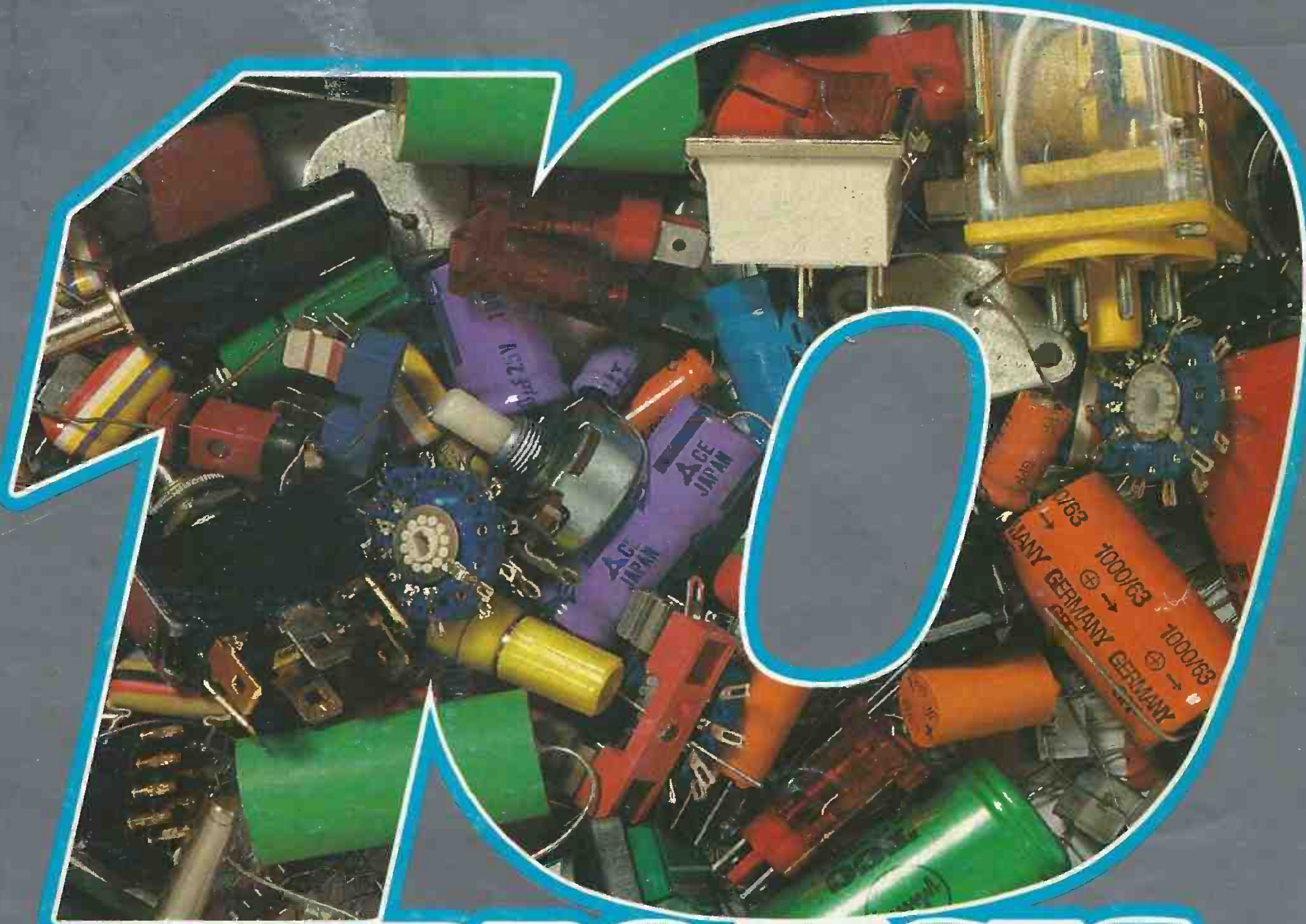
An Argus Specialist Publication

electronics today

INTERNATIONAL NOVEMBER 1983 85p



10 PROJECTS

including:

- Logic probe — monitor up to 16 points all at once
- Active loudspeaker — novel, economic design
- Drum synthesiser — modular for flexibility
- Filter/amplifier for DAC/ADC — clean up your interfacing
- Multiple output port — expandable up to 40 on/off outputs

OVER 100 PAGES
Best value for money in electronics!

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

Star sounds**
Star quality**
Star features**

Free SECURICOR DELIVERY on all orders over £100 (UK mainland only) Add just £2.50 on lower price orders

BIG NEWS ABOUT OUR LATEST ADVANCES IN **ROBOTICS** SEE INSIDE BACK COVER

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! Complete kit **£97.50** + VAT

TRANSCENDENT 2000 — Although only a 3 octave keyboard the '2000' features the same design ingenuity, careful engineering and quality components of its larger brethren. The kit is well within the scope of the first time builder — buy it, build it — play it! You will know you have made the right choice.
Complete kit **£165.00** + VAT

SALES COUNTER Collect your order from the factory. Open 9-12/1-4.30 Mon- Fri. Easy parking, no waiting

This versatile modular mixer, featured as a constructional article in Practical Electronics can be built up to a maximum of 24 inputs, 4 outputs and an auxiliary channel. Each input channel has Mic and Line inputs, variable gain, bass and treble controls and a parametric middle frequency equalizer. There are send and return jacks, auxiliary, pan and fader controls and output and group switching. The output channels have PPM displays and record and studio outputs. The auxiliary channel also has a PPM display and there is a headphone monitor jack and a built-in talk-back microphone. The mixer modules plug into base units each of which takes up to 6 channels. To eliminate hum, the power supply is in a separate cabinet.

KIT PRICES

Input channel	£19.90	Base unit and wooden front	£27.50
Output channel	£18.50	Pair of mahogany end cheeks	£12.50
Auxiliary channel	£22.50	Power Supply and cabinet	£19.50
Blank Panel	£3.00		

All prices are VAT exclusive

Digital Delay Line — With its ability to give delay times from 1.6 mSecs to up to 1.6 secs. Many powerful effects including phasing, flangine, 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
£9.50 + VAT

Free Soldering Practise Kit on request with your first kit — useful tips, well illustrated.

TRANSCENDENT POLYSYNTH — A four octave polyphonic synthesiser with outstanding design characteristics and versatility and performance to match.
Complete kit **£230.00** plus VAT (single voice)
Extra voice (up to three more) **£35.60** plus VAT

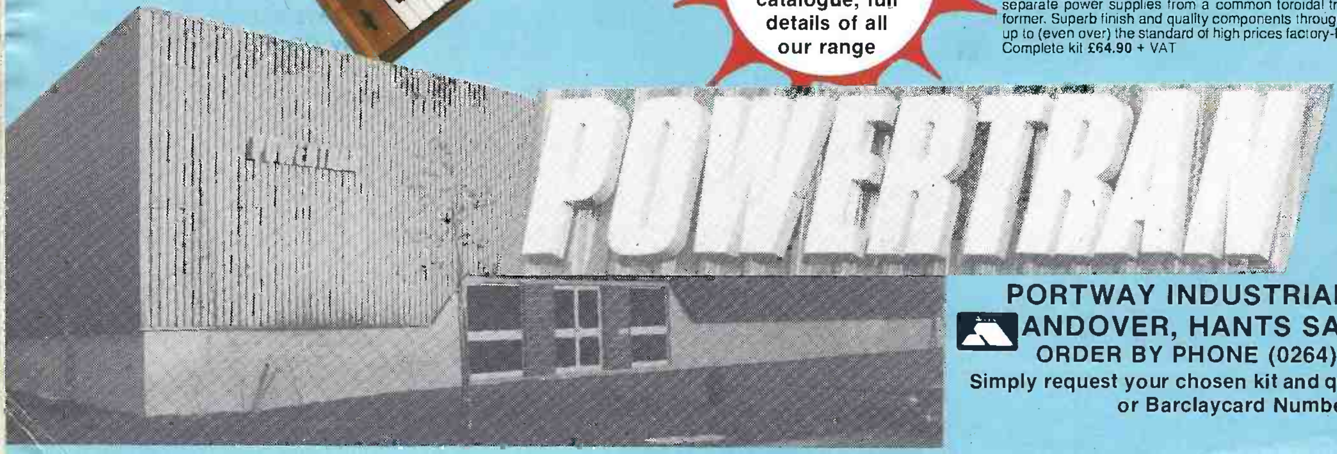
MPA 200 — is a low price, high power 100W amplifier, its smart styling, professional appearance and performance, make it one of our most popular designs. With adaptable inputs the mixer accepts a variety of sources yet straightforward construction makes it ideal for the first time builder. Complete kit **£49.90** + 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 **£49.50** + 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 **£175.00** + VAT

SP2 200 twice the power with two of the reliable, durable and economic amps from the MPA 200; fed by separate power supplies from a common toroidal transformer. Superb finish and quality components throughout — up to (even over) the standard of high prices factory-built units! Complete kit **£64.90** + VAT

Component packs for most kits are available See our great free catalogue, full details of all our range



WORLD LEADERS IN ELECTRONIC KIT DESIGN AND SUPPLY

PORTWAY INDUSTRIAL ESTATE
ANDOVER, HANTS SA10 3NM.
ORDER BY PHONE (0264) 64455
Simply request your chosen kit and quote your Access or Barclaycard Number.

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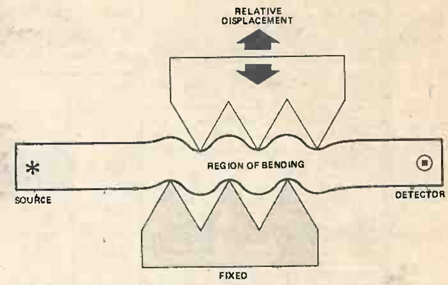
FEATURES



PROJECTS

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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 65p 6 way 80p
8 way 85p 10 way 100p
(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 68p

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; 6 /2 way 65p
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

THUMBWHEEL Mini front mounting
Decade Switch Module 220p
B.C.D. Switch Module 275p
Mounting Cheeks (per pair) 75p

VEROBOARD 0.1in

	clad	plain
2½ x 3¾	85p	—
2½ x 5"	100p	—
3¾ x 3¾	100p	—
3¾ x 5"	115p	—
3¾ x 17"	390p	198p
4¾ x 17"	495p	275p
Pkt. of 100 pins		55p
Spot face cutter		150p
Pin insertion tool		185p

VQ Board 195p
DIP Board 395p
Vero Strip 95p

PROTO DECs
Veroblock 405p
S-Dec 360p
Eurobreadboard 520p
Bimboard 1 575p
Superstrip SS2 1350p

VERO WIRING PEN + spoool 340p
Spare spool 75p
Combs 6p

DALO ETCH RESIST PEN
Plus spare tip 100p

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

ULTRASONIC TRANSDUCER
40KHz 325 pr

IDC CONNECTORS

	PCB Plugs with latch Strt	PCB Plugs with latch Angle pins	Female Header Plug	Female Card Edge Connect
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	—
20 way	145p	166p	125p	195p
26 way	175p	200p	150p	240p
34 way	205p	236p	160p	320p
40 way	220p	250p	190p	340p
50 way	235p	270p	200p	395p
60 way	—	—	230p	495p

EURO CONNECTORS

	Female Socket Strt. Pins	Female Socket Angle Pins	Male Plug Strt. Pins	Male Plug Angle Pins
DIN41617 31way	170p	—	—	175p
DIN41612 2x32 A+B	275p	320p	220p	285p
DIN41612 2x32 A+C	295p	340p	240p	300p
DIN41612 3x32 A+B+C	360p	385p	260p	395p

PANEL METERS

FSD
60 x 46 x 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"
425p each

RELAYS

Miniature, enclosed, PCB mount.
SINGLE POLE Changeover
RL6-91 205 Ω Coil; 12 V DC (10V5 to 19.5 V). 10 A at 30 V DC or 250 V AC 185p
DOUBLE POLE Changeover. 6 A 30 V DC or 250 V AC
RL6-100 53 Ω Coil, 6 V DC (5V4 to 9V9) 190p
RL6-111 205 Ω Coil, 12 V DC (10V7 to 19V5) 195p
RL6-114 740 Ω Coil, 24 V DC (22 V to 37 V) 200 p

AMPHENOL PLUG

	IDC	Solder
24way IEEE	475p	450p
36way Centronics	525p	485p

COPPER CLAD BOARDS

Fibre glass	Single-sided	Double-sided	S.R.B.P.
6" x 6"	100p	125p	9.5" x 8.5" 110p
6" x 12"	175p	225p	

DIL SOCKETS

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

EDGE CONNECTORS .1

2 x 18 way	180p
2 x 22 way	199p
2 x 23 way	175p
2 x 25 way	225p
2 x 28 way	190p
2 x 30 way	245p
2 x 36 way	295p
2 x 40 way	315p
2 x 43 way	395p
2 x 75 way	550p

DIL PLUG (Header)

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

RIBBON CABLE price per foot

	Grey	Color
10 way	15p	28p
16 way	25p	40p
20 way	30p	50p
24 way	40p	65p
34 way	60p	85p
40 way	70p	90p
50 way	85p	110p
64 way	100p	135p

ZIF DIL SOCKETS
24 pin 575p
28 pin 820p
40 pin 975p

CRYSTALS

32.768KHz	100
100KHz	236
200KHz	268
455KH	370
1MHz	275
1.008M	275
1.28MHz	392
1.6MHz	395
1.8NHz	395
1.8432M	200
2.0MHz	225
2.4576M	200
3.278M	150
3.5794M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.80MHz	200
4.194304M	200
4.433619M	100
5.0MHz	180
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	225
7.0MHz	150
7.168MHz	250
7.68MHz	200
8.0MHz	150
8.08333M	395
8.86723M	175
9.00MHz	150
10.0MHz	175
10.24MHz	200
10.7	150
12.0MHz	175
12.528M	300
14.31814M	170
16.0MHz	200
18.0MHz	180
18.432M	150
20.0MHz	200
19.968MHz	150
24.0MHz	170
24.930MHz	325
26.69M	150
27.648M	170
27.145M	190
38.66667M	175
48.0MHz	170
100.0MHz	296
116.0MHz	250

ASTEC UHF MODULATORS

6 MHz Standard 325p
8 MHz Wideband 450p

BUZZERS, miniature, solid-state 6V: 9V & 12V 70p
PIEZO TRANSDUCERS PB2720 55p

LOUDSPEAKERS
Miniature, 0.3W: 8Ω
2in, 3½in, 2¼in, 3in 80p
2½in 40Ω, 64Ω or 80Ω 80p

ELEKTOR PROJECTS
We stock most of the parts

JUMPER LEADS (Ribbon Cable Assembly)

Length	14 pin	16 pin	24 pin	40 pin
Single ended DIP (Header Plug) Jumper 24 inches	145p	165p	240p	380p
Double ended DIP (Header Plug) Jumper 6 inches	185p	205p	300p	485p
12 inches	198p	215p	315p	490p
24 inches	210p	235p	345p	540p
36 inches	230p	250p	375p	595p

IDC Female Header Socket Jumper Leads 36"

	20 pin	26 pin	34 pin	40 pin
Single ended	180p	200p	280p	300 p
Double ended	290p	370p	480p	525p

ANTEX SOLDERING IRON
C-15W 495p CS17W 495p
G-18W 520p XS25W 525p
Spare tips, assorted sizes 85p
Spare Elements 225p
Iron stand with sponge 175p

SIL SOCKET
0.1" pitch 20 way 65p

'D' CONNECTORS miniature

	9 way	15 way	25 way	37 way
MALE				
Solder lugs	80p	105p	160p	250p
Angle pins	150p	210p	250p	365p
PCB pins	120p	130p	195p	295p
FEMALE				
Solder lugs	105p	160p	200p	335p
Angle pins	165p	215p	290p	440p
PCB pins	150p	180p	240p	420p
COVERS	85p	80p	80p	100p
IDC 25way 'D' Plug				385p
Socket				450p

TRANSFORMERS:

3-0-3V; 6-0-6V; 9-0-9V; 12-0-12V; 15-0-15V @ 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; 2x5V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A 295p (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 485p (60p p&p)
Specially wound for Multirail Computer PSUs
50VA: Outputs +5V/5A; +12V, +25V, -5V, -12V at 1A 575p (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

1A	TO220 +ve		Plastic -ve	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	45p

100mA TO92 Plastic package

5V	78L05	30p	79L05	60p
6V	78L06	30p	—	
8V	78L08	30p	—	
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

ICL7660	248p	TAA550	50p
LM309K	135p	TDA1412	150p
LM317K	320p	78H05 +5V/5A	560p
LM317KP	99p	78H12 +12V/5A	580p
LM323K	450p		
LM337	175p	78HG +5V to +25V 5A	599p
LM723 Var	36p		
RC4194	375p	79HG +2.25V to 24V 5A	685p
RC4195	160p		

SOLDERCON PINS
Ideal for making SIL or DIL Sockets
100 pins 75p
500 pins 350p

ALUM BOXES

3 x 2 x 1"	65p
4 x 2½ x 2"	85p
4 x 2½ x 2½"	103p
4 x 4 x 2"	105p
4 x 4 x 2½"	120p
5 x 4 x 1½"	99p
5 x 4 x 2½"	120p
5 x 2½ x 1½"	90p
5 x 2½ x 2½"	130p
6 x 4 x 2"	120p
6 x 4 x 3"	150p
7 x 5 x 3"	180p
8 x 6 x 3"	210p
10 x 4 x 3"	240p
10 x 7 x 3"	275p
12 x 5 x 3"	280p
12 x 8 x 3"	295p

25way 'D' CONNECTOR RS232
Jumper Lead Cable Assembly
18" long, Single end, Male 495p
18" long, Single end, Female 525p
36" long, Double Ended, M/M 1025p
36" long, Double Ended, F/F 1050p
36" long, Double Ended, M/F 995p

● SPECIAL OFFER ●

2532-3 . . . . 285p
2764-250 ns 410p
6116-120 ns 375p
6522 . . . . 275p

MONITORS

- ZENITH — 12" Green, Hi-Resolution Popular £ 75
- MICROVITEC 1431. 14" Colour RGB input. Connecting cable incl. £ 250

NEW NEW NEW

BROTHER 8300 DAISY WHEEL PRINTER/TYPEWRITER

Provides very high quality type in any of six interchangeable styles including Italics, Script and 4 conventional typefaces. It is therefore ideal for business use. It connects directly to a BBC Micro via standard centronics interface or can be used as a stand alone typewriter. As typewriter, it has a built in timing function to measure the operator's speed making it ideal for teaching or invoicing jobs correctly. Friction feed; 11 CPS; 12" max width; 5 different colour ribbons. Portable. Supplied complete with hard cover carrying case.
(£7 carr) Only: £399

CMOS

4000	10	4075	13	4541	140
4001	10	4076	50	4543	70
4002	12	4077	13	4544	150
4006	50	4078	15	4548	40
4007	14	4081	13	4549	375
4008	32	4082	13	4553	246
4009	24	4085	50	4554	190
4010	24	4086	80	4555	36
4011	10	4089	125	4556	36
4012	18	4093	20	4557	320
4013	20	4094	70	4558	120
4014	46	4095	95	4559	396
4015	40	4096	70	4560	160
4016	20	4097	290	4561	104
4017	32	4098	75	4562	495
4018	45	4099	110	4566	165
4019	25	4160	95	4568	250
4020	42	4161	99	4569	175
4021	40	4162	99	4572	36
4022	40	4163	99	4580	460
4023	13	4174	99	4581	260
4024	32	4175	105	4582	99
4025	13	4194	105	4583	90
4026	80	4408	790	4584	40
4027	20	4409	790	4585	60
4028	39	4410	725	4597	330
4029	45	4411	675	4599	290
4030	15	4412	775	40085	90
4031	125	4415	480	40097	45
4032	80	4419	280	40098	42
4033	125	4422	770	40100	215
4034	140	4435	850	40101	130
4035	45	4440	998	40102	140
4036	275	4450	350	40103	175
4037	115	4451	350	40104	95
4038	110	4490	350	40105	105
4039	250	4500	675	40106	35
4040	40	4501	28	40107	80
4041	40	4502	60	40108	198
4042	40	4503	40	40109	80
4043	40	4504	75	40110	225
4044	40	4505	186	40114	240
4045	105	4506	35	40161	194
4046	46	4507	35	40163	50
4047	40	4508	130	40174	45
4048	40	4510	46	40176	50
4049	25	4511	45	40181	220
4050	25	4512	50	40182	90
4051	45	4513	199	40192	75
4052	60	4514	115	40193	70
4053	50	4515	115	40194	70
4054	85	4516	55	40195	75
4055	85	4517	275	40244	196
4056	85	4518	40	40245	196
4057	1915	4519	30	40257	196
4059	435	4520	50	40373	160
4060	45	4521	90	40374	160
4061	1195	4522	125	45106	596
4062	995	4526	70		
4063	85	4527	85		
4066	24	4528	70		
4067	245	4529	150		
4068	14	4530	90		
4069	16	4531	130		
4070	13	4532	70		
4071	13	4534	400		
4072	13	4536	275		
4073	15	4538	80		
		4539	90		

OPTO

LS400C	255
OCP71	120
ORP12	86
ORP61	85
2N5777	45
BPX25	195
BPW21	295

OPTO ELECTRONICS

LEDs with Clips	
TIL209 Red	10
TIL211 Grn	14
TIL212 Yel.	14
TIL220 .2" Red	12
.2" Green, Yellow or Amber	14
0.2" Bi colour Red/Green	95
Green/Yellow	98
0.2" Tri colour Red/Green/Yellow	85
Hi-Brightness Red	59
Flashing red 0.2" red	55
Square LEDs, Red, Green, Yellow	45
Rectangle Stackable LEDs Red, Green or Yell	18
Triangular LEDs Red	18
Green or yellow	22
LD271 Infra Red	46
SFH205 Detector	118
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	75
TIL117	125
4N33 Photo Darlington	135
7 Segment Displays	
TIL312 .3" CA	105
TIL313 .3" CC	105
TIL321 .5" CA	115
TIL322 .5" CC	115
DL704 .3" CC	99
DL707 .3" CA	99
FND357 Red	120
FND500	115
.3" Green CA	150
.6" Green CA	215
.3" ± 1 Red CA	150
.3" ± 1 Green CA	150
DVM176	£22
LCD 3½ Digits	495
LCD 4 Digits	530
LCD 6 Digits	625

NEONS
Rectangular, nut fixing Red, Amber, Green 30p
REFLECTIVE Optical Switch type TIL139 170p
SLOTTED Optical Switch similar to RS Comp.'s 186p

COMPUTER CORNER

- RX80 100 CPS, 9 x 9 matrix, dot addressable graphics, condensed & double width printing, Normal, Italics & Elite Char., Tractor Feed, Bidirectional, Logic seeking £285
- FX80 10" Tractor & Friction feed, 160 CPS, bidirectional Logic seeking, 9 x 11 matrix, hi-res bit image, Normal, Italic & Elite Char. Super & Subscript. Proportional spacing. FREE 500 sheets £385
- SEIKHOSA GP100A. 10" Tractor feed. 80 column, 30 CPS, Normal & Double width Char. Dot Res Graphics. FREE 500 Sheets. £175
- SEIKOSHA GP250X: 10", 50 CPS, Normal and Double width and height Char. RS232 and Centronics Intrf. standard £235 (£7 carr).
- Printer Cable for our printers and BBC MICRO £12
- SOFTY-2: The complete Microprocessor development system. Accepts any 24pin 5 V EPROM. £169
- TEX EPROM ERASER Erases up to 32 ICs in 15-30 minutes £ 33
- TEX EPROM ERASER with a safety switch . . . . £ 35
- TEX EPROM ERASER plus our Solid State ELECTRONIC TIMER £44
- ELECTRONIC TIMER, Solid State, 15-30 min. Connects directly to above Erasers. Protects your expensive Chips from overcooking. Our timer pays for itself in no time £15
- SPARE 'UV' Lamp bulb £8
- POWER SUPPLY. Regulated with Overload protection. Variable Output, 5 V to 15 V at 4 A. Professionally finished £38
- C12 COMPUTER GRADE CASSETTES in library case 40p
- 8½" & 9½" Fan Fold Paper (1000 Sheets) . . . . . £7 (carr 150p)

FLOPPY DISC DRIVES TEAC (BBC Compatible)

- CS50A — Single Cased with PSU, 40 track, 5¼" S/S 100K £170
- CD50A — Twin Cased with PSU, 40 trach, 5¼" S/S 200K £330
- CS50E — Single Cased with PSU, 80 track, 5¼" S/S 200K £245
- CD50E — Twin Cased with PSU, 80 track, 5¼" S/S 400K £475
- 10 Verbatim Diskette 5¼" S.S.S.D. (5 yrs warranty) £20
- 10 Verbatim Diskettes 5¼" D.S.D.D. (5 yrs warranty) . . . £35
- 10 Verbatim Diskettes 8" S.S.D.D. (5 years warranty) . . . £28
- 10 Wabash Diskettes, 5¼", S/S £15
- 10 Wabash Diskettes, 5¼", S/S £25
- MITSUBISHI DISC DRIVES: Uncased, Double, Density, Double track, 5¼" Slim line. ONE MEGA BYTES. Track Density 96TPI. Track to track access time 3 msec. . . . . only: £225
- MITSUBISHI Single Slimline, 5¼" Cased with PSU. DSDD. 1 Megabyte. (400 K with BBC) £275
- MITSUBISHI Twin Slimline, 5¼" Cased with PSU. DSDD, 2 Megabyte, (800 K with BBC) £535

N.B. P&P on above items is extra.

NEC PC8023BE-C PRINTER

Europe's most popular Printer

100CPS bi-directional, Logic seeking, 80 column, 7 x 9 Dot matrix head, true descenders on lower case, Superscript & Subscript & Underlining facility. Proportional spacing, Forward & reverse line feed, Tractor or friction feed, Hi-res & block graphics. Auto underling. Plus FREE 500 sheets of Paper.

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12 K of fig — FORTH in ROM, Full RS232 and 24 Bits of I/O for Centronics and Control use. Can be used from BASIC or FORTH. Will work on 16 K or 48 K Spectrum. Many other features.

only: **£59**

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

COMTECH ELECTRONICS

TRANSISTORS

BC 107B	12p	BC 546	10p	BF 195	12p	MPSA 55	20p	2N2907A	25p
BC 108C	12p	BC 546B	10p	BF 196	12p	MPSA 56	20p	2N3053	23p
BC 109C	10p	BC 547B	9p	BF 197	12p	MPSA 63	22p	2N3054	56p
BC 113/4	16p	BC 548B	9p	BF 198	10p	MPSA 64	22p	2N3055	50p
BC 115/6	17p	BC 548C	9p	BF 199	12p	MPSA 92	24p	2N3055H	75p
BC 119	28p	BC 549C	9p	BF 200	40p	MPSA 93	24p	2N3440	58p
BC 139	32p	BC 550C	10p	BF 224	15p	TIP 29A	30p	2N3441	120p
BC 140	28p	BC 556	10p	BF 244C	22p	TIP 29B	33p	2N3442	120p
BC 141	29p	BC 556B	10p	BF 245	25p	TIP 29C	33p		
BC 142	27p	BC 557B	9p	BF 256C	32p	TIP 30A	30p	2N3702	10p
BC 143	27p	BC 557C	9p	BF 256LC	35p	TIP 30B	33p	2N3703	10p
BC 160	30p	BC 558B	9p	BF 257	32p	TIP 30C	36p	2N3704	10p
BC 161	32p	BC 558C	9p	BF 258	32p	TIP 31A	33p	2N3705	10p
BC 169C	8p	BC 559C	9p	BF 259	35p	TIP 31B	35p	2N3706	10p
BC 171B	9p	BC 560C	10p	BF 336	36p	TIP 31C	37p	2N3707	10p
BC 172C	9p	BC 637	20p	BF 337	39p	TIP 32A	33p	2N3708	10p
BC 173C	9p	BC 638	20p	BF 338	40p	TIP 32B	35p	2N3771	150p
BC 177B	15p	BC 639	22p	BF 457	32p	TIP 32C	37p	2N3772	170p
BC 178C	15p	BC 640	24p	BF 458	32p	TIP 33A	55p	2N3773	190p
BC 179	15p	BCY 70	18p	BF 459	37p	TIP 34A	60p	2N3819	20p
BC 182	9p	BCY 71	18p	BF 494	12p	TIP 41A	46p	2N3823	50p
BC 182B	9p	BCY 72	17p	BF 595	16p	TIP 41C	60p	2N3866	95p
BC 183B	9p	BD 115	50p	BF 596	20p	TIP 42A	46p	2N3903	10p
BC 183C	9p	BD 131	45p	BFX 29	28p	TIP 42C	60p	2N3904	10p
BC 184B	9p	BD 132	48p	BFX 30	28p	TIP 110	45p	2N3905	10p
BC 184C	9p	BD 133	70p	BFX 84	28p	TIP 115	45p	2N3906	10p
BC 212	9p	BD 135	30p	BFX 85	28p	TIP 120	70p	2N4030	30p
BC 212B	9p	BD 136	30p	BFX 87	27p	TIP 121	70p	2N4033	30p
BC 213B	9p	BD 137	30p	BFX 88	23p	TIP 122	70p	2N4037	40p
BC 213C	9p	BD 138	35p	BFY 50	23p	TIP 126	70p	2N4058	10p
BC 214B	9p	BD 139	35p	BFY 51	22p	TIP 127	70p	2N4059	10p
BC 214C	9p	BD 140	35p	BFY 52	22p	TIP 2955	70p	2N4060	10p
BC 237	7p	BD 203	70p	BSY 95A	23p	TIP 3055	70p	2N4061	10p
BC 238	9p	BD 204	70p	BU 205	140p	TIS 44	20p	2N4062	10p
BC 239	9p	BD 205	70p	BU 206	150p	TIS 90	24p	2N4400	15p
BC 251	9p	BD 206	70p	BU 208	140p	TIS 92	20p	2N4401	15p
BC 300	36p	BD 239A	40p	MJ 2500	230p	2N1613	30p	2N4402	15p
BC 301	32p	BD 239C	50p	MJ 2501	245p	2N1711	30p	2N4403	15p
BC 302	32p	BD 240A	42p	MJ 2955	90p	2N1893	30p	2N5400	18p
BC 303	32p	BD 240C	50p	MJ 3000	210p	2N2218	24p	2N5401	20p
BC 304	32p	BD 241A	42p	MJ 3001	225p	2N2218A	25p	2N5457	28p
BC 307	10p	BD 241C	54p	MJE 340	48p	2N2219	24p	2N5458	27p
BC 308	10p	BD 242A	42p	MJE 350	70p	2N2219A	25p	2N5459	25p
BC 309	10p	BD 242C	54p	MJE 370	80p	2N2221A	20p	2N5460	38p
BC 327	12p	BD 243A	55p	MJE 371	84p	2N2222	18p	2N5550	18p
BC 328	12p	BD 243C	68p	MJE 520	60p	2N2222A	20p	2N5551	20p
BC 337	12p	BD 244A	64p	MJE 521	68p	2N2368	23p	2N6027	23p
BC 338	12p	BD 244C	78p	MJE 2955	80p	2N2369A	15p	2N6028	23p
BC 413C	10p	BF 180	30p	MJE 3055	68p	2N2484	24p		
BC 414C	10p	BF 181	30p	MPSA 05	20p	2N2646	48p		
BC 415C	10p	BF 182	30p	MPSA 06	20p	2N2904	22p		
BC 416C	10p	BF 183	30p	MPSA 12	22p	2N2904A	23p		
BC 477	25p	BF 184	30p	MPSA 13	22p	2N2905	23p		
BC 478	23p	BF 185	30p	MPSA 42	23p	2N2906A	22p		
BC 479	24p	BF 194	12p	MPSA 43	23p	2N2907	23p		

ZENERS

400 mW 2V7-36V 6p
1.3 W 4V7-51 V 10p

THYRISTORS

C 106D	
C 116D	70p
C 126D	90p
C 126M	98p
MCR 101	30p
MCR 102	34p
T 2800D	110p
T 2800M	165p
2N4443	120p
2N4444	130p
2N5060	23p
2N5061	24p
2N5062	29p
2N5064	32p

TRIACS

C 206	55p
C 225D	60p
C 226D	70p
C 226M	90p
C 236	90p
C 236M	120p
C 246D	98p
C 246M	140p
BR 100	30p

BRIDGE RECTIFIERS

W 005	18p
W 01	20p
W 02	22p
W 04	24p
W 06	28p
W 08	32p
3A/50V	40p
3A/100V	42p
3A/200V	44p
3A/400V	46p
6A/50V	75p
6A/100V	80p
6A/200V	88p
6A/400V	94p
25A/100V	185p
25A/200V	198p
25A/400V	220p

LED's

3mm red	7p
5mm red	7p
3mm green	10p
5mm green	10p
3mm yellow	10p
5mm yellow	10p
clips	3p
rectangular	
Red	10p
Green	14p
Yellow	14p

CMOS

4000	14p	40162	52p
4001	14p	40163	52p
4002	14p	4501	16p
4006	50p	4502	55p
4007	16p	4503	34p
4008	50p	4504	98p
4011	14p	4506	70p
4012	15p	4508	145p
4013	24p	4510	50p
4014	54p	4511	52p
4015	46p	4512	48p
4016	24p	4513	98p
4017	42p	4514	110p
4018	47p	4516	55p
4019	30p	4517	180p
4020	46p	4518	52p
4021	42p	4520	55p
4022	46p	4522	65p
4023	14p	4526	64p
4024	38p	4528	56p
4025	14p	4529	72p
4026	84p	4530	92p
4027	29p	4531	70p
4028	42p	4532	88p
4029	48p	4541	70p
4030	18p	4544	120p
4035	56p	4551	88p
4040	48p	4553	180p
4041	48p	4554	148p
4042	42p	4555	48p
4043	44p	4556	48p
4044	44p	4557	160p
4046	55p	4558	110p
4048	30p	4559	390p
4049	25p	4560	170p
4050	25p	4566	120p
4051	52p	4568	270p
4052	52p	4569	140p
4053	54p	4572	42p
4066	28p	4573	198p
4068	15p	4574	198p
4069	15p	4575	198p
4070	15p	4580	280p
4071	15p	4584	38p
4072	15p	4585	74p
4073	15p	4599	178p
4074	15p		
4075	15p		
4077	15p		
4078	15p		
4081	15p		
4082	15p		
4093	32p		
4098	78p		
40161	52p		

CPU IC's

6800	395p
6802	550p
6808	520p
6810	250p
6820	250p
6821	190p
6840	595p
6850	180p
6852	360p
6880	140p
6885	130p
6889	140p
68000	POA
8T26A	140p
8T28	120p
8T95	140p
8T97	140p
8T98	140p
8080A	400p
8085A	500p
8156C	600p
8212C	198p
8216C	140p
8224C	220p
8228C	450p
8251AC	495p
8253AC	800p
8257C	750p
8259C	900p
8288	£16
TMS9980A	£22
TMS9981N	£25
TMS9901N	590p
TMS9902N	550p
Z80A 4M	580p
Z80A P10	500p
Z80A DMA	£16
2101-4A	350p
2114-4	120p
2147-70nS	600p
2147-45nS	700p
2716	400p
4164-150nS	£10
4016-200nS	£7
5101LC	340p
5101LC-1	395p

IC SOCKETS

8 pin	7p	28 pin	16p
14 pin	8p	40 pin	20p
16 pin	9p	SPECIAL OFFERS	
18 pin	11p	25 x 22 pin	270p
20 pin	14p	25 x 28 pin	340p
22 pin	14p	10 x 40 pin	185p
24 pin	16p	25 x 40 pin	440p

VOLTAGE REGULATORS

Positive 100mA	
78L05	30p
78L12	30p
78L15	30p
78L18	45p
78L24	45p
1 A TO220	
7805	36p
7808	55p
7812	36p
7815	36p
7818	36p
7824	40p
5 A TO3	
78H05	540p
Negative 100 mA	
79L05	50p
79L12	50p
79L15	50p
1 A TO220	
7905	45p
7906	65p
7908	65p
7912	55p
7915	55p
7924	65p
—Variable—	
LM 309K	120p
LM 317K	250p
LM 317T	98p
LM 337T	180p
LM 350T	395p
LM 723CN	35p
78H05	540p

OPTO

TIL 32	55p
TIL 38	40p
TIL 78	50p
TIL 100	100p
TIL 111	85p
2N5777	50p
4N25	80p
4N28	70p
4N33	128p
4N35	150p
4N37	100p
BPX 38	390p
BPX 43	340p
TIL 221 (high output clear red)	20p

LINEAR IC's

CA 3046	72p	LM 565	100p	SAA5041	£25
CA 3065	190p	LM 567	150p	SAA5050	£10
CA 3080	72p	LM 709	35p	SAA5052	£10
CA 3086	56p	LM 710	70p	SL490	300p
CA 3089	170p	LM 711	60p	SN76115	98p
CA 3090AQ	300p	LM 733	75p	SN76660	90p
CA 3130E	95p	LM 741	14p	TBA120S	70p
CA 3140E	44p	LM 747	50p	TBA520Q	200p
CA 3160E	100p	LM 748	35p	TBA550	240p
CA 3161E	140p	LM 1458	36p	TBA570Q	200p
CA 3240AE	165p	LM 3900	47p	TBA625	100p
CA 3240E	110p	MC 1455	16p	TBA800	70p
CA 3260E	100p	MC 1458	34p	TBA810AS	95p
CA 810QM	250p	MC 1496	70p	TBA810S	95p
LF 347	160p	MC 1748	35p	TBA820	75p
LF 351	45p	MC 3302	72p	TBA820M	78p
LF 353	80p	MC 3401	68p	TBA920	195p
LF 355	85p	MC 3403	65p	TBA950	210p
LF 356	88p	NE 529	220p	TCA270	120p
LF 357	110p	NE 531	160p	TCA800	250p
LM 301A	26p	NE 532	56p	TCA940	180p
LM 307	54p	NE 544	200p	TDA1022	550p
LM 311	60p	NE 550	160p	TDA1024	130p
LM 318	120p	NE 555	16p	TDA2002	100p
LM 324	40p	NE 556	45p	TDA2003	150p
LM 339	46p	NE 558	170p	TDA2004	295p
LM 348	60p	NE 565	140p	TDA2005M	395p
LM 358	48p	NE 560	150p	TDA2006	240p
LM 380	68p	NE 567	110p	TDA2020	250p
LM 380-8	80p	NE 570	350p	TDA2030	220p
LM 381	140p	NE 571	320p	TDA2040	450p
LM 381	120p	NE 644	POA	TDA2054M	130p
LM 384	125p	NE 645	POA	TL061	40p
LM 386	68p	RC 4558	48p	TL062	80p
LM 387	135p	SAA1027	550p	TL064	120p
LM 393	70p	SAA1056	495p	ULN2001	80p
LM 555	16p	SAA5000	350p	ULN2003	80p
LM 556	45p	SAA5010	580p	ULN2004	80p
		SAA5020	620p		
		SAA5030	£10		
		SAA5040	£18		

CAPACITORS

Electrolytic radial/axial.

