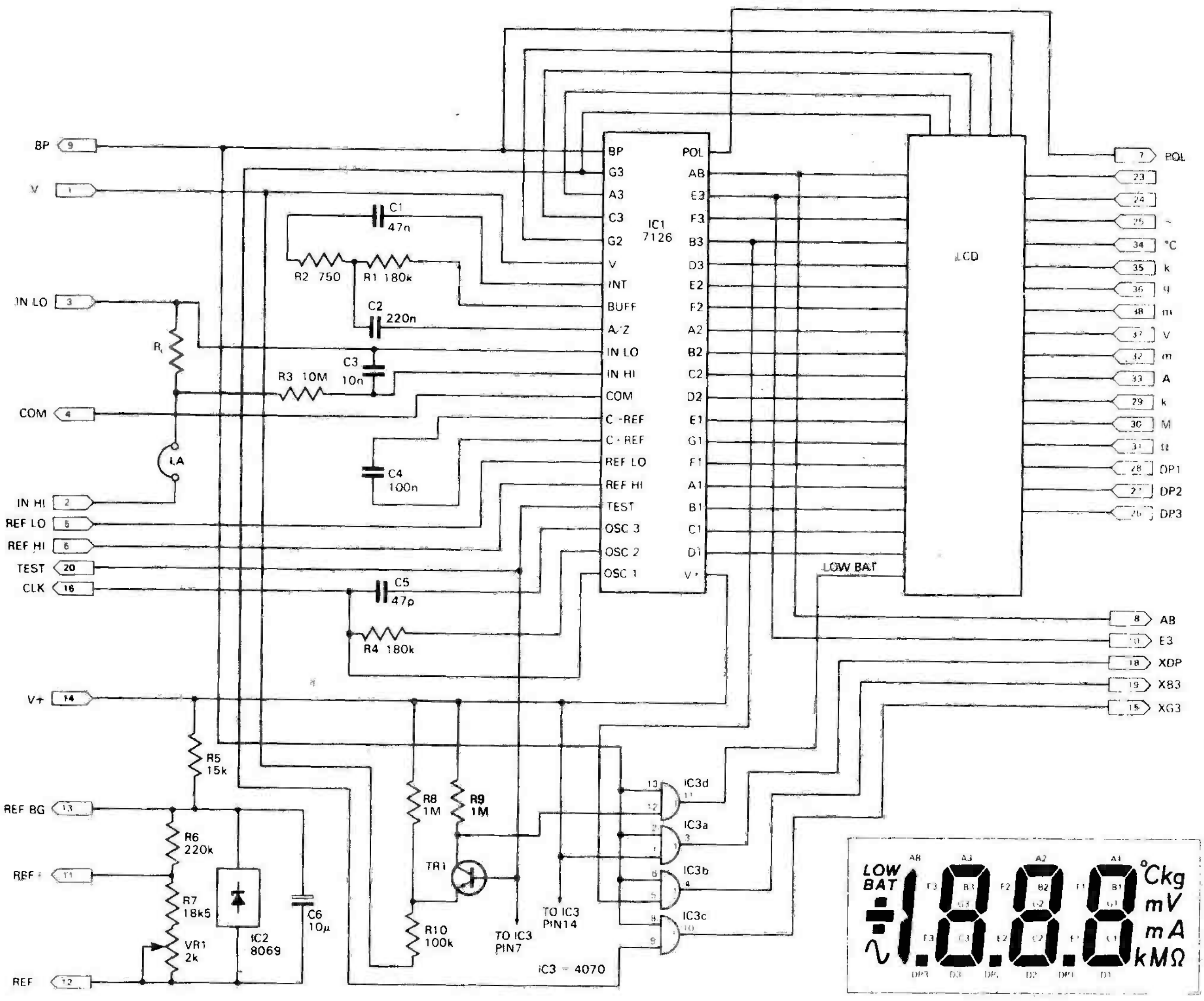


Fig. 3 Circuit diagram of the module. R1, R2 and C1 determine the integrator time constant and C2 reduces the susceptability to noise of the auto-zero circuitry. The display is guaranteed to read zero when the analogue input is 0 V. An input filter formed by R3 and C3 assists with overload protection for the 7126 IC. The input voltage may exceed the supply voltage provided the input current does not exceed 100 uA. The frequency of the internal oscillator is determined by R4 and C5 and provides three samples per second typically. The module is calibrated by means of VR1 for a full scale reading of 200 mV with link LA in circuit and resistor R_c omitted.

number of unexpected bonuses for the designer. A square wave clock signal, an extra negative supply rail, a bandgap precision voltage reference, a common rail for op-amp references, plus four logic signals for autoranging meter circuits — all these signals are available for use in external circuits. Table 1 charts the pin numbers in numerical order with their symbols and basic functions.

Supply Rails

The module can be operated from a single supply between 5 V and 15 V across pins 1 and 14, at a current of 100 uA, using the bandgap reference. However, the internal reference can be used instead, reducing the current to 50 uA with a minimum voltage of 7 V. A low battery warning indicator is set to come on at 6V4, determined by the R8/R10 potential divider. R10 can be altered if required; 220k gives a 7V2 warning.

Legends/Annunciators

The symbols can be enabled very easily by directly connecting the XDP output on pin 18 (an inverted backplane signal) to the required segment. This may also be done via logic or switches for automatic selection of the decimal points.

Inputs

Pins 2 and 3 are the non-inverting and inverting inputs respectively; these analogue inputs are truly differential and may be operated to within 0V5 below the positive supply and 1 V above the negative supply. Common mode rejection ratio within this range is typically 86 dB.

Voltage References

The Analogue Common pin is included primarily to set the common mode voltage for battery operation or for any system where the input signals are floating with respect to the power supply. The common pin sets a voltage that is approximately 2V8 more negative than the positive supply. This is selected to give a minimum end-of-life battery voltage of about 6 V. However, the analogue common has some of the attributes of a reference voltage. When the total supply voltage is large enough to cause the zener to regulate (greater than 7 V) the common voltage will

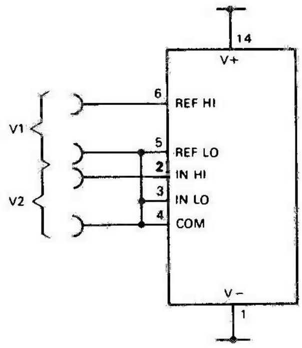


Fig. 4 Measuring the ratio of two voltages. The maximum input voltage is ±2 V with a 9 V supply.

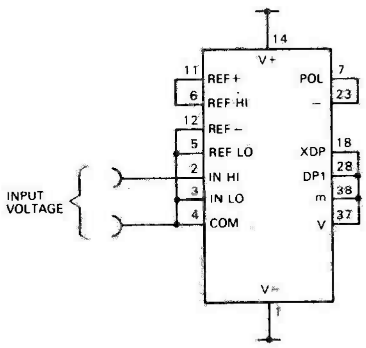
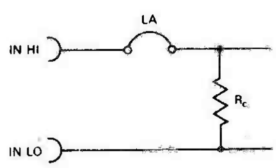


Fig. 5 Measuring a floating voltage source with 200 mV full scale. Autopolarity indication is implemented, together with the decimal point and mV annunciation.

TABLE 2



REQUIRED FSD	LA	R_c
2 V	10M	1M0
20 V	10M	100k
200 V	10M	10k
2000 V	10M	1k0
200 uA	LINK	1k0
2 mA	LINK	100R
20 mA	LINK	10R
200 mA	LINK	1R

have a low voltage coefficient (0.001%), low output impedance (about 15R), and a temperature coefficient typically less than 800 ppm/°C.

The analogue-to-digital converter of the IC operates in a ratiometric mode, such that the digital display is 1000 V2/V1, as shown in the diagram of Fig. 4. Here, the inverting inputs of the reference and voltage inputs are both connected to common (REF LO and IN LO). REF HI is normally connected to the 100 mV bandgap reference from REF+ as shown in Fig. 5, thus giving the 200 mV full-scale deflection. Output REF+ is 100 mV with respect to REF − when the latter is correctly terminated. REF BG is 1V2 with respect to REF −. REF − should normally connect to the COM terminal as the diagram indicates.

To alter the full-scale reading of the DVM module, the link LA and resistor R_c shown in the circuit of Fig. 3 should be altered. Table 2 shows the values required for several ranges of current and voltage.

Outputs

The polarity output on pin 7 is a square wave in-phase with the backplane signal when the analogue input has positive polarity and in anti-phase when the input has negative polarity. It can be connected directly to the " − " symbol (pin 23) for normal polarity indication. The clock on pin 16 may be used for systems timing or as an input to override the internal oscillator and control the sample rate. If CLK is connected to V − the display may be held at a particular value but this should not be connected for extended periods as the steady DC potential applied to the LCD may cause the segments to "burn".

The oscillator frequency is divided by four before it clocks the decade counters. It is then further divided to form the three convert-cycle phases. These are signal integrate (1000 counts), reference de-integrate (0 to 2000 counts) and auto-zero (1000 to 3000 counts). For signals less than full scale, auto-zero gets the unused portion of reference de-integrate. This makes a complete measure cycle of 4000 (16000 clock pulses) independent of input voltage.

An oscillator frequency of 48 kHz is used for three readings per second.

Test

The test pin serves two functions. It is coupled to the internally generated digital ground through a 500R resistor (digital ground is set at approximately 5 V below +V). Thus when operated from a single battery supply, TEST can be used as the 0 V rail for externally generated segment drivers, such as decimal points (or any other presentation the user may want to include on the LCD display), or it may be used as a common mode reference level to ensure compatibility with most op-amps.

If TEST is connected to V+ the LCD segments will be turned on and the display will read as shown in Fig. 6 (This mode should not be used for extended periods, to avoid damage to the LCD).

Fig. 6 The display when in the 'TEST' condition.