Value/	V	price
0.47	25	5p
0.47	63	6p
1 µF	63*	6p
2.2	16	5p
2.2	63*	6p
4.7	25	6p
4.7	63*	6p
10 µF	10	5p
10 µF	16	6p
10 µF	25*	6p
10 µF	63*	7p
22 µF	16	6p
22 µF	25	6p
22 µF	63*	9p
47 µF	10	7p
47 µF	25	8p
47 µF	63	12p
100	10*	6p
100	16	8p
100	25	10p
100	63	18p
220	10*	8p
220	16	10p
220	25*	14p
220	63	24p
470	10	14p
470	25*	20p
1000	10	18p
1000	25*	28p
2200	10	32p
2200	25*	45p

* axials only available these values, radial available on all of above.

Tantalum bead.

Value/	V	price
0.1 µF	35	12p
0.22	35	12p
0.33	35	12p
0.47	35	12p
0.68	35	12p
1 µF	35	12p
2.2 µF	35	16p
3.3 µF	35	18p
4.7 µF	25	20p
6.8 µF	25	20p
10 µF	16	20p
15 µF	16	28p
22 µF	16	35p
33 µF	16	60p
33 µF	10	36p
47 µF	10	60p
68 µF	10	80p
60 µF	6.3	60p
100µF	6.3	70p
100µF	3	38p
150µF	6.3	90p

Ceramic Plate 63/100 V 1.8 pF to 4N7 5p.

Polystyrene 5% 63 V: 10 pF to 1 nF 9p each. 1n2 to 10 nF 12p each.

Polyester C352 series 250 V 0.01, 0.015, 0.022, 0.033, 0.047 6p. 0.068, 0.1 8p, 0.15, 0.22 10p, 0.33, 0.47 12p, 0.68 18p, 1 µ 22p.

Disc Ceramic: 10 N 4p.

DIODES

AA 119	9p
BAX 13	5p
BAX 16	6p
OA 47	9p
OA 90	7p
OA 91	7p
OA 95	8p
OA 200	7p
OA 202	8p
1S44	6p
1S921	9p
1N914	3p
1N916	4p
1N4148	3p
1N4149	4p
1N4001	3p
1N4002	4p
1N4003	4p
1N4004	5p
1N4005	5p
1N4006	6p
1N4007	6p
1N5401	11p
1N5402	12p
1N5403	13p
1N5404	13p
1N5405	14p
1N5406	14p
1N5407	15p
1N5408	16p
6A/100V	25p
6A/200V	28p
6A/400V	30p

HEATSINKS

TO5 push on 6mm (80°C/W) 16p each. 12mm (60°C/W) 28p each.
TO3 14°C/W 30p each.
TO3 10°C/W 110p each.
TO126/220 18°C/W 25p.
All in matt black finish.

RESISTORS

¼ Watt Carbon film 5% E24 series 4.7 R-2M2 1p each.
½ Watt Carbon film 5% E12 series 1R-10M 2p each.
⅛ Watt Metal film 1% E24 series 10R-1M 4p each.
250p per 100, one value only. 280p per 100 mixed values.
2.5 Watt wire-wound OR22-10 ohms E12 series 25p each.
Presets: miniature horizontal & vertical 8p each 100R-500K.
Multiturn cermet trimmers 100R-500K 88p each.
Potentiometers: Single gang 1K to 1M 32p each. Single gang with DPST switch 68p each. Dual gang 80p each.

[illegible]

2.5" X1"	25p
2.5"X3.75"	90p
2.5"X5"	110p
3.75"X3.75"	110p
3.75"X5"	115p
pak of 100 pins	55p
spot face cutter	150p

HARDWARE

each
4xTO3 mounting kits 20p 64 mm Loudspeakers 8R 70p
4xTO66 mounting kits 20p 64R 78p each. 300mW rating.
5 xTO126 bushes/washers 14p PP3 battery snaps 6p each.
10xTO220 bushes/washers 22p 4xHP7 battery holder 22p
5 xTO3P bushes/washers 14p 6xHP7 battery holder 32p
20mm panel fuseholder 32p 20mm chassis fuseholder 7p
4mm plugs 12p. 4mm sockets 20p. 4mm insulated terminals 30p. 3.5mm jack socket 15p. 3.5mm jack plug 15p Phono sockets 15p. Switches: miniature toggle, SPST 60p, SPDT 68p, DPDT 78p each. Miniature push buttons: 1A/250V push to make 16p. push to break 23p. Midget rotary switches, pcb terminals 2P6W, 4P3W, 3P4W 39p each. Slide switch 1A/250V DPDT (22 x 12 x 8 mm) 16p.

BRAND NEW COMPONENT PACKS

CP100 60 IC sockets, 8, 14, and 16 pin 20 of each	440p
CP101 20 BC182/BC212 transistors, 10 of each	130p
CP102 20 BC183/BC213 transistors, 10 of each	100p
CP103 20 BC184/BC214 transistors, 10 of each	130p
CP104 20 BC549C/BC559C transistors, 10 of each	130p
CP105 20 BC550C/BC560C transistors, 10 of each	160p
CP106 100 1N914 switching diodes, 75-100V/75mA	240p
CP107 100 1N916 switching diodes, 75/100V/75mA	280p
CP108 100 1N4148 switching diodes, 75-100V/75mA	160p
CP109 500 1N4148 switching diodes, 75-100V/75mA	680p
CP110 30 1N4002 1A/400V rectifiers	100p
CP111 10 MC1458 Dual op amps (741 type)	320p
CP112 100 400mW zeners, 4 of each 2V7 to 33V	450p
CP113 100 1.3W zeners, 4 of each 4V7 to 51V	850p
CP114 4 LF351 JFET op amps, Low noise	170p
CP115 4 LF353 JFET op amps, dual low noise	300p
CP117 50 mixed LED's 3mm/5mm/rect/red/green/yellow	400p
CP119 100 1N4002 1A/100V rectifiers	270p
CP120 10 C106D 400V/4A thyristors	250p
CP121 10 NE556 dual timer IC's	400p
CP124 100 mixed electrolytic capacitors 10-63V/1-1000µF	£6
CP125 5 LM317T 1A/TO220 variable regulators	440p

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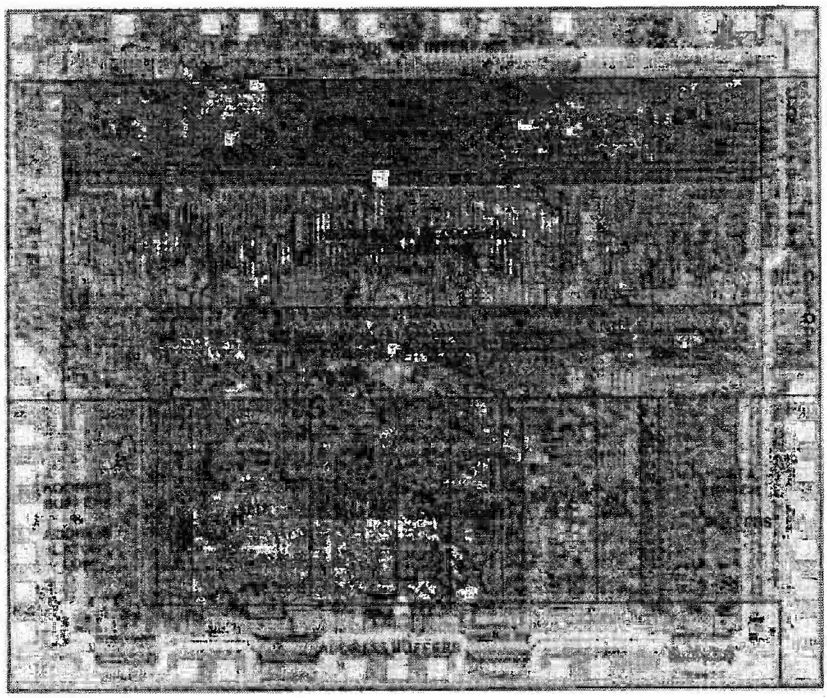

Photo of the CMOS 6502 processor courtesy of Rockwell International.

16 Channel A-to-D Board

Following on in our series of projects aimed at but not exclusively for the Mircotan, here is an A-to-D board to help you connect your computer to the outside world. If you built the D-to-A board of some months ago or would like to use your computer for control or monitoring, here is the project for you, as it will be suitable for 6502 and Z80 systems.

ZX Controlled Burglar Alarm

The idea of using a home computer to control a burglar alarm would have seemed crazy a few years ago. Laterly, however, the ZX81 seems to have become so common that many are languishing on shelves gathering dust. Well here's a job for them — controlling a buglar alarm system. The system can also be used with the Spectrum.

Modular Preamplifier

Just so that the computer freaks don't get it all their own way, here's a top-quality preamplifier that is modular in construction. The author himself describes the design as an Audio Leggo Kit, and that's just what it is. The basic unit is a motherboard into which you slot the modules that you want — so if you don't want tone controls, you don't have to have them. But unlike other preamps, you can change your mind at a later date.

Lightsaver

Problem: when light-bult filaments are cold, their resistances are very low, so when you turn on the light a very heavy current will flow momentarially: this problem is exacerbated if you just happen to turn on when the mains cycle is near its maximum voltage. Solution: buy next month's ETI and find out!

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- Giant TV screen video games.
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*see next page

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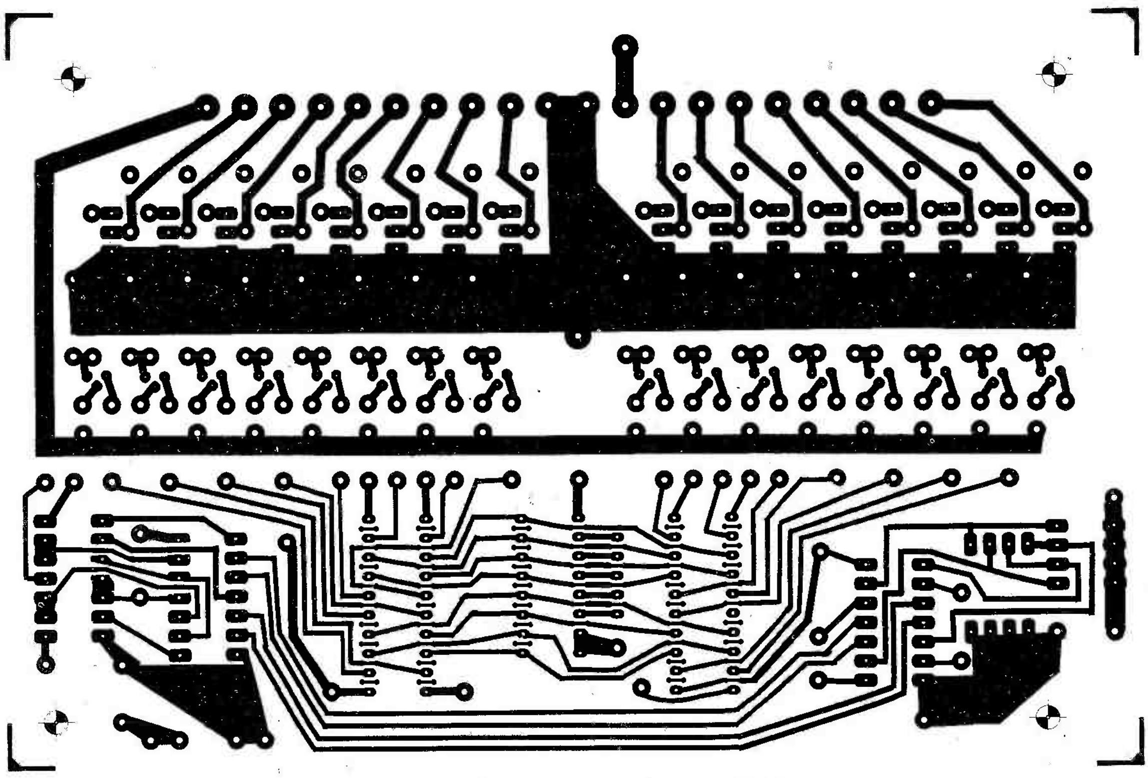
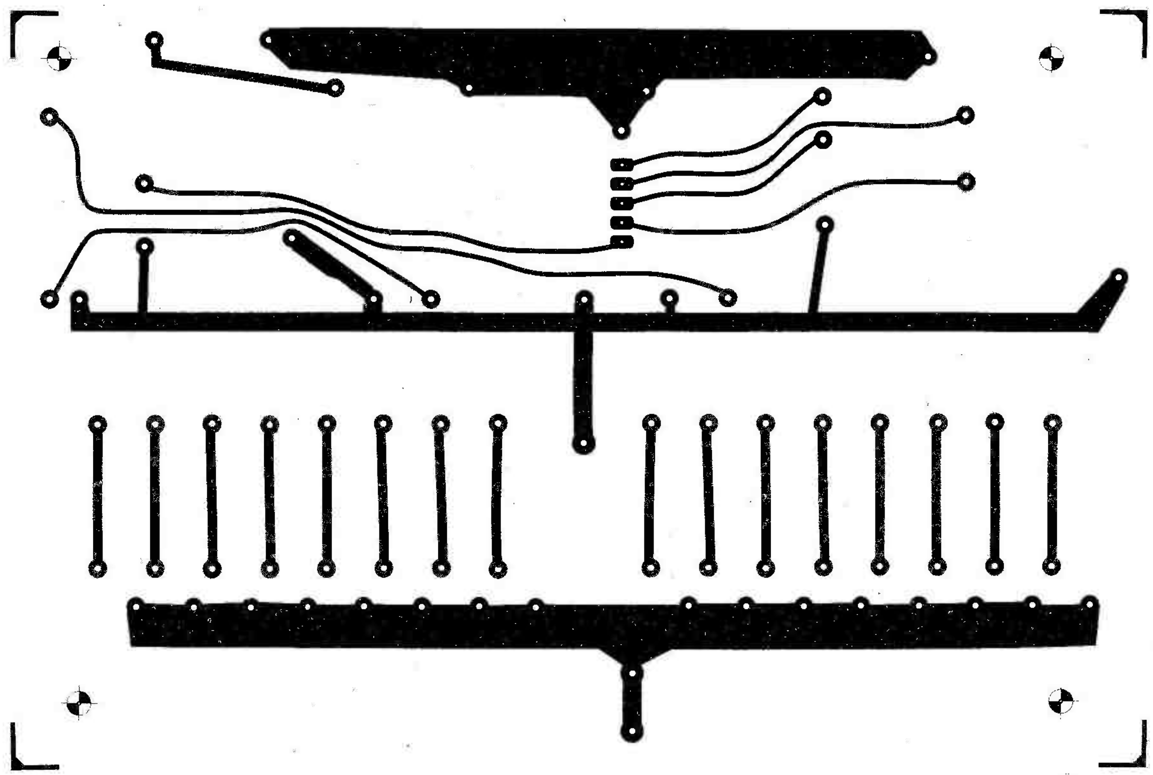
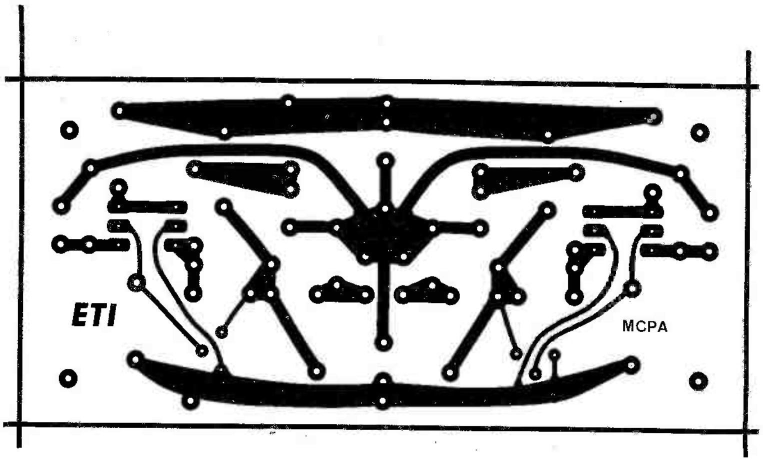
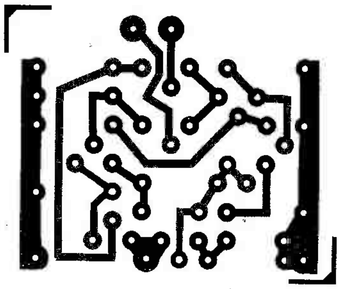


Sorry! These two are foil patterns for the Output Driver, published way back in July (we've only just had space for them now).

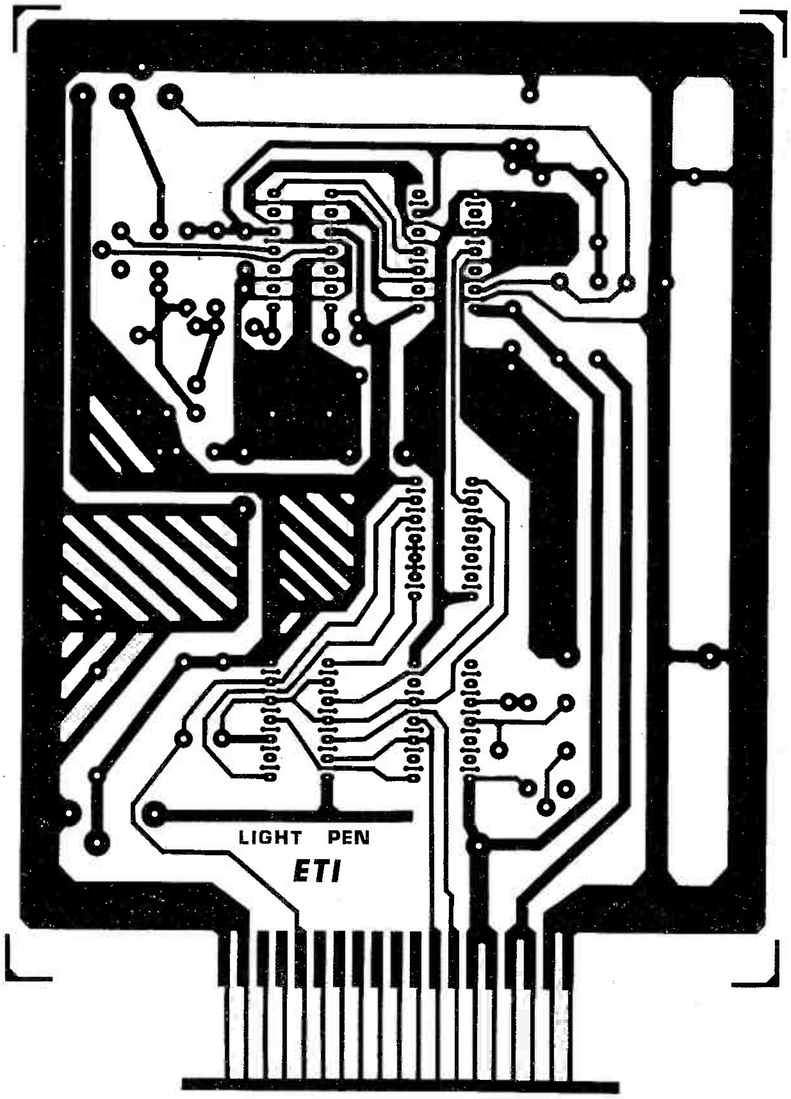




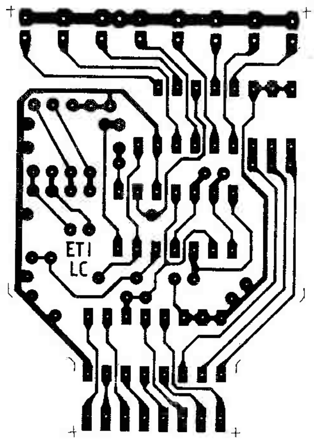
The Moving Coil Head Amplifier.

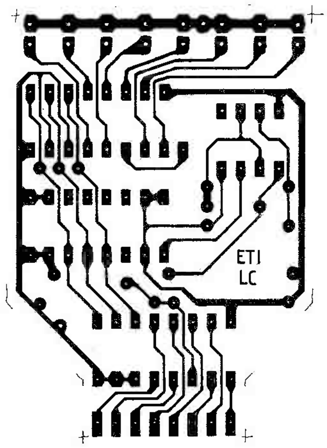


The Gain Block from Audio Design; note that this will not be available through the PCB service.

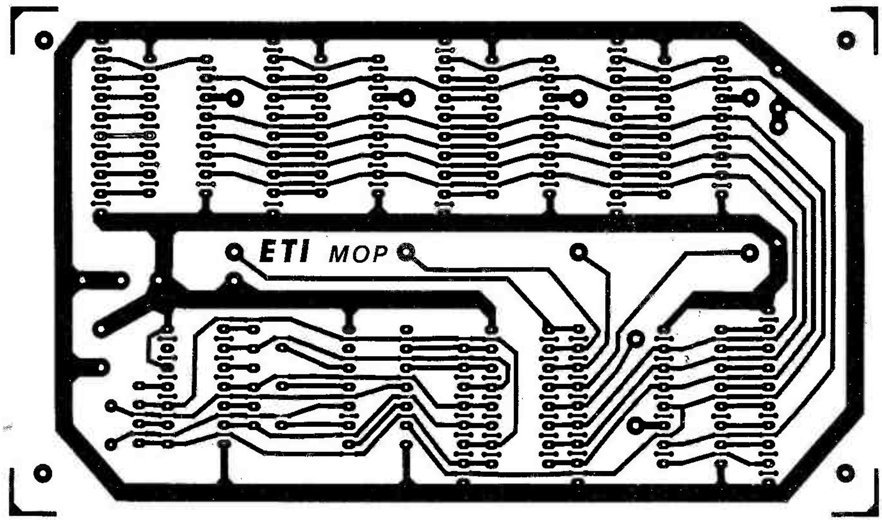


The Fast Light Pen.

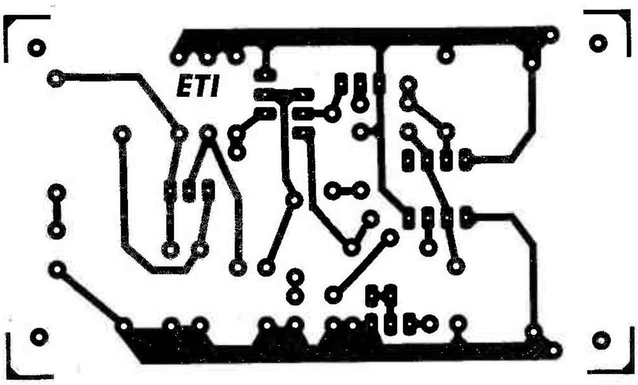




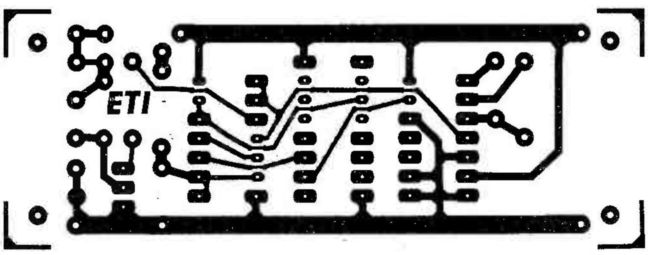
The Logic Clip.



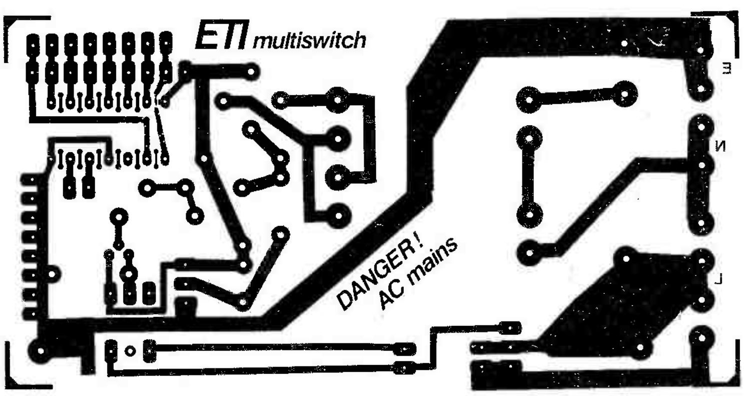
The Multiple Output Port.



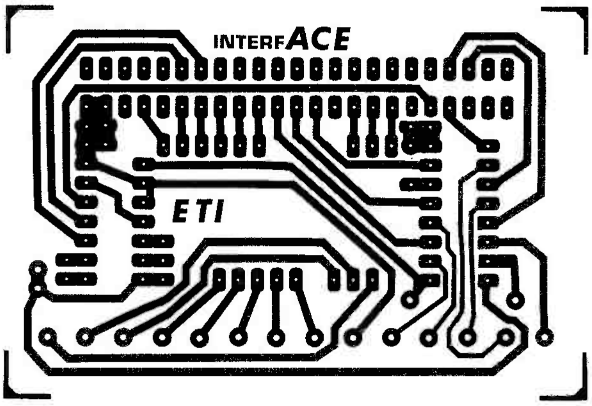
The Mini Drum Synth Module.



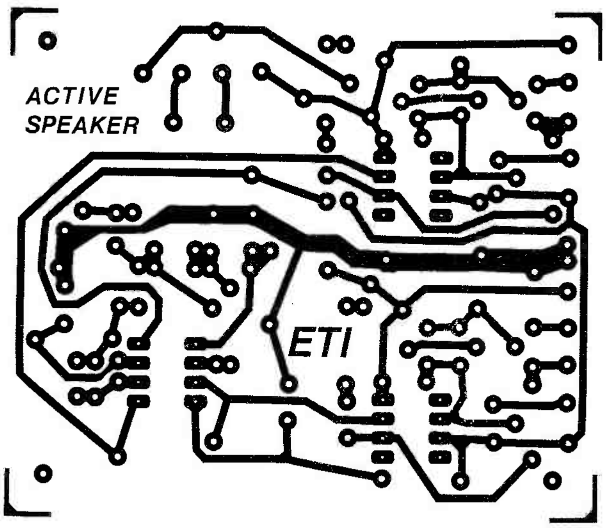
The Alarm Extender.



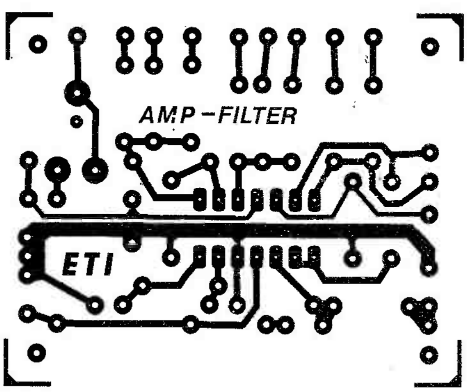
The Multiswitch.



The Ace Interface.



The Active Loudspeaker.



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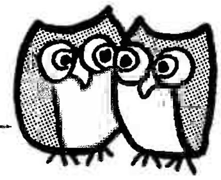

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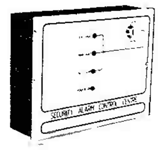

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E.T.I. — SEPTEMBER 83 ADVERTISERS INDEX

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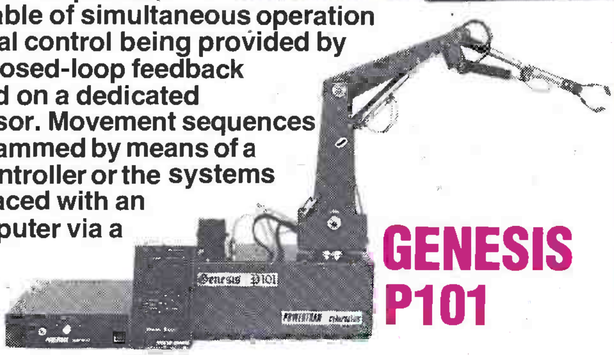
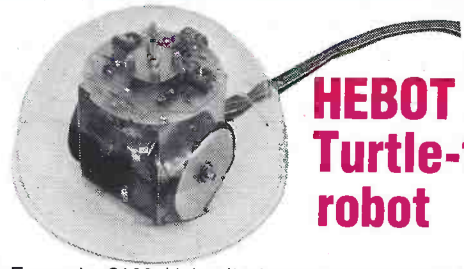


GENESIS P101

The top-of-the-range P102 has dual speed control, enhanced memory and double acting cylinders for increased torque on the wrist and arm joints. There is position interrogation via the RS232C interface, increasing the versatility of computer control and inputs are provided for machine tool interfacing.

All Genesis robots are available either ready-built or in kit form. The latter provides not only extra economy but also valuable additional training as an assembly project.

GENESIS P102



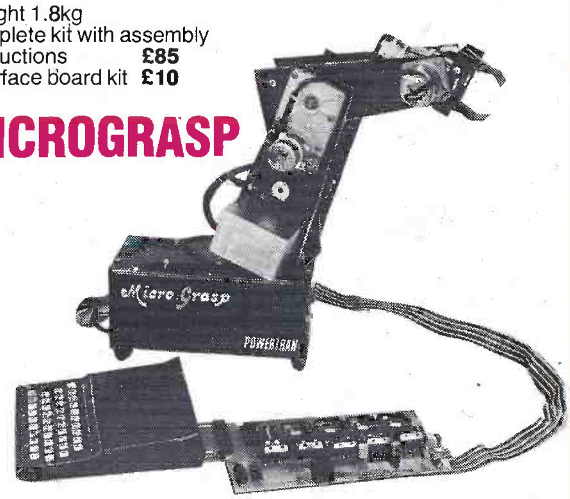
HEBOT II Turtle-type robot

For under £100, Hebot II takes programming off the VDU and into the real world. Each wheel is independently controlled by a computer, enabling the robot to perform an almost infinite number of moves. It has blinking eyes, a two-tone bleep and a solenoid-operated pen to chart its moves. Touch sensors coupled to its shell return data about its environment to the computer enabling evasive or exploratory action to be calculated.

The robot connects directly to an I/O port or, via the interface board, to the expansion bus of a ZX81 or other microcomputer.

HEBOT II

Weight 1.8kg
complete kit with assembly instructions **£85**
Interface board kit **£10**



MICROGRASP

A real, programmable robot for under £200! Micrograsp has an articulated arm jointed at shoulder, elbow and wrist positions. The entire arm rotates about its base and there is a motor driven gripper. All five axes are motor driven and servo controlled, giving positive positioning. The robot can be controlled by any microcomputer with an expansion bus – the Sinclair ZX81 being particularly suitable.

MICROGRASP

Weight 8.7kg, lifting capacity 100g
Robot kit with power supply **£145.00**
Universal computer interface board kit **£48.50**
23 way edge connector **£2.50**
AX81 peripheral/RAM pack splitter board **£3.00**

GENESIS S101

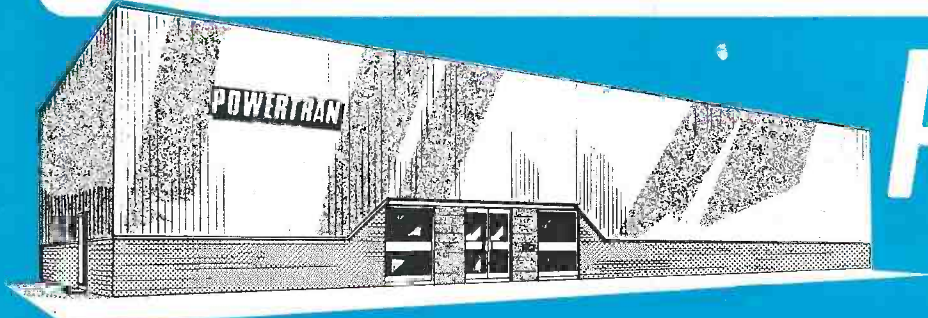
Weight 29kg, lifting capacity 1.5kg
4-axis model (kit form) **£425**
5-axis model (kit form) **£475**
5-axis complete system (kit form) **£737**
5-axis complete system (ready built) **£1,450**

GENESIS P101

Weight 34kg, lifting capacity 1.8kg
6-axis model (kit form) **£675**
6-axis complete system (kit form) **£945**
6-axis complete system (ready built) **£1,650**

GENESIS P102

Weight 36kg, lifting capacity 2kg
6-axis system (kit form) **£1175.00**
6-axis system (ready built) **£1950.00**
Powertran Cortex microcomputer
self-assembly kit **£295.00**
ready-built **£395.00**



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PORTWAY INDUSTRIAL ESTATE, ANDOVER, HANTS SP10 3ET. TEL (0264) 64455 Telex 477407

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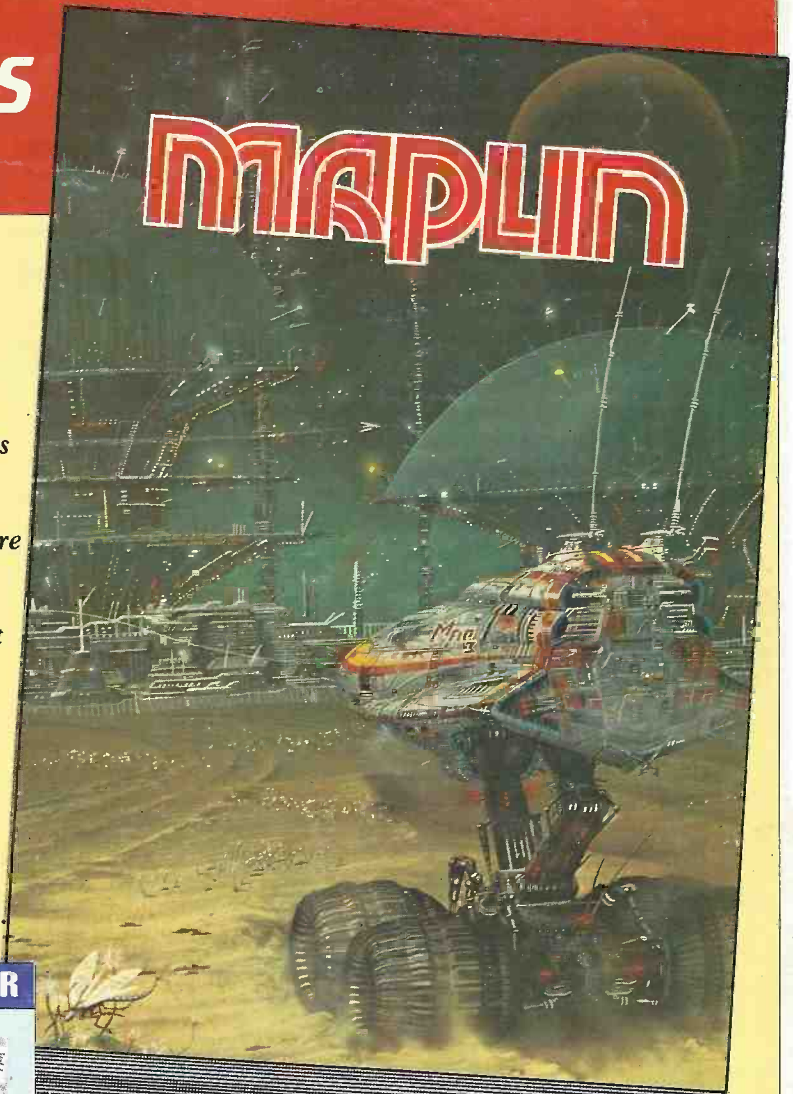
NOW WITH PRICES ON THE PAGE



More data, more circuits, more pictures, in the brand new 480 page Maplin catalogue. Take a look at the completely revised Semiconductor section or the new Heathkit section with descriptions and pictures of dozens of kits and educational products from digital clocks to 16-bit business computers. The much expanded computer section itself, gives details of hundreds of pieces of software for Atari, BBC, Commodore 64, Dragon, Spectrum and VIC20. In addition to all this you'll find hundreds of fascinating new items spread through the rest of the catalogue.

As always, the Maplin catalogue is tremendous value for money and now has prices on the page!

Pick up a copy at any branch of W.H.Smith or in one of our shops for just £1.35 or send £1.65 including postage to our Rayleigh address. On sale from 1st Nov 1983.

PROJECTS FOR THE HOME CONSTRUCTOR

Choose from our huge range of value-for-money projects. Projects like our Modem, Mosfet Stereo Amplifier, Home Security System, Frequency Counter and Home Computer add-on kits. Full construction details in our Project Books and brief specifications in our new catalogue. Dozens of fascinating new projects coming soon including a Keyboard for the ZX Spectrum with electronics to make all shifts, single-key operations. Full details in Project Book 9 on sale 11th November 1983. Order As XA09K. Price 70p.

NEW MAPLIN STORE IN SOUTHAMPTON

Opening on 1st November 1983, our new south coast store is at 46–48 Bevois Valley Road, Southampton (Tel: 0703 25831). You will find our full range of components, projects and computers on sale. We are within easy reach of the city centre with good parking close by. Call in and see us soon.

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Price £1.35 + 30p post and packing. If you live outside the U.K. send £2.20 or 11 International Reply Coupons.
I enclose £1.65.

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*Opens 1st November 1983. *All shops closed Mondays.*
All prices include VAT and carriage. Please add 50p handling charge to orders under £5 total value (except catalogue).

DIGEST

Holophony — The Continuing Saga

We received a great deal of interested enquiries over our item on Holophony back in July. At the same time, elsewhere in the press a certain amount of cynicism was expressed over the system. Well now you can judge for yourself because a record of holophonic sound effects is available.

Out on CBS (CBS recording number TA3278), the record is a 12′ 45 RPM and seems to be titled Zuccarelli Holophonic by Zuccarelli Labs Ltd, and your very own intrepid editor has been giving it a listen! He writes: "I must say I was somewhat disappointed at the quality of the effects, they were nothing like as good as when played through Hugo Zuccarelli's own equipment. Also the sleeve notes are far from complete — they fail to mention that you should use single-driver speakers or small-cone headphones".

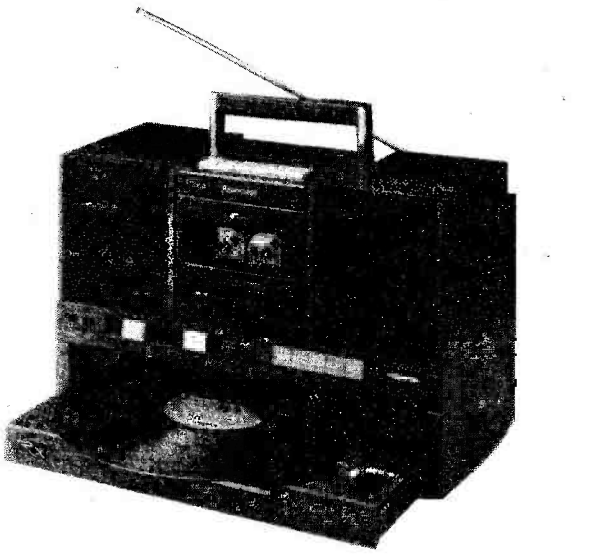
Readers will also be interested to note that the Sennheiser dummy head recordings mentioned in September's READ/WRITE are available from Hayden Laboratories Ltd, Hayden House, Chiltern Hill, Chalfont St Peter, Gerrards Cross, Bucks SL9 9UG, tel 0753 888447, at £1.15 each plus 57p postage and packing. There are just two recordings, both on 7′ 45s; one is just a straight demonstration of the dummy head in a room with a commentator walking around and talking to you; the other has various sound effects, such as a jet aircraft passing overhead and a choir surrounding the dummy head.

IEEE Interface For The BBC

Cambridge Systems Technology, a new specialist computer company, has produced the first, fully operational IEEE interface for the BBC microcomputer. The CST Procyon allows users to communicate with the wide range of instruments operating to the IEEE-488 international standard, and is particularly valuable in educational or scientific establishments. It enables a BBC micro to be interfaced with high quality plotters and printers, frequency counters, voltmeters or disc drives, but may also be used to connect the "Beeb" to CBM equipment via a specially written Commodore filing system. It responds to any high level language including LISP, FORTRAN, FORTH, BASIC or APL.

The PROCYON is supplied with an 8k EPROM which fits a vacant sideways ROM socket in the BBC micro and supplies an IEEE filing system which can cope with up to 16 connected devices, accepting standard operating system file commands as well as special instructions or user-defined options. Data is transferred at up to 70k bytes of information per second, and the system is helpful and virtually fool-proof with extensive user advice facilities, error checking and visual indications of operating status.

A straightforward but comprehensive manual is supplied with the system, containing tutorials for beginners and advice on maximising the PROCYON's effectiveness. Cambridge Systems Technology, 30 Regent Street, Cambridge CB2 1DB, Tel (0223) 323302.



Slipped Disc?

A couple of months ago we featured two so-called portable audio units in Digest and wondered, in view of their ever increasing complexity and weight, just how long it would be before someone fitted wheels to one. Panasonic's SG-J500 does indeed have a revolving addition, but instead of being there to ease the load it just adds to it, for this truly monstrous beastie comes complete with a push-button, slide out turntable.

Part of a new range of portable audio units called 'RX Sound', the SG-J500 features an auto stop cassette deck and a three band tuner as well as the turntable and delivers four watts (whether RMS or peak is not specified) through its 'full range' speaker system. Weight is not specified, Panasonic being content to describe it as 'lightweight', and price is £133.50.

The RX-F32L from the same range does not have a turntable, presumably because they didn't have room for one after including the four, full range speakers, surround effect ambience stereo, Dolby noise reduction, loudness switch, and automatic tape search system. However, for those who simply must have everything, Panasonic have produced an add-on turntable unit, the SL-N15. This is described as 'jacket sized' (we think they mean record jacket sized) but is in reality rather thicker and features linear tracking.

Last, but presumably not least since it is the most expensive item in the range, the RX-C45L. This features a five-band graphic equaliser, ten watts per channel output, Dolby noise reduction, metal tape compatibility, full auto stop, and again it can be used in conjunction with the SL-N15 turntable. There is also something in the press release about 'soft touch', but apparently this refers to the machine rather than to potential purchasers.

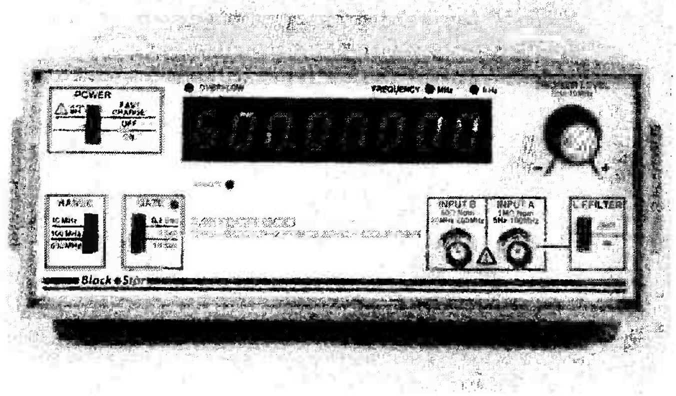
The RX-F32L costs £144.50 and the RX-C45L costs £177.50. Price of the SL-N15 is not given. All items should be available through Panasonic's authorised dealers nationwide.

Electronic Typewriters with RS232

National Panasonic recently launched a new range of electronic typewriters in the USA and now plan to market them in the UK from about the middle of next year. The two new machines, designated KX-E701 and KX-E708, are both available with an optional RS232C interface, thus enabling them to be used as letter quality printers.

The KX-E701 is described as an economically priced, standard electronic typewriter, while the KX-E708 is a full-feature model with a forty character display. Just what is meant by economical is not clear since no prices have been announced; indeed, when we telephoned panasonic UK to quiz them about it, they seemed unaware that the machines were due here at all! So perhaps you'll just have to make our typewriter interface after all . . .

Panasonic Business Equipment (UK) Ltd, 107-109 Whitby Road, Slough, Berkshire SL1 3DR, tel Slough 75841.



Low Cost DFM

The Meteor 600 is the first in a series of digital frequency counters announced by Black Star Ltd. It has a frequency measurement range of 2 Hz-700 MHz, sensitivity of 25mV at 600 MHz and resolution down to 0.1 Hz, and also features 8 × ½" bright LED displays, 3 gate times, 2 inputs, a trigger level control and an integral low pass filter. The counter is housed in an attractive, sturdy, custom-moulded A.B.S. case with tilt stand. It can be operated from rechargeable batteries or mains and is supplied complete with a mains adaptor/charger and a comprehensive instruction manual. A wide range of optional accessories is also available.

The Meteor 600 costs £115 plus VAT and is available from Black Star Ltd, 9A Crown Street, St. Ives, Huntingdon, Cambs. PE17 4EB, tel. 0480-62440.

Hello, Computer Speaking . . .

If your micro is feeling lonely, why not introduce it to a wider circle of friends with the new UDS V.21 LP modem from Codex (UK) Ltd? This 300 baud stand alone machine comes in either manual or automatic answering versions and is approved for connection to the Public Switched Telephone Network, from which it draws its power. It stands only one inch high and is designed to fit neatly underneath the telephone. With a selling price of around £200 for the manual version and £250 for the automatic model, Codex anticipate a lot of interest from the small business and hobbyist markets, and are currently seeking distributors for the product to whom they are prepared to offer generous quantity discounts. Codex (UK) Ltd, 114/116 Thornton Road, Surrey CR4 6XB, tel. 01-689 2101.

Sculptured Circuits

Dowty Circuits Ltd have signed an agreement with Advanced Circuit Technology of America giving them exclusive rights to manufacture what they call sculptured circuits in this country. This patented technology permits the physical carving of copper into various shapes by a chemical milling process, allowing the thickness of a piece of copper to be varied along its length. In this way, connector systems can be fabricated in which each conductor has both its terminal pins and flexible lead made from a single continuous piece of copper, thereby increasing reliability, reducing series resistance, and reducing assembly costs, time, etc. Dowty anticipate the production of a wide range of standard and custom designs with various conductor diameters, pin densities, finishes and terminations. Dowty Circuits Ltd, Industrial Estate, Terminus Road, Chichester, West Sussex PO19 2UA, Tel 0234 784516.

Shorts

• ITT Cannon have introduced the AXR audio connector range, a successor to their industry standard XLR range, which features easier assembly, greater RFI protection, improved cable clamping, and lower cost. The AXR has from three to seven contacts plus a mains version, comes in sixteen shell styles, and is available from PSP Electronics Ltd, Unit 2, 2 Bilton Road, Perivale, Greenford, Middlesex UB6 7DX.

• 3M have introduced a new Scotchlok connector which may be attached to an existing cable in one action using a pair of pliers and which provides a fully insulated tapping point for a standard ¼" blade connector. Also new is an inline fuseholder which assembles onto wire ends without prior stripping, again with only one action. Electro-Products Group, 3M United Kingdom PLC, 3M House, PO Box 1, Bracknell, Berkshire RG12 1JU, tel 0344 58755.

• Data I/O has published a thirty-two page booklet entitled 'Programmable Logic — A Basic Guide for the Designer'. It covers all aspects of design, programming and testing including a worked example, and is available free-of-charge from Microsystem Services, PO Box 37, Lincoln Road, Cressex Industrial Estate, High Wycombe, Bucks HP12 3XJ, tel 0494 41661.

• Och Aye, hoots mon, and the rest! Scottish ETI readers should note that the first Scottish Home Computer and Electronics Show is coming and will feature micros, software, CB, ham, hi-fi and video equipment. Venue is the Anderston Centre in Glasgow and the whole caledonian caboodle runs from the 11th to the 13th November. Details from Ann Lowe, Trade Exhibitions Scotland, 53/55 Commissioner Street, Crieff, Perthshire PH7 4DA, tel 0764 - 4204.

• CHO-JAC is a bonded foil and polymer sheath designed to protect ribbon cables against electromagnetic and radio frequency interference. Available in sizes to fit 16, 26, 34, 40, 50, and 60 way cables, it is claimed to give a shielding effectiveness of up to 65 db and is supplied in 100 ft rolls. Chomerics Europe, Chomerics House, 14-18 Church Street, Slough, Berkshire SL1 1PZ, tel. (0753) 822242.

• The EX 110 is a new, plunger type, electrically heated desoldering tool which weighs four ounces and is designed to be operated for extended periods without tiring the operator. It features a cassette system which eases removal of the accumulated solder, operates from the mains, has a bit temperature of 420°C, and costs about £18 plus VAT. Nietronix Ltd, West End Trading Estate, Blackfriars Road, Nailsea, Bristol BS19 2DJ, tel 0272 856697.

• We are often asked by readers to recommend someone who will repair and re-calibrate test meters, etc, and usually have to admit defeat. PIL will not, as far as we know, repair meters but they will re-calibrate them and whats more they'll do it to Defence Standard 05-24. Ring 01-639 0155 for details.

• Cambridge Microelectronics have introduced a 2516, 2532, 2716 and 2732 EPROM programmer for the ZX81. ROM-81 provides all the standard programming functions, requires four PP3 batteries, is housed in a neat ABS case which plugs into the back of the ZX81 and has a further expansion adaptor, and comes complete with a taped control program and user notes. Price is £19.95 plus VAT from Cambridge Microelectronics Ltd, 1 Milton Road, Cambridge CB4 1UY, tel 0223 - 314814.

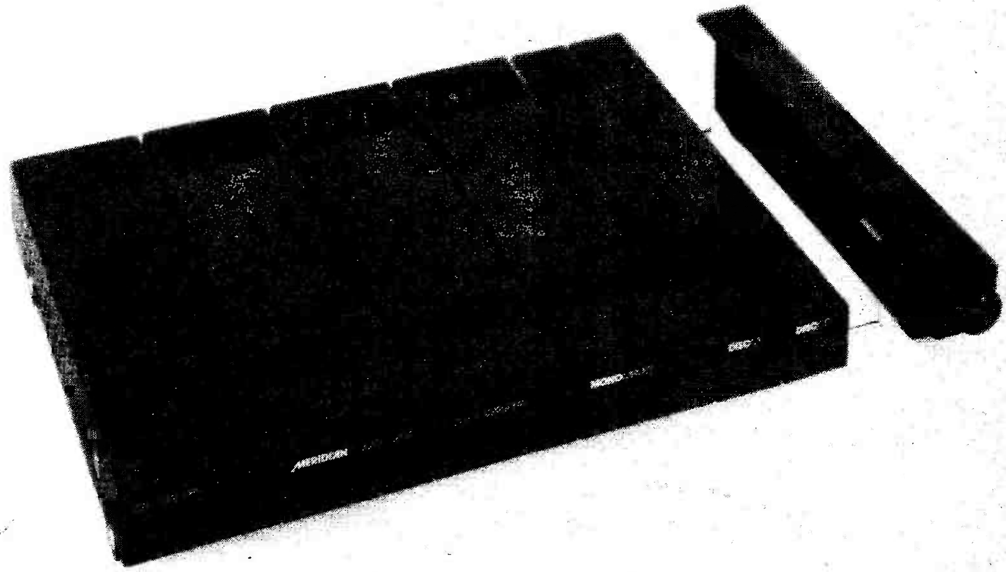
• They may not be giving computers away with breakfast cereals yet but they are giving them with courses. Prophet Systems Ltd are running one and two day training courses in computer assisted business modelling at their Jacobean manor at Polebrook, Peterborough, and are giving away a Prophet II microcomputer to each participant. Polebrook Management Systems Ltd, Polebrook Hall, Peterborough PE8 5LN, tel 0832 72052.

• The TG-3 is a hand-held, battery operated television test generator with a direct UHF output to suit a standard 625 line set. It provides 2 MHz lines for focus check, grating pattern, dot pattern, and plain white raster, and costs £46 inclusive from Video Techniques, 101 Derby Street, Bolton, Lancashire BL3 6HH, tel 0204 - 26916.

• OK Industries new FG-201 function generator provides highly accurate sine, square and triangle waveforms from 1 Hz to 1 MHz into 50 ohms and offers both AM and FM modulation. There is also a 5 ohm output for sine and triangle while square wave may be used simultaneously with either as a trigger. The FG201 costs £230 plus VAT and is manufacturered by OK Industries UK Ltd, Dutton Lane, Eastleigh, Hampshire, tel 0703-610944.

• Industrialists and Researchers are invited to the First International Conference on Lasers in Manufacturing to be held at the Brighton Metropole from 1st-3rd November. Hewlett-Packard, Rolls-Royce, and BL will be among those contributing to the conference, which aims both to highlight recent experience and to consider the future of the laser in industry. Details from The Conference Director, LIM-1, IFS (Conferences) Ltd, 35-39 High Street, Kempston, Bedford MK42 7BT, tel 0234 853605.

Plug-Together Amplifier System



If building a hi-fi amplifier from scratch sounds a bit too much like hard work, why not cheat and buy a new Boothroyd Stuart Meridian Component Amplifier? With this system you can buy just those modules you want and simply plug them together to produce an amplifier system tailored precisely to your requirements.

The Meridian Component Amplifier System consists of a number of modules of matching appearance which plug together to form a neat, slimline unit. Two coin-slot headed screws further secure the units to ensure a good connection and to prevent bits falling off when you move it around! The basic unit is a stereo power amplifier with a switch-mode power supply operating at 40 kHz. The amplifiers are conservatively rated at thirty-five watts RMS each and the power supply ensures that high power transients are accommodated without straining. Although built and sold as a single unit, this block is visually divided into four adjacent modules so as to match the appearance of the rest of the system. A slim module, half the width of the apparent power modules, contains the stereo preamplifier and volume control, and this plugs onto the right hand end of the basic block. Up to twenty (yes, twenty) input modules can be added between the power and preamp modules catering for magnetic and moving coil pickups, tape, etc, and just in case this leaves you with a monster several feet long there is also a splitter module which allows you to stack one row of modules on top of another. Other modules either already available or soon to be introduced include tone controls, an FM stereo tuner, and a power supply for the preamp alone which allows you to dispense with the main power block when driving active loudspeakers or a separate power amplifier.

Although no specifications were included in the press release, Boothroyd Stuart assure us that performance in all areas is to a very high standard and that distortion in particular is so low as to be almost immeasurable. The basic unit with preamplifier and one (disc) input should sell for about £375 including VAT. Boothroyd Stuart Ltd, 13 Clifton Road, Huntingdon, Cambridge PE18 7EJ, tel 0480 57339.

Cool, Calm and Connected

Pye Electro Devices (PED) Ltd have introduced a series of fans which use a piezoelectric system rather than the conventional magnetic system. The Series 13 module A and B cooling fans have almost no moving parts and are intended for use as spot cooling devices in solid state systems.

Piezoelectric materials can be made to change shape when a voltage is applied to them. In the new fans, two flexible piezo ceramic elements are laminated to a flexible metal strip such that, when a voltage is applied, one side expands and the other contracts, causing the metal strip to bend. Two such fan blades, matched and fed with alternating voltages such that they move in phase quadrature, produce a highly focussed stream of air. PED claim that such a system offers near infinite life since there are so few moving parts. Other advantages include very low noise output, a complete absence of electro-magnetic and radio-frequency interference, no starting surge, and very low power consumption. Versions are available for use on 115 V AC 60 Hz, 220/240 V AC 50 Hz, and DC supplies from 5 to 12 V and maximum dimensions are 71 mm x 55 mm x 17mm. Pye Electro Devices Ltd, Relay and Solenoid Division, Exning Road, Newmarket, Suffolk CB8 0AX. Tel (0638) 665161.

Microtan And Microtutor Are Alive And Well . . .

And living in Dulwich. Microtanic, formerly purely a software house, have bought all rights to the Microtan and to the Microtutor. Not only that but they've launched a magazine for Microtan owners, Microtan World (Why are we advertising competitors? — Ed).

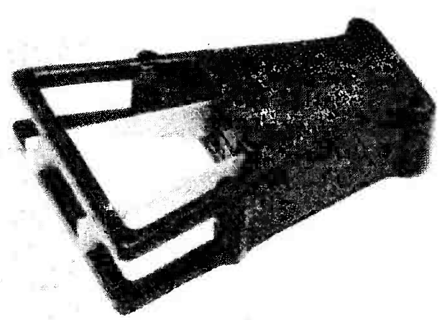
To do this, Microtanic have had to overcome enormous problems and they seem to be coping admirably despite it all. To ETI, it comes as a relief to see this excellent computer being kept alive, as it is truly an experimenter's system, as a casual perusal of some of the recent issues of ETI will testify.

Readers should direct their enquiries to Microtanic Computer Systems Ltd, 16 Upland Road, Dulwich, London SE22, tel 01-693 1137.

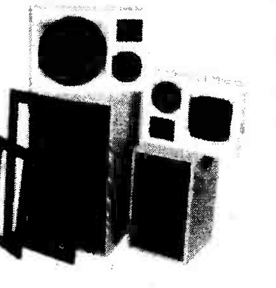
Hi-Fi VHS Announced

Ten Japanese companies have collaborated to produce a common standard for a hi-fi VHS video cassette recorder. Akai, Canon, Clarion, Hitachi, JVC, Matsushita, Mitsubishi, Orion, Sharp, and Tokyo Sanyo will produce machines to the new standard and a number of companies are expected to produce compatible videotapes with hi-fi stereo sound.

In the existing VHS video system, video signals are recorded and played back by rotary heads while fixed heads are used for audio signals. In the new system, two additional rotary heads are provided exclusively for the audio signals. It is claimed that this, plus the use of frequency modulated 1.3 and 1.7 MHz carriers, produces a marked improvement in dynamic range, distortion level, and wow and flutter. Other features include a newly-developed noise reduction system and the ability to use existing software on the new machines and vice-versa, although no details are given on how this is achieved.



MULLARD SPEAKER KITS



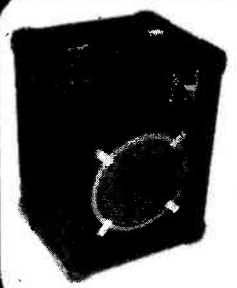
Purposefully designed 40 watt R.M.S. and 30 watt R.M.S. 8 ohm speaker systems recently developed by MULLARD'S specialist team in Belgium. Kits comprise **Mullard woofer** (8" or 5") with foam surround and aluminium voice coil. **Mullard** 3" high power domed tweeter. **B.K.E.** built and tested crossover based on Mullard circuit, combining low loss components, glass fibre board and recessed loudspeaker terminals. SUPERB SOUNDS AT LOW COST. Kits supplied in polystyrene packs complete with instructions.

8" 40W system — recommended cabinet size 240 × 216 × 445mm
Price £14.90 each + £2.00 P & P.

5" 30W system — recommended cabinet size 160 × 175 × 295mm
Price £13.90 each + £1.50 P & P.

Designer approved flat pack cabinet kits, including grill fabric. Can be finished with iron on veneer or self adhesive vinyl etc.
8" system cabinet kit £8.00 each + £2.50 P & P.
5" system cabinet kit £7.00 each + £2.00 P & P.

OMP 80 LOUDSPEAKER



The very best in quality and value.

Ported tuned cabinet in hard-wearing black vynide with protective corners and carry handle. Built and tested, employing 10in British driver and Piezo tweeter. Spec: 80 watts RMS; 8 ohms; 45Hz-20KHz; Size: 20in x 15in x 12in; Weight: 30 pounds.

Price: £49.00 each
£90 per pair
Carriage: **£5 each £7 per pair**

BK ELECTRONICS

Prompt Deliveries
VAT inclusive prices
Audio Equipment
Test Equipment
by
Thandar
and
Leader

PANTEC

HOBBY KITS. Proven designs including glass fibre printed circuit board and high quality components complete with instructions.

FM MICROTRANSMITTER (BUG) 90/105MHz with **very** sensitive microphone. Range 100/300 metres. 57 x 46 x 14mm (9 volt) **Price: £7.99p**

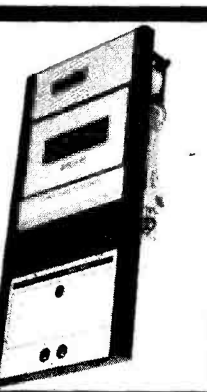
DIGITAL THERMOMETER -9.9°C to +99.9°C. LED display. Complete with sensor. 70 x 70 mm (9 volt) **Price: £27.60p**

3 WATT FM TRANSMITTER 3 WATT 85/115MHz varicap controlled. professional performance. Range up to 3 miles 35 x 84 x 12 mm (12 volt) **Price: £12.49p**

SINGLE CHANNEL RADIO CONTROLLED TRANSMITTER/RECEIVER 27MHZ Range up to 500 metres. Double coded modulation. Receiver output operates relay with 2amp/240 volt contacts. Ideal for many applications. Receiver 90 x 70 x 22 mm 9/12 volt) **Price: £16.49** Transmitter 80 x 50 x 15 mm (9/12 volt) **Price £10.29** P&P All Kits +50p. S.A.E. for complete list.

3 watt FM Transmitter

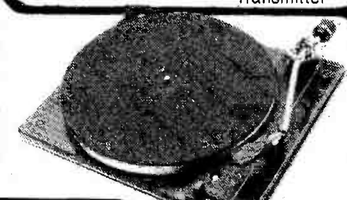
STEREO CASSETTE TAPE DECK MODULE



Comprising of a top panel and tape mechanism coupled to a record/play back printed board assembly. Supplied as one complete unit for horizontal installation into cabinet or console of own choice. These units are brand new, ready built and tested.

Features: Three digit tape counter. Autostop. 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 × 11¼in. Clearance required under top panel 2¼in. Supplied complete with circuit diagram and connecting diagram. Attractive black and silver finish.
Price £26.70 + £2.50 postage and packing.
Supplementary parts for 18V D.C. power supply (transformer, bridge rectifier and smoothing capacitor) **£3.50.**

BSR P256 TURNTABLE



P256 turntable chassis ● S shaped tone arm ● Belt driven ● Aluminium platter ● Precision calibrated counter balance ● Anti-skate (bias device) ● Damped cueing lever ● 240 volt AC operation (Hz) ● Cut-out template supplied ● Completely manual arm. This deck has a completely manual arm and is designed primarily for disco and studio use where all the advantages of a manual arm are required.
Price £31.35 each. £2.50 P&P

LOUDSPEAKERS POWER RANGE

THREE QUALITY POWER LOUDSPEAKERS (15", 12" and 8" See 'Photo). **Ideal for both Hi-Fi and Disco applications.** All units have attractive cast aluminium (ground finish) fixing escutcheons.
Specification and Prices.

15" 100 watt R.M.S. Impedance 8 ohms. 50 oz. magnet. 2" aluminium voice coil. Res. Freq. 20 Hz. Freq. Resp. to 2.5KHz. Sens. 97dB. Price: £34.00 each + £3.00 P&P

12" 100 watt R.M.S. Impedance 8 ohms. 50 oz. magnet. 2" aluminium voice coil. Res. Freq. 25Hz. Freq Resp. to 4 KHz. Sens. 95dB. Price: £24.50 each + £3.00 P&P

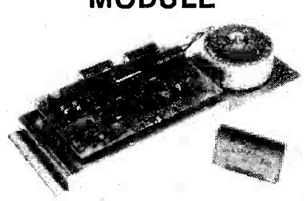
8" 50 watt R.M.S. Impedance 8 ohms. 20 oz. magnet. 1½" aluminium voice coil. Res. Freq. 40Hz. Freq. Resp to 6 KHz. Sens. 92dB. Black Cone. Price: £9.50 each. Also available with black protective grille Price: £9.99 each. P&P £1.50.

12" 85 watt R.M.S. McKENZIE C1285GP (LEAD GUITAR, KEYBOARD, DISCO) 2" aluminium voice coil, aluminium centre dome, 8 ohm imp., Res. Freq. 45Hz., Freq. Resp. to 6.5KHz., Sens, 98dB. **Price: £23.00** + £3 carriage.

12" 85 watt R.M.S. McKENZIE C1285TC (P.A., DISCO) 2" aluminium voice coil. Twin cone. 8 ohm. imp., Res. Freq. 45HZ., Freq. Resp. to 14KHz. **Price £23** + £3 carriage.

15" 150 watt R.M.S. McKENZIE C15 (BASS GUITAR, P.A.) 3" aluminium voice coil. Die cast chassis. 8 ohm imp., Res. Freq. 40Hz., Freq. Resp. to 4KHz. **Price: £47** + £4 carriage.

OMP POWER AMPLIFIER MODULE



New model.
Improved specification

NEW OMP100 Mk.II POWER AMPLIFIER MODULE Power Amplifier Module **complete** with integral heat sink, toroidal transformer power supply and glass fibre p.c.b. assembly. Incorporates drive circuit to power a compatible LED Vu meter. New **improved** *specification makes this amplifier ideal for P.A., Instrumental and Hi-Fi applications.*

SPECIFICATION
Output Power:— 110 watts R.M.S.
Loads:— Open and short circuit proof 4/16 ohms.
Frequency Response:— 15Hz - 30KHz -3dB.
T.H.D.:— 0.01%.
S.N.R. (Unweighted):— -118dB ±3.5dB.
Sensitivity for Max Output:— 500mV @ 10K.
Size:— 360 x 115 x 72 mm Price:— £31.99 + £2.00 P&P. Vu Meter Price:— £7.00 + 50p P&P.

MOSFET versions available up to 300W. R.M.S.

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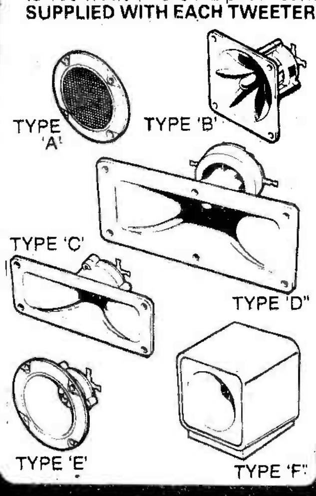

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TYPE 'C' (KSN6016A) 2" × 5" wide dispersion horn. For quality Hi-fi systems and quality discos etc. **Price £5.99 each.**

TYPE 'D' (KSN1025A) 2" × 6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. **Price £7.99 each.**

TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-fi monitor systems etc. **Price £4.99 each.**

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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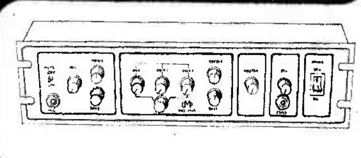
MIXERS Disco

OMP PRO MIX MONO



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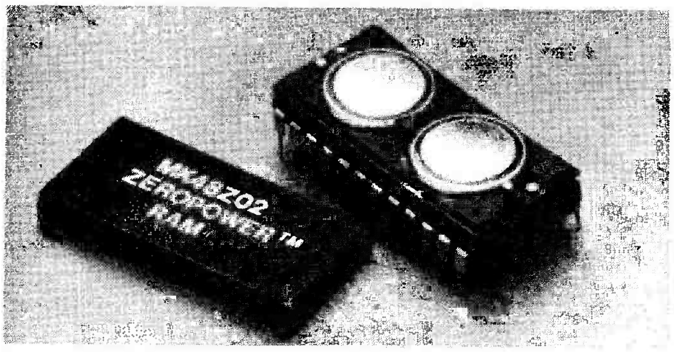
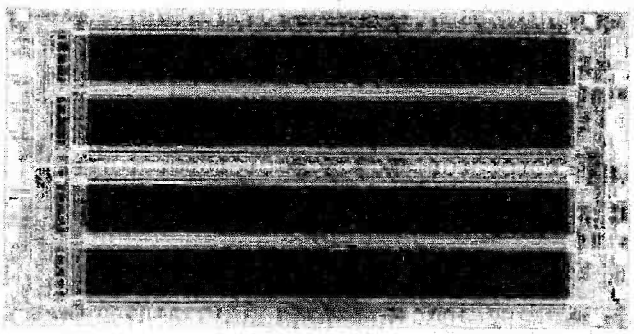


Non-Volatile Static RAM

It seems such an obvious idea that we are amazed no one has tried it before! In order to give their new 16K static RAM the retention characteristics of a ROM, Mostek Corporation have included a lithium energy source within the IC package itself.

Designated the MK48Z02 Zeropower RAM, the new device uses HCMOS technology to ensure low current drain, resulting in a minimum operating life of five years (at 25°C) on its internal lithium cell. It is organised as 8 × 2K, comes in a standard 24-pin DIP package, and has the same pin-out as, for example, the 2716 EPROM, allowing it to directly replace 16K static RAMs in many applications. No additional circuitry is required for interfacing to microprocessors since access time, read cycle, and write cycle are all below 250 nS and require only a single +5V supply. Features include an automatic write protection circuit which comes into operation whenever Vcc drops below 4.5 volts, thus preventing inadvertent loss of data on power up and power down, and, as with other static RAMs, there is no limit on the number of write cycles that can be performed.

The MK48Z02 Zeropower RAM is available in 200 nS and 250 nS access time versions, and one-off prices are around £43 and £39 respectively. Mostek UK Ltd, 1 Valley Drive, Kingsbury Road, London NW9, tel. 01-204 9322.



Third-Generation 64K RAM

United Technologies' Mostek Corporation claim to have produced a third-generation 64K dynamic RAM which provides access times of 80 ns to 120 ns. The MK45H64 uses the latest Mostek scaled NMOS process technology known as the LD3 process, featuring silicon gate, double-level poly interconnect, 1.5u channel lengths and 200 A capacitor oxide for maximum critical charge. It can be used in virtually any on-line storge memory system, including mainframe computers, minicomputers, microcomputers, and with microprocessors, and in applications such as video and graphics memory, buffer memory and terminal memory.

Multiplexed address inputs allow the MK45H64 64K dynamic RAM to be packaged in a standard 16-pin DIP with only 15 pins required for basic functionality. It is designed to be compatible with the JEDEC standards for 64K × 1 dynamic RAMs, and features very fast page mode cycle times (equal to RAS access) and has TRAS (max) specified at 40 uS, allowing an entire page of 256 bits to be accessed within a single RAS cycle. The device also features a hidden refresh cycle which enables the component's output to be held valid for up to 40uS by holding CAS active low, allowing refresh cycles to be performed while holding data valid from a previous cycle.

Mostek U.K. Ltd, 1 Valley Drive, Kingsbury Road, London NW9. tel 01-204 9322.

Stepper Motor Control/Drive IC

New from RIFA is a monolithic IC designed for controlling and driving bipolar stepper motors, or the direct control of d.c. motors, solenoids or relays.