SPECIFICATION

Input impedance:	>100M
Full scale reading:	199.9 mV
Accuracy:	0.05% of reading ±1 digit
Power supply:	5 − 15V DC
Power consumption:	50 uA (in low power mode), typically 8,000 hours PP3 life
Sample rate:	3 readings per second
Auto-zero:	No necessity to adjust for offsets
Auto-polarity:	Automatic polarity indication eliminates the need to reverse input leads to obtain correct reading.
Overrange warning:	1 in leading digit with other digits suppressed
Bandgap reference (50 ppm/°C typ.)	incorporated for excellent stability of reading
Digit height:	15 mm (0.6″) can be read at distances up to 10 metres
Low battery warning:	direct display, voltage threshold easily adjusted
Operating temperature:	0°C to 50°C
Overall dimensions:	72 x 36 x 12 mm
Panel cut-out:	68 x 33 mm
Display annunciators:	many useful legends are built into the custom LCD which may be activated as required
Auto-zero	With the inputs shorted, the display should read zero, the negative sign being. displayed about 50% of the time
Overrange:	Inputs greater than full scale will cause suppression of the three least significant digits, i.e. only 1 or − 1 will be displayed
Polarity	The absence of a polarity sign indicates a positive input reading. A negative input is indicated by a negative sign.

ETI

ETI PCB SERVICE

Up until now PCBs were always the hardest component to obtain for a project. Of course you *could* make your own, but why bother anymore?
Now you can buy your boards straight from the designers — us! As of this issue all (non-copyright) PCBs will be available automatically from the ETI PCB Service. Each board is produced from the same master used to build our prototypes, so you can be *sure* it's accurate, and will be finished to the high standard you would expect from ETI.
In addition to the PCBs for this month's projects, we are making available some of the more popular designs from our recent past. See the list below for details. Please note that NO OTHER BOARDS ARE AVAILABLE. If it's not listed, we don't have it!

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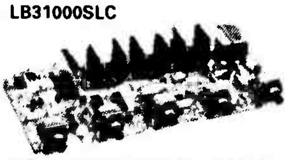

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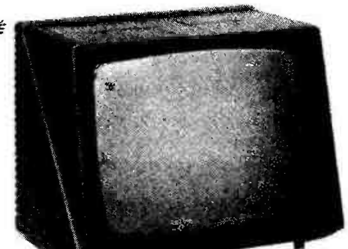

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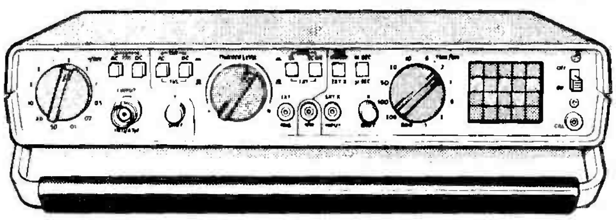

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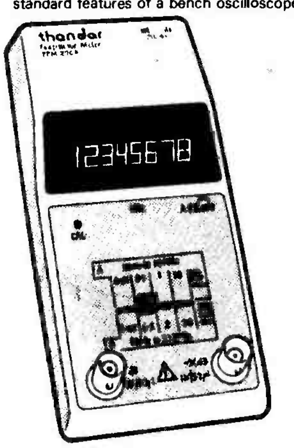

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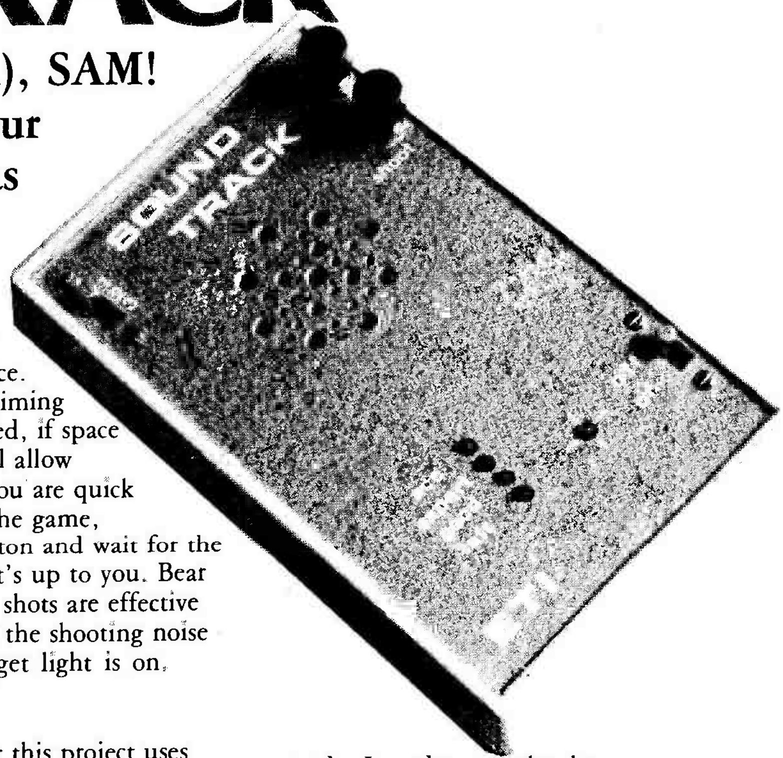
SOUND TRACK

Play it again (and again, and again), SAM! When you feel like working off your aggressions, try to zap the nasties as they fly past. Design and development by Phil Walker.

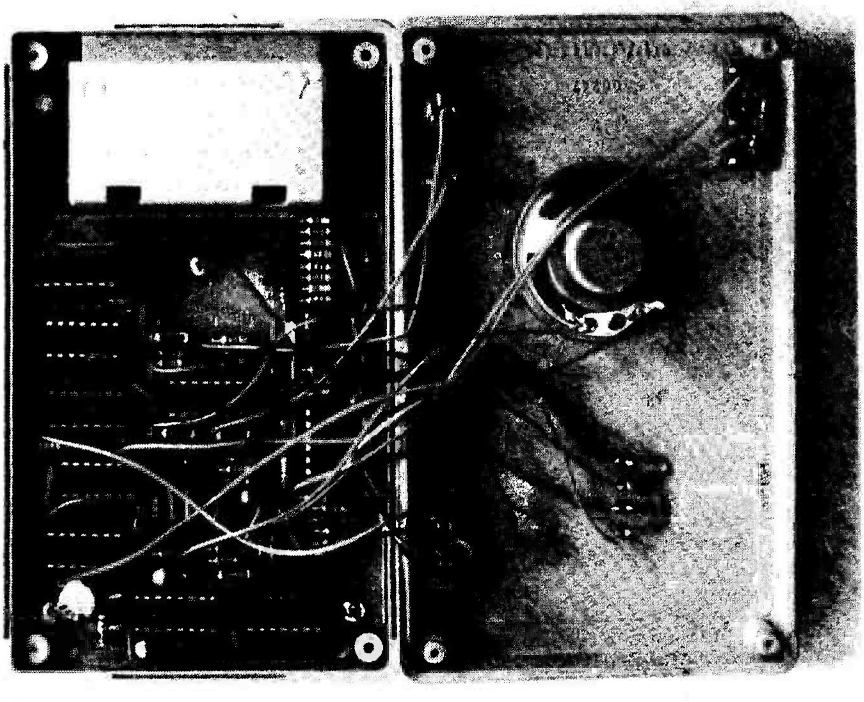


The ETI Sound Track is an 'arcade' game you can carry in your pocket. It requires no special displays as all the cues are sounds. The object of the game is to intercept all 15 of the attackers with your own armament. In order to do this you have to judge the best moment to fire from the simulated sound of the attacker. It is made more realistic by the fact that both volume and frequency changes due to Doppler shift are included. As the game progresses the speed of the attack increases to prevent you getting too used to one pace. Also there are three levels of skill which determine how difficult it is to hit the attackers at all.

At the end of the game, if enough of the attackers have been intercepted, an LED will light up to give an assessment of your performance. As an option, an aiming control can be fitted, if space permits, which will allow multiple shots if you are quick enough. To start the game, press the reset button and wait for the first attack. Now it's up to you. Bear in mind that your shots are effective only at the end of the shooting noise and while the target light is on.

The Circuit

The circuit for this project uses standard op-amps, CMOS counters and gates and a special sound effects IC. This allows us to make fairly realistic sounds to simulate an object flying past, some sort of weapon being fired and an explosion if a successful interception has been made. In order to make the completed project hand-held, the PCB is fairly crowded but quite a lot has been put onto it.



The heart of the system is a voltage controlled oscillator operating at a frequency of less than 0.2 Hz. This provides two outputs; one is an asymmetrical triangle wave which controls the attack sound effect and simulates the position of the target while the other output is a logic signal to drive the score counters. The VCO frequency is modified by the attack counter such that the attacks proceed more rapidly as the game progresses.

The fire control section of the circuit produces two signals. The first of these is a long pulse which causes the shooting sound to be made by the sound generator. The second, immediately after, is a short pulse which enables the hit detector. If at the same time the ramp from the VCO is within the limits of the window discriminator in the hit detector, then a HIT will be registered and the HIT counter updated. At the same time the sound generator will be switched to provide an explosion effect.

The sound select logic and analogue control switching (in the absence of any other demand) will assume an attack sequence and configure the sound generator to give a mixture of white noise and a tone. As the ramp voltage from the VCO falls, simulating an attack, the volume will increase to a maximum and then decrease again. Simultaneously, as the volume reaches its peak, the pitch of the tone will decrease rapidly and stabilise at a lower level to simulate Doppler shift. While the ramp voltage returns to its starting level the sound generator is inhibited.

If either shooting or explosion effects are demanded, these will take precedence over the attack sound. The explosion is produced by envelope-shaping the white noise source in the chip while the shooting sound is given by an audio frequency VCO, frequency-modulated by a much lower frequency triangle wave.

The display given by the LEDs is to give some indication of the number of successful interceptions made in a game. The first LED will light when eight out of the 15 attacks have been stopped. The next will light at 12, then 14, and finally 15. There is one other LED which flashes each time a HIT is possible, but note that the shoot button usually has to be pressed before it lights.