The PBL 3717 is a 16-pin monolithic bipolar IC that includes LS-TTL-microprocessor compatible logic inputs, three addressable current comparators, and a full H-bridge output stage with built-in protection diodes. Configured with one winding of a bipolar stepper motor, the PBL 3717 requires very few external components to form a complete control and drive stage within LS-TTL or microprocessor-based stepper motor systems. It is capable of either half- or full-step modes, and offers a range of current control from 5mA to 500mA continuous without a heat sink, up to 800mA with a heat sink, and 1.0 A peak. Current levels may be either selected in steps or continuously varied, and supply voltage range is from 10V to 45V with a 15V reference input. It will accept analogue or digital logic inputs of 6V at 10mA, for which the ideal rise and fall times are stated as 2.0us.

Though designed principally for stepper motor applications, the PBL 3717 may alternatively be used to drive conventional d.c. motors by the appropriate adjustment of its input signals.

The operational temperature range of the PBL 3717 is 0 to +70°C, and it is produced in the industry standard 16-pin plastic DIL package. RIFA AB, Market Chambers, Shelton Square, Coventry, Tel (0203 27259

IGT Is Here

The General Electric Company of the USA has announced the commercial availability of a new type of power semiconductor device called the Insulated Gate Transistor or IGT. It is a gate turn on-turn off device in which, it is claimed, the advantages of power MOSFETs and bipolar transistors are combined. The result is a device which has a high input impedance like a MOSFET but a low on-state conduction loss like bipolar transistors.

The cell design and MOS gate structure of the IGT are similar to that of power MOSFETs. The major difference is that the resistance of the epitaxial drain region is modulated to a low value when the gate is turned on, resulting in very low on-state voltage drops and a forward conduction characteristic similar to a PIN rectifier. This allows devices rated at 500 V to operate at current densities twenty times greater than power MOSFETs and five times greater than bipolar transistors, giving a significant reduction in both chip size and cost.

IGTs either already available or soon to be introduced include a 10 A, 500 V device in a TO-220 package and a 25 A, 500 V device in a TO-218 package. They are available with a range of gate turn off times from about four micro seconds down to less than 1 microsecond. General Electric say that IGTs will cost much less than equivalent power MOSFETs and will compare favourably with bipolar transistors and darlingtons. International General Electric Company of New York, Demesne, Dundalk, Ireland, tel 010-35342 32371.

High-Performance Sample-and-Hold Amplifier

Zeltex have introduced a new sample-and-hold amplifier known as the ZMP-241 which, when used in front of 16-bit converters, has demonstrated an error contribution so small as to be impossible to discern at the output of the ADC.

The amplifier has been optimised for use with 16-bit A-Ds where it allows sampled data rates of over 58 kHz to be achieved. Data sheet figures include a settling time of 10µsec for a 20V step, a slew rate of 5V per µsec and a small signal bandwidth of 700 kHz. Peak-to-peak noise over the 10 Hz to 100 kHz frequency range is only 75µV, and the droop rate, a measure of how long a sample-and-hold amplifier maintains its accuracy after a sample has been taken, is 5mV per second.

100-off price of the ZMP-241 is £64 and it comes in a 50 × 50 × 10 mm metal case which provides a very high level of radio frequency interference screening. Data Beta Limited, 23A Buckingham Avenue, Slough, Berkshire, SL1 4QA. Tel: (0753) 75933/4.

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BBC Micro Computer System

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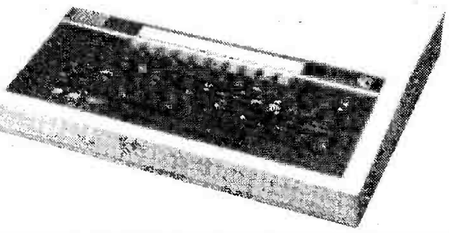

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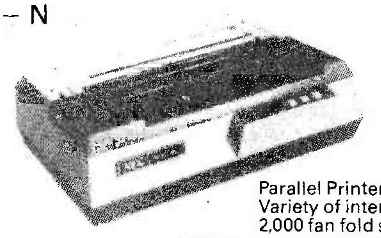

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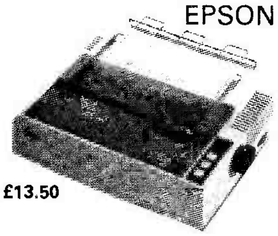

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This board provides 8 high quality 28 pin sockets for expanding the computer's sideways ROM capacity by a further 128K. (As 8K Eproms consume about 40mA on standby and 16K much higher, in our opinion addition of 8 extra ROMS will not overload the computer psu nor cause internal overheating). All ROM sockets are of turned pin type gold contacts to ensure that numerous insertions and extractions will not wear out or deform them. The board is fully buffered and also dimensioned to ensure non interference with other on board components. Full fitting instructions supplied. **£25 + £2 p&p.**

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For little more than the cost of an 800K disc drive, you can now considerably extend your BBCs capabilities. The twin drives, together with the Z80 card, gives you 64K of memory and includes a database, word processor etc. Comes complete with manuals, CP/N Operating System, Demonstration and Utility programs etc. The system is fully compatible with CP/M* thus allowing the use of professional business software. **£825 + £8 p&p.**
Special offer from Torch: free software worth £1,000, for a limited period only and subject to availability.
*CP/M is a trademark of Digital Research.

CONNECTOR SYSTEMS

I.D. CONNECTORS
(Speedblock Type)

No of ways	Header Plug	Receptacle	Edge Conn.
10	**90p**	**85p**	**120p**
20	**145p**	**125p**	**195p**
26	**175p**	**150p**	**240p**
34	**200p**	**160p**	**320p**
40	**220p**	**190p**	**340p**
50	**235p**	**200p**	**390p**

JUMPER LEADS
24'' Ribbon Cable with Headers

	14-pin	16 pin	24 pin	40-pin
1 end	**145p**	**165p**	**240p**	**350p**
2 ends	**210p**	**230p**	**345p**	**540p**

24'' Ribbon Cable with Sockets

	20-pin	26 pin	34-pin	40-pin
1 end	**160p**	**200p**	**280p**	**300p**
2 ends	**290p**	**370p**	**480p**	**525p**

Ribbon Cable with D. Conn.
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10-way	**40p**
16-way	**60p**
20-way	**85p**
26-way	**120p**
34-way	**160p**
40-way	**180p**
50-way	**200p**
64-way	**280p**

D CONNECTORS

No. of ways	9	15	25	37
MALE				
Solder	**80p**	**105p**	**160p**	**250p**
Angled	**150p**	**210p**	**250p**	**365p**
FEMALE				
Solder	**105p**	**160p**	**200p**	**335p**
Angled	**165p**	**215p**	**290p**	**440p**
Hoods	**90p**	**85p**	**90p**	**100p**

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RS 232 JUMPERS
(25-way D)
24'' Single end Male **£5.00**
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EURO CONNECTORS

	Plug	Skt.
DIN 41617		
21-way	**160p**	**165p**
31-way	**170p**	**170p**
DIN 4161Z		
2×32-way St. Pin	**220p**	**275p**
2×32-way Ang. Pin	**275p**	**320p**
3×32-way St. Pin	**260p**	**300p**
3×32-way Ang. Pin	**375p**	**350p**

EDGE CONNECTORS

	0.1''	0.156''
2×18-way	–	**140p**
2×22-way	**190p**	**240p**
2×23-way	**175p**	–
2×25-way	**225p**	**220p**
2×28-way	**190p**	–
1×43-way	**260p**	–
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DIL HEADERS

	Solder Type	IDC Type
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16pin	**50p**	**110p**
24pin	**100p**	**150p**
40pin	**200p**	**225p**

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7422	22p
7423	22p
7425	25p
7426	24p
7427	22p
7428	22p
7430	18p
7432	22p
7433	22p
7437	22p
7438	60p
7439	36p
7440	22p
7441	55p
7442A	40p
7444	70p
7445	75p
7446A	50p
7447A	65p
7448	65p
7450	20p
7451	18p
7453	20p
7454	20p
7460	30p
7470	30p
7472	25p
7473	25p
7474	27p
7475	32p
7476	25p
7480	48p
7481	120p
7482	90p
7483A	48p
7484A	90p
7485	90p
7486	30p
7489	170p
7490A	32p
7491	48p
7492A	36p
7493A	32p
7494	75p
7495A	38p
7496	50p
7497	120p
74100	120p
74104	50p
74105	55p
74107	27p
74109	27p
74110	45p
74111	55p
74112	170p
74116	90p
74118	90p
74119	75p
74120	75p
74121	32p
74122	36p
74123	45p
74125	34p
74126	36p
74128	45p
74132	43p
74136	38p
74141	55p
74142	175p
74143	200p
74144	200p
74145	75p
74147	90p
74148	75p
74150	120p
74151A	40p
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74160	55p
74161	55p
74162	55p
74163	55p
74164	60p
74165	75p
74166	90p
74167	200p
74170	150p
74172	250p
74173	65p
74174	55p
74175	50p
74176	55p
74177	50p
74178	90p
74179	90p
74180	55p
74181	140p
74182	50p
74184	120p
74185A	120p
74190	60p
74191	60p
74192	60p
74193	60p
74194	50p
74195	50p
74196	48p
74197	48p
74198	120p
74199	120p
74221	80p
74251	60p
74259	100p
74265	55p
74273	120p
74276	120p
74278	100p
74279	55p
74283	50p
74285	160p
74286	160p
74290	75p
74293	90p
74298	120p
74351	150p
74365A	48p
74366A	48p
74367A	48p
74368A	48p
74376	100p
74390	90p
74393	150p
74490	120p

74LS SERIES

74LS00	20p
74LS01	20p
74LS02	20p
74LS03	20p
74LS04	20p
74LS05	20p
74LS08	20p
74LS09	20p
74LS10	20p
74LS11	20p
74LS12	20p
74LS13	25p
74LS14	36p
74LS15	20p
74LS20	20p
74LS21	20p
74LS22	20p
74LS26	20p
74LS27	20p
74LS28	20p
74LS30	20p
74LS32	25p
74LS33	20p
74LS37	20p
74LS38	20p
74LS40	20p
74LS42	36p
74LS47	60p
74LS48	60p
74LS51	20p
74LS54	20p
74LS55	20p
74LS73A	20p
74LS74A	30p
74LS75	30p
74LS76A	27p
74LS83A	46p
74LS85	60p
74LS86	25p
74LS90	32p
74LS91	60p
74LS92	40p
74LS93	32p
74LS95B	50p
74LS96	90p
74LS107	33p
74LS109	33p
74LS112	33p
74LS113	30p
74LS114	32p
74LS122	60p
74LS123	60p
74LS124/629	150p
74LS125	36p
74LS126	36p
74LS132	42p
74LS133	30p
74LS136	30p
74LS138	42p
74LS139	42p
74LS145	75p
74LS147	120p
74LS148	120p
74LS151	50p
74LS153	50p
74LS154	150p
74LS155	40p
74LS156	40p
74LS157	40p
74LS158	35p
74LS160A	50p
74LS161A	50p
74LS162A	45p
74LS163A	45p
74LS164	48p
74LS165A	60p
74LS166A	90p
74LS168	140p
74LS169	110p
74LS170	100p
74LS173A	90p
74LS174	45p
74LS175	45p
74LS181	120p
74LS183	120p
74LS190	60p
74LS191	60p
74LS192	60p
74LS193	60p
74LS194A	50p
74LS195A	50p
74LS196	60p
74LS197	54p
74LS221	80p
74LS240	70p
74LS241	70p
74LS242	60p
74LS243	60p
74LS244	70p
74LS245	140p
74LS247	70p
74LS248	70p
74LS249	70p
74LS251	45p
74LS253	45p
74LS256	200p
74LS257A	45p
74LS258A	45p
74LS259	80p
74LS260	35p
74LS261	80p
74LS266	25p
74LS273	75p
74LS275	175p
74LS279	35p
74LS280	180p
74LS283	50p
74LS290	55p
74LS292	900p
74LS293	50p
74LS295	70p
74LS297	900p
74LS298	65p
74LS299	200p
74LS321	240p
74LS323	200p
74LS324/624	150p
74LS348	140p
74LS352	70p
74LS353	70p
74LS356	175p
74LS363	180p
74LS364	180p
74LS365A	36p
74LS366A	36p
74LS367A	36p
74LS368A	36p
74LS373	75p
74LS374	75p
74LS375	60p
74LS377	90p
74LS378	85p
74LS379	92p
74LS390	60p
74LS393	90p
74LS395A	100p
74LS399	120p
74LS445	100p
74LS465	120p
74LS466	120p
74LS467	120p
74LS490	130p
74LS540	120p
74LS541	150p
74LS608	700p
74LS610	£19
74LS612	£19
74LS624	150p
74LS626	150p
74LS628	150p
74LS629	150p
74LS640	200p
74LS640-1	250p
74LS641	200p
74LS642-1	250p
74LS643	200p
74LS643-1	250p
74LS644	200p
74LS645	200p
74LS645-1	250p
74LS668	70p
74LS669	70p
74LS670	120p
74LS674	550p
74LS682	250p
74LS684	400p
74LS687	450p

74S SERIES

74S00	30p
74S02	30p
74S04	30p
74S05	60p
74S08	60p
74S10	40p
74S11	60p
74S20	40p
74S21	50p
74S22	50p
74S30	40p
74S32	70p
74S37	60p
74S51	75p
74S74	75p
74S85	300p
74S86	90p
74S112	90p
74S113	90p
74S114	90p
74S124	300p
74S132	110p
74S133	60p
74S138	110p
74S139	120p
74S140	60p
74S151	180p
74S153	180p
74S157	250p
74S158	195p
74S163	300p
74S174	250p
74S175	320p
74S188	150p
74S194	300p
74S195	300p
74S196	300p
74S200	450p
74S201	320p
74S225	650p
74S240	250p
74S241	300p
74S244	300p
74S251	250p
74S258	250p
74S260	70p
74S261	300p
74S262	850p
74S283	300p
74S287	225p
74S288	150p
74S299	550p
74S373	400p
74S374	400p
74S387	250p
74S472	1150p
74S474	400p
74S475	825p
74S571	620p
74S573	900p

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74C00	20p
74C04	20p
74C08	20p
74C10	20p
74C14	30p
74C20	20p
74C32	25p
74C42	80p
74C48	120p
74C73	50p
74C74	45p
74C76	50p
74C83	120p
74C85	120p
74C86	30p
74C90	70p
74C93	70p
74C95	106p
74C107	70p
74C150	300p
74C151	100p
74C154	300p
74C157	150p
74C160	90p
74C161	90p
74C162	90p
74C163	90p
74C173	48p
74C174	90p
74C175	90p
74C192	100p
74C193	115p
74C194	120p
74C195	100p
74C221	150p
74C244	160p
74C245	180
74C373	160p
74C374	160p
74C902	70p
74C911	750p
74C912	700p
74C922	370p
74C923	450p
74C925	500p
74C926	500p
74C928	500p

74ALS Series

74ALS00	30p
74ALS02	30p
74ALS04	30p
74ALS08	30p
74ALS10	35p
74ALS20	35p
74ALS32	35p
74ALS74	50p
74ALS138	150p
74ALS139	150p
74ALS573	200p
74ALS574	400

4000 CMOS

4000	10p
4001	10p
4002	12p
4006	50p
4007	14p
4008	36p
4009	24p
4010	24p
4011	11p
4012	16p
4013	20p
4014	48p
4015	40p
4016	20p
4017	32p
4018	45p
4019	25p
4020	48p
4021	40p
4022	45p
4023	13p
4024	32p
4025	13p
4026	80p
4027	20p
4028	40p
4029	45p
4030	15p
4031	125p
4032	80p
4033	125p
4034	140p
4035	40p
4036	275p
4037	110p
4038	110p
4039	290p
4040	40p
4041	40p
4042	40p
4043	40p
4044	40p
4045	105p
4046	50p
4047	50p
4048	50p
4049	24p
4050	24p
4051	45p
4052	60p
4053	60p
4054	50p
4055	90p
4056	90p
4059	450p
4060	55p
4063	90p
4066	27p
4067	225p
4068	14p
4069	14p
4070	14p
4071	14p
4072	14p
4073	14p
4075	14p
4076	48p
4077	16p
4078	16p
4081	14p
4082	15p
4086	55p
4089	125p
4093	24p
4094	90p
4095	75p
4096	70p
4097	290p
4098	90p
4099	100p
4500	575p
4502	60p
4503	45p
4504	75p
4505	400p
4506	35p
4507	35p
4508	130p
4510	45p
4511	45p
4512	48p
4514	120p
4515	110p
4516	55p
4518	40p
4520	50p
4521	90p
4522	120p
4526	60p
4527	60p
4528	50p
4532	70p
4534	400p
4536	270p
4538	90p
4539	70p
4543	75p
4553	245p
4555	35p
4556	35p
4557	300p
4560	120p
4566	160p
4568	250p
4569	170p
4572	30p
4583	90p
4584	40p
4585	75p
40014	40p
40085	90p
40097	45p
40102	140p
40103	170p
40105	110p
40106	40p
40109	100p
40110	275p
40163	60p
40174	50p
40175	75p
40193	75p
40244	160p
40245	180p
40257	160p
40373	160p
40374	160p
14411	700p
14412	800p
14416	380p
14419	280p
14490	350p
14495	300p
14500	700p
14599	290p

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74C926	£5
74C928	£6
72168	£22
ZN1040	670p

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ADC0808	990p
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AY1-5050	99p
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AY3-8912	500p
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CA3019	80p
CA3046	70p
CA3048	220p
CA3059	285p
CA3060	350p
CA3080E	70p
CA3086	48p
CA3089E	200p
CA3090AQ	375p
CA3130E	90p
CA3130T	110p
CA3140E	40p
CA3140T	90p
CA3160E	100p
CA3161E	150p
CA3162E	450p
CA3189E	300p
CA3240E	110p
CA3280G	200p
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DAC0808	£2
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ICL7660	250p
ICL7611	95p
ICL8038	300p
ICM7217	750p
ICM7555	80p
ICM7556	140p
LC7120	300p
LC7130	325p
LC7137	270p
LF347	150p
LF351	48p
LF353	95p
LF356P	95p
LF357	110p
LF13331	350p
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LM301A	25p
LM307	50p
LM308N	75p
LM310	120p
LM311	70p
LM318	150p
LM319	215p
LM319N	160p
LM324	30p
LM334Z	90p
LM335Z	140p
LM339	40p
LM348	65p
LM358P	60p
LM377	175p
LM380	75p
LM381AN	180p
LM382	120p
LM386	90p
LM387	120p
LM389	95p
LM391	150p
LM392N	60p
LM393	100p
LM394CH	300p
LM709	36p
LM710	50p
LM711	70p
LM725	300p
LM733	60p
LM741	18p
LM747	70p
LM748	35p
LM1011	480p
LM1014	150p
LM1801	300p
LM1830	250p
LM1871	300p
LM1872	300p
LM1886	£5
LM1889	350p
LM2917	200p
LM3302	75p
LM3900	50p
LM3909	85p
LM3911	125p
LM3914	200p
LM3915	200p
LM3916	225p
LM13600	110p
M51513L	230p
M51516L	500p
MB3712	200p
MB3730	400p
MC1310P	150p
MC1413	75p
MC1458	36p
MC1493	100p
MC1495L	350p
MC1496	70p
MC3340P	120p
MC3401	50p
MC3403	65p
MF10CN	320p
MK50240	900p
MK50398	700p
ML920	800p
MM57160	620p
MN6221A	600p
NE531	140p
NE544	150p
NE555	16p
NE556	45p
NE564	420p
NE565	120p
NE566	155p
NE567	140p
NE570	410p
NE571	400p
NE592	60p
NE5532	130p
NE5533	140p
NE5534P	110p
NE5534AP	125p
PLL02A	500p
RC4136	60p
S566B	225p
SAA1900	£16
SAD1024A	1150p
SFF96364	800p
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SP0256AL	£10
TA7120	300p
TA7130	160p
TA7204	150p
TA7205	90p
TA7222	150p
TA7310	150p
TBA231	120p
TBA800	80p
TBA810	100p
TBA820	80p
TBA950	225p
TC9109	750p
TCA210	250p
TCA220	350p
TCA270	350p
TCA940	175p
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TDA1008	320p
TDA1010	200p
TDA1022	500p
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TDA1170	300p
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TL083	75p
TL084	90p
TL094	200p
TL170	50p
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UA2240	120p
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XR210	400p
XR2206	400p
XR2211	575p
XR2240	120p
ZN414	80p
ZN419C	190p
ZN423E	130p
ZN424E	130p
ZN425E	340p
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ZN428E	450p
ZN429E	210p
ZN450E	790p
ZN459	600p
ZN1034E	200p
ZN1040E	670p
ZNA134	£23
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VOLTAGE REGULATORS
FIXED PLASTIC

1A	+ve		-ve	
5V	7805	40p	7905	45p
6V	7806	40p	7906	45p
8V	7808	40p	7908	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p	7924	45p
5V 100mA	78L05	30p	79L05	45p
6V 100mA	78L06	30p		
8V 100mA	78L08	30p		
12V 100mA	78L12	30p	79L12	50p
15V 100mA	78L15	30p	79L15	50p

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AD161/2	45p
BC107/8	13p
BC109C	14p
BC169C	12p
BC172	12p
BC177/8	17p
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BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC337	16p
BC338	16p
BC461	25p
BC477/8	30p
BC516/7	40p
BC547B	14p
BC548C	12p
BC549C	16p
BC557B	14p
BC559C	16p
BCY70	18p
BCY71	22p
BD131	75p
BD132	80p
BD135/6	40p
BD139	40p
BD140	40p
BD189	60p
BD232	60p
BD233	75p
BD235	85p
BD241	60p
BD242	60p
BD379	60p
BD380	60p
BD677	40p
BF244B	35p
BF256B	50p
BF257/8	32p
BF337	30p
BF39	25p
BFR40/1	25p
BFR79	25p
BFR80/1	25p
BFR96	180p
BFX29	40p
BFX30	27p
BFX84/5	25p
BFX86/7	27p
BFX88	27p
BFX89	180p
BFY50	24p
BFY51/2	24p
BFY56	33p
BFY90	80p
BRY39	45p
BSX19/20	24p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
BUX80	600p
BUY69C	350p
E310	50p
MJ802	400p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJ4502	400p
MJE340	60p
MJE2955	100p
MJE3055	70p
MPF102	40p
MPF103/4	30p
MPF105	30p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSA93	40p
MPSU06	63p
MPSU07	60p
MPSU56	90p
MPSU65	78p
TIP29A	35p
TIP29C	40p
TIP30A	35p
TIP30C	40p
TIP31A	40p
TIP31C	45p
TIP32A	40p
TIP32C	40p
TIP33C	80p
TIP34A	90p
TIP34C	120p
TIP35A	120p
TIP35C	140p
TIP36A	130p
TIP36C	150p
TIP41A	50p
TIP41C	55p
TIP42A	60p
TIP42C	65p
TIP54	160p
TIP120	75p
TIP121	75p
TIP122	80p
TIP142	120p
TIP147	120p
TIP2955	78p
TIP4055	70p
TIS93	30p
VN10KM	50p
VN66AF	90p
VN88AF	£1
ZTX108	12p
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ZTX452	45p
ZTX500	15p
ZTX502	16p
ZTX504	18p
ZTX552	55p
ZTX652	60p
ZTX752	70p
2N697	25p
2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	36p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	25p
2N2222A	25p
2N2369A	17p
2N2484	25p
2N2646	40p
2N2904/5	25p
2N2906A	25p
2N2907A	25p
2N2926	9p
2N3053	25p
2N3054	55p
2N3055	35p
2N3442	140p
2N3553	240p
2N3584	250p
2N3643/4	48p
2N3702/3	10p
2N3704/5	10p
2N3706/7	10p
2N3708	10p
2N3773	200p
2N3819	20p
2N3823	30p
2N3866	90p
2N3902	700p
2N3904	15p
2N3906	16p
2N4037	65p
2N4056	65p
2N4123/4	27p
2N4125/6	27p
2N4401/3	27p
2N4427	90p
2N4871	50p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5245	40p
2N5401	60p
2N5459	30p
2N5460	60p
2N5485	36p
2N5875	250p
2N6027	30p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1306	100p
2SC1307	150p
2SC1957	90p
2SC1969	150p
2SC2028	80p
2SC2029	200p
2SC2078	160p
2SC2335	200p
2SC2612	200p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	200p
40290	250p
40361/2	75p
40408	90p
40409	100p
40410	100p
40594	120p
40595	120p
40673	75p
40871/2	100p

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68B09E	£16
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8039	300p
8080A	250p
8085A	350p
8086	£22
8088	£18
8748	£18
INS8060	£11
TMS1601	£12
TMS9980	£20
TMS9995	£12
Z8	£24
Z80A	300p
Z80AS10/0/1	£9
Z80AS10/2/9	£9
Z80B	£9
8279	440p
8284	350p
8288	£11
8755	£16
9901	£10
9902	£3
TMS4500	£14
TMS5220	£12
TMS9909	£9
TMS9911	£16
Z80P10	250p
Z80AP10	280p
Z80CTC	250p
Z80ACTC	280p
Z80ADART	700p
Z80ADMA	£9
Z80SI 0/1/2	£9

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6522	310p
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6532	550p
6551	650p
6821	100p
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4164-15	450p
4416-15	500p
4532-20	250p
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5101	300p
5516	750p
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6116LP-3	550p
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DS8836	150p
DS8838	225p
DS8880	170p
LF13201	450p
MC1488	55p
MC1489	55p
MC3418	950p
MC3446	250p
MC3459	450p
MC3470	650p
MC3480	850p
MC3486	500p
MC3487	300p
MC4024	325p
MC4044	325p
MC14411	675p
MC14412	750p
75107	90p
75110/12	160p
75114/15	160p
75121/22	140p
75150P	120p
75154	140p
75159	220p
75365	150p
75451/2	72p
75453/4	72p
75491/2	65p
8T26	120p
8T28	120p
8T95/96	90p
8T97/98	90p
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2.00	225p
2.45760	210p
2.5	250p
2.662	250p
3.276	150p
3.5795	100p
3.686	300p
4.00	150p
4.194	200p
4.43	110p
4.608	250p
4.915	250p
5.0	175p
5.068	£2
6.0	150p
6.144	150p
7.0	150p
7.168	175p
8.00	175p
8.86	175p
10.00	175p
10.5	250p
10.7	150p
12.00	150p
14.318	175p
14.756	250p
15.00	200p
16.00	200p
17.7	200p
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24 pin	24p
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16 pin	45p
18 pin	50p
20 pin	66p
22 pin	75p
24 pin	75p
28 pin	100p
40 pin	130p

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BY127	12p
BYX36300	20p
OA47	8p
OA90/91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/2	12p
1N5403/4	14p
1N5404/5	14p
1N5404/7	19p
IS920	9p

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1A 100V	20p
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2A 100V	35p
2A 400V	45p
3A 200V	60p
3A 600V	72p
4A 100V	95p
4A 400V	100p
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6A 100V	100p
6A 400V	120p
10A 400V	200p
25A 400V	400p

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6A 500V	88p
8A 400V	75p
8A 500V	95p
12A 400V	85p
12A 500V	105p
16A 400V	110p
16A 500V	130p
T2800D	130p
TIC 206D	60p
TIC 226D	75p
TIC 246D	110p

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8A 600V	180p
12A 400V	160p
16A 100V	180p
16A 400V	180p
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ACE INTERFACE

Game playing and typing in should be fast and furious on the Jupiter Ace because of the use of FORTH. But with a membrane keyboard? Doug Bollen shows how to get round the rubber.

It is strange that something as simple as a set of keys and a joystick should pose such a problem for both makers and users of low cost computers. Beneath that intractable rubber keyboard, in an unassuming plastic box, lies many a good computer, spoilt by the lack of a real human interface. Of course, the reason for this is a price differential of at least twenty-five quid.

A typewriter-style keyboard can reduce frustration, and more than double program and test entering speed if the key-scan plus display routine in the computer ROM is fast enough to cope with fleeting fingers. Old mini and mainframe keyboards can be picked up now and then quite cheaply, and some of them have excellent magnetic switches. Alternatively, a good low-cost keyboard may be built with readily available switches mounted on a piece of Veroboard.

Video games are great fun, but can you imagine piloting an airliner or spacecraft with four keypresses? There is no standard for games software direction keys so a programmable joystick is an absolute necessity for the dedicated games-player.

Once you've acquired a keyboard and a joystick, you need an interface to connect them to the computer. At this rate of expenditure you could have bought a 'Flash MK IIB' computer, but never mind, it is all part of the learning process, and those plug-in-add-ons can be very versatile.

The Jupiter Ace has a fast key-scan routine which is capable of electric typewriter performance. The space key is a trifle slower than normal, but all other keys respond well, particularly when aided by a software or hardware key beep. If the relatively large user memory (51K expanded) of this compact language machine is taken into account along with its other features, an Ace with full-travel keyboard is capable of serious work in areas of text and data handling, as well as super-speed gaming.

This project allows a full-travel keyboard and a joystick, acting on

HOW IT WORKS — INTERFACE

The Ace rubber keyboard uses an input port which occupies eight addresses, but all even addresses (AØ low) are reserved for internal use. Data lines DØ-D4, and address lines A8-A15 are used for key-scan, while D5 is reserved for tape load. The remaining three data bits may be ignored here. Because the five Ace data lines are up with no keypress, and the Ace TTL keyboard buffers have a relatively high output impedance for logic 1, it is possible to pull down the data lines externally during keyscan, and this saves on hardware and software.

Ace keys are positioned in a matrix of 5 data lines by 8 address lines. In normal inputting key-scan mode, no keypress and multiple keypresses (other than shifts) return a zero; this is also the case with INKEY. If the keyboard is read by 'address IN' (refer to Fig. 3), a combination of any five keys on each matrix line YØ-Y7 will give a multiple keypress code. For example, F7FE IN (keys 1-5) is binary 111111 with no keypress, five keys at once 1ØØØØØ, key '1' on XØ 11111Ø, and key '5' on X4 1Ø1111. The MSB is the tape port which toggles between 1 and Ø only when you input a tape signal.

There is nothing very mysterious about the interface circuit of Fig. 1, it is merely a six-bit input port running in tandem with the Ace's own keyboard port, and addressed by AØ low. Two three input NORs (IC1) are configured to give an active low enable to buffer/driver IC2 during an input request. Diodes D1-D8 serve to isolate each address line. Spare input T is the alternative LOAD port. XØ-X4 and YØ-Y7 form the interface input lines.

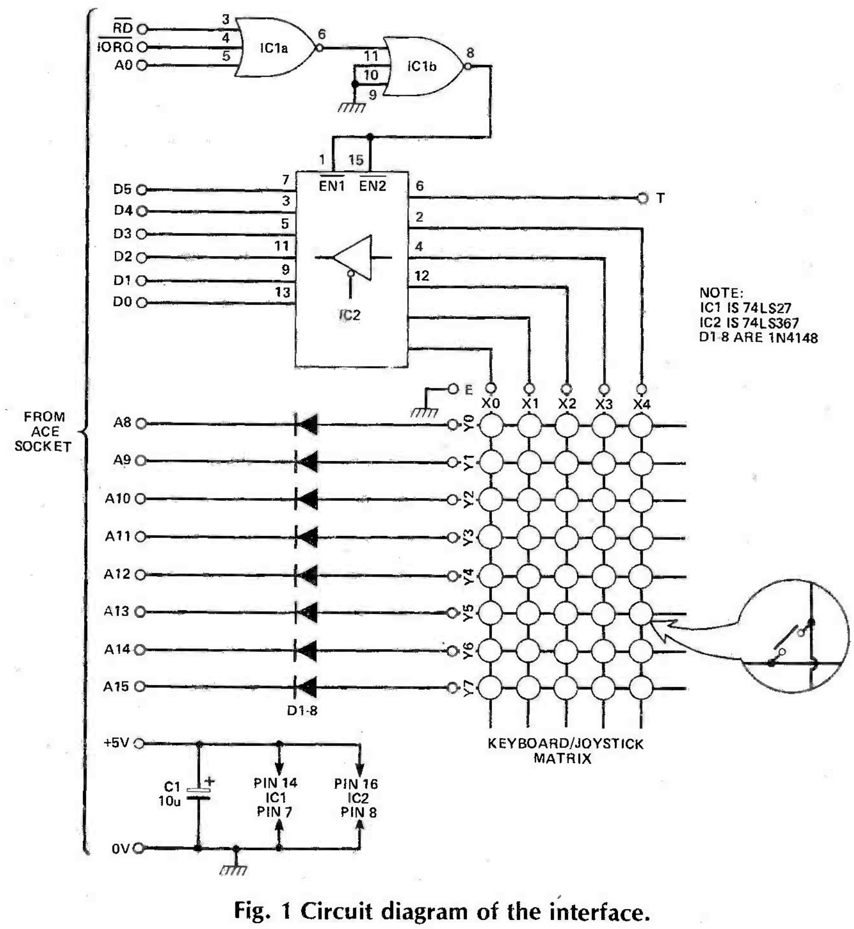
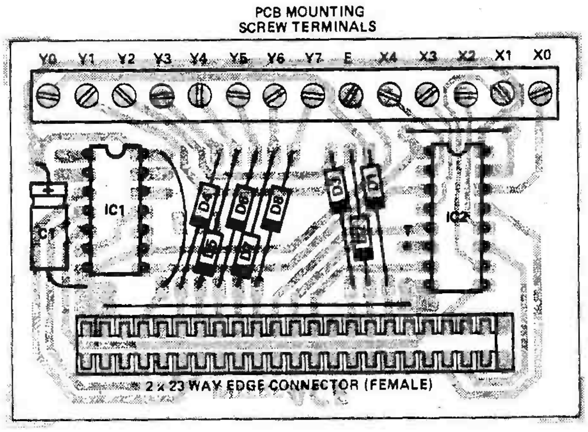


Fig. 1 Circuit diagram of the interface.



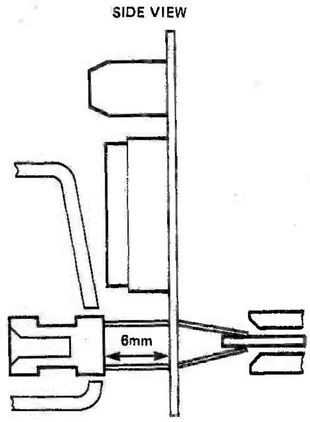


Fig. 2 (a) Overlay diagram of the PCB. **(b) detail of assembly of edge connector.**

any pre-selected group of five keys, to be plugged into the back of the Ace, which will not invalidate the manufacturer's guarantee or require additional software. The interface circuit mimics the Ace's internal hardware so that dual keyboards and joystick effectively operate in parallel and simultaneously. An additional input provides DC access to the internal tape-load port of the Ace for experimental purposes.

The ability to simulate key-press with a switch (without a mess of wires soldered to the computer mainboard) can provide a range of useful facilities. Allowing for shift functions and unprintable codes, there are 106 individual codes which may be obtained using INKEY during program execution, and each represents a discrete input channel. Multiple key-presses of up to forty keys are also possible with the IN word, or a compact machine code routine, and this will yield 255 key combinations or channels.

A three-octave monophonic music keyboard, fitted with suitable contacts, can make use of the ready-made and debounced key-scan routine in Ace ROM, and leave 70 additional channels free for other functions. Multi-key-press offers three octave polyphonic operation.

A small panel of insulated material, with forty 3.5mm jack sockets, will serve as a general purpose patch-panel for switch interfacing, and is handy for quick, softwareless joystick programming. With the switch combinations available, and an equal number of possible computer responses, many other applications should spring to mind.

Construction

Ace edge connectors are not widely available, but you can use a cut-down ZX Spectrum connector, a modified ZX81 connector, or one cut from a long block. Make sure that the edge connector wire length is at least 14mm. Some, but not all, ZX81 connectors can be modified by carefully pushing out two contacts at the end of each block with a small pair of pliers and reinserting them in the ZX blanking key position, then fitting the blanking key at the end of the row to suit the Ace.

Insert the edge connector half-way into the plain side of the PCB with the blanking key to the right.

PARTS LIST

CAPACITOR

C1	10uF 10V tubular electrolytic

SEMICONDUCTORS

IC1	74LS27
IC2	74LS367
D1-D8	1N4148

MISCELLANEOUS

Double sided 23-way edge connector (see text); 14-way PCB mounting screw terminals (see text); 14-pin IC socket; 16-pin IC socket; PCB (see Buylines); keyboard; joystick (see text).

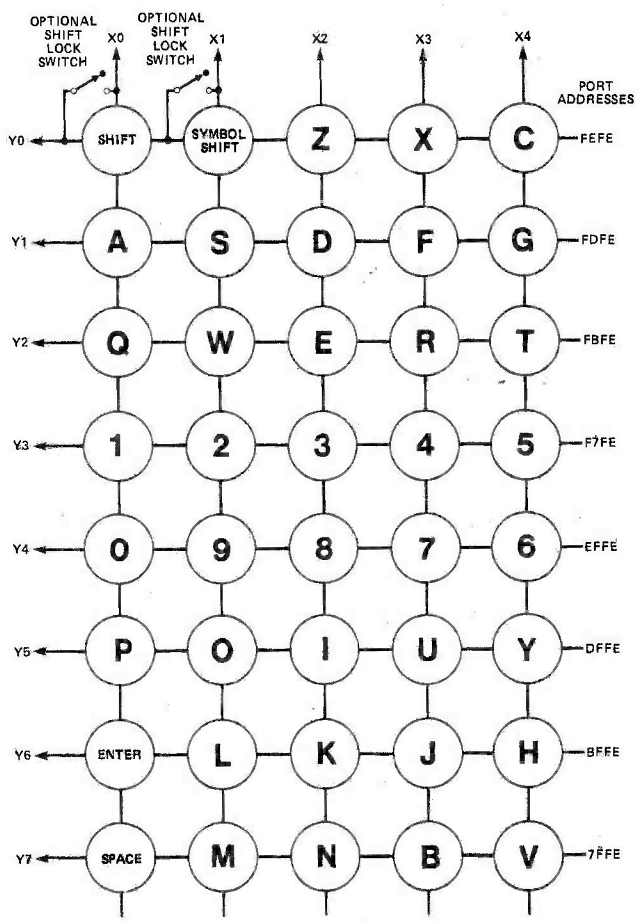


Fig. 3 The coding of the keyboard matrix

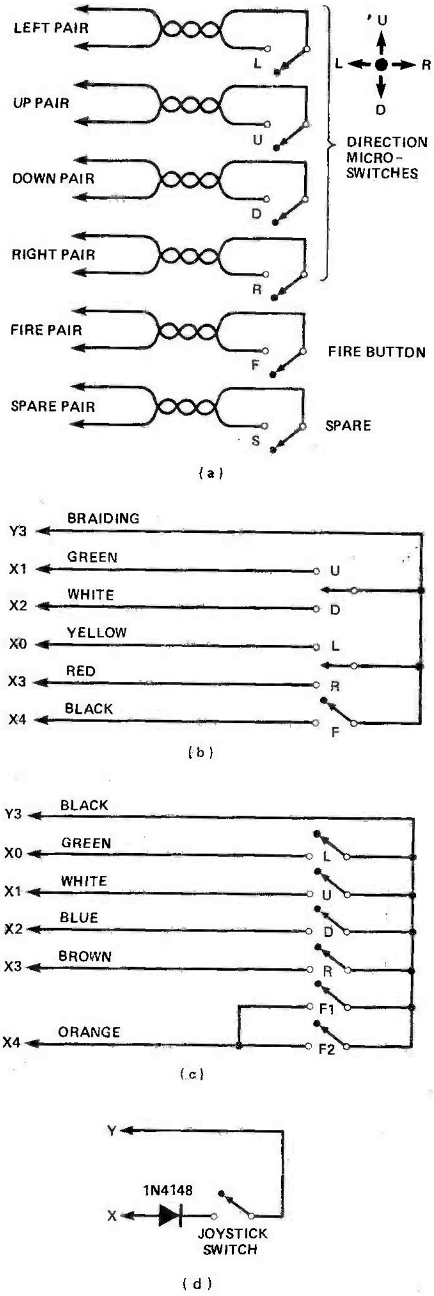


Fig. 4 Different Joystick configurations: a. a microswitch joystick rewired for the Ace and multipress on any six keys; b. pot switch joystick (Voltmace) shown for multi-press on keys 1 to 5; c. diaphragm switch joystick (Spectrovideo Quickshot) shown for multipress on keys 1 to 5; d. use of isolating diodes to avoid ghosting.

Lay a pencil along the top row of wires, on the foil side of the PCB, and apply pressure to the pencil to bend the wires inwards (see Fig. 2). Now bend the remaining row of wires inwards and adjust until the a suitable male edge connector strip into position between the wires, making sure that there is plenty of contact area free for the Rampack, and solder the wires to the strip. Position the edge connector parallel to the PCB in all planes, 6mm away from the board, and solder to the PCB.

Now check all solder joints with a magnifying glass (even if you do have good eyesight!) and look for whiskers or blobs of solder which may cause a short between adjacent strips. Clean minute blobs of flux from the extender strip with a brass wire brush. Plug the interface into the Ace and remove it, with power supplies OFF, several times, to remove oxidisation from the computer board. If you have a Rampack, push it on and off the interface rear extender strip too. Now switch on and check that the Ace behaves normally. With clean contacts, it should be possible to rock the Rampack slightly without crashing. Look for dry joints or dirty contacts if there is malfunctioning.

Insert the remaining components and link wires on the PCB, but leave out the longest link for the time being. Observe capacitor and diode polarities and DIL socket orientation. The screw terminal block can be made up of 8 + 4 + 2, 8 + 3 + 3, or 4 + 4 + 4 + 2 assemblies. It may be necessary to sandpaper the end of the blocks for a good fit on the PCB. You can insert and solder the long link wire after the diodes have been soldered.

Before inserting the ICs, check that the Ace works normally with the interface in position. Switch off, insert ICs the correct way up, and test again. The interface should have no effect on the Ace. Just to make sure, try a LOAD from a trusty tape and check all key-presses on the rubber keyboard.

Wire up the underside of your add-on keyboard according to the keyboard layout in Fig. 3, and fit optional shift lock switches if required. Try to keep switch interconnecting wiring as short as possible, to minimise circuit strays.

Your keyboard can be wired straight to the PCB terminal block, with about ½ metre of ribbon cable, and all key-presses then tested. If some keys work erratically, or are slow on repeat, try earthing the computer via the negative side of the power supply jack plug. A joystick can also be wired to the PCB terminal block, but cannot be reconfigured without switching the computer off because of edge connector wobble. It is a good idea to run a flexible length of ribbon cable from the PCB to two 2 A terminal blocks for the joystick, which can then be reconfigured while the computer is running.

Joysticks

There are many weird and wonderful joysticks now on the market. Analogue joysticks with pots are not suitable for this

```
: LEFT
 ." left"
;

: UP
 ." up"
;

: DOWN
 ." down"
;

: RIGHT
 ." right"
;

: FIRE
 ." fire"
;

: MULTIPRESS
 0 IN 31 AND ( get keypress and
mask off unwanted bits)
 DUP 1 AND 0=
 IF
  ( is D0 low?)
  LEFT
 THEN
 DUP 2 AND 0=
 IF
  ( is D1 low?)
  UP
 THEN
 DUP 4 AND 0=
 IF
  ( is D2 low?)
  DOWN
 THEN
 DUP 8 AND 0=
 IF
  ( is D3 low?)
  RIGHT
 THEN
 DUP 16 AND 0=
 IF
  ( is D4 low?)
  FIRE
 THEN
 DROP ( discard keypress)
;
: TEST
 BEGIN
  CLS MULTIPRESS 500 0
  DO
   ( slow routine down for displ
ay)
  LOOP
  0
 UNTIL
;
```

Fig. 5 Five-key FORTH multi-press routine.

HOW IT WORKS — MULTIPLE KEY ROUTINE

READ is a table containing a 5 × 8 byte array of ASCII codes relating directly to the logical layout of the Ace keyboard. At the end of this table is an 8 byte array, which is a table of keyboard port addresses (high byte only).

The word KEY picks up from the stack the start address of the READ table and the ASCII key value to be tested. It searches the table until it finds a match to the key value. If there is no match the routine is aborted with ERROR Ø as an invalid key code has been used.

By the time a valid match is found, the Z80's B and D registers contain an indirect pointer to the relevant port address for the key which is to be tested (B register), and the key's position within that port as a data bit (D register). If the bit is reset (= Ø), then the key is being pressed and a 1 is placed on the stack, otherwise a Ø is stacked, thus giving a true or false flag for testing with IF . . . THEN.

interface. There are 'floppy-stick' joysticks which do not 'click' but use switches which look like pots. Then there are diaphragm switch joysticks, and microswitch joysticks which 'click'. Leaving aside personal styling preferences and magnetic switch joysticks, the microswitch type is preferred for this interface, but diaphragm switch joysticks (Atari, Quickshot) will work over a limited range of keys and can be rewired (with some difficulty) for all keys.

If you can find or make a microswitch joystick it should be wired as in Fig. 4a. The pot type switch (Fig. 4b) cannot be rewired for all key positions, but will multipress a five key row. The diaphragm switch joystick, Fig. 4c, can be rewired for all keys by cutting the tracks on the switch PCB and rewiring as in Fig. 4a, but make sure there are no solder joints under the switch actuator plastic ring. Unmodified, the diaphragm switch type will multipress five keys as in Fig. 4b.

If you rewire the joystick according to Fig. 4a, use pairs of twisted insulated wire about ½ metre long. If you are also making a patch panel (which has a socket for each key), the joystick pairs can be terminated with 3.5mm insulated jack plugs. To configure the joystick for a program, merely insert the appropriate plug in the socket position corresponding to the keypress, or clamp the wire pairs in the terminal blocks by following the key/matrix diagram of Fig. 3.

Certain key combinations of diagonal plus fire button could conceivably produce unwanted responses with a few examples of commercial software. To avoid keypress 'ghosting', place an isolating diode in each joystick 'x' wire, as in Fig 4d.

Programming For The Interface

Good games software must be responsive and easy to control, not to be confused with difficult to play. There is nothing worse than a sluggish 'thing' which hesitantly jerks in four directions and freezes (together with the whole scenario) during a zap. It takes all the fun out of what might otherwise be an excellent game.

Multipress action is not difficult to achieve on the Ace, if INKEY is discarded in favour of IN. Up to five simultaneous keys (those in the vertical groups X0-X4 in Fig. 3 combined with other vertical groups) will give a total of 31 keypress combinations. Apart from the eight directions plus zap, pressing right plus left (or up plus down) could produce a tenth and eleventh response, but this is not possible on a joystick alone.

In the five key multipress routine Fig. 5, you supply the direction and zap definitions, in place of the demo definitions inside the dot quotes. All five-key groups are operative because MULTIPRESS uses Ø IN. If you want to employ only one group of keys, change number base to HEX, edit MULTIPRESS, and replace Ø with an address from Fig. 3, then redefine

```
CREATE READ 48 ALLOT

  IN
 16 BASE C! 48 0
 DO
  RETYPE NUMBER DROP OVER I
  + C!
 LOOP
 DECIMAL
;

: HEX
 16 BASE C!
;

READ IN

43 53 7A 78 63 61 73 64
66 67 71 77 65 72 74 31
32 33 34 35 30 39 38 37
36 70 6F 69 75 79 D 6C
6B 6A 68 20 6D 6E 62 76
FE FD FB F7 EF DF BF 7F

DEFINER MC
 VIS CR ." BYTES:"
 RETYPE NUMBER DROP CR BASE
 C@ HEX SWAP ." ENTER"
 0
 DO
  RETYPE NUMBER DROP C,
 LOOP
 CR BASE C!
DOES>
 CALL
;
REDEFINE IN

MC KEY (NOTE:on bytes prompt
enter 52)

DF D5 DF E1 E5 6 8 E
5 16 1 7E BB 28 B CB
22 D 23 20 F6 10 F0 E1
E7 0 3E 8 90 E1 1 28
0 9 85 6F 46 E FE ED
78 2F A2 11 0 0 28 1
13 D7 FD E9

DEFINER MC
DOES>
 CALL


REDEFINE MC
```

```
3FAE DF         RST  18
3FAF D5         PUSH DE
3FB0 DF         RST  18
3FB1 E1         POP  HL
3FB2 E5         PUSH HL
3FB3 06 08      LD   B,08
3FB5 0E 05      LD   C,05
3FB7 16 01      LD   D,01
3FB9 7E         LD   A,(HL)
3FBA BB         CP   E
3FBB 28 0B      JR   Z,3FC8
3FBD CB 22      SLA  D
3FBF 0D         DEC  C
3FC0 23         INC  HL
3FC1 20 F6      JR   NZ,3FB9
3FC3 10 F0      DJNZ 3FB5
3FC5 E1         POP  HL
3FC6 E7 00      RST  20,00
3FC8 3E 08      LD   A,08
3FCA 90         SUB  B
3FCB E1         POP  HL
3FCC 01 28 00   LD   BC,0028
3FCF 09         ADD  HL,BC
3FD0 85         ADD  L
3FD1 6F         LD   L,A
3FD2 46         LD   B,(HL)
3FD3 0E FE      LD   C,FE
3FD5 ED 78      IN   A,(C)
3FD7 2F         CPL
3FD8 A2         AND  D
3FD9 11 00 00   LD   DE,0000
3FDC 28 01      JR   Z,3FDF
3FDE 13         INC  DE
3FDF D7         RST  10
3FE0 FD E9      JP   (IY)
```

Fig. 6a. All-keys multiple-key read program listing; b. assembler listing for the program (relative addressing).

the MULTIPRESS and return to decimal. The word TEST places MULTIPRESS inside a BEGIN UNTIL loop and slows it down to allow time for a screen display. MULTIPRESS would normally be inside your program loop.

All Keys Multiple Key Read Routine

Gary Knight has kindly consented to the publication of his own forty key machine code routine.

To use the multiple key read routine you need to place on the stack the ASCII code of the lower-case letter or the number which appears on that key. So, to execute the word LEFT if the 'l' key is being pressed you would use:
ASCII l READ KEY IF LEFT THEN
You can test for the ENTER, SPACE, CAPS SHIFT and SYMBOL SHIFT keys by placing on the stack decimal 13, decimal 32, ASCII C or ASCII S (note the last two are in upper-case). See the 'How It Works' section for this routine.

Type in everything in the listing (Fig. 6a) exactly as it stands. There are two tables of numbers (after READ IN and after MC KEY). Type each hex number and press ENTER after each.

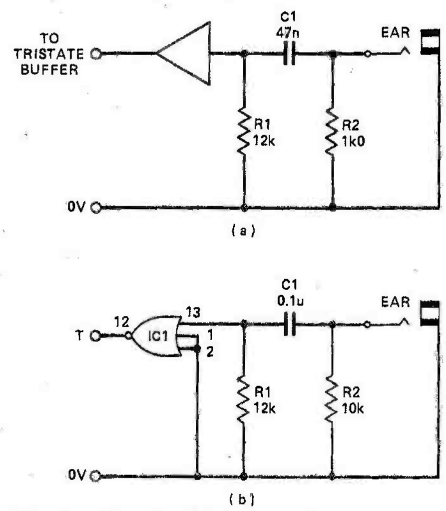


Fig. 7a. Standard Ace tape input port circuit; b. alternative tape port using spare gate on interface.

Tape Port and Keybeep

The standard Ace tape port input circuit is shown in Fig. 7a. R1 biases the gate input to about 2V, and R2 acts as a tape recorder output load resistor. If the gate is omitted, it is possible to feed straight into the interface T connection from the circuit of Fig. 7a, but gate buffering is desirable.

A suggested circuit for an alternative tape port is given in Fig. 7b. The spare three input NOR in IC1 is pressed into service (the inverted signal works) and C1 is increased in value to improve sensitivity. A higher value for R2 makes it possible to feed from DIN plugs on some tape recorders. With DC access to the tape port, you can experiment with input filtering, etc.

BUYLINES

**The following are available from I.T.M. KJ Interface PCBs £4.45 per set.
KJ Interface Kits with PCBs £11.50 each (including full documentation).
Assembled and tested KJ Interfaces (uncased) with applications documentation £14.50 each.
All prices inclusive of VAT and postage. SAE for further details of KJ interfaces, patchboards etc.
I.T.M. 119a Culverley Road, Catford, London SE6. (01-698 5351).
Long wire ZX81 or Spectrum edge connectors are available from Technomatic (see text). PCB mounting screw terminals (0.2" pitch) and keyboard switches from Maplin or Ambit International (see text). Other components are not difficult to obtain.**

ETI

AUDIO DESIGN

Enough of this theoretical agonising over distortion and noise! John Linsley Hood shows us what is to be actually done about these problems — following up with a practical example, a project for a moving coil PU head-amp.

In the preceding parts of this series I have taken a, necessarily brief, look at the basic techniques of small-signal audio circuit design, and mentioned some of the problems. However, I haven't so far talked much about distortion, or looked at how these design techniques would be employed to produce a technically advanced piece of circuitry, such as is now expected in up-market hi-fi gear. I will now remedy this deficiency.

Distortion

In its most general context, this refers to the way in which the output signal from some part of the signal handling chain differs from that present at its input, excepting that due solely to uniform and frequency independent amplification or attenuation. In normal use, this term is taken to refer to the waveform distortion of a continuous uniform (*steady state*) sinusoidal waveform, either as a result of regularly occurring kinks or bends in this waveform (**harmonic distortion** — so called because the distortion products occur at frequencies which are harmonically related to the fundamental frequency) or as a result of the inadvertent interaction, due to imperfections in the signal handling channel, of two — or more — frequencies simultaneously present (**intermodulation distortion**).

Harmonic distortion can be measured by a simple test instrument of the kind shown in Fig. 1, known as a **total harmonic distortion** or **THD** meter, in which the incoming signal is measured by an AC millivoltmeter, either directly, or through a sharply tuned 'notch' filter. If the meter is set to read full scale with the filter shorted out, and then this reading is compared with the smaller reading obtained after the notch filter is used to remove the fundamental, what will be left, as a fraction of the original, is the total harmonic distortion, plus, alas, the noise and hum accompanying the original signal.

A better, but more complicated, way of measuring harmonic distortion is to use a **harmonic analyser** — shown in Fig. 2. In this the AC millivoltmeter is fed by a sharply-tuned variable-frequency filter having a narrow passband. This allows the magnitude of signals present at any frequency to be compared with the magnitude of the signal at the fundamental frequency, and allows the user to avoid spurious results due to hum and noise. The magnitude of individual harmonics can then be identified, which gives a more significant assessment of what has happened to the signal on its passage through the unit under test. In the particular case of intermodulation distortion, this relates to the way in which two signals may combine within the signal handling stage to produce the so-called 'sum and difference' frequencies of the two components.

Although there were different standards employed, a fairly typical intermodulation distortion test would have used, for example, two frequencies at 70 Hz and 3 kHz, in a 10:1 ratio, and the Harmonic Analyser would then have been used to measure the amount of 2930 Hz and 3070 Hz present as a result of the non-linearity of the unit under test. More modern tests, of a similar kind, would use two identical magnitude signals at, say 19 kHz and 20 kHz and a simple low-pass filter could then be used to isolate for measurement the spurious 1 kHz (difference) frequency.

It has been claimed that this particular test gives results which correlate very significantly with the way in which an audio amplifier sounds. I am sceptical about this, if only because I know I could design an amplifier which would do well in this test and yet would sound awful.

The snag, of course, in all these tests is that they relate only to 'steady state' continuous sinewave tones, which really have very little to do with the sort of signals which audio equipment has to handle — with the occasional exception of the lovers of very slow-moving organ or flute music. Most of the sounds which inform or delight the listener are random, transitory and irregular in waveform. There is a relationship between the way in which an amplifier, say, will handle a steady state signal and the way in which it will sound on real life signals such as speech or music, but this is neither a simple nor a complete one; distortion measurements, though they relate to an important aspect of the behaviour of the system are not, of themselves, as meaningful as the advertisers of hi-fi goodies would have us believe. They need to be inter-

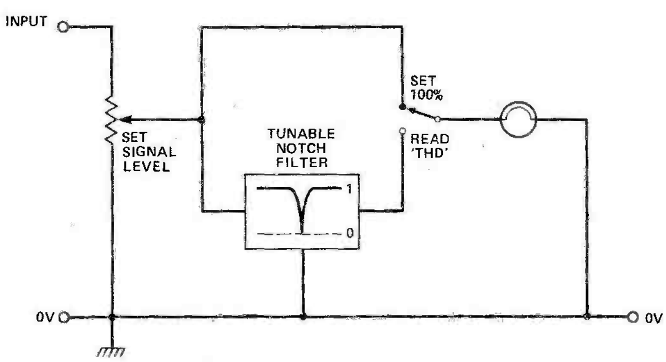


Fig. 1 Total harmonic distortion measuring instrument.

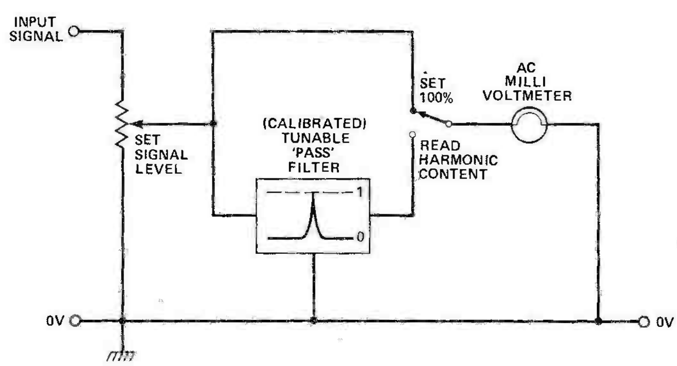


Fig. 2 Harmonic analyser arrangement.

preted, and weighted, in the light of experience and with an eye to their applicability.

So, in addition to knowing how to design for low distortion, we also need to have some understanding about the relative importance of the various types, so that if there is some need for compromise, the right decisions can be made. Happily, this isn't too difficult.

Harmonic Distortion

If a sinewave is asymmetrically distorted, as shown in Fig 3a this will give rise to even harmonics (2nd, 4th, 6th etc.). If the distortion is fairly smooth, as would be the case in most simple low-level signal stages without negative feedback, the main harmonic produced would be the 2nd. This is simply the same note, but one octave higher, and is therefore consonant, as would be the 4th, 8th and 16th harmonics, which would give the same note two, three and four octaves higher. Small amounts of such low-order harmonics — up to, say, 0.5-1.0% are musically quite tolerable, and may give an apparent richness to the sound quality — much liked by the devotees of old valve amps.

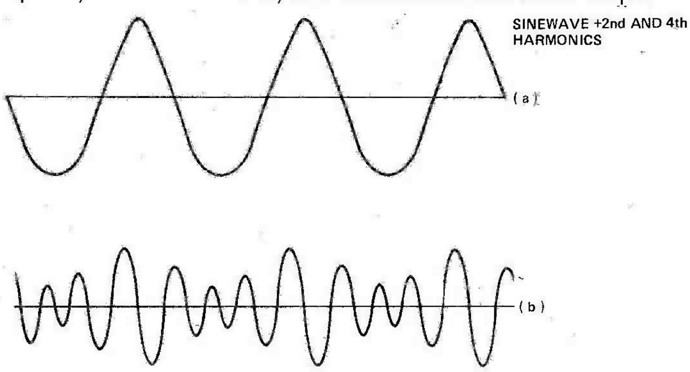


Fig. 3 Harmonic (a) and intermodulation (b) distortion.

The reason why one doesn't want even musically innocuous harmonics is shown in Fig. 3b. If a smaller signal at a different frequency were present, along with this bigger sinewave, its amplitude would vary with the excursion of output voltage — simply because the waveform distortion implies a variation in stage gain as a function of output voltage. This is what is known as **intermodulation distortion.**

Higher order even harmonics, such as the 6th, 10th, 12th, 14th, are dissonant (if 256 Hz is middle C, its third harmonic would be 768 Hz which is somewhere near G in the octave above, and the 6th harmonic would be near the G in the octave above that), as are all the 'odd' harmonics, to an extent which increases rapidly as their 'order' increases.

The odd harmonics are due to symmetrical bending of the waveform, as shown in Figs. 4a and 4b, the latter case being that due to crossover defects in push-pull systems. As an invariable rule, the smaller the proportion of the waveform which is bent the higher the harmonic, and probably the worse it will sound. In the particular case of crossover distortion in push-pull stages, in addition to making nasty sounds, it also removes low magnitude signals from the output, which makes the system have a 'thin' sound. The same sort of kinks at the tips of the waveform, as in Fig. 4c, due to symmetrical clipping, would just make the sound rather hard and 'edgy' — yet both of these could be the same harmonics, present in a numerically identical quantity, but merely shifted in phase. As a kind of working rule, 0.1% of third harmonic would not be musically objectionable (though the equipment would sound 'cleaner' without it). 5th, 7th and above should not be present above some 0.02% for a plea-

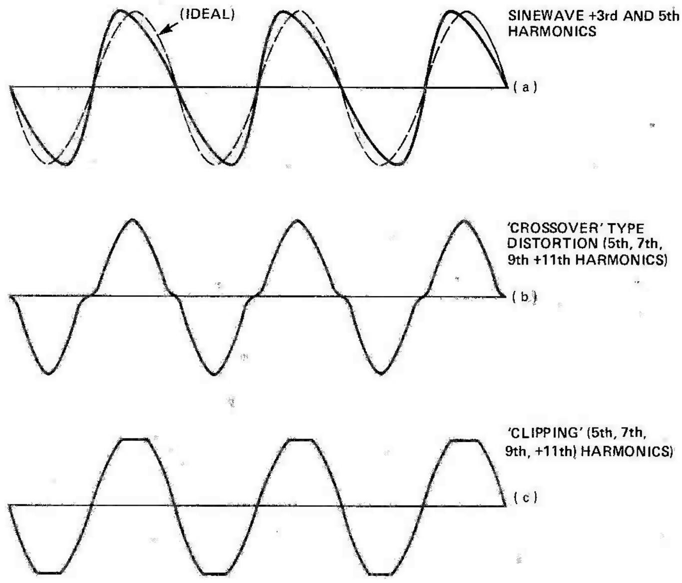


Fig. 4 Waveforms containing odd harmonic distortion.

sant sounding result.

Since these are the kinds of harmonic produced by class AB (low quiescent current) push-pull transistor output stages, it is easy to see why very low orders of THD are demanded nowadays from such amplifiers, while the old valve jobs could get away with ten times as much as this, and still be applauded.

Intermodulation Distortions (IMD)

If an incoming sinewave signal is 'bent', this implies that, for that amount of signal swing, the gain of the system varies as a function of the output voltage. It follows from this that any other signals present at the same time will be modulated in amplitude, as I've already shown in Fig. 3b. This has the effect of muddling up the sound, and making it more difficult to separate the individual components.

If an amplifier limits, either because it has been driven into clipping through too big an input signal, or because it has been made to try to follow a transient which is too fast for it, it is obvious that other signals present while it has been driven into a limit condition will be lost. This second condition is known as **slew rate limiting** or, more fancifully, as **transient intermodulation distortion (TID).** Both of these problems are shown in Fig. 5 (over page).

Although a lot of technical capital has been made from TID, both in relation to its description and in relation to its cure, it is, in reality, rather less pervasive than normal IM distortion, if only because it only happens on transients, and it is rather more simple for the user to avoid — just drive it a little less hard!

Reducing Distortion

Harmonic distortions usually arise from one or other of three causes: non-linearity of device voltage/current transfer characteristics; intrusion of unwanted signals (which could be distorted versions of the wanted ones) from supply lines, or by capacitive coupling from later stages (which will tend to exaggerate the higher frequency components); and by coupling of unwanted components into the signal line by poorly arranged earth line return paths.

The first of these, and part of the second, is a question of circuit design, the rest is a matter of care in layout. Being aware, for example, of the need to prevent capacitive coupling of output signals back to earlier stages

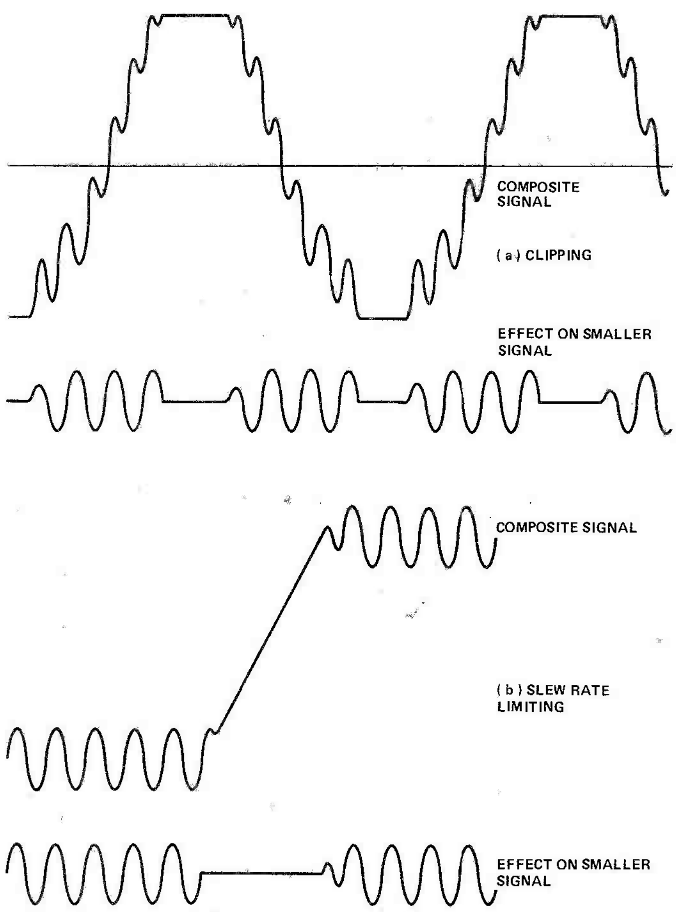


Fig. 5 Intermodulation distortion types due to (a) clipping and (b) slew rate limiting.

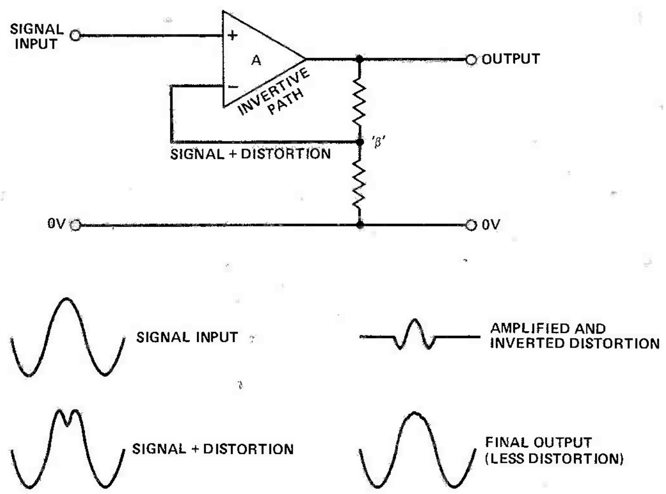


Fig. 6 Negative feedback arrangement and results.

leads quite naturally to the thought that these parts of the circuit should be kept as far apart physically as practicable (or necessary). Being conscious of the undesirability of output circuit currents flowing in input signal paths can, without much mental stress, lead one to more elegant wiring layouts — so this isn't difficult to do adequately. It is the knowing (and remembering) which is the hard bit.

The Use Of Negative Feedback

Designing for low distortion is more demanding of thought. The major implement in this task is the use of **negative feedback (NFB)**, in which a proportion of the outpur signal is — effectively — subtracted from the input signal. If the output signal contains components which are not present in the input, these components will be amplified in an inverted phase, as shown in Fig. 6, and will tend to cancel the distortion components present in the output.

This technique does work, and works well, but there are snags! The first of these is that the distortion components will themselves be distorted, so that an amplifier, without feedback, having 2nd and 3rd harmonics, will, with feedback, also contain 4th, 6th and 9th — and could well sound less pleasant. Also, the use of NFB is likely to make the amplifier much less stable at HF, with the possibility of continuous or incipient oscillation. This also is ruinous for sound quality, and gave rise, some years ago, to a vogue among the less inspired circuit designers for circuits without any NFB at all. The real answer to these problems is to have enough gain in the amplifier for a decent amount of NFB to be used, and to design it with an adequate stability margin, which means mainly not having too many stages within the NFB loop.

Because the final distortion figure of any feedback amplifier (by this we normally mean an amplifier with *negative* feedback) depends on the initial distortion, then we need to make the amplifier as linear as possible in its open-loop condition. The formulae for calculating the effect of feedback (negative or positive) are:

$$A' = \frac{A}{(1 - \beta A)}$$

$$D_f = \frac{D}{(1 - \beta A)}$$

where A is the gain without feedback (negative for an inverting amplifier) A' is the gain after feedback is applied (if A is large enough, then we can use the approximation $A' = -1/\beta$), β is the proportion of the signal fed back, D is the distortion without feedback and D_f the distortion with feedback.

The expression $(1 - \beta A)$ is known as the **feedback factor,** and it reduces the gain and distortion equally in simple systems. It is normally expressed in decibels, for example 20dB of feedback which implies that the gain has been reduced by a factor of 10. If A and β are both positive, then the feedback factor will be less than one and both the gain and distortion will be increased, up to the point where $\beta A = 1$, where the gain becomes infinite and the amplifier will oscillate.

A High Quality, Low-Distortion Gain Block

So, how does one design, say, a low-distortion small-signal amplifier. The distortion arises because of bending in the input characteristics of the device, as shown in Fig. 7. Here I have illustrated the input voltage/output current characteristics of a small-signal silicon junction transistor and a junction FET. The bipolar transistor is obviously much more bent, and will therefore give a more distorted output, but because the upward slope of the graph is much steeper it will also give much more gain. An important point to remember, though, is that the smaller the signal which is applied to the input, the less the distortion — simply because any curve becomes a straight line if a small enough part of it is used. This means that if, by some means, we can get a high enough gain from the stage, the waveform distortion due to the input characteristic curvature will be made very small. So, one must design to get the best stage gain.

Another useful point is that push-pull circuits, because they are symmetrical, cause asymmetrical distortions to cancel out, largely. The bending of a transistor V_{base} vs. I_c

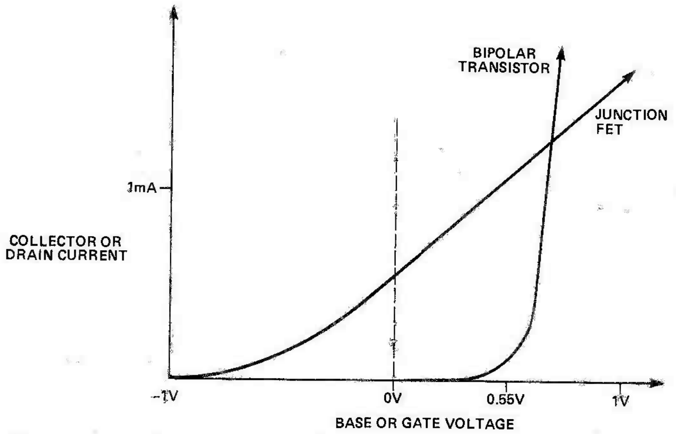


Fig. 7 Input characteristics of bipolar and field-effect transistors.

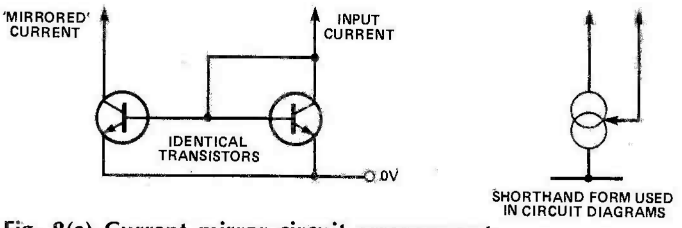


Fig. 8(a) Current mirror circuit arrangement.