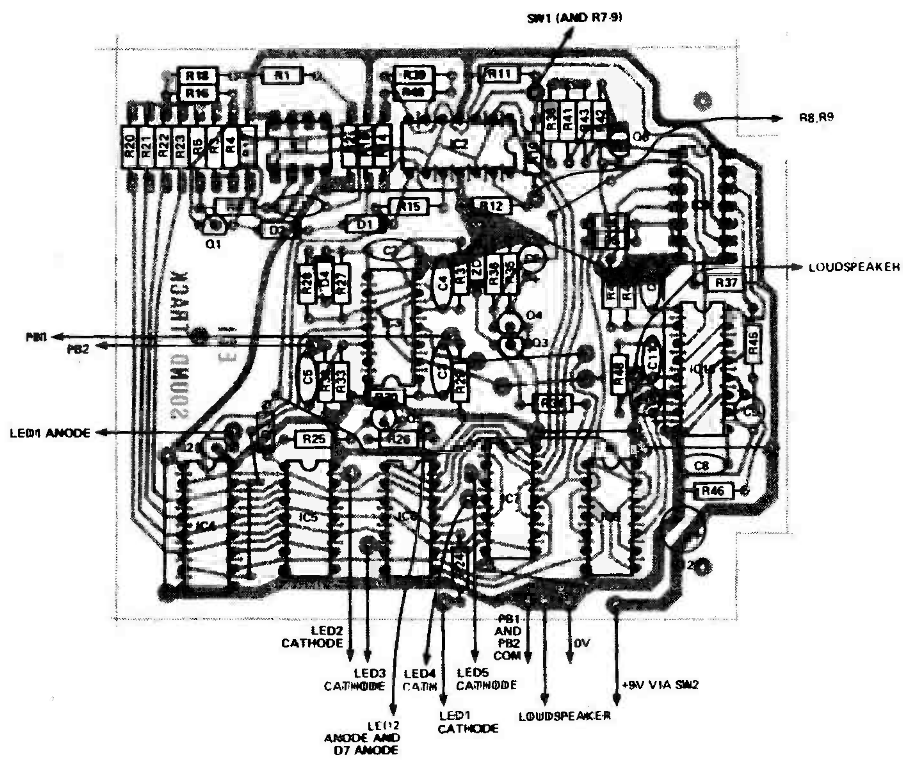


Fig. 1 Component overlay for the Sound track hand-held 'arcade' game. Note that some components are mounted off-board; see the photographs.

Construction

No major problems should be encountered in making this project; care must be taken when soldering the board as there are many places where tracks run between IC pins. Make sure that all the links are in place and that diodes, ICs and polarised capacitors are the right way round. Low profile IC sockets may be used but the case we used may then be a little tight.

SW1, R6 and R7 were mounted so that they fitted beside the battery compartment on one side while PB1 and PB2 went the other side. The LEDS are mounted on the front of the box so that they poke through the panel; use a little glue to hold them in place. Some interconnection work and components have to be put on to these (D7-10) and this should be kept as close to the panel as possible. If there is room, fit RV1 and R7 but this will only be possible if a very small potentiometer is available or a different box is used.

All interwiring should be carried out using thin flexible wire and kept as short as practicable. When fixing the loudspeaker check first that it will fit in the desired position and adjust fixing pillars etc. to ensure this. It is

PARTS LIST

Resistors (all ¼W, 5%)	
R1,2,4,12,39	100k
R3,5,6,22,29, 30	
R31,32,33,35	1M0
R7,15	220k
R8,46	6k8
R9,10,42	15k
R11,41	82k
R21,27	2M2
R14,23	470k
R16	180k
R17,19,37	27k
R18	150k
R20	4M7
R25	47k
R24,26,38	1k0
R28,48	10k
R34,36	22k
R40	3k3
R43	4k7
R44	1k5
R45	68k
R47	12k
R13 is not used	
Potentiometer	
RV1	100k linear
Capacitors	
C1,8	100n polycarbonate
C2	220n polycarbonate
C3,5	4n7 ceramic
C4,11	1n0 ceramic
C6	2u2 16 V tantalum
C7	10n ceramic
C8	68n polycarbonate
C9,10	10u 10 V PCB electrolytic
C12	100u 10 V PCB electrolytic
Semiconductors	
IC1	TL082
IC2	TL084
IC3	4093B
IC4	4520B
IC5	4012B
IC6	4023B
IC7,8	4011B
IC9	4066B
IC10	SN76495 (see Buylines)
Q1,2,3,4,6	BC182L
Q5	BC212L
D1-10	1N4148
ZD1	5V6 400 mW zener
LED1,3,4,5	Green miniature LED
LED2	Red miniature LED
Miscellaneous	
SW1	miniature 3-position slide switch
PB1,2	miniature push-to-make push-button
SW2	miniature slide switch (on/off)

Case (Pac-tec type HP); PP3 battery and connector; knob for pot; loudspeaker (1" dia, 8 ohm) — see Buylines; PCB (see Buylines).

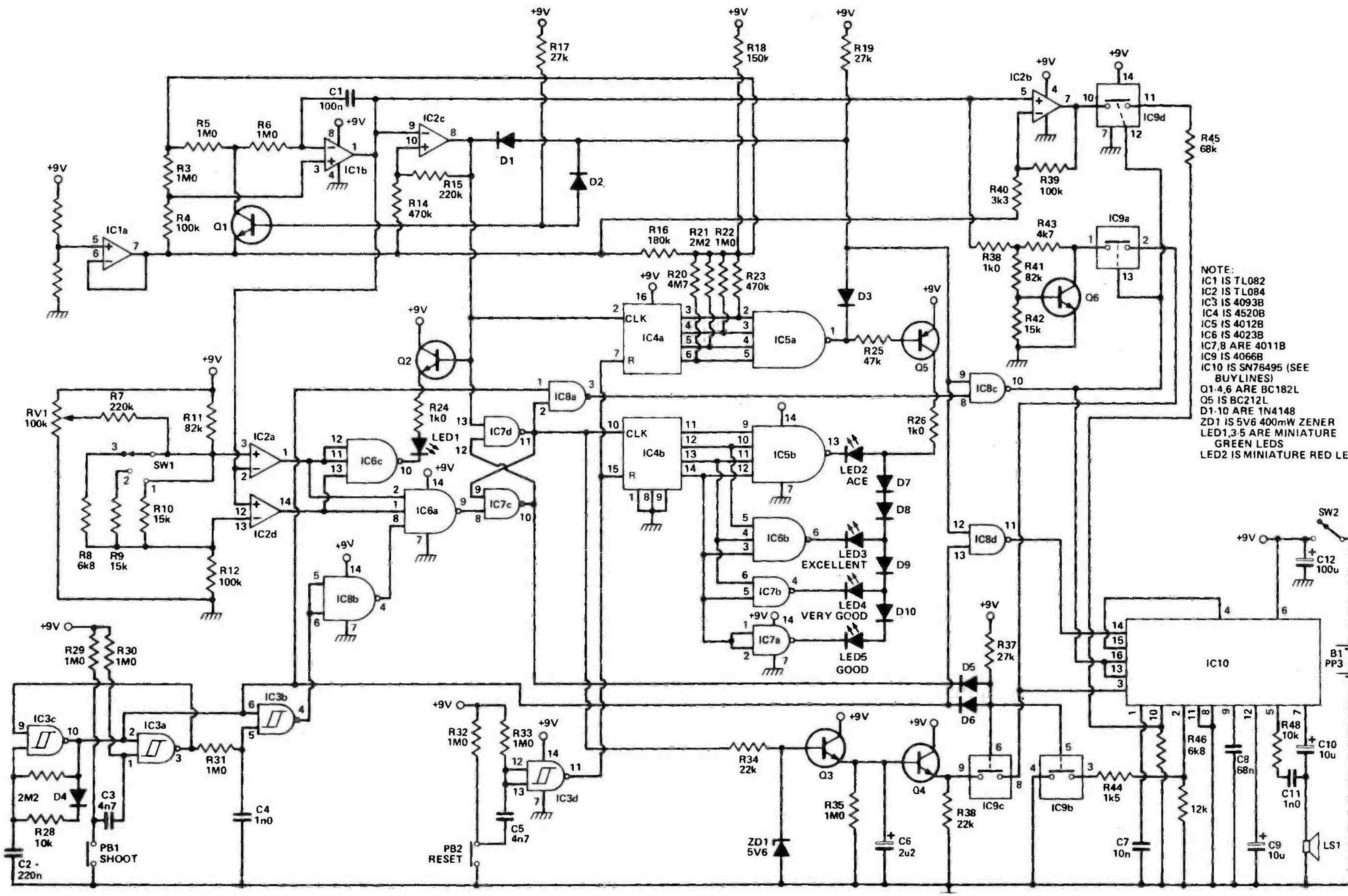


Fig. 2 Circuit diagram for the Sound Track.

HOW IT WORKS

IC1b buffers the voltage at the junction of R1 and R2 to give a reference at half the supply. IC1a and IC2c form a very low frequency voltage controlled oscillator. R20-23 make a simple D-to-A converter which varies the VCO frequency by a small amount as the game progresses. The timing for the whole game is derived from the VCO and provision is made by D1-3 to stop the circuit oscillating when the required 15 attacks have been counted by IC5a.