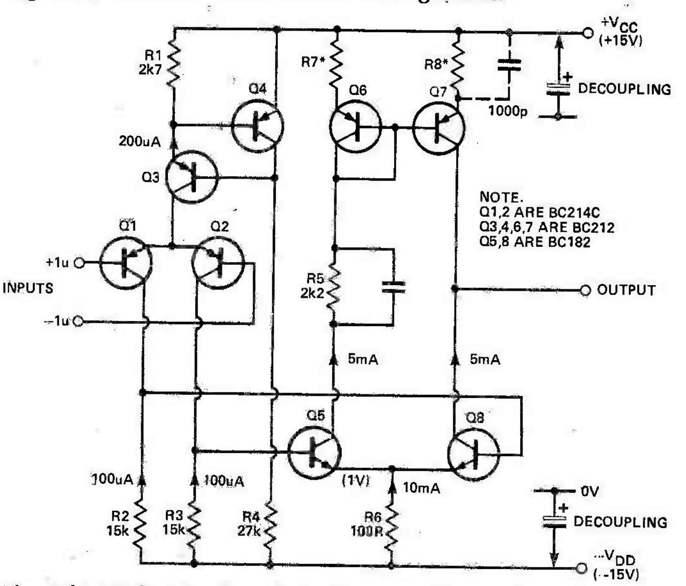


Fig. 8(b) High gain, low distortion gain block. R7 and R8 (marked with *) are optonal 100R resistors which lessen the need to match the characteristics of Q6 and Q7 — they could be replaced with links.

characteristic is asymmetrical, therefore a push-pull input system, such as a long-tailed pair discussed in part 1 of this series, would have less distortion — by a factor of perhaps 10 — than the equivalent single-ended input stage.

To simplify the problems of stability when negative feedback is applied, it is preferable to limit the loop, around which the feedback is applied, to two gain stages. Probably the best of the possible circuit configurations is the one in which an input long-tailed pair is followed by another push-pull amplifier stage, which is, in turn, loaded by a **current mirror** of the kind shown in Fig. 8a. A working stage of this kind is shown in Fig. 8b. I have shown this in a standard op-amp form, with a + and − DC supply, two inputs (one inverting, one non-inverting) and an output, so we can use this exactly as if it were an IC op-amp in any appropriate circuit. However, it has the advantage that it will, with suitable transistors, be usable up to DC supply voltages of 50 V or so, allowing an output voltage swing of some 96 V P−P, or an RMS output of some 34 V, which would give good headroom.

In this circuit Q3, Q4 and R1 and R4 act as a constant-current source, in which, if the current through R1 produces a voltage greater than 0.55 V, Q4 will turn on and steal the base current from Q3, to prevent Q3's emitter current from increasing any further. With the values shown this holds the current through Q1 and Q2 to 100μA each, which gives a satisfactorily high input impedance to this stage. For example, if Q1 and Q2 have current gains of 200, the base currents required will only be 0.5μA.

The best input noise figure in this stage will be given if the input transistors (Q1, Q2) are PNP types — because they have N-type base regions — and for the sort of DC supply voltages which I envisage in this application (±15 V, so that we can also use ICs) BC214Cs are ideal. In order to get a good output drive capability from this gain-block, I have chosen to make Q5 and Q8 pass 5 mA each, which is 10 mA through R6. If this is 100R, the potential drop across it will be 1 V. So, to provide 0.55 V across the base-emitter junctions of Q5 and Q8, the voltage drop across R2 and R3 must be 1.55 V. Since Q1 and Q2 each pass 100 μA, then R2 and R3 must each be 15.5k — the preferred value of 15k is near enough, in practice. This defines the component values, with the exception of R4, which isn't really critical in value, and R5C1 which is a phase correcting circuit.

The gain/bandwidth, noise and THD figures for this circuit block are quite excellent (see Table 1), and allow it to be used in a very high quality audio preamp to obtain a standard of performance which would not be bettered by an commercial unit on the market, though some of the more astronomically priced ones might equal it. If one restricts the ± DC supplies to 15 V, one could substitute any commercial unit on the market, though some of the the LF351 or the TL071, for this gain block with only a small lowering of audio performance, though, as mentioned above, the gain block is not so restricted in DC supply potentials.

The Passive Components

There are a few further points which are worthy of comment, at this stage, concerning components. Quite a lot of thought has been given to the sound quality changes imparted to audio circuitry by the components used. So far here, we have only considered the way in which the circuit will work, and what values of components we should employ. However, when we actually get down to the detailed design of audio stages, we can no longer simply say a resistor is a resistor is a resistor . . .! There are two main problems with real resistors, excess noise due to random variations in the path current will actually take through the resistance track and voltage dependence of resistance (even at power levels too low to wam it up significantly).

The consensus of opinion here is that metal film types are the best, with metal oxide types comparable in performance, followed by carbon film, and with carbon

Gain. (without NFB) 30,000x
Bandwidth. 300KHz
Distortion: Less than 0.003% at 1KHz at x100 gain
Square wave performance. No overshoot.
IMD. Not measurable.
Input noise resistance. 1k5
Note. The circuit is stable, as it stands, for gains (set by NFB) down to 5. For unity gain use, an output Zobel network of 1000pF and 180 ohms should be added.

Table 1 Performance of the gain block.

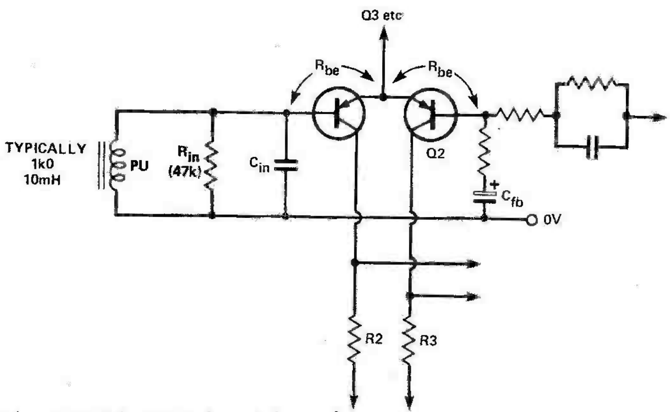


Fig. 9 RIAA stage input impedances.

composition, a long way down the list. For low values of resistance, wirewound types are excellent, but for higher values the inductive effects are troublesome. In the case of capacitors, non-polar types are always better, with polypropylene, polystyrene, polycarbonate and polyester film types shown in descending order of preference. (This is largely a function of dielectric loss and hysteresis.) In the polar types (electrolytics), low equivalent series resistance (low ESR) capacitors are preferable, but in the absence of these, supply line bypass capacitors should always be bypassed with a smaller non-polar film type. If you are really fussy you can bypass this again by a smaller monolithic ceramic type. For low signal levels, if large capacitance values are necessary, in the audio path, use one of the new low-leakage miniature aluminium types. Tantalum bead types, in addition to being very dear, are now thought to spoil the clarity of the signal.

Returning to our gain block of Fig. 8b, for the best sound quality, the DC supply lines should always be stabilised — in addition to being bypassed to the 0 volt line by an adequately large low ESR capacitor. Up to ±24 V we can use IC voltage regulators for this purpose, which is the most economical solution.

RIAA Equalisation Stage

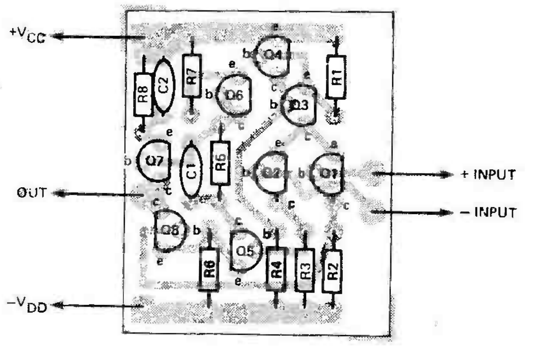
At the conclusion of this series, I propose to describe a high quality audio amplifier and preamp as a 'proof of the pudding'. The gain block just described will make an excellent RIAA input stage for this, though there are a few other considerations in the way it is used. In the last part of this series, I referred to resistor noise, a thing which is present in all low level circuitry as a measurable background. In the case of Fig. 8b, the important part, in relation to resistor noise, is the input circuit, shown in Fig. 9 in the way it would be connected for an RIAA equalisation stage.

Here we have two input transistors, each with their own internal input resistance (R_{be}), and with external impedances between their bases and the 0 V line, which are effectively in series with R_{be} so far as the noise resistance is concerned. Since the noise components due to these add as the root of the squares, and this gives the same result as if all the resistors were added together as a lump noise resistance, the task, for minimum noise, is to try to make the total – R_{in} (in parallel with the pick-up impedance) $+R_{be}(Q1)$ $+R_{be}(Q2)$ $+R_{be}$ (in series with C_{fb}) – as small as practicable. Here is a snag. For any sensible value of collector current for Q1 and Q2 this will be larger than likely values for R_{fb} and Z_{pu}, and limits the lower value of noise resistance to some 1k5, at low frequencies. (At higher frequencies the inductive impedance of the 10 mH or so of the PU coil will be the dominant factor anyway).

This compares with noise resistance of 4 to 5k for the better third generation audio op-amps now available. From the noise figure graph shown in the last part of this series, 1k5 will give a noise output of 0.7 μV at room temperature and 20 kHz bandwidth. This would give a signal to noise ratio of some 73dB, with reference to a typical 3 mV/5cm/sec output signal from a low output PU. However, in practice, the shape of the RIAA correction curve, which slopes down with increasing frequency, limits the effective bandwidth to about 2 kHz, and allows a practical S/N ratio of about 83dB from this sort of input noise resistance. (The TL071/LF353 would give an S/N figure, under the same conditions, of around 79 dB, which is still good).

It should be remembered, however, in order not to get lost in the wild and woolly world of specifications, that the average LP disc, when new and played on a good turntable, can manage only about 65dB S/N. Moreover, when one has had it for a little while and played it a few times, this S/N ratio is likely only to be about 55-60dB, due to surface noise.

In the last part of this series, when talking about op-amp ICs, I described a good quality, simple, two stage RIAA equalisation module, using a passive RC second



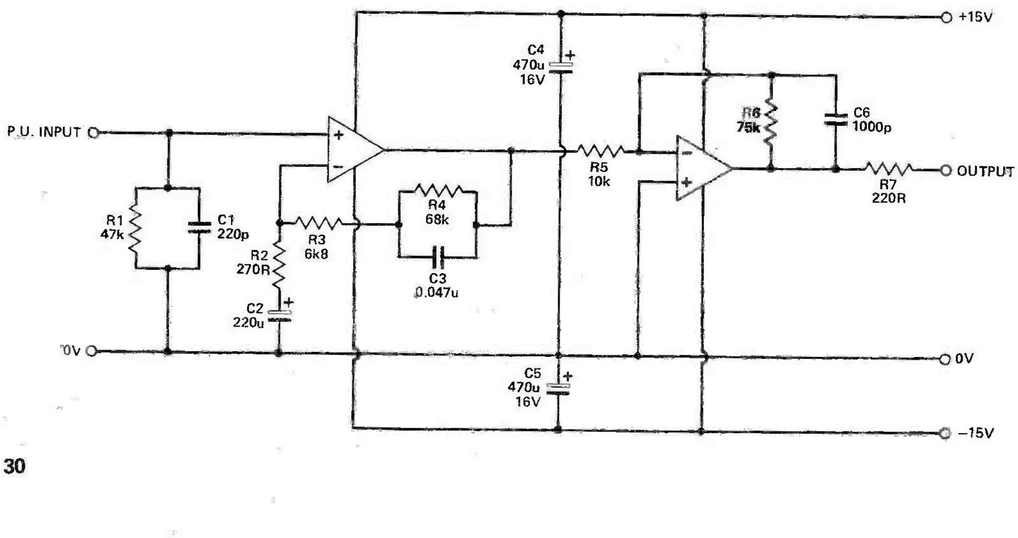


Fig. 10 (left) High quality RIAA equalisation stage, based on the gain block of Fig. 8(b) or a high-quality op-amp.

Fig 11. (above) Component overlay for gain block of Fig. 8(b).

stage to cope with the 1 kHz-21 kHz part of the response curve. One can get a bigger output signal before overload (ie, more 'headroom') if one uses an active RC stage for the second part. A complete circuit for one channel is shown in Fig. 10.

For any readers who would like to experiment with the gain block, a suitable PCB layout for a single unit is shown in Fig. 11. However, I would like to postpone further discussion of the use of the gain block (and the design of the PCB) until I describe the complete preamp later in this series.

Moving Coil Head Amps

To the great sorrow of those companies who had been making a good living from the manufacture of precision, light-weight PU arms, aimed at the increasingly light and free tracking moving magnet or variable reluctance PU cartridges, the more massive low-output moving coil units (which are more ideally mounted on the end of a short length of crowbar) have swept the ultimate-fi scene. This is mainly, I think, because of their more vivid and dramatic stereo presentation — though the MM brigade are fighting back on this score and are narrowing the audio gap.

For the moment, MC cartridges are the choice of the critical users, and these mainly have a very low output which is typically in the range 50-500μV for a 1 cm/sec recorded velocity. This level of output is too low for it to be used directly with a normal RIAA input stage, so a head amplifier is needed. This has to work with an input load impedance of typically 50 ohms, and must be designed for the lowest possible transistor and input circuit noise if it is to compete satisfactorily with the rather more mundane step-up transformer.

When head amps of this type were first employed, the low effective input noise resistance was achieved by putting a lot of small signal transistor stages in parallel, so as to reduce the overall input resistance. This was a bit inelegant as an approach, and now it is more common to choose an input transistor which has an adequately low base-emitter effective resistance on its own (these are often to be found among the plastic encapsulated small power transistors, in the 3-4 A I_c, 30-40V V_{ce} range). The actual device type must be chosen with some care, from a manufacturer of known quality. I prefer Motorola, ITT or National Semiconductors, though this is not an exhaustive list. The device should also be tested before use, under the actual operating conditions.

The circuit should then be chosen to make the gain of the first stage sufficiently high that the noise contributed by later stage transistors can be neglected in comparison

Moving Coil PU Head Amp

The theoretical background for this circuit has been discussed in the main section of Audio Design, so all that remains to be done here is to give the practical details necessary to construct the project.

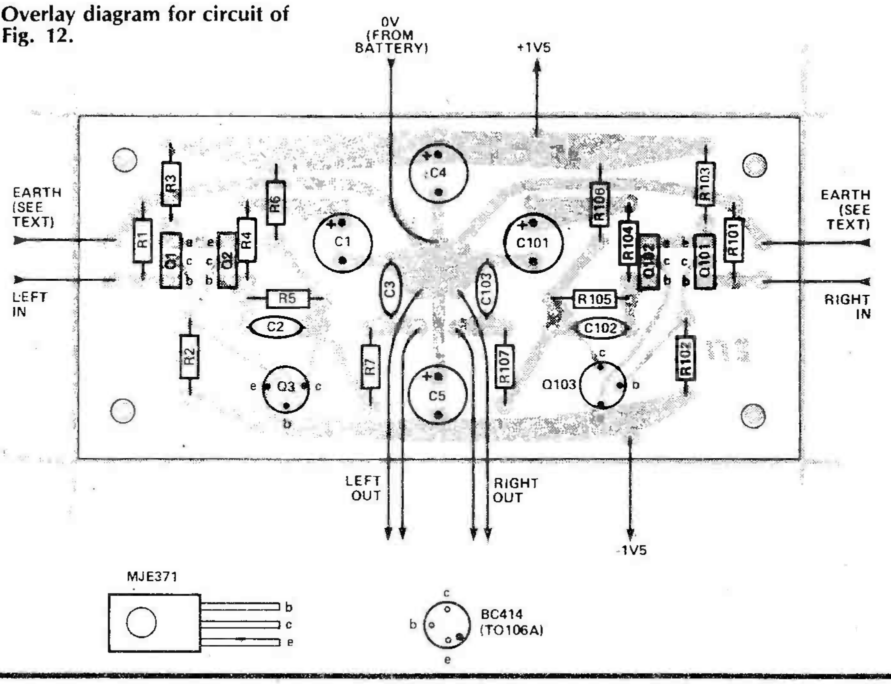
There are only two points that need to be made: firstly, the electrolytic capacitors used should be low ESR types; if you don't find these easy to obtain, then you could get away with using ordinary or tantalum types (whatever your convictions are) suitably bypassed with unpolarised capacitors.

The second point concerns the earthing. We've shown an earthing point near the input. However, there are bound to be cartridges and/or systems for which use of this particular earthing point will cause massive hum loop problems, so we recommend that you tread very carefully on your choice of earthing. Remember that you are dealing with a very small signal!

The unit should be small enough to mount in the base of most record decks. However, the magnetic field of the motor may just manage to cause problems too . . . In any case, be very careful not to obstruct the suspension of the turntable and arm.

One final point is that you will need an on-off switch: to save the bind of having to switch the head amp, you could use a relay driven from the PSU of the pre- or power amplifier. Using a relay means that you isolate the head amp from the earth system on the main amp.

Overlay diagram for circuit of Fig. 12.



PARTS LIST

RESISTORS (all metal film, 5% or better)

R1, 101	47R
R2, 102	2k2
R3, 103	1k8
R4, 104	15R
R5, 105	680R
R6, 106	470R
R7, 107	330R

CAPACITORS

C1, C101	470μ, 4V7 min, low ESR electrolytic
C2, 3, 102, 103	1n0 polypropylene or polystyrene
C4, 5, 104, 105	470μ low ESR electrolytic

SEMICONDUCTORS

Q1, 2, 101, 102	MJE371
Q3, 103	BC414

MISCELLANEOUS

PCB, case to suit, battery holders, switch.

with the amplified signal. Additionally, the values of the resistors used in the circuitry should be kept as low as the circuit design can allow, and the transistors, especially the input one(s), should be operated at collector currents which will minimise R_{be} and 'shot' noise.

On the other hand, because the signal levels are so low, the harmonic distortion from such a stage can usually be ignored. This situation does not apply, however, to transient performance, so the stability margin of the negative feedback loop, if one is used, should be high. Also, perversely, the tonal characteristics of the components used, especially the capacitors in the signal line, seem to grow more important as the signal levels are reduced. So, the moral is to use the best quality components one can afford at this stage.

Having laid down these general guide-lines, the actual design of a good quality low-noise MC head amplifier is not too difficult, and I have shown a suitable circuit in Fig. 12, with a PCB layout for this in Fig. 13. Because of the very low signal levels involved, hum pick up is likely to be a problem in an 'integrated' system, so it makes life a lot simpler if one can design it so that the whole unit can be housed in a small screened box, separate from the main preamp, and isolated apart from the input and output signal connections. 'Single-point' earthing of the head amp circuitry is also very desirable.

The actual circuit in Fig. 12 is a very straightforward two stage voltage amplifier, using an input long-tailed pair of suitable PNP input transisotrs, biased to operate a 250uA, which is near the optimum value for the devices chosen. The second stage amplifier transistor (Q3) is a very low noise small-signal type operated at 3mA collector current (determined by R6). The overall gain is controlled to

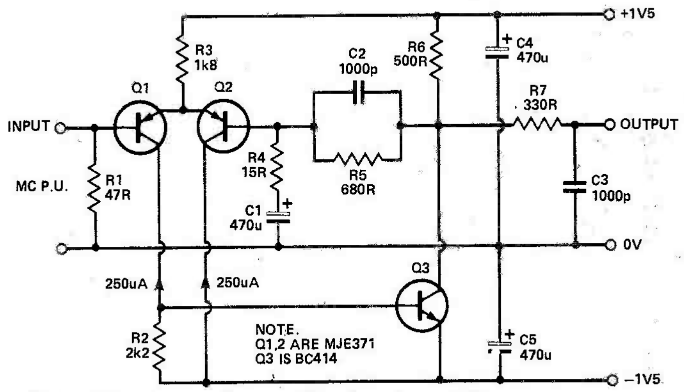


Fig. 12 Moving coil cartridge head amplifier.

45 by the feedback resistors R5 and R4. The –3dB point is set to 20 Hz (a very suitable value for record replay use) by C1. In order to avoid the possibly deleterious characteristics of capacitors in the signal path, the head amp uses a direct-coupled circuit, where the DC NFB also holds the output DC value to 0V, plus or minus a few millivolts.

Metal film resistors, and appropriately chosen capacitors (low ESR types for C1, C3 and C4, and polystyrene foil types for C2 and C5) should be employed. Because the supply voltages for which the unit has been designed are ±1.5 V, it is possible to run the unit from a pair of alkaline manganese cells, or ordinary 1.5 V 'HP' series batteries, of AA, C or D sizes (the bigger sizes will make for more economical running) which allows the unit to be separately powered and eases the task of getting a hum-free system. **ETI**

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MINI DRUM SYNTH

Why beat about the bush when you could be beating upon our latest up-beat offering? Design by A.G. Atkins; development by Phil Walker.

Since commercial drum machines first appeared in the late '70s there have been numerous designs published for the home constructor. Some of them were very good, some were not too bad, and some appeared in magazines other than ETI, but almost without exception they were comparatively complex and cost quite a lot to build. Whilst the little unit described here cannot claim as many facilities as some of its illustrious forbears, it does offer good performance at a very low price, and it is very easy to build.

The circuit is that of a manually operated, single channel drum synthesiser. The input sensor consists of a small loudspeaker operating as a microphone, the circuit being arranged so that a light tap on the loudspeaker will cause the synthesiser to produce a drum beat. The circuit includes controls for the adjustment of pitch, decay time and output level and features two basic pitch modulation envelopes. With SW1 open, the pitch remains constant throughout the drum beat, while with SW1 closed, the pitch falls sharply as the beat decays. With short decay times this latter effect produces a very natural sound, while with longer decay times the sound becomes less drum-like but if anything more interesting, opening up lots of possibilities for off-beat effects.

Construction

Construction is pretty straightforward since everything except the potentiometers, the switch, the input sensor, the battery, and the output connector is mounted on the PCB. The IC can, if desired, be fitted into a socket, but however you do it make sure it's the right way round. The same goes for the electrolytic capacitors (C1, 2, 3, and 6) the two diodes, and of

HOW IT WORKS

The input sensor can be almost any small loudspeaker. Its output is fed to the amplifier formed by Q1 and its associated components. The amplified signal is converted into pulses by Q2 which then charge up C4. This charge leaks away via R6 and RV1, the latter setting the decay time. Q3 acts as a buffer, passing the voltage on C4 to Q5 via R9. IC1, the 555 timer is connected to form a free-running oscillator whose frequency is controlled by RV3. The oscillator output is fed via R10 to the base of Q5. Q5 acts as a crude modulator, the output from its collector taking the form of a series of pulses whose amplitude is determined by the voltage on C4. These pulses are then fed to the output via D2 and RV2.

If SW1 is closed, current flows from the collector of Q4 into the oscillator circuit. The magnitude of this current is roughly proportional to the voltage on C4, and causes the oscillator frequency to increase as C4's voltage increases and to decrease when it falls. Thus, as the charge on C4 leaks away after each trigger pulse, the oscillator frequency will drop from its initial value.

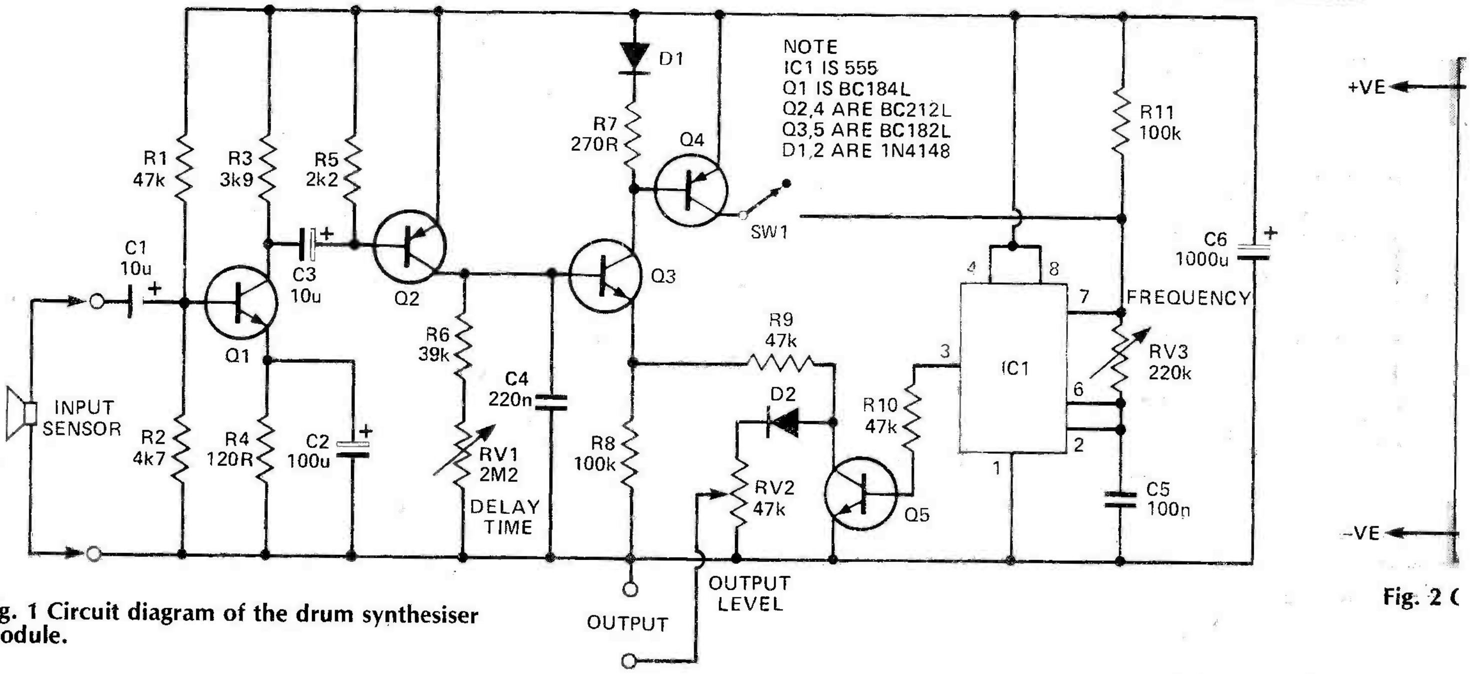
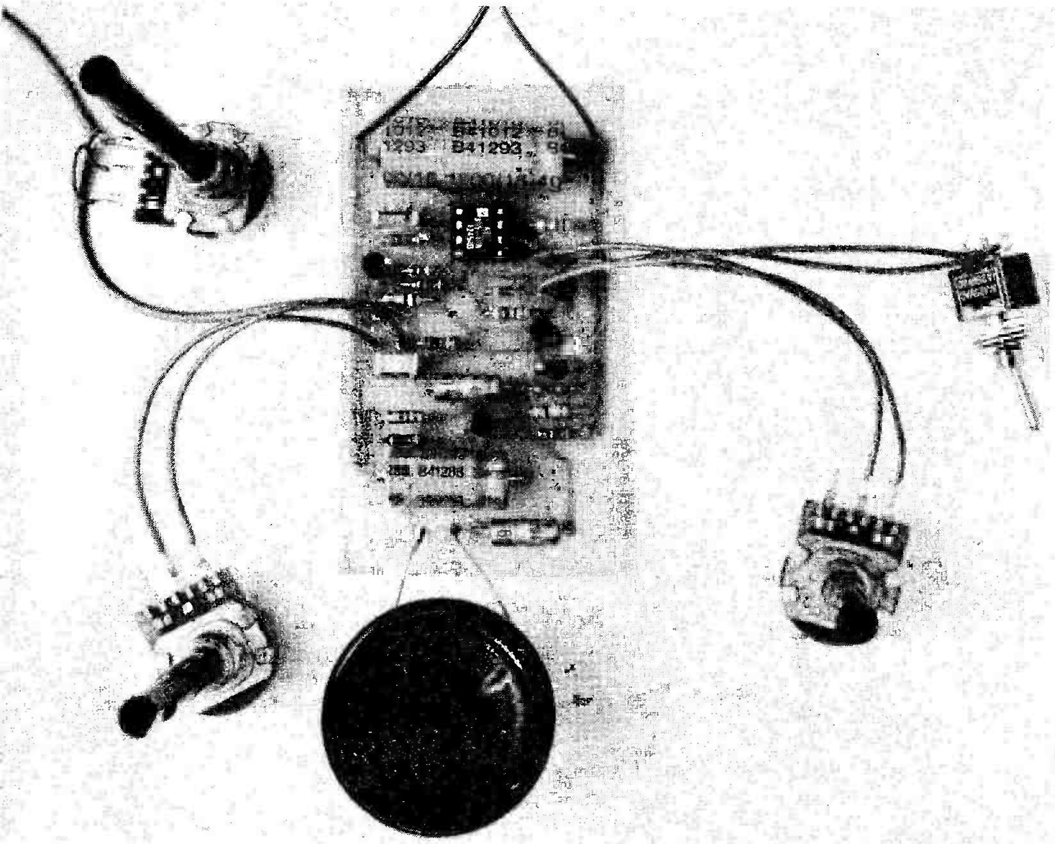


Fig. 1 Circuit diagram of the drum synthesiser module.

Fig. 2 (



Going Modular

For the ambitious constructor, this simple circuit offers plenty of scope for development. Several units could be built and set to produce different sounds, allowing a comprehensive mini drum kit to be built up. Taking the idea a stage further, some of our more experienced readers might feel able and inclined to produce a multi-channel drum synthesiser to their own requirements. By dispensing with the input sensor and modifying the input amplifier, the circuit could be adapted to trigger from logic pulses, whereupon any number of units might be controlled from a fairly simple digital timing circuit. From there on, the sky's the limit.

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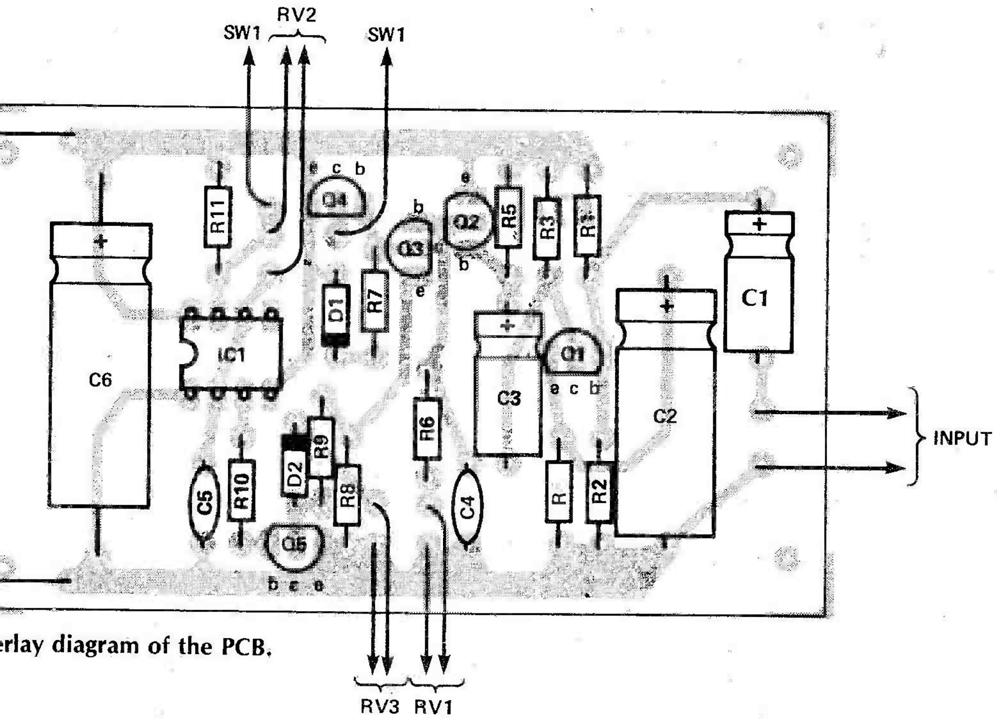
course all the transistors. No case has been described since there are no real layout problems and almost anything you can come up with should be suitable. One possibility, however, is to mount all the bits in a drum-shaped container with the sensor held against the underside of the upper surface. The instrument can then be 'played' by tapping on this surface with a pencil, or your fingers, or even a drum-stick! If preferred, the electronics can be mounted in a more conventional case and the sensor connected via a suitable length of lead. Ordinary twisted flex should be fine; since the sensor has a very low impedance there should be no problems with noise pick-up. SW1 can be any single pole switch, and if the battery is to be permanently installed in the case you may wish to include an on-off switch.

PARTS LIST

RESISTORS (all ¼W, 5%)	
R1, 9, 10	47k
R2	4k7
R3	3k9
R4	120R
R5	2k2
R6	39k
R7	270R
R8, 11	100k
RV1	2M2 linear
RV2	47k log
RV3	220k linear
CAPACITORS (10V working min)	
C1, 3	10u electrolytic
C2	100u electrolytic
C4	220n polyester
C5	100n polyester
C6	1000u electrolytic
SEMICONDUCTORS	
IC1	555
Q1	BC184L
Q2, 4	BC212L
Q3, 5	BC182L
D1, 2	1N4148
MISCELLANEOUS	
SW1	single pole switch

PCB (see Buylines); 9V battery (any size); small loudspeaker of between 8 and 80 ohms; battery connector; output connector; case; on-off switch, IC socket, knobs, etc. as desired.



erlay diagram of the PCB.

BUYLINES

Absolutely no problems at all with this one. All of the components, semiconductors included, are available from any number of regular advertisers, and the PCB is, as always, available through our PCB service (see page 89).

ALARM EXTENDER

Is your alarm system the talk of the neighbourhood? Fit ETIs simple add-on unit and protect your social conscience. Design by S.W. Terry.

Many of the alarm systems currently in use, whether commercial designs or home-made units, have an ouput that remains on continuously once triggered, stopping only when reset. There is obviously a danger with such alarms that they will be triggered when you are absent for a long period, initially drawing attention as desired but going on to cause considerable anoyance to the neighbours. At its worst, this could result in your facing a little legal unpleasantness. One way of overcoming the problem is to have an alarm which sounds only for a pre-determined time, long enough to attract attention but not so long that it becomes a nuisance to those nearby.

The ETI Alarm Extender provides this facility and is designed so that it may be easily fitted to existing alarm installations. It will work from any supply voltage between five and fifteen volts, enabling it, in most cases, to be connected directly to the existing supply and making it ideal for use with car alarm systems. With the values of R1 and C1 given the alarm will sound for about twenty minutes, but this may readily be adjusted to suit the requirements of the user.

Construction

Everything except the relay is mounted on the PCB. The three ICs are CMOS types and are best mounted in sockets rather than soldered direct. Make sure that they are inserted the right way round, and similarly take care with Q1, C3, and D1. Note that C3 is quite close to the mounting holes at that end of the PCB, and that if a physically

HOW IT WORKS

IC1 is a 4047, a CMOS multivibrator which can operate as a monostable, but which is here used as a bistable, its frequency being set by R1, C1. IC2, a 4020, is a 14-stage ripple binary counter which counts the pulses generated by IC1. When the ALM input is low, IC3b pulls pin 4 of IC1 high which prevents it oscillating, while IC3d holds pin 11 of IC2 high, thus holding its output low.

When ALM goes high, the relay is turned on via IC3b, IC3a, and Q1. IC1 and IC2 are enabled and IC1 starts supplying pulses at the rate of about 12 Hz (assuming the values of R1, C1 given) to IC2. After 16,384 pulses have been received, the Q14 output (pin 3) of IC2 goes high, turning off the relay and preventing further input pulses from reaching IC2.

The period can be adjusted by altering the values of C1 and R1, and is equal to

36,045 R1 C1 seconds.

The output time can also be halved by using Q13 (pin 2) instead of Q14 on IC2.