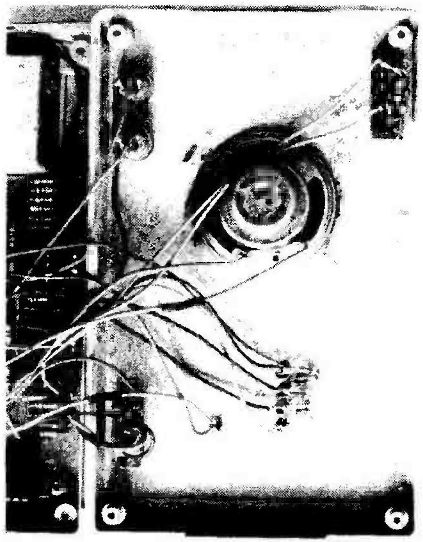
IC2a and IC2d form a window comparator whose position and width can be varied by RV1 and SW1. IC3a and IC3c are connected as a monostable and are triggered by PB1 being closed. C3 ensures that the period of the monostable is not affected by further closures of PB1. When the monostable time ends, IC3b is enabled for a short time determined by R31 and C4. This signal is inverted by IC8b and is applied with the outputs from the window comparator circuit to IC6a. If all the inputs to this IC are high at the same time this signifies a "HIT" and the output of IC6a will go low. This action causes the latch formed by IC7c and IC7d to be set with IC7c output high. The resulting low on IC4b clock input increments that counter, increasing the score, while further counting on the same attack run is prevented by the latch action in IC7c/d. IC5b,6b,7b and 7d decode the outputs from IC4b to give a suitable display on the LEDs when Q5 is enabled by IC5a at the end of the game. IC3d is used to debounce the reset switch PB2 and the circuit at its input ensures that only a short pulse is available at its output.

The analogue control signals for the sound generator chip IC10 ae produced in three parts and switched into circuit when required by IC9. The control signals for IC9 and IC10 are derived by IC8a, 8c,8d and an AND gate made up of D6, D5, and R37.

The analogue control signals are produced individually. The Doppler style fall in frequency as each attack progresses is produced by IC2b. This device has a fairly high gain and at the start of the attack its output is driven to the positive rail by the ramp output from the VCO. As the ramp voltage falls past the reference voltage the output of IC2b will change from positive to negative quickly (but not instantanously). If there is no other sound required at the time this output will modulate the oscillator in IC10 via R45.

Another effect required to simulate an object passing is that the noise produced by it will first increase and then decrease. This is accomplished by the circuit around Q6. At high voltages Q6 will be fully on and the output is low. At low voltages Q6 will be off but the output will again be low. As the voltage applied to the circuit increases, (until the voltage on the base of Q6 is sufficient to make it conduct) the output voltage will be the same as the input. When, however, Q6 starts to conduct, the junction of R38, R41, and R43 will stay at a constant potential. The reason for this is that as the input voltage rises, more current will flow into the circuit via R38. A small amount of this will go through R41 to drive Q6 further into conduction, drawing the rest out via R43. This action will continue until the voltage across Q6 is virtually zero again. The output from Q6 drives the volume control pin of IC10 via IC9a.

The last effect is of a decaying explosion. While IC10 will produce the noise of the explosion, the decay envelope has to be generated by Q3 and Q4. Most of the time the base of Q3 is held at 5V6 by the output of IC7d (part of the "HIT" latch). In the event of a "HIT" being registered, the base of Q3 will now be driven low. C6, which previously was held at about 5 V by Q3, will start to discharge via R35. The voltage on C6 is buffered by Q4 and fed to IC10 by IC9c. Also for the explosion effect, R44 is connected into circuit by IC9b. This changes the noise slightly to give a more realistic sound. C11 and R48 are included in the amplifier circuit feedback to give more prominence to the mid-frequencies and cut down on the hiss effect of the digital generation of the various noises.



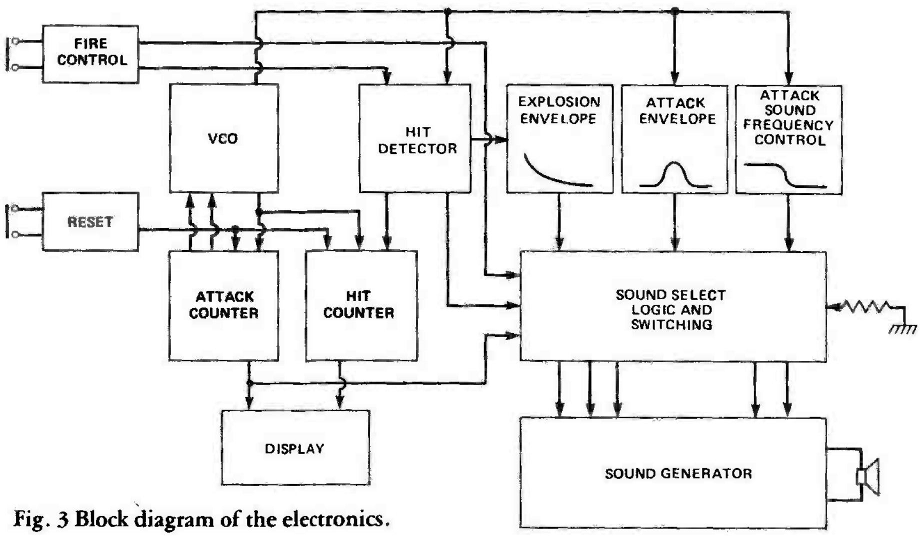
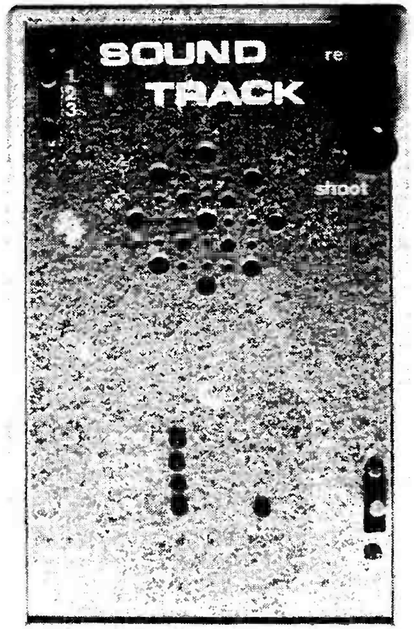


Fig. 3 Block diagram of the electronics.

intended that it fits with part of the cone overlapping the battery compartment so a little shaving with a sharp knife may be required. When the speaker position is known, drill a series of holes in the panel and glue it into position.

The wiring may now be completed and the box assembled to finish the project Fit a PP3 battery to the connectors and it should be ready.



The on-off switch, SW2, is mounted on the front panel at the bottom right-hand side such that it will be over R38, 41-43.

BUYLINES

Not too much here that's hard to find. The sound generator chip is one of the latest ones from the Texas Instruments range, so it should be available from TI stockists such as Technomatic and Watford Electronics. The Pac-tec case is available from Watford or direct from OK Machine and Tool Ltd, 22 Dutton Lane, Eastleigh, Hants. The speaker is type R3812 from Henry's Radio, while the PCB is available from us via our PCB Service (see page 69).

ETI

DATA SHEET

The HOS-100 high speed, bipolar, voltage follower/buffer amplifier is designed to provide high current drive at frequencies from D.C. to 125MHz. Featuring a slew rate of 1400V/μs, output drive of ±10mA into 1KΩ loads, excellent phase linearity (2°) and low distortion (<0.1%).

Ideal for wide range for buffer applications including high impedance input buffers for fast A to D convertors and comparators, coaxial cable drivers, yoke drivers in high resolution CRT displays etc.

Features

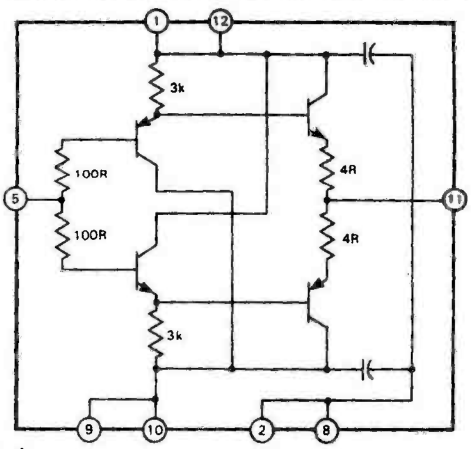
☐ Wide Bandwidth - d.c. to 125MHz
☐ High Slew Rate - 1400V/μs
☐ Operating Temperature Range −25°C to +85°C
☐ High Output Drive - ±10V with 100Ω Load

Applications

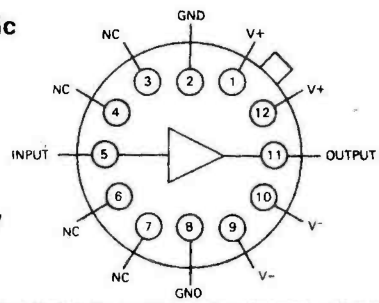
☐ Current Boosters
☐ High Speed A/D Input Buffers
☐ Coaxial Cable Drive
☐ High Speed Line Drivers
☐ Video Impedance Transformation

Absolute Maximum Ratings

Supply Voltage (V+ to V−) 40V
Maximum Power Dissipation 1.5W
Input voltage .... Equal to supply Voltage
Maximum Continuous Output Current .... ±100mA
Maximum Peak Output Current .... ±250mA
Operating Temperature Range (Case) .... −25°C to +85°C
Storage Temperature .... −65°C to +150°C
Lead Temperature (Soldering 10 sec) .... +300°C
Maximum Junction Temperature .... +175°C



Internal Schematic



Top view

Figure 1

Electrical Characteristics

(V_S = ±15V, R_L = 1kΩ, T_C = 25°C)

Parameters	Conditions	Min	Typ	Max	Units
Input Bias Current			5	25	μA
Input Impedance	V_{IN} = 1V rms, f= 1kHz	100	200		kΩ
Voltage Gain	V_{IN} = 1V rms, f = 1kHz	0.94	0.96	1.0	V/V
Output Offset Voltage	R_S = 50Ω		10	25	mV
Output Offset Voltage T_C	R_S = 50Ω		25	75*	μV/°C
Output Impedance	V_{IN} = 1V rms, f = 1kHz, R_S = 500Ω		8	12*	Ω
Output Voltage Swing	R_S = 50Ω, V_S = ±5V	±12*	±13 6		V
Supply Current	V_{IN} = 0V, V_S = ±15, V_S = ±5		15 10	20	mA mA
Power Consumption	V_{IN} = 0V		450	600	mW
Slew Rate	V_{IN} = ±10V, R_S = 50Ω	1000	1400		V/μs
Bandwidth	V_{IN} = 1V rms, R_S = 50Ω	100	125		MHz
Rise Time	ΔV_{IN} = 0.5V, R_S = 50Ω		2		ns
Propagation Delay	ΔV_{IN} = 0.5V, R_S = 50Ω		1.5		ns
Phase Nonlinerearity	BW = 1 to 20MHz, R_S = 50Ω		2		Degrees
Harmonic Distortion	f > 1kHz, R_S = 50Ω		<0.1		%