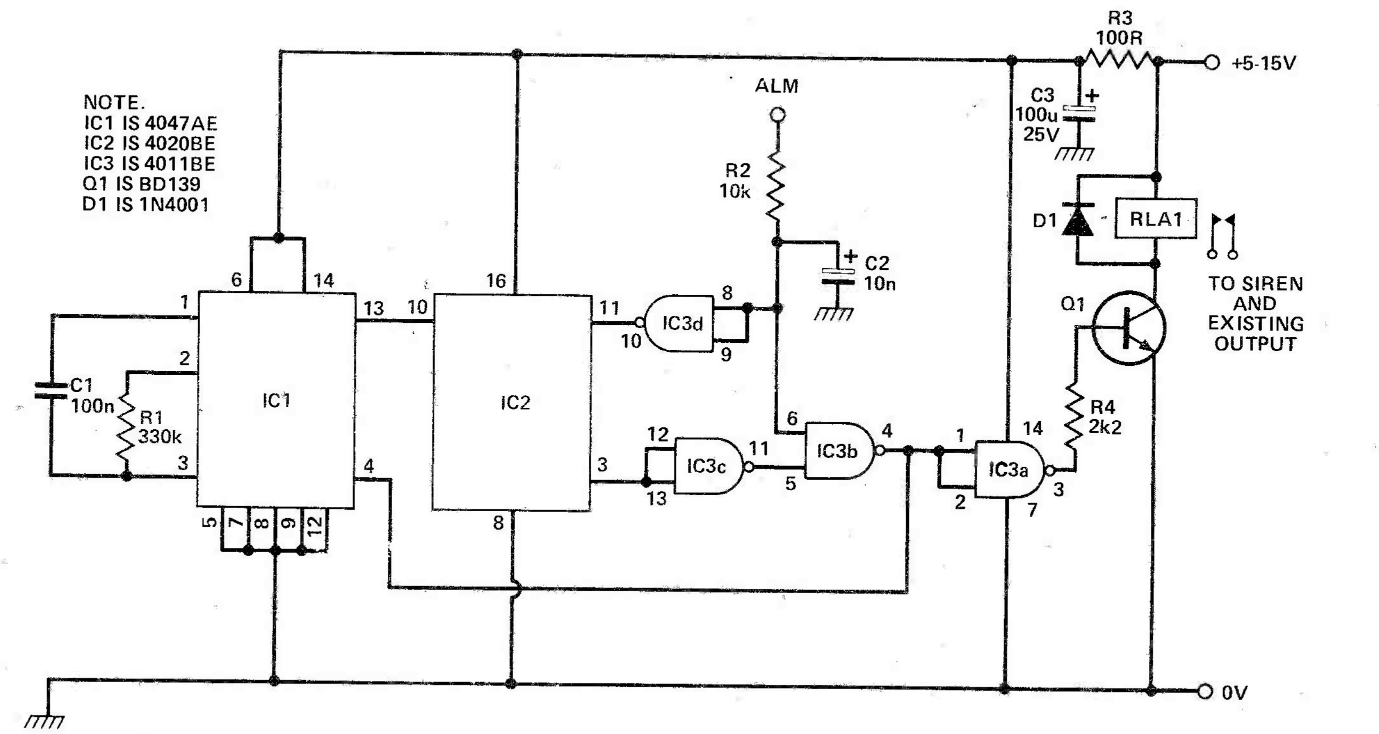


Fig. 1 Circuit diagram of the alarm extender

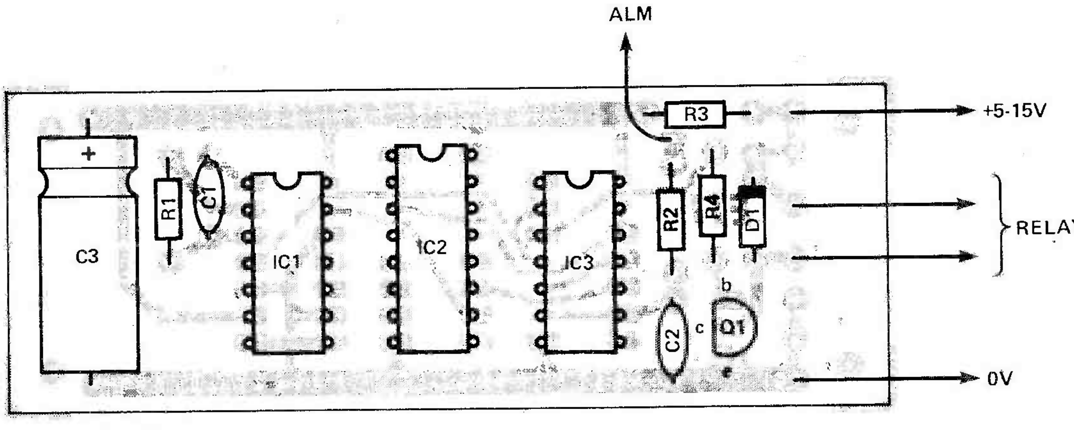


Fig. 2 Component overlay for the PCB

large capacitor is used here you may need to pass the mounting bolts or whatever through the holes before fitting it.

No case has been shown since it is assumed that the unit will be fitted inside an existing alarm, but if this proves impractical almost any small case would be suitable. Note that, if the alarm is fitted outdoors, the case and inter-unit wiring should be made as weathertight as possible. The relay can be mounted on a simple bracket, or even set in Araldite if you prefer.

Having built and installed the PCB and relay, the final step is the modification of the existing alarm wiring. If the alarm circuitry operates on a voltage higher than fifteen volts (you did check the alarm voltage before commencing construction, didn't you?) you will have to arrange a suitable dropper circuit. This should not present too many problems because the Alarm Extender is fairly tolerant of supply voltage variations. Aim for a supply voltage of rather less than fifteen (eg, twelve volts) so as to allow some room for manouevre. If the alarm voltage falls within the range five to fifteen volts and is stabilised there are no problems and you can connect the Alarm Extender directly.

Moving on to the input and relay connections, you will have to locate within the existing alarm wiring the output lead. Depending on the type of alarm you have, this may be the + ve feed to the relay which activates the output transducer (bell, siren, etc.), or it may be the direct connection between a semiconductor switching device and the output transducer. Again, you should check this before commencing construction since we cannot guarantee that the alarm extender will work with *ALL* alarm systems. Having located this lead (and only after switching the alarm off!), break it and take the two ends to the two normally open contacts on the relay of the alarm extender. Identify which of these leads comes from the alarm trigger circuitry and run a further lead from it to the ALM input on the alarm extender. Note that, if the alarm runs from a high voltage and you have had to drop the supply rail before connecting the alarm extender, you may also need to insert a further resistance in series with the ALM input (or to increase R2 in value). The unit is now ready for testing.

PARTS LIST

RESISTORS (all ¼W, 5%)	
R1	330k (see text)
R2	10k (see text)
R3	100R
R4	2k2
CAPACITORS	
C1	100n (see text)
C2	10n
C3	100u tubular electrolytic 16 V (min) working
SEMICONDUCTORS	
IC1	4047
IC2	4020
IC3	4011
Q1	BD139
D1	1N4001

MISCELLANEOUS
185R, 12V relay (Varley VP2 or similar); PCB; two 14 pin and one 16 pin DIL sockets; mounting bolts, spacers, etc.

BUYLINES

A suitable relay is available from Maplin and everything else is just too available for words. For the PCB see page 89.

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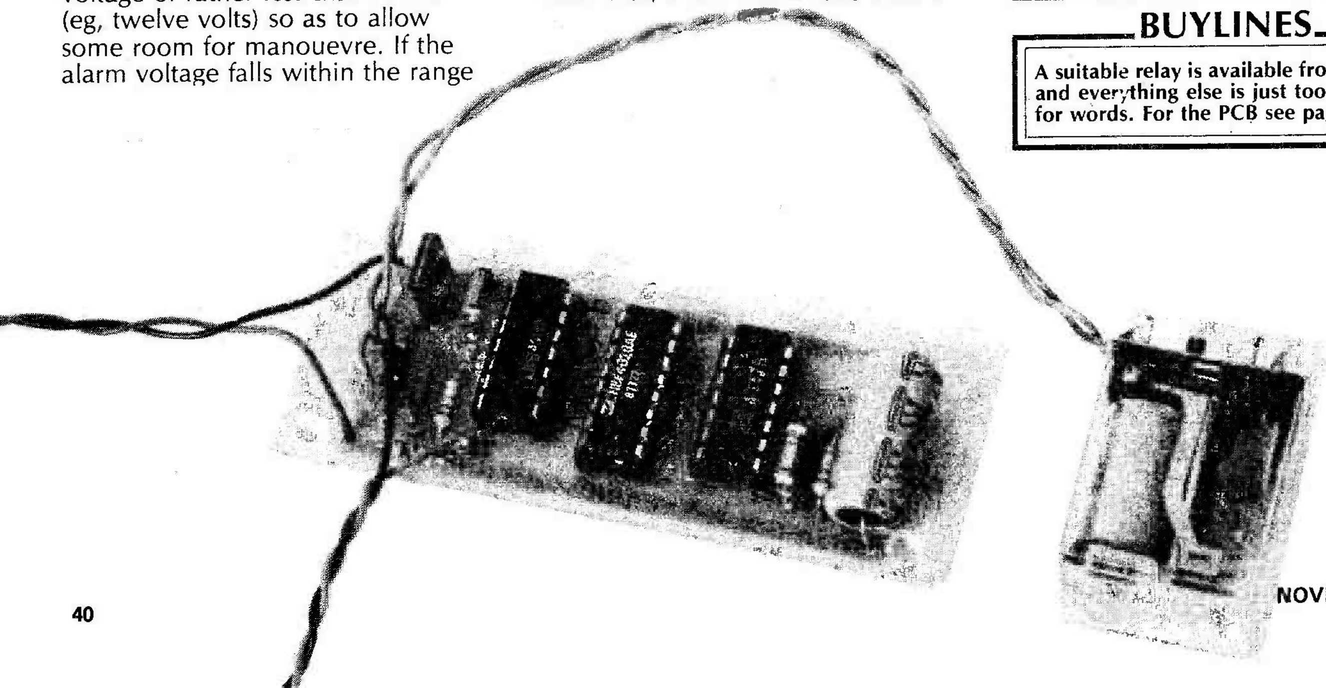
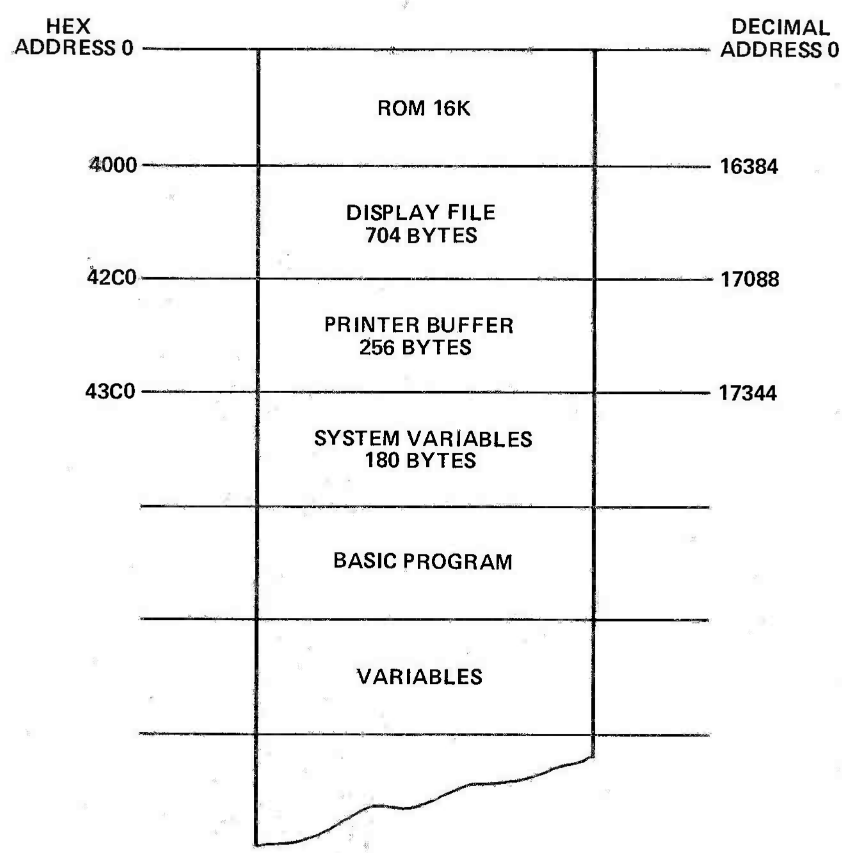


MACHINE CODE PROGRAMMING

In this second part of this series, Bob Bennett looks for implied and immediate addresses on the computer's memory map.



Whereabouts in RAM your machine code program will go depends on the memory structure of your computer. A look at the computer's memory map will show the areas in RAM reserved by the computer for 'housekeeping' duties. These duties consist of keeping tabs on everything that happens whilst the computer is switched on. Figure 5 shows a portion of a memory map for no computer in particular; how it works is fairly simple, but does require a lengthy explanation.

The **display file** is shown as occupying 704 addresses, each of one byte: these 704 bytes store information relating to the picture on the screen. The working area of the screen in our example consists of 32 columns by 22 rows, and 32 times 22 equals 704. The reason I referred to working area is that there are usually two rows at the bottom of the screen reserved for the input data. As a rule the top left hand corner of the screen is position 0,0, and this is the first address in the display file. Suppose that you printed the letter A in position 0,0: the code for letter A would be stored in address 16384.

The **print buffer** is merely a temporary store for data going out to a printer, but this area can often be used by the programmer.

Any good computer handbook has a section devoted to the **system variables,** which are a series of reserved addresses usually given short names. These addresses contain information, dealing with which comprises the major portion of the housekeeping I mentioned before. Each system variable consists of one, two, or very rarely, three or more bytes. If there is only one byte then the address will usually contain a number, the value of which may determine the action to be taken by the computer. The Spectrum, for example, has a single byte system variable called PIP that contains a number which determines the length of the keyboard click.

If there are two bytes, then the two consecutive addresses of the system variable themselves hold an address. This is usually the starting address of an area in RAM where a particular variable is stored. For example, when you assign letters or strings as variables, the information relating to those variables is held in an area of memory. If you had a system variable called VARS, this would consist of two bytes, and would hold the starting address of that area.

The area of RAM, from the system variables onwards, is the part that is of primary interest to machine code programmers. As your list of variables is added to, or subtracted from, then the area it occupies can fluctuate. This is true of the area taken up by your BASIC program, as you add or delete lines. Areas in RAM can be reserved for machine code programs, and there is usually plenty of information around telling you how to do it for your particular computer.

How . . .

Once you have found out where to put your program, the next task is to get it there! There is really only one way it can get there, but there are several methods of doing it (that's a bit like saying 'there is only one road to Rome, but there are many means of transportation'). The program is POKEd into addresses, byte by byte. Starting with the first address, and the first byte, the addresses are incremented after each POKE.

If you have never met POKE before it's how you get information into RAM. Consider this example of a direct command, POKE 32000,119 decimal: this means place the decimal number 119 into address 32000. If your computer allows you to use hex direct then the command could be POKE 32000,77 hex. The complementary command to POKE is PEEK, so, after entering the above example, the instruction PEEK 32000 would cause the number 119 decimal to be printed to the screen. Of course, you can only POKE information into RAM, but you can PEEK at either RAM or ROM.

Probably the most widely used method of entering machine code programs into home micros is via a hex loader. If your micro doesn't support hex direct then the hex code has to be entered as a string, sliced and then converted to decimal before POKEing into the addresses. Otherwise, the decimal conversion can be left out. Another method might use the READ/DATA statements if your computer has them.

Assemblers and compilers can also be used to get your program into memory. Taking the assembler first, this is a program that could either be resident in ROM or loaded in via tape, etc. This will take your assembler language statements and convert them into machine code. Before the program can run, however, the statements are checked for validity, and an opportunity is given to edit the program. A compiler is a program, usually loaded into the computer, which converts a higher level language, such as BASIC, into machine language. If the last two methods have to be loaded in then they do use up memory, which is usually a precious commodity. So how the program gets into the computer is a combination of personal preference and what your computer will support.

What . . .

The instruction set, mentioned last month, is where you will find all the instructions you will use in machine code programing. Ideally they will be in tabular form, giving both decimal and hexadecimal notation, and sometimes you might find the binary form given as well. Also they should include the assembler mnemonics, and the number of bytes per instruction. Those of you with Sinclair micros have everything that you need, apart from the byte count, in the handbook. Because the instruction set for the Z80 is very comprehensive I will be using that for the examples I give. Don't worry if your computer doesn't have a Z80 CPU, the same principles will apply.

Don't Forget The Post Code!

Before very long 16-bit micros will be as common in the home as the eight-bit ones are now, but until then I will be dealing only with the eight-bit variety. Addressing modes are simply a way of getting round the fact that addresses require 16 bits, but our data word is only eight bits long. The first addressing mode I'll explain is the implied because it is the simplest, and only one byte long.

Sometimes known as the register direct, the **implied mode** is so named because the data source and destination are implied in the instruction. For example, to load the B register with the contents of the C register requires the instruction 41 hex in the Z80 set. Here the source is the C register and the destination the B register, this could be shown as C—>B. Incrementing and decrementing registers, and No OPeration and RETurn instructions use the implied mode.

NOP, or no operation, is self explanatory, nothing happens (nothing, that is, except a fractional waste of time). This is a very useful instruction that could be used in a timing loop, or to occupy addresses that you intend to overwrite with data later on in the program. Or perhaps you haven't quite decided what to do in one patch of the program. An approximate number of NOPs will reserve the space for you until you have made up your mind. As for the RETurn, this is perhaps the most important instruction you will use. Without it, in some computers, you could be stuck in an infinite loop. In its simplest form, it can be regarded as an instruction to return to the place from whence you were sent — more will be explained later.

All simple register to register transfers use the implied mode, but as an exercise see how many of these instructions you can find in your set. The golden rule is that there is only byte in the whole instruction.

For Your Immediate Attention

The immediate mode is the next easiest addressing mode that you can use. As with the implied, the immediate mode does not involve any addresses, but there are now two bytes per instruction. The instruction 3E hex in the Z80 set means load register A with the number that follows; in the 6502 set the same instruction would be A9 hex. This might have the mnemonic Ld A,n, or M—>A, or even MVI A,D8; note well that the names are not CPU instructions; they are just humanised memory aids. That last mnemonic sums everthing up nicely because it means, move immediate(ly) into A a data byte of eight bits. Other instructions of this type include add n to a patricular register or subtract n from a particular register. Again as an exercise, pick out all the immediate mode instructions out of your set.

Now that we have reached two byte instructions, I'd like to clear up a point that seems to confuse newcomers to machine code programming. The idea that the same byte can represent two different things might seem at first glance to be perplexing, but stop and think. Let me take as an example the instruction above, load A with n. This could be written in a Z80 program as 3E, 3E (or for the 6502,A9,A9). What happens is that when the computer gets to the first 3E it regards it as an instruction, an instruction to load the byte that follows (which also happens to be 3E) into register A. What the second number stands for is up to you, as the programmer, to decide. It may be just a number you want to manipulate, or it could be the code of a character you want to print to the screen. Whatever, the computer recognised the first 3E (or A9), as an instruction requiring two bytes. After carrying out that instruction the computer would carry on with the rest of the program from the instruction which came after the second bytre. Every instruction belongs to a class that requires one, two, or more bytes for proper execution. It is the programmers responsibility to ensure that the computer starts off in the right place! **ETI**

MULTISWITCH

Light seeks switches; in fact, lots of switches: object, turning on (and off). Bright idea by D J Rayner; development by Dave Bradshaw.

Have you ever wished you could have extra light switches controlling the same light, yet baulked at the idea of ripping out your plastering to install those four-way mains cables that this necessitates? Figure 1a shows what would be involved in wiring up such a system in the conventional way.

Never fear, help is at hand, in the form of the ETI Multiswitch. The equivalent circuit diagram is shown in Fig. 1b. In fact this diagram doesn't show all the unit's advantages; here are a few more:

- all wiring is at earth (or +5 V relative to earth) so there's no need to use mains cable. You can use the thinnest cable you can get hold of, so it can be concealed fairly easily without the need to chase it into the wall;
- similarly, the switches do not have to be mains-rated, although you can leave your existing switches in place and use them;
- you can have up to eight switches all controlling the same light, and you can add or remove switches without having to alter any of the rest of system;
- finally, as the light can be switched on and off from lots of different positions, it's likely to be switched on and off quite a lot! Zero voltage switching can improve bulb life dramatically under these circumstances, and so the unit has been designed to allow the light to come on only when the line voltage is close to zero.

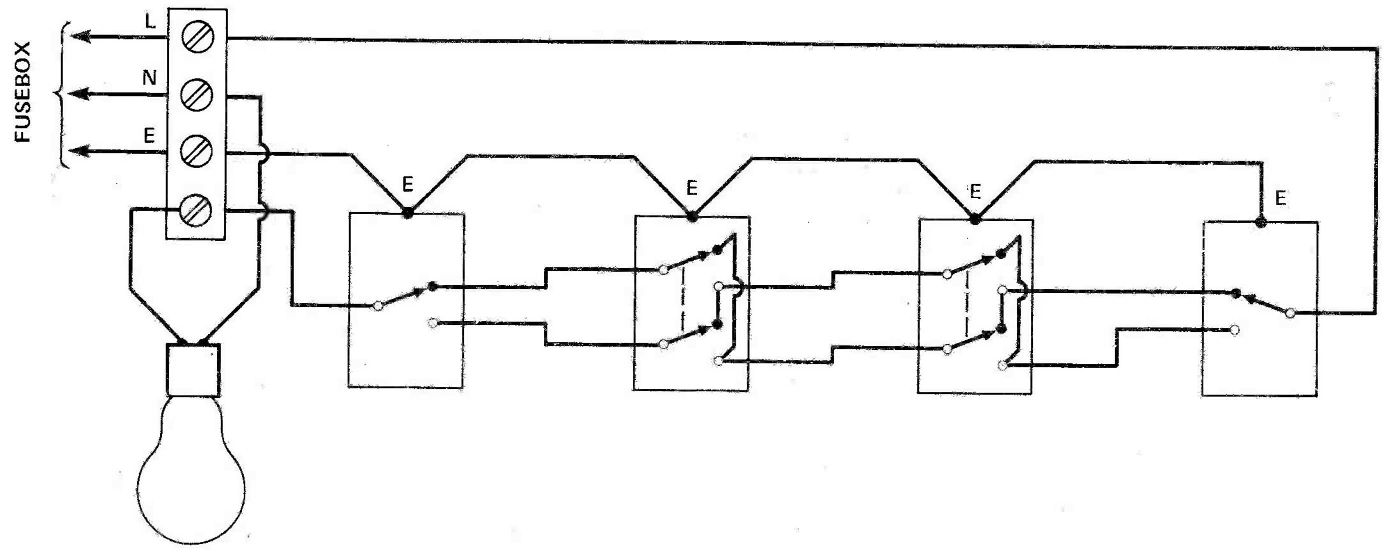


Fig. 1a Ah, in the good old days this was the circuit you'd have to use to switch a light from more than a couple of switches; it was a good circuit — it kept many a plasterer in gainful employment, not to mention the copper mills . . .

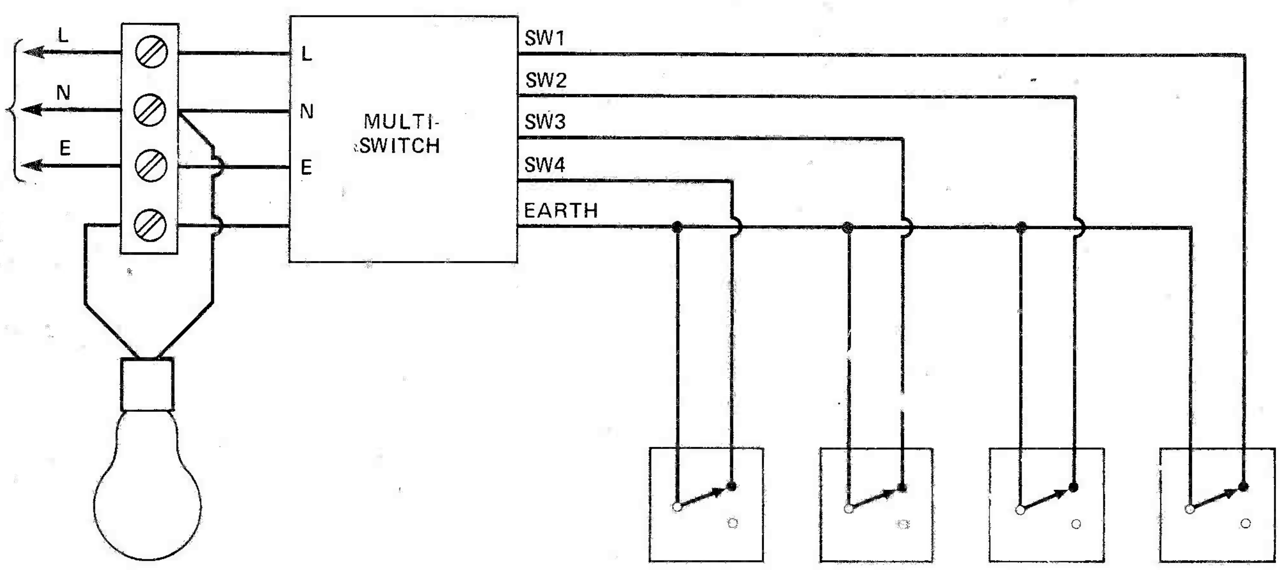


Fig 1b . . . then those young heathens from ETI came along and designed a thingummy that didn't require big thick wires to be buried in the wall — such is progress.

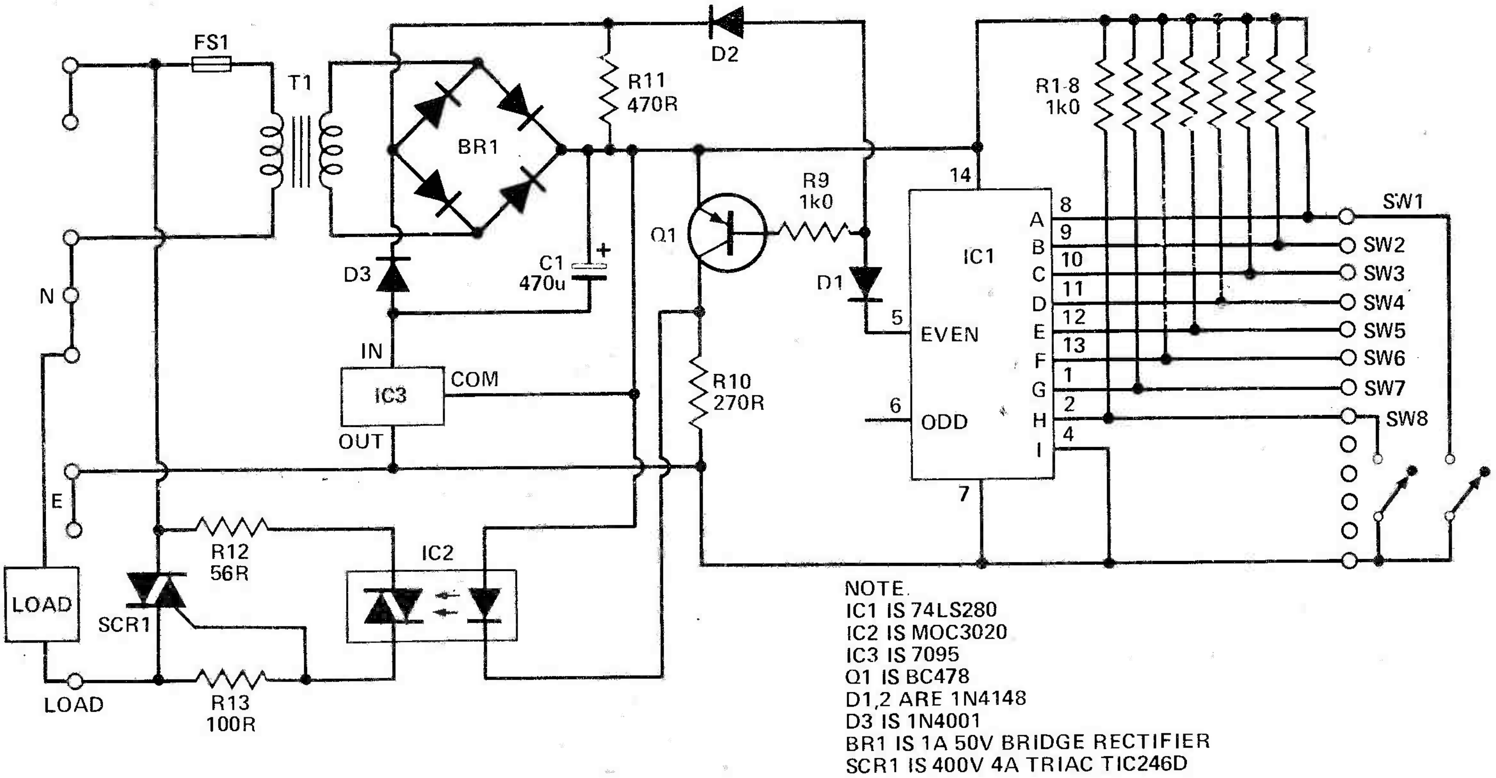


Fig. 2 Circuit diagram of the thingummy.

The idea for this unit germinated when it was noticed that the Karnaugh map required for such a unit was exactly the same as that for a parity checker, ie the output should change state when one and only one of several inputs changes state (ie, a switch goes from open to closed or vice-versa).

Unfortunately, there is no readily available CMOS parity checker (at least, not that we could find), and therefore the circuit had to be implemented using TTL. However, once it was decided that a PSU had to be designed, it was noticed that for very little extra in the way of components, the unit could also be made to perform zero voltage switching, as mentioned already.

Construction

Not very much needs to be said about the construction of the PCB itself, though it should be pointed out that mains is present on about half of the board, and it should be accorded with suitable respect. You can finish it off by installing it in a suitable plastic or metal case — note that if you use a metal case it must be earthed. Make holes at opposite ends for the mains cables and the switch wiring.

Installation

The unit is intended to be installed well out of the way of tiny,

IC1 is the parity checker. All inputs are pulled high by R1 to 8, unless any of the switches SW1 to 8 are closed. Fewer switches may be used, and unused inputs left unconnected. We have left you the option of using either even or odd parity outputs, so that you can arrange for the lights to be either on or off with all the inputs high.

If the parity is odd, then the even output from IC1 will be low, the base of Q1 will be pulled low via D1 turning it on, and the LED in IC2 will be extinguished, so that SCR1 will also be off.

The extra circuitry to detect zero voltage crossing consists of D2, D3 and R11. When no current is flowing from BR1, D3 frees the negative output of BR1 from remaining at the voltage at the negative end of C1. Thus the negative output voltage from BR1 will rise to the positive supply voltage, pulled up by R11. Q1 can only turn off when this voltage is close to the positive supply voltage (and when the even output of IC1 is high). When Q1 turns off, the load will be energised via IC2 and SCR1.

If you need to drive only a very small lamp, you could drive it directly using just IC2, and omitting SCR1. However, this risks blowing IC2 should the bulb blow (it's not uncommon for light bulbs to go momentarily S/C when blowing).

RESISTORS (all ¼W 5% unless stated)	
R1-8	SIL resistor pack, 8 by 1k0
R9	1k0
R10	270R
R11	470R, ½W
R12	56R
R13	100R
CAPACITOR	
C1	470µ 16V PCB type
SEMICONDUCTORS	
IC1	74LS280
IC2	MOC3020 opto-triac
IC3	7905 regulator (−5V)
Q1	BC478 or similar
D1, 2	1N4148 or similar
D3	1N4001 or similar
BR1	1A 50V bridge rectifier
SCR1	400V 4A(min) triac, TIC246D or similar

MISCELLANEOUS
Transformer (mains to 9V + 9V, 3VA total, PCB mounting, see Buylines); 20mm fuse (0A5 max) plus PCB mounting holder; PCB-mounting screw terminals, vertical (2 off); PCB; case; veropins for switch connections; switch to choice (see text).

BUYLINES

The transformer that the PCB is designed for is available from Rapid Electronics, and they sell it as their standard 3VA PCB mounting type. The PCB is, as ever, available through our PCB service.

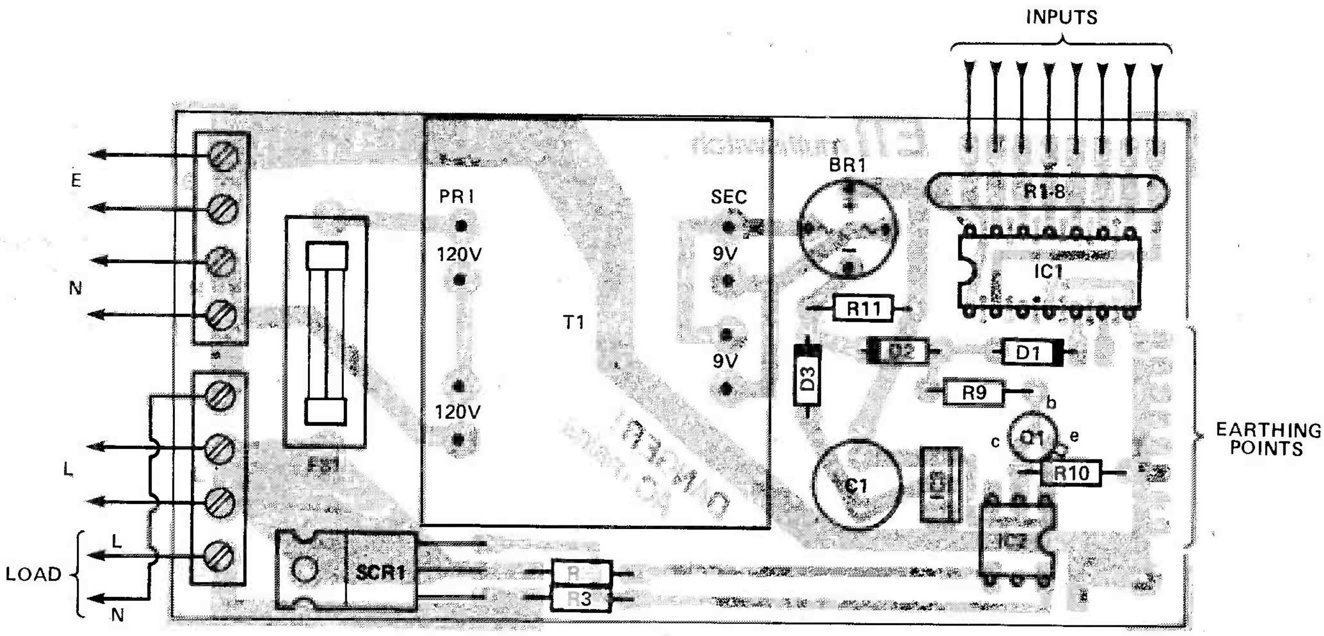


Fig. 3 Overlay diagram of the thingummy. Note that R11 gets a little warm and should be mounted standing slightly proud of the board.

inquisitive fingers, and it is **not** suitable to be treated as anything but a piece of electrical wiring hardware. The screw terminals are **not** intended to support either the weight of the unit, or of a light fitting, etc. If you do use the unit with flex, rather than fixed cable wiring, then you must anchor the cable in some way, by using suitable cable glands for instance.

Fig. 1b shows the wiring diagram if you're using the unit in a new system; alternatively, you can wire up an existing two-position circuit (provided it's in good condition) as just one switch, by earthing one end and connecting the other as an input to the Multiswitch.

ETI

MULTIPLE OUTPUT PORT

Is your computer a megalomaniac at heart? Here's a circuit that will allow it to have up to 40 slaves, by Stephen Huckstepp.

This project is intended for use with virtually any computer, the only prerequisite being access to the data and address buses and to the control signals IORQ and WR or their equivalents.

There can be up to 40 on/off outputs from the port, all of which can be used to drive external circuitry. The port is expanded in groups of eight, with eight being the minimum (well, you could have a port with no outputs if you really wanted . . .). As the board makes provision for the maximum number of outputs, subsequent expansion up to the maximum is no problem.

However, the main draw-back is that this circuit will be fairly slow and software-intensive to operate. This is because each write operation outputs to only one bit in any group of eight outputs, but to each group simultaneously. So, for instance, while writing to bit 3 in group 2, you will be writing to bit 3 in all the other groups (though not the same information). Most of the software you will need will involve setting up the data in the correct format to go to the port.

Provision has not been made to drive equipment that requires a handshake control. However, an alternative use for a spare output data line from the computer might be as a 'data valid' signal, rather than as a clear as suggested in the 'How It Works' section.

Construction

There is very little to say about the construction of this project except to recommend that the usual CMOS precautions should be followed. Although all the devices used are relatively inexpensive, it is probably still a good idea to use IC sockets, as failed device could be a !!!! to remove.

When connecting up to the computer, note that the lines for D5 and D7 have been transposed on the PCB. Check your computers memory map to set up a suitable address for the port, and use the links to make the port occupy this address.