*Applies over full temperature range -25°C to +85°C

Typical Performance Curves

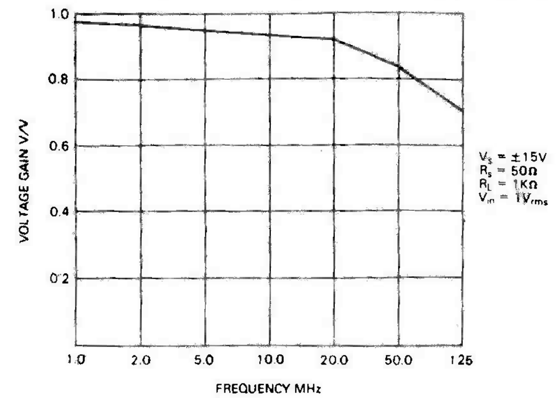


Figure 2: Frequency response

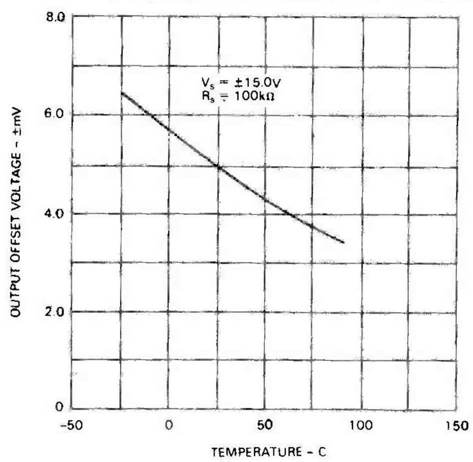


Figure 3: Output offset voltage vs temperature

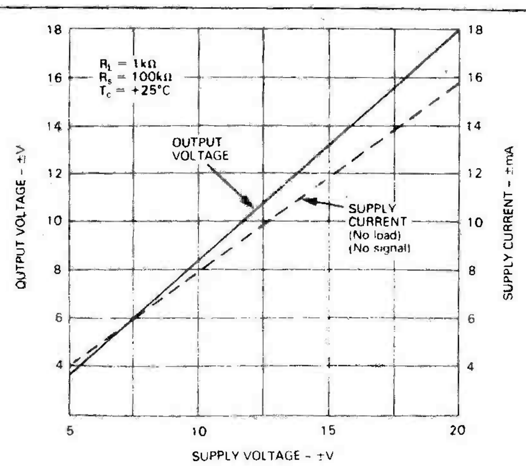


Figure 4: output voltage vs supply voltage Supply current vs supply voltage

Applications

Layout Considerations

As is the case with any high-speed design, proper layout is critical to avoid the introduction of unnecessary errors due to high-frequency coupling, stray capacitance, and the like. Large ground planes should be used whenever possible to provide a low resistance, low inductance circuit path, as well as shielding the effects of high-frequency coupling. Sockets should be avoided, as the increased inter-lead capacitance can degrade bandwidth. Input and output connections should be kept as short as practical.

Capacitive Loading

The HOS-100 has been designed to drive capacitive loads of several thousand picofarads (such as coaxial cable) without oscillation. In these applications, peak current resulting from (C x dv/dt) should be limited below the absolute maximum peak current rating of ±250mA.

Also, power dissipation due to driving capacitive loads plus standby power should be kept below the total power rating of 1.5W.

Typical Applications

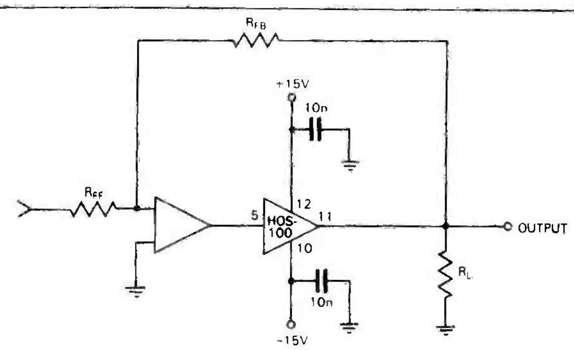


Figure 5: Current booster

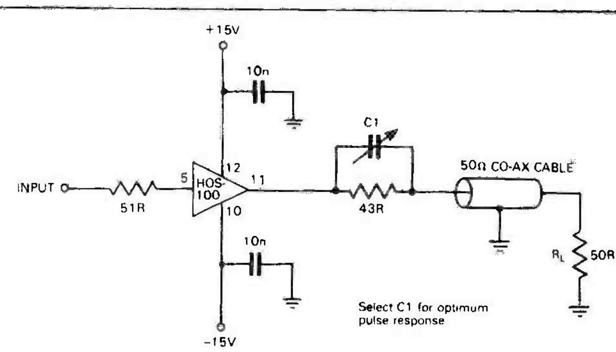


Figure 6: Coaxial cable driver

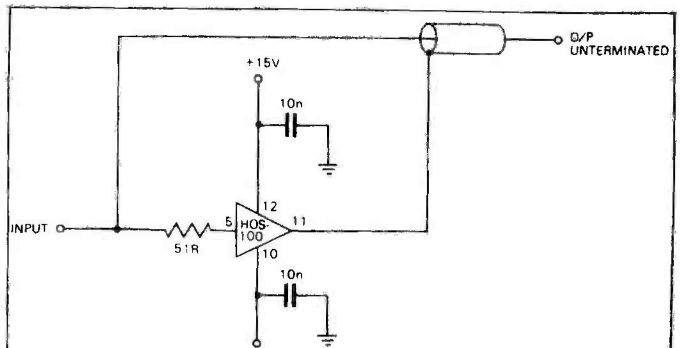


Figure 7: High speed shield/line driver

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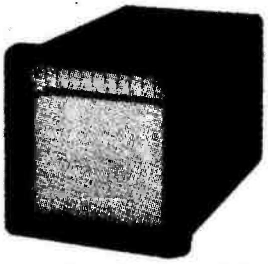
Made in USSR

Series H3020

SPECIAL OFFER



Basic error: 2.5%
Sensitivity: 8mA F.S.D.
Response: 0.2 sec.
Width of each channel:
Single and three-pen recorders: 80mm
Five-pen recorders: 50mm

Chart speeds, selected by push buttons: 0.1 0.2 0.5-1.0-2.5-5.0-12.5-25 mm/sec.
Chart drive: 200-250V 50Hz
Recording: Syphon pen directly attached to moving coil frames. Curvlinear co-ordinates.
Equipment: Marker pen, timer pen, paper footage indicator, 5 rolls of paper, connectors, ink etc.
H3020-3 (Three pen): 475mm wide × 384mm deep × 165mm high inc VAT .... **PRICE £69**
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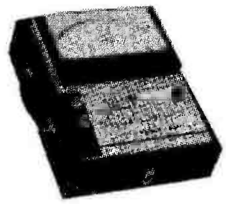
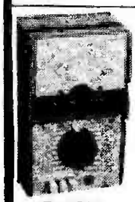
All recorders supplied complete in a sturdy custom built wooden carrying case. Carriage: £10.00 per recorder

MULTI-RANGE UNIVERSAL PORTABLE AC/DC RECORDING VOLTAMMETER H390
(SUPPLIED WITH 5 CHART ROLLS)



Measurements ranges, AC/DC:	5-15-150-250-500mA, 1.5-5 Amps 5-15-150-250-500V
Accuracy.	1.5% DC, 2.5% AC
Chart width:	100mm
Chart drive:	220-250V AC mains
Chart Speed:	20-60-180-600-1800-5400 mm/hour
PRICE: £70.00	Carriage £6.00



MULTIMETER — TYPE U4324 — 20,000 O.P.V.

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D.C. Voltage:	0.6-1.2-3-12-30-60-120-600-1200V
A.C. Voltage:	3-6-15-60-150-300-600-900V
Resistance:	500Ω-5-50-500kΩ
Accuracy:	d.C. 2.5%: A.C. 4% (of F.S.D.)

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240v:	6-0-6v	100m/a	58p	52p	43p
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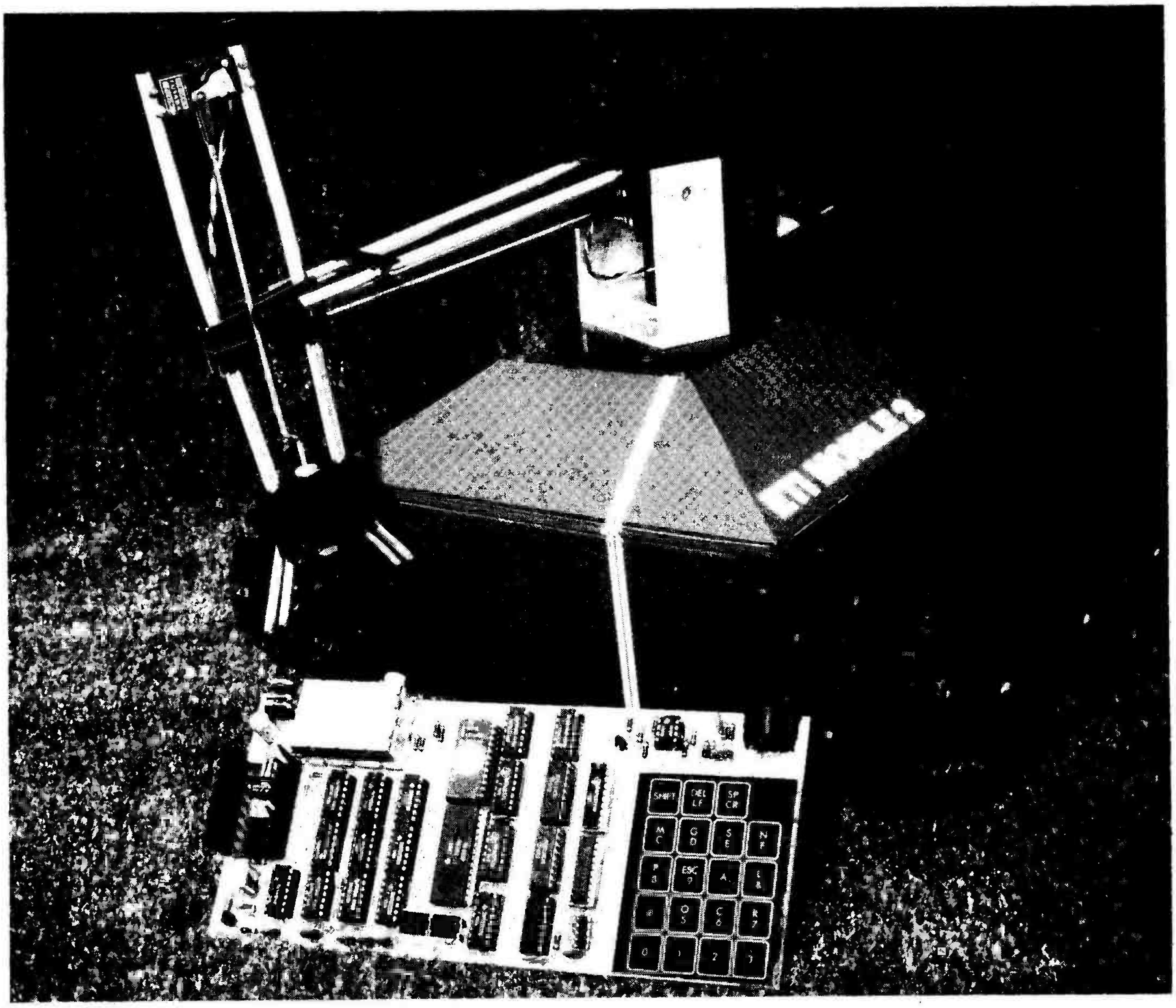


ETI MOBILE 2

Enough of this 'you and us' attitude – it's time for some reader involvement. We've been publishing robot modules thick and fast, but now it's your turn to be inventive; together we can make beautiful robots.

Regular readers will have followed our Motor Control series with (we hope!) a curious interest. It may have crossed your mind to wonder exactly what ETI is up to *now.* All this talk of Robot Control and no robot!

Way back in our April issue we showed the base of our Mobile 2, and since then have been steadily mounting modules into it, building up the basis of an advanced robotics project.

This month it's time to lay out the complete series and to involve the future participants and designers in the project – you! We have developed a complete mobile, with arm and computer link which we will be presenting over the next few months. After that it's up to you, our readers. We hope to be able to continue the series with projects and features based upon your designs and programs for the Mobile 2.

Too Mobile?

The complete ETI Mobile comprises a tracked base with servo driven arm – for which a low-cost metalwork kit is available – infra-red proximity detectors, on-board interface and control circuitry, wireless link to a home computer port and an experimental positional detection system.

The home computer acts as the "brain" and can be thus programmed to make decisions upon the information returned to it by the Mobile. The latter's motor drive system is linked via an eight-bit port arrangement to the control board, placing the tracks directly under computer control.

This means that a set of pre-arranged instructions can be sent to the mobile, causing it to follow a path around obstacles and obstructions, thus functioning in any environment. As the computer carries all the software, decisions upon "what to do if..." can be modified and expanded at the touch of a cursor!

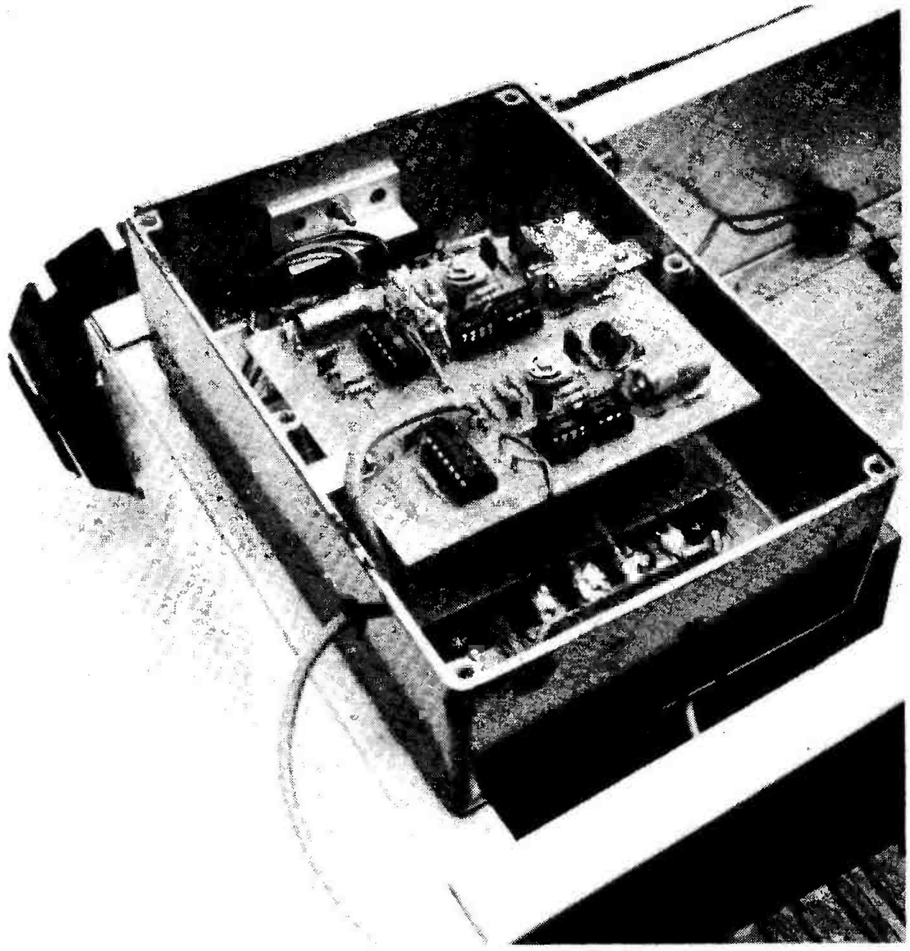
Similarly, the arm is ported onto the bi-directional data link and can be software controlled from the computer. Alternatively the arm may be used as a 'stand-alone' design, for which the interface has also been configured.

Some Arm In it

The servo-driven manipulator we are proud of! Produced in conjunction with Remcon Electronics, it overcomes many of the complex mechanical hang-ups which beset earlier constructs.

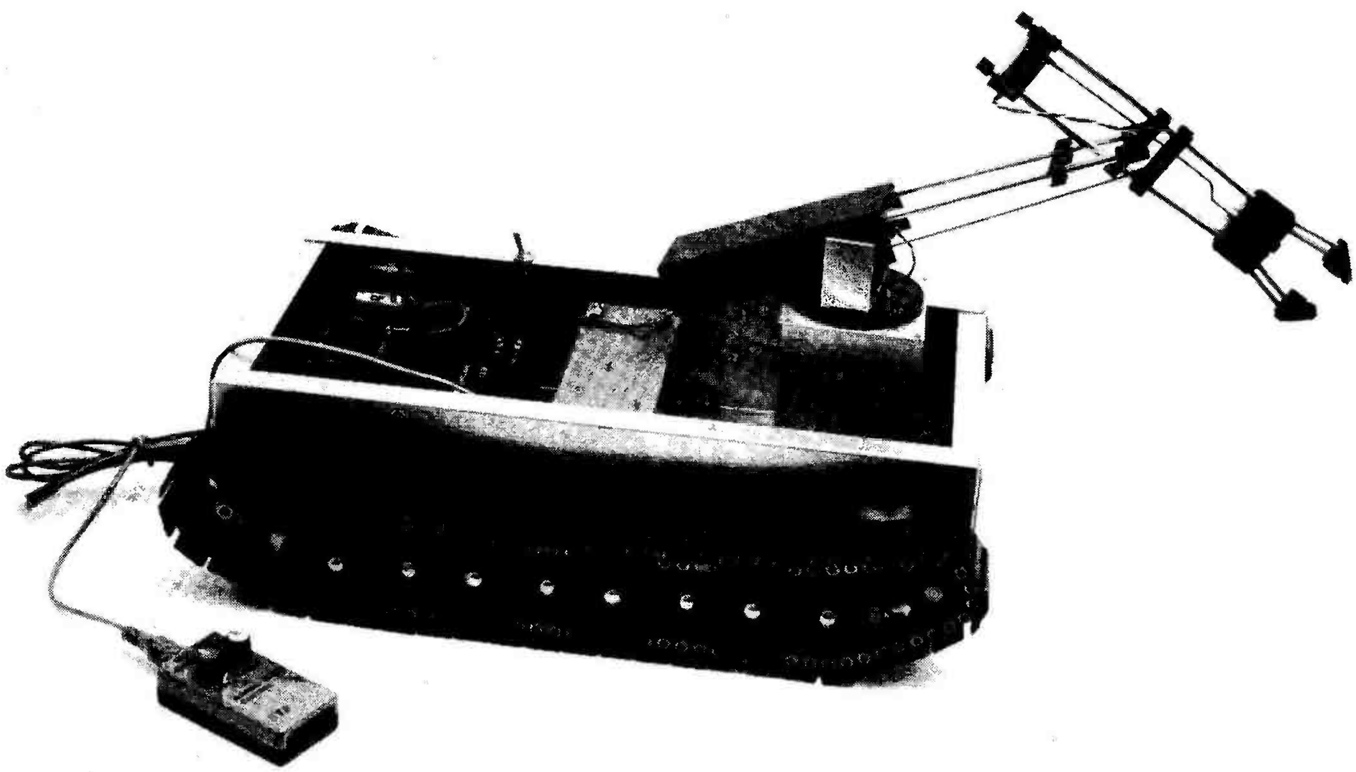
It is ideal for teaching purposes, being controllable by any of:

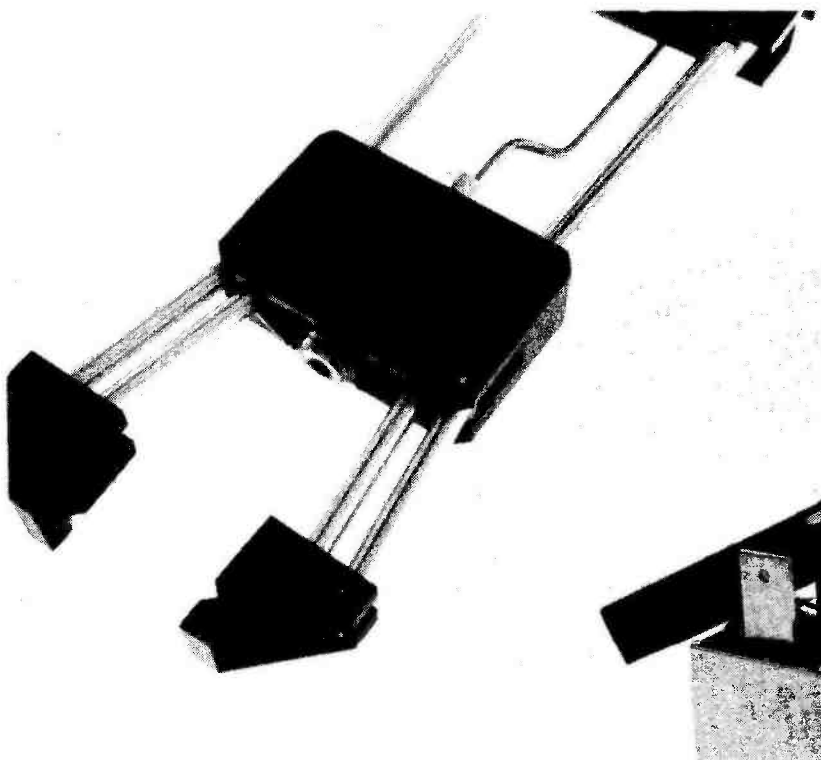
(i) a standard radio control system, such as employed in model aircraft, etc.
(ii) a 'tele-operator' which allows direct instruction of the arm – and the pupil operating it.
(iii) a microcomputer, using our interface.

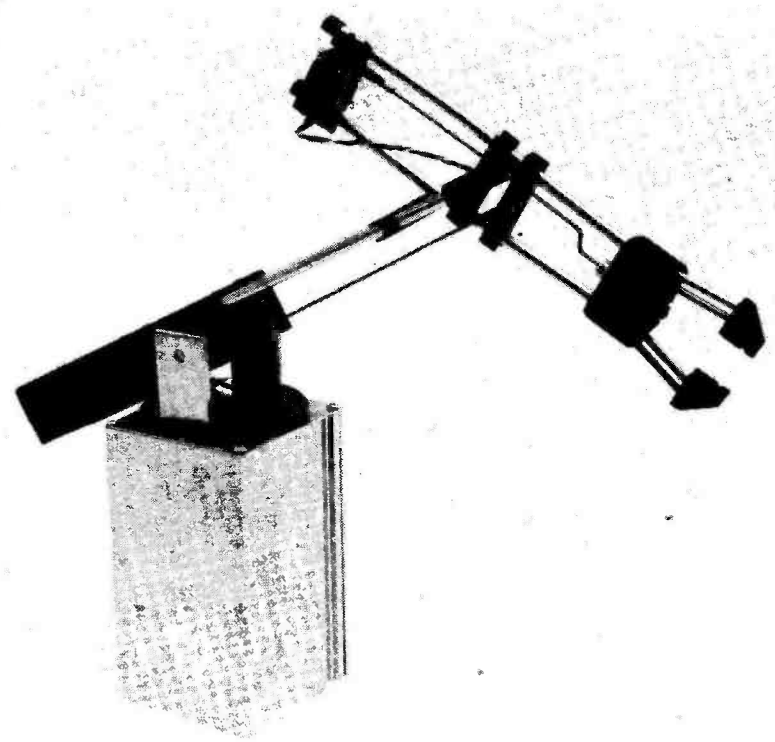


Above: The analogue PWM control board and motor driver board for the Mobile 2.

Below: The Mobile 2 with hand controller and servo manipulator.







Above: Just when you thought it was safe to go back into the workshop...a close-up of the jaws.

Right: The arm is not limited to use on the Mobile 2 – it can also find applications as a free-standing unit.

MOBILE 2 – MECHANICAL SPECIFICATION

TRACTOR UNIT	
Dimensions:	19¾" x 13½" x 5½" high (unloaded)
Ground Clearance:	1¼" unladen
Operational Payload:	11 lbs.
Will climb a 3" stepped obstruction with full payload.	
Ratio of drive units:	60:1 (variable, see Buylines).
Drive Voltage:	7V2
Starting Current:	9 A
Running current:	3A5
Operational Velocity:	2.5 feet per second.
Smooth Incline Capability:	30°

By varying the type of servo employed, the function and power of the arm can be selected to suit the application required.

To reduce the load placed on the servos, the arm is designed to be self-balancing, whatever servos are used. On the standard manipulator, high resolution types are employed to improve accuracy as much as possible while under computer control.

The mechanical set-up of these arms is critical for best performance, and for that reason we have arranged that they be supplied built and tested, as part of the mobile metalwork, or as a separate item if you prefer. Buylines has the details.

Base Comments

The heart of the whole system is the tractor unit upon which the Mobile is constructed. The final design, although very simple in appearance, has only been arrived at after much debate and experimentation.

Tracks were used for their superior abilities with regard to climbing obstacles and coping with varying surfaces, ie. carpet, concrete, vinyl, etc. Infra-red rotation counters are fitted to both the motordrive shafts, to enable accurate control to be exercised over both the base speed and direction.

A brief spec of the capabilities of the base are given elsewhere in this article. All the metalwork is purpose built, and pre-drilled for our range of modules. After having tried out various commercial options – model tank mechanics, for example – we came to the conclusion that not only is it the superior to have custom metalwork made – it is actually cheaper! Initially we had ruled it out purely on grounds of expected price level.

How Close Encounters?

Mobile 2 is a fairly large beast to let loose around your living room (19 x 13 x 5" approx. not including arm and cover!) and so it is important that it be prevented from colliding with obstacles. Remember that so far as *it* is concerned anything in the way, be it your prize drinks cabinet, hi-fi speaker or granny, is simply an obstruction.

In our June 82 edition we published our 'Proximity Detector' module, of which Mobile 2 has four. They are mounted above each track corner and may be angled, such that even glancing contact is prevented. They provide adequate protection.

The control board logic is so configured that the IR detectors provide an override which halts operation of any program, so long as an obstacle is present. Unless programmed to do anything else, the mobile will halt at any obstruction large enough to register on two detectors, ie a wall.

Well Developed Robot

Our Mobile 2 is presented as an open-ended project. We want our readers to carry it on and develop it as far as they can. The modules to come from *us* will be:

1) Arm Interface and control circuitry, to allow stand-alone control, or porting to main PCB of Mobile 2.
2) Main Control PCB – mounted within the mobile and will accept up to four eight-bit peripherals, with appropriate strobing, and operate in conjunction with the link.
3) Computer Link – a bi-directional data transfer system which has as a receiver a home computer system to which it connects via a standard interface.
4) Experimental Positional System – to allow the Mobile to 'map' its environment and thus function more precisely.

One future use for the Mobile – which we are still working on – is that of office messenger. It would be 'called' to a particular room or desk, loaded with papers, etc, and dispatched to another location, programmed at point of departure. It will have to avoid doors, people and cats whilst doing so! That one may be a while coming if left to us, but we'll get there! It would use the same metalwork and basic electronics.

"If left to us" is the key phrase there – what about that vast reservoir of design talent and ingenuity that goes under the name of ETI's readership? It's about time *you* got into robotics, too!

Once we complete the basics of this project, then its up to you to carry it on. Even now, if you have any ideas or strong feeling as to how the Mobile should grow, let's hear them. We will publish what correspondence we can on the subject and implement any ideas which are practical!