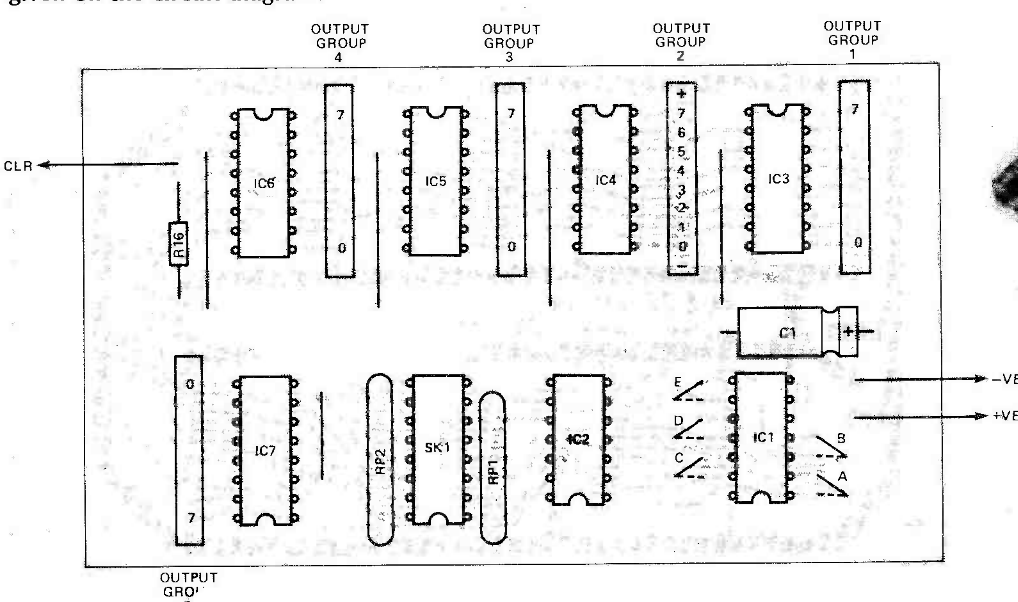
BUYLINES

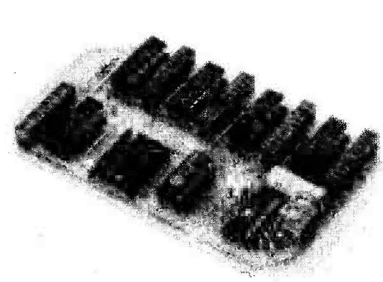
Nothing in this project should cause any difficulties. The SIL connectors are available from Maplin and others, the ICs are widely available, and the PCB is available through our very own PCB service.

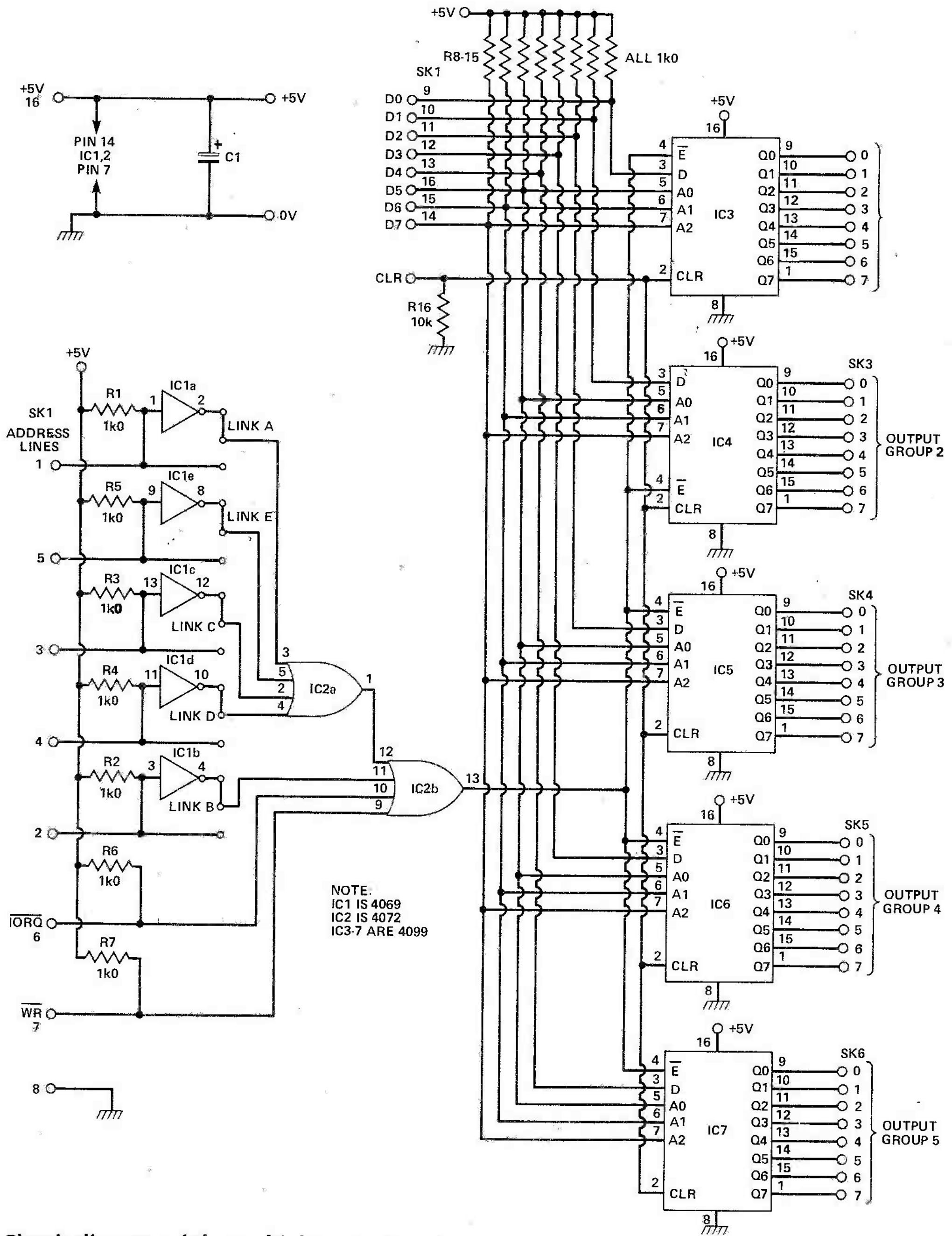
PARTS LIST

RESISTORS	
R1-7	SIL resistor pack, 7 by 10k
R8-15	SIL resistor pack, 8 by 10k
R16	10k ¼W 5%
CAPACITOR	
C1	100µ 6V (min) tubular electrolytic
SEMICONDUCTORS	
IC1	4069
IC2	4072
IC3-7	4099
MISCELLANEOUS	
SK1	16-pin DIL socket and header plug
SK2-5	10-way SIL connectors, 0.1" pitch
PCB; case to choice; wire, etc.	

Overlay diagram of the multiple output port; note that the pin-out for SK1 is given on the circuit diagram.







Circuit diagram of the multiple output port.

HOW IT WORKS

This circuit is based on the 4099 eight-bit latch, used for IC3 to 7, which is one of the cheaper low-power latches that are readily available. The circuit shown is relatively slow to operate, but is very cheap to build!

Five address lines are used to select the port; the inverters, IC1a to e can be selected in or out using the links, so as to set up an address that is convenient.

IC2 decodes both the address and the port request lines, IORQ and WR. The output from IC2b enables all the chip select lines on all the latches. Thus when a write operation occurs, the same bit on all the latches is written to at once.

Of the data bits, D5 to D7 are used to address the bit to be written to. The remaining data bits are the data that is to be written, D0 being the data for the selected bit in the first latch (IC3), D1 for the second latch (IC4), etc.

Because of the mode of addressing selected, if you want to leave a particular bit in one latch unchanged, while altering the same bit in the other latches, you must re-write the same data as before.

There is no need to install all the latch ICs if you do not need them, the system will still work with just one latch in position (though you'll only get eight outputs, of course). If you don't use the full capability, you may find it useful to connect the clear (CLR) input to one of the unused data bits.

Note that the data inputs D5 to D7 feed inputs on all five latches; this may make it necessary to buffer these lines at the computer, depending on what other peripherals are connected to the data bus.

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BFR41 22p
BFR79 22p
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BFR81 22p
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BFS61 1.00
BFS98 1.10
BFT19 1.65
BFT66 2.48
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ME1001 45p
ME1002 45p
ME1075 45p
ME1100 45p
ME1120 48p
ME3002 25p
ME4001 45p
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ME4003 45p
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ME4102 25p
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ME4104 25p
ME6001 25p
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ME6003 25p
ME6101 29p

ME6102 28p
ME8001 47p
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BRY55-300 67p
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TIC44 35p
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TIC106D 49p
TIC106M 68p
TIC116A 66p
TIC116B 68p
8A
TIC116C 71p
TIC116D 73p
TIC116M 80p
TIC126A 72p
TIC126B 72p
12A
TIC126C 73p
TIC126D 77p
TIC126M 96p

DOMESTIC SCRS/TRIACS
2N4444 1.80
BT101-500R 1.40
BT106 2.25
BT116 Use TIC116M
BT119 2.37
BT120 2.27
BT121 2.22

TRIACS

Texas 400V
TO220 Case
TIC206D(4A) 66p
TIC225D(8A) 74p
TIC226D(8A) 88p
TIC236D(12A) 1.16
TIC246D(16A) 1.22
TIC253D(20A) 1.90
TIC263D(25A) 2.11
TIC263N (25A 800V) 2.46

Other Triacs
2N5756 (TO5) 1.44
2N6070 1.00
2N6155(TO127) 3.39
40432 (Quadrac) 2.23
40486(TO5) 1.65
40512 2.70
40576(TO66) 3.33
40842 1.92
BT139-600 1.95

ZENER'S

400-500mW
E24 Series
2.4-47V 7p

1.3 Watt
E24 Series
3.3-82V 14p

2.5 Watt
E24 Series
7.5 75V 1.10

5W wired ended following voltages only
3V3, 3V6, 4V3, 4V7, 5V6, 7V5, 8V2, 8V7, 9V1, 10V, 12V, 20V, 33V, 51V, 62V, 68V 1.25

20W Pos. Stud
(BZY93 series)
E24 values
7V5-75V 2.10

OPTO

LED LAMPS
R = Red
G = Green
Y = Yellow

Large Diffused 1+ 50+
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

Lage clear
R5C 12p 10p
G5C 17p 13p
Y5C 17p 13p

Super bright large. High Efficiency. At least 100 times brighter than standard LEDs for the same current.
R5U 38p 29p
G5U 42p 34p
Y5U 42p 34p

RECTANGULAR LEDs
Stackable End to End
R5R 17p
G5R 18p
Y5R 19p

RECTANGULAR LEDs WITH BOWED TOP (Tombstone)
R5B 21p
G5B 22p
Y5B 23p

MISC. OPTO
2N5777 45p
2N5778 60p
2N5779 70p
4N25 74p
4N27 74p
4N28 74p
BP104 1.00
BPW34 1.43
BPX25 2.47
BPX29 2.47
BPX48 6.76
BPX60 4.75
BPX61 3.48
BPX63 2.93
IL74 55p
ILD74 95p
ILQ74 1.85
LD271 40p
LD461 25p
LD466 1.45
LD468 1.65
LD471 27p
LD476 1.20
LD478 1.45
LD479 1.66
LD481 27p
LD486 1.25
LD488 1.70
LD489 1.89
LD599 81p
MOC3020 1.49
ORP12 95p
TIL32 71p
TIL38 44p
TIL78 60p
TIL81 1.60
TIL100 72p
TIL116 1.10
TIL138 2.40
TIL139 2.40
TIL209 9p
TIL211 14p
TIL212 14p
TIL312 1.02
TIL313 1.02
TIL401 3.50
TIL403 3.80
TIL406 4.10
TIL722A 49p

LIN IC'S

AY1-5050 95p
AY3-8910 3.66
AY3-8912 4.40
CA3018 75p
CA3018A 1.99
CA3020 1.99
CA3020A 3.90
CA3021 3.20
CA3022 3.12
CA3026 1.52
CA3028A 95p
CA3028B 1.99
CA3029 1.44
CA3030A 2.97
CA3033 5.44
CA3034 5.18
CA3036 2.65
CA3039 1.50
CA3041 3.47
CA3042 3.47
CA3043 2.75
CA3046 69p
CA3047 4.60
CA3048 2.15
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 3.20
CA3071 3.30
CA3075 2.10
CA3076 3.42
CA3078T 2.25
CA3080 1.89
CA3080A 3.95
CA3080E 70p
CA3081 1.90
CA3085 1.35
CA3086 48p
CA3089E 1.95
CA3090AQ 3.70
CA3130E 87p
CA3130T 1.80
CA3140E 39p
CA3140T 95p
CA3160AE 99p
CA3161E 1.59
CA3162E 4.49
CA3240E 1.04
HA1366W 2.40
HA388 2.54
ICL7106 6.85
ICL7107 9.50
ICL8038 2.99
ICM7555 80p
LC7120 3.20
LC7130 3.40
LC7137 3.95
LF347 1.50
LF351 47p
LF353 92p
LF355 83p
LF356 92p
LF357 1.09
LF397 4.62
LF13201 2.99
LF13331 3.30
LF13741H 68p
LF13741N 59p
LM10CH 4.50
LM11CH 4.50
LM114 7.50
LM301AH 95p
LM301AN 19p
LM305AH 2.90
LM305H 88p
LM307H 69p
LM307N 45p
LM308AH 3.15
LM308AN 2.14
LM308H 95p
LM308N 88p
LM309K 1.35
LM310H 1.95
LM310N 1.89
LM311H 1.04
LM311N 69p
LM317K 2.80
LM317T 1.75
LM318H 2.40
LM318N 1.49
LM319H 2.48
LM319N 2.10
LM324N 29p
LM335 1.30
LM337K 4.39
LM337MP 1.65
LM337T 1.76
LM339AN 1.60
LM339N 44p
LM345K 8.60
LM348N 62p
LM349N 1.09
LM350K 4.60
LM359N 1.44
LM360N 3.88
LM376N 65p
LM377N 1.69
LM378N 3.40
LM379S 4.50
LM380N 75p
LM380NB 1.50
LM381AB 2.26
LM381N 1.40
LM382N 1.12
LM383T 3.40
LM384N 1.40
LM386N1 88p
LM386N4 1.20
LM388N 2.43
LM387N 1.25
LM391N60 1.70
LM391N80 1.93
LM392N 76p
LM393N 96p
LM394H 3.80
LM396K 13.49
LM709N8 64p
LM709CH 1.00
LM710CH 89p
LM710CN 52p
LM711CH 1.38
LM711CN 70p
LM723CH 95p
LM723CN 35p
LM725CH 3.40
LM725CN 3.19
LM733CN 69p
LM741CH 96p
LM741CN 15p
LM741CN14 80p
LM747CN 69p
LM748CH 1.00
LM748CN 35p
LM748C14 70p
LM1011 8.60
LM1303N 1.20
LM1304N 2.50
LM1305 3.10
LM1307 2.75
LM1310N 1.45
LM1330N 2.25
LM1458 44p
LM1496 75p
LM1800 3.24
LM1801 2.99
LM1812 8.00
LM1818 4.00
LM1820 2.15
LM1828 4.79
LM1830 2.44
LM1845 4.12
LM1848 2.89
LM1850 2.75
LM1871 3.25
LM1872 4.39
LM1877 3.95
LM1886 7.44
LM1889 3.77
LM2907N 2.75
LM2907NB 2.60
LM2917N 1.89
LM2917N8 1.89
LM3301 1.60
LM3302 74p
LM3401 65p
LM3404 75p
LM3406 1.45
LM3524 6.77
LM3900 48p
LM3905 1.25
LM3909 79p
LM3911 1.20
LM3914 2.50
LM3915 2.50
LM3916 2.50
LM4250CH 2.63
LM250N 2.38
LM13500 95p
MB3712 2.18
MB3756 3.80
MB8719 7.95
MC1303 1.20
MC1304 2.50
MC1305 3.10
MC1307 2.76
MC1310 1.45
MC1330 2.25
MC1352 2.25
MC1456 2.25
MC1458 44p
MC1466L 6.95
MC1468L 4.30
MC1495 4.90
MC1496 75p
MC3302 1.00
MC3340 1.20
MC3357 2.48
MC3401 65p
MC3403 75p
MC3404 75p
MC3405 1.45
MC3446 3.25
MC4024 3.25
MC4044 3.25
MF10 3.50
MM5387 9.95
MM58174 7.50
NE529 2.25
NE531N 1.36
NE540L 4.95
NE543N 2.50
NE544N 1.95
NE555 16p
NE556 45p
NE558 1.89
NE560 3.25
NE565 1.18
NE566 1.49
NE567 1.37
NE570 4.07
NE571 3.99
NE592 1.95
NE5534A 1.25p
OM335 7.20
PLL02A 4.95
PLL03A 12.75
RC4136 59p
RC4194 3.95
RC4195 2.95
S556B 2.59
SAA1024 4.99
SAB3209 3.99
SAB3210 3.18
SAS560 2.59
SAS570 2.59
SAS580 2.95
SAS590 2.95
SFF96364 7.99
SL470 3.47
SL490 3.47
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
SN76008 3.90
SN76018 3.90
SN76003N 2.95
SN76013N 2.95
SN76023N 2.95
SN76033N 2.95
SN76477 4.20
SN76550 80p
SN76666 2.90
SO41P 1.95
SO42P 1.95
TA7066 4.49
TA7072 3.49
TA7073 4.25
TA7120 1.99
TA7130 1.75
TA7202 4.49
TA7203 4.99
TA7204 1.99
TA7205 1.20
TA7210 6.95
TA7222 1.75
TA7223 3.98
TA7227 5.82
TA7310 1.49
TAA263 3.88
TAA300 3.95
TAA320 2.05
TAA521 1.50
TAA522 2.47
TAA550 73p
TAA560 2.35
TAA570 2.35
TAA621 2.95
TAA661A 2.50
TAA661B 2.50
TAA700 2.60
TAA930A 2.50
TAA930B 2.63
TAA970 2.45
TBA120AS 69p
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 2.80
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
TBA820 75p
TBA820M 85p
TBA920 1.95
TBA920Q 1.97
TBA950 2.25
TBA990 2.65
TBA990Q 2.74
TCA105 3.00
TVA160C 2.67
TCA210 2.76
TCA220 3.44
TCA270 2.44
TCA440 2.69
TCA450 2.65
TCA660B 4.15
TCA730 4.80
TCA740 4.80
TCA750 4.85
TCA760 2.75
TCA800 3.50
TBA800Q 3.60
TCA830S 1.90
TCA910 2.19
TCA940 1.69
TDA1002 3.39
TDA1003 3.94
TDA1004 3.94
TDA1005 3.94
TDA1006 3.94
TDA1008 2.99
TDA1010 1.79
TDA1022 4.95
TDA1024 1.14
TDA1170 3.10
TDA2002 3.25
TDA2003 3.25
TDA2020 2.99
TDA2030 2.85
TDA2522 4.20
TDA2523 4.95
TDA2530 3.30
TDA2532 4.95
TDA2540 4.10
TDA2541 4.10
TDA2560 4.10
TDA2571 4.40
TDA2581 3.75
TDA2582 3.95
TDA2590 5.20
TDA2591 4.73
TDA2593 3.15
TDA2600 6.95
TDA2610 3.90
TDA2611A 2.50
TDA2640 3.64
TDA3000 2.78
TDA3300 15.60
TL061 40p
TL062 60p
TL064 95p
TL071 24p
TL072 45p
TL074 99p
TL081 24p
TL082 45p
TL083 75p
TL084 89p
TL170 49p
TL430 69p
UAA170 1.69
UAA180 1.69
ULN2003 75p
UPC575C2 2.00
UPC1024H 99p
UPC1025H 3.95
UPC1032H 1.60
UPC1035C 2.95
UPC1156H 2.75
UPC1158H 99p
UPC1181H 1.95
UPC1182H 3.75
UPC1183H 2.95
UPC1185H 6.45
UPC1186H 1.58
UPC1188H 4.50
UPC1190C 3.50
UPC1212C 1.60
UPC1213C 2.00
UPC1228H 1.37
UPC1447H 1.40
UPC1470H 1.29
UPC2002H 2.95
UPC2002V 2.95
XR2206 2.92
XR2207 4.00
XR4212 1.80
ZN414 1.00
ZN419 2.25
ZN1034 1.99
ZNA134E 29.95
ZNA234E 8.47

74 TTL

7400 16p
7401 16p
7402 16p
7403 16p
7404 16p
7405 16p
7408 14p
7409 14p
7410 14p
7411 18p
7412 18p
7413 18p
7414 25p
7416 19p
7417 19p
7420 15p
7421 19p
7422 19p
7423 19p
7425 19p
7426 19p
7427 19p
7428 26p
7430 14p
7432 22p
7433 22p
7437 25p
7438 21p
7440 15p
7441 55p
7442 32p
7443 89p
7444 89p
7445 49p
7446 59p
7447 39p
7448 44p
7450 15p
7451 15p
7453 15p
7454 14p
7460 15p
7470 34p
7472 25p
7473 25p
7474 19p
7475 25p
7476 25p
7480 49p
7481 1.19
7482 64p
7483 38p
7484 69p
7485 59p
7486 19p
7489 1.68
7490 19p
7491 35p
7492 25p
7493 25p
7494 36p
7495 36p
7496 35p
7497 89p
74100 79p
74104 49p
74105 55p
74107 19p
74109 25p
74110 35p
74116 49p
74118 55p
74119 59p
74120 59p
74121 25p
74122 35p
74123 35p
74125 35p
74126 34p
74128 35p
74132 29p
74136 27p
74141 55p
74142 1.73
74143 2.08
74144 2.08
74145 50p
74147 74p
74148 59p
74150 49p
74151 39p
74153 39p
74154 53p
74155 39p
74156 39p
74157 29p
74159 75p
74160 59p
74161 48p
74162 39p
74163 39p
74164 39p
74165 49p
74166 48p
74170 1.25
74172 2.49
74173 59p
74174 54p
74175 49p
74176 39p
74177 45p
74178 79p
74180 40p
74181 1.15
74182 80p
74184 89p
74185 69p
74186 4.69
74188 2.48
74190 48p
74191 48p
74192 45p
74193 45p
74194 39p
74195 39p
74196 45p
74197 39p
74198 79p
74199 83p
74221 53p

TTL & CMOS
Pls phone for latest prices

74LS TTL

74LS00 15p
74LS01 15p
74LS02 15p
74LS03 15p
74LS04 15p
74LS05 15p
74LS08 15p
74LS10 15p
74LS11 15p
74LS12 15p
74LS13 15p
74LS14 24p
74LS15 15p
74LS20 15p
74LS21 15p
74LS21 15p
74LS22 15p
74LS27 15p
74LS28 15p
74LS30 15p
74LS32 15p
74LS33 15p
74LS37 15p
74LS38 15p
74LS40 15p
74LS42 28p
74LS47 35p
74LS51 14p
74LS54 14p
74LS65 14p
74LS73 60p
74LS74 60p
74LS75 60p
74LS76 60p
74LS78 60p
74LS83 36p
74LS85 41p
74LS86 16p
74LS90 24p
74LS92 29p
74LS93 24p
74LS95 39p
74LS96 93p
74LS107 35p
74LS109 23p
74LS112 22p
74LS113 19p
74LS114 22p
74LS122 32p
74LS123 36p
74LS124 89p
74LS125 24p
74LS126 25p
74LS132 29p
74LS136 24p
74LS138 39p
74LS139 28p
74LS145 69p
74LS147 99p
74LS148 75p
74LS151 37p
74LS153 39p
74LS154 79p
74LS155 29p
74LS156 36p
74LS157 24p
74LS158 29p
74LS160 31p
74LS161 35p
74LS162 35p
74LS163 35p
74LS164 40p
74LS165 49p
74LS168 84p
74LS169 85p
74LS170 69p
74LS173 49p
74LS174 34p
74LS175 34p
74LS181 88p
74LS183 1.05
74LS190 28p
74LS191 28p
74LS192 28p
74LS193 28p
74LS194 32p
74LS195 32p
74LS196 45p
74LS197 45p
74LS221 95p
74LS240 95p
74LS241 95p
74LS242 95p
74LS243 95p
74LS244 95p
74LS245 95p
74LS247 95p
74LS248 95p
74LS249 95p
74LS251 29p
74LS253 32p
74LS257 29p
74LS258 35p
74LS259 55p
74LS261 99p
74LS266 18p
74LS273 54p
74LS275 1.25
74LS279 29p
74LS280 89p
74LS283 39p
74LS289 4.70
74LS290 39p
74LS293 39p
74LS295 74p
74LS298 79p
74LS299 1.49
74LS323 1.59
74LS324 1.45
74LS325 2.96
74LS326 2.39
74LS327 2.39
74LS347 95p
74LS348 89p
74LS352 61p
74LS353 61p
74LS362 7.25
74LS365 29p
74LS366 29p
74LS367 29p
74LS368 29p
74LS373 55p
74LS378 68p
74LS386 1.14
74LS390 46p
74LS393 42p
74LS395 89p
74LS396 1.90
74LS398 2.70
74LS399 1.59
74LS445 99p
74LS490 2.20
74LS540 89p
74LS541 79p
74LS640 99p
74LS641 99p
74LS643 99p
74LS644 99p
74LS669 99p
74LS670 1.19
74LS673 5.50
74LS674 9.99
74LS688 1.19

74S TTL

74S00 28p
74S02 28p
74S04 28p
74S08 58p
74S20 38p
74S30 60p
74S32 70p
74S40 1.45
74S64 1.02
74S65 1.02
74S74 75p
74S85 2.99
74S86 62p
74S112 75p
74S113 90p
74S124 2.95
74S132 1.09
74S133 60p
74S138 97p
74S139 1.10
74S140 2.50
74S153 7.95
74S157 2.20
74S163 3.00
74S174 2.50
74S175 3.20
74S188 1.40
74S189 1.40
74S194 1.90
74S200 4.50
74S201 2.40
74S225 2.40
74S261 3.00
74S262 8.50
74S287 2.19
74S288 1.99
74S289 1.67
74S301 3.20
74S470 3.25
74S471 6.25
74S473 12.50
74S474 3.99
74S475 7.95
74S571 6.09
74S573 9.00

74 CMOS/TTL

74C00 30p
74C02 30p
74C04 13p
74C08 30p
74C10 30p
74C14 39p
74C20 35p
74C30 35p
74C32 35p
74C42 99p
74C48 1.40
74C73 75p
74C74 75p
74C76 60p
74C83 1.25
74C85 1.25
74C86 1.10
74C89 3.95
74C90 1.05
74C93 1.05
74C95 1.25
74C107 60p
74C151 2.09
74C154 2.99
74C157 2.10
74C160 1.05
74C161 1.05
74C162 1.05
74C163 1.05
74C164 1.20
74C165 1.20
74C173 45p
74C174 1.50
74C175 1.05
74C192 1.05
74C193 1.05
74C194 3.75
74C195 1.05
74C200 6.50
74C221 1.55
74C901 57p
74C902 57p
74C903 57p
74C904 57p
74C905 7.75
74C907 57p
74C908 1.10
74C911 8.50
74C912 8.50
74C914 1.10
74C915 1.55
74C918 1.30
74C920 11.00
74C922 4.85
74C923 4.99
74C925 5.75
74C926 5.75
74C928 6.25
74C929 11.40
74C930 4.40
74C932 1.95

40 CMOS

4000 16p
4001 16p
4002 16p
4006 49p
4007 19p
4008 32p
4009 24p
4010 24p
4011 16p
4012 19p
4013 19p
4014 46p
4015 39p
4016 19p
4017 32p
4018 45p
4019 24p
4020 42p
4021 39p
4022 39p
4023 19p
4024 32p
4025 19p
4026 79p
4027 28p
4028 39p
4029 43p
4030 19p
4031 1.19
4032 79p
4033 1.19
4034 1.29
4035 44p
4036 2.49
4037 1.13
4038 99p
4039 2.45
4040 39p
4041 39p
4042 39p
4043 39p
4044 39p
4045 99p
4046 44p
4047 39p
4048 39p
4049 22p
4050 23p
4051 44p
4052 58p
4053 49p
4054 79p
4055 83p
4056 83p
4059 4.35
4060 42p
4063 79p
4066 22p
4067 2.39
4068 19p
4069 19p
4070 19p
4071 19p
4072 19p
4073 19p
4075 19p
4076 45p
4077 19p
4078 19p
4081 19p
4082 19p
4085 49p
4086 60p
4089 1.23
4093 19p
4094 69p
4095 71p
4096 69p
4097 2.88
4098 74p
4099 89p

45 CMOS

4502 55p
4503 39p
4507 33p
4508 1.26
4510 44p
4511 44p
4512 48p
4514 1.13
4515 1.13
4516 55p
4518 39p
4519 29p
4520 48p
4521 88p
4526 68p
4527 62p
4528 74p
4532 69p
4534 3.96
4536 2.59
4538 78p
4539 89p
4543 68p
4553 2.25
4555 35p
4556 35p
4560 1.49
4566 1.49
4569 1.65
4584 39p
4585 59p

COMP IC'S

CPUs
1802 6.50
6502 3.24
6800 2.10
6802 2.40
6809 6.20
8035 3.49
8080A 2.50
8085A 3.49
8900 57.75
9900 19.95
SCMP1 20.00
Z80A 2.98
Z80B 8.60

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2102AL2 1.35
2111-1 3.00
2114(200ns) 99p
2532 2.98
2564 5.98
2708 2.95
2716 (5v) 2.10
2764 3.95
4027 3.00
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4118-3 3.25
4164 4.25
5204 7.50
6116P3 3.85
6514 3.30
6810 1.15
7489 1.65
74189 4.00

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74LS289 3.25
74LS287 3.05
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ADC0816 14.95
ADC0817 10.39
AY5 1013A 3.00
AY5-1015 2.99
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MC1466L 6.95
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SAA5070 16.95
TMS6011 3.65
8T26 95p
8T28 1.20
8T95 85p
8T97 85p
81LS95 80p
81LS96 85p
81LS97 90p
81LS98 85p
6522 3.19
6522A 4.00
6532 5.70
6821 1.09
6845 6.50
6847 6.50
6850 1.10
6852 2.40
6875 4.85
8131 3.75
8154 9.00
8155 3.50
8212 1.10
8216 99p
8223 1.80
8224 1.10
8226 2.50
8228 2.19
8238 5.75
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8250 8.40
8251 2.50
8253 3.95
8254 10.00
8255 2.19
8257 4.00
8259 3.82
8279 3.75
8601 1.20
9062 2.20
Z80ACTC 2.60
Z80ADART 5.50
Z80ADMA 6.70
Z80APIO 2.70
ZN425E8 3.39
ZN426E8 2.97
ZN427E8 5.99
ZN428E8 4.05

V.REGS

(See also Linear ICs)
— Positive —
100 mA
78L05A 29p
78L12A 29p
78L15A 29p
78L24A 29p

500 mA TO202
7805M 55p
7812M 55p
7815M 55p
7842M 55p

1 Amp TO220
7805T 39p
7812T 39p
7815T 39p
7824T 39p

1.5 Amp TO03
7805K 1.39
7812K 1.39
7815K 1.39
7824K 1.39

— Negative —
100 mA TO92
79L05 49p
79L12 49p
79L15 49p

500 mA TO202
7905M 65p
7912 65p
7915M 65p
7924M 65p

1 Amp. TO220
7905T 44p
7912T 44p
7915T 44p
7924T 44p

1.5 Amp. TO3
7905K 1.99
7912K 1.99
7915K 1.99
7924K 1.99

TECH TIPS

Cassette Logic Driver

Mike Hobbs, Basingstoke

This circuit allows microcomputers with cassette motor relays to control a logic controlled cassette deck with a remote control socket. It was originally designed for the BBC Microcomputer but will be suitable for many others. The circuit was designed to drive a TEAC C-3X cassette deck but is suitable for any machine where the control inputs are grounded to operate the control circuitry.

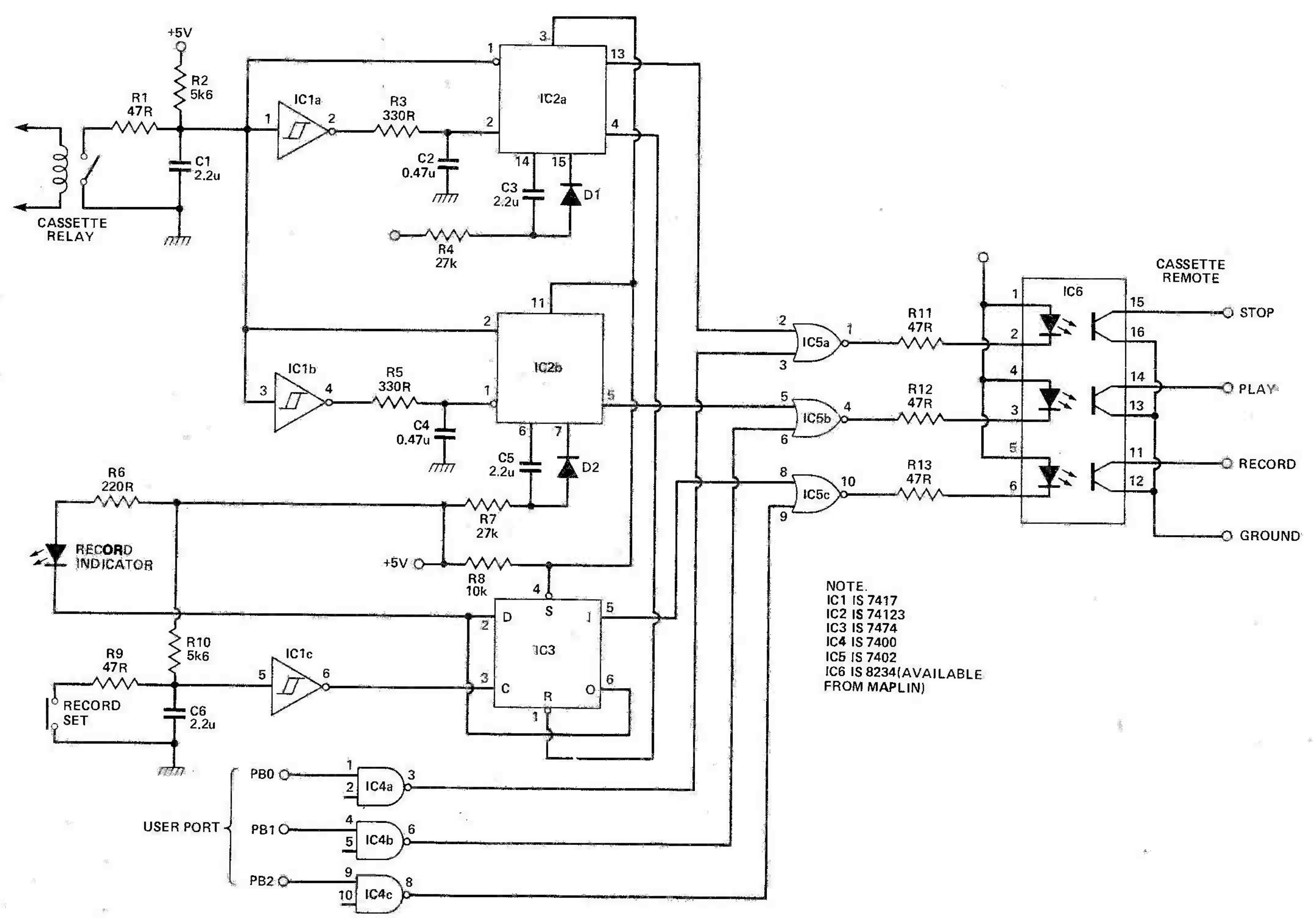
When you LOAD a program the cassette relay closes and this is used to trigger IC2b to give the cassette deck a PLAY pulse. When the cassette relay opens it triggers IC2a to give a STOP pulse. When you need to SAVE a program you press the RECORD SET button before pressing RETURN on the computer. IC3 holds the record mode until the STOP pulse clears it when the operation is complete. This is done to prevent inadvertently recording when intending to read into the computer.

Additionally the circuitry around IC4 provides control from the computer user port so you can have direct control from the software. Obviously it is a simple matter to extend the capabilities of this interface to provide control of the rewind and fast forward functions also. In fact there is a spare gate in IC4, IC5 and IC6 which can be used for, say, the rewind function without any additional ICs being required. The computer user port has direct control over the cassette control signals and therefore the software must provide the correct pulse duration to activate the deck solenoids. The user port signal lines must be driven low to activate the cassette deck because on the BBC Microcomputer the port is set up as an input port on power-up which means that the inputs to IC4 will float high and not try to activate all cassette solenoids at once!

Isolation is provded by the opto-isolator so that there is no risk of damaging components in either the interface or the cassette deck due to different earth potentials or accidental shorting.

IC1 is a schmitt trigger inverter IC to eliminate contact bounce which is quite considerable on some microcomputer cassette relays.

The whole interface will fit