Next month, we commence construction of the Mobile with the base, motors and speed control. Past modules which will be used in the Robot were published in:

1) ETI March 82 p. 61-63
2) ETI April 82 p. 94-97
3) ETI May 82 p. 34-36
4) ETI June 82 p. 66-70

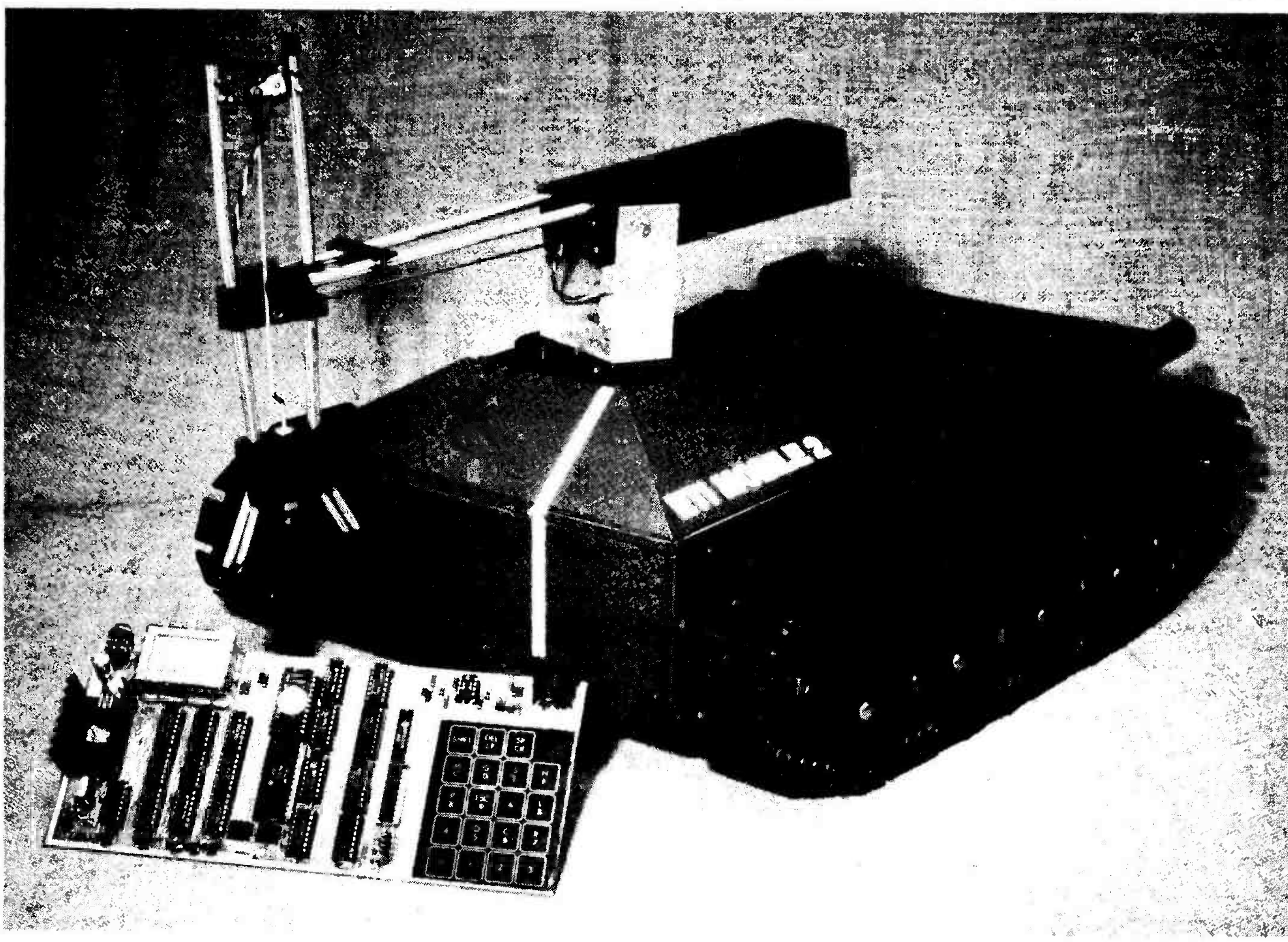
Photocopies are available from our offices if you've been foolish enough to lose your back issues! (Enclose £1.25 – inclusive of p&p – for each article. Address your request to: Xerox Department, ETI, 145 Charing Cross Road, London, WC2H 0EE)

BUYLINES

The metalwork for this project is all available from Remcon Electronics Ltd, 1 Church Road, Bexleyheath, Kent (Tel. 01-304 2055)

They supply the tractor unit as a complete kit with full assembly instructions. All injection moulded components for track and suspension system are included – as is an assembly spanner! The aluminium chassis is ready punched and drilled with all required fixings. Motors and gearboxes are supplied as assembled and coupled to the output shafts. The final ratio of the gearboxes may be varied between 300:1 and 3:1 to obtain different performances from the mobile. The price complete, including VAT and p + p, is £125. Drive units are available separately at either £21.25 without shafts, or £26.75 with. Prices are inclusive.

The manipulator, supplied built and tested and ready wired, will be described more fully in a forthcoming article, but is available now, with high precision servos, for £175 all inclusive.



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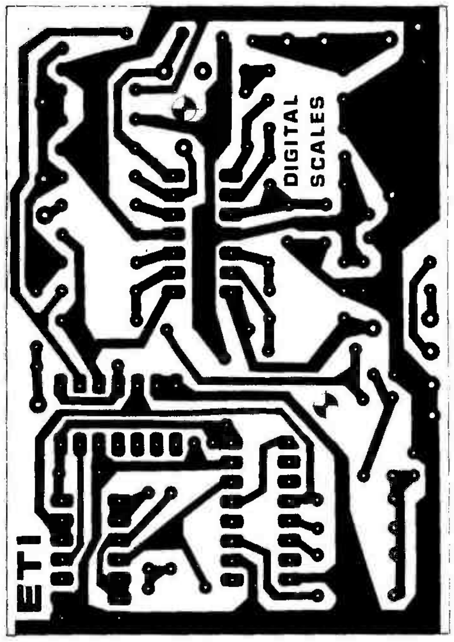

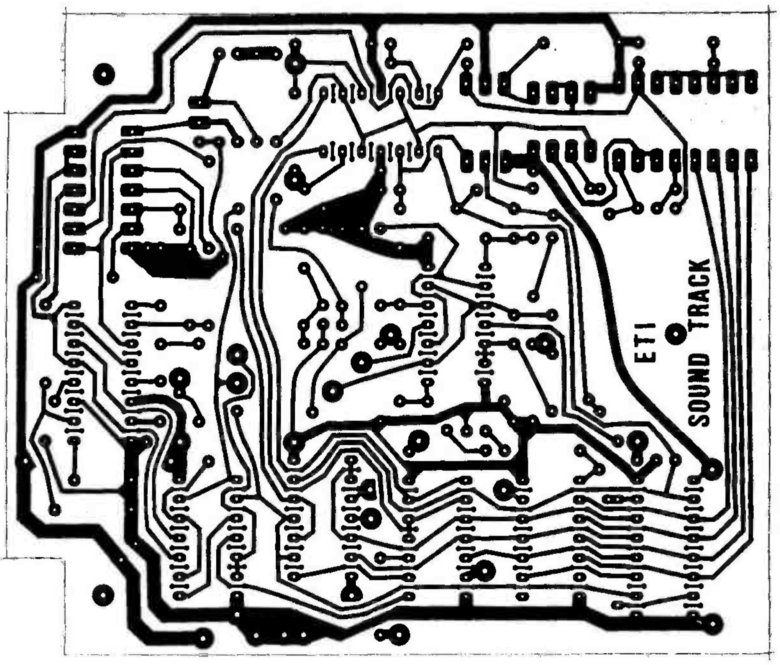

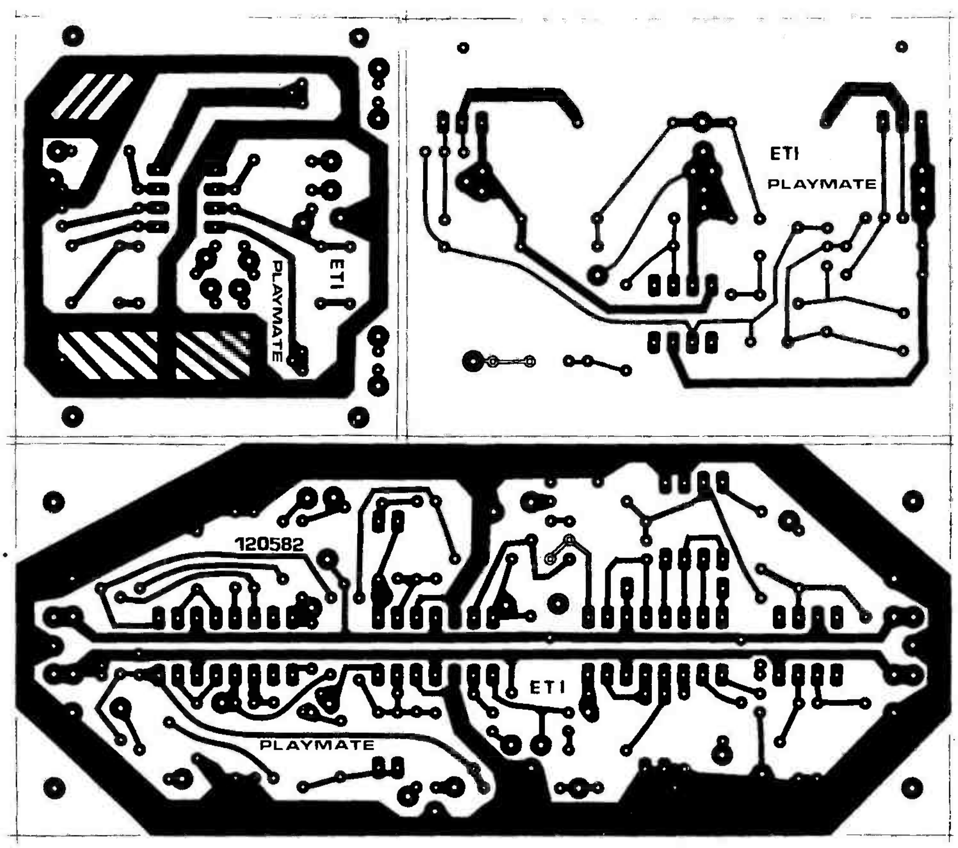

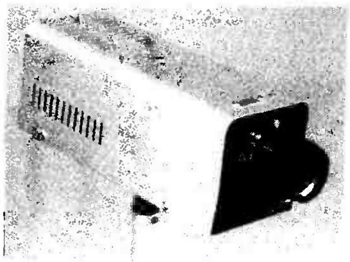

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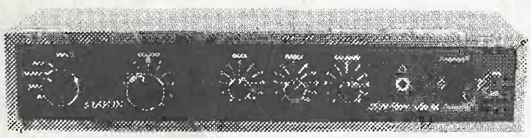

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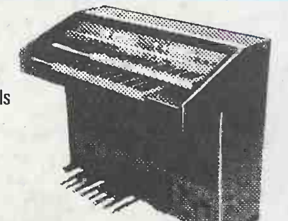

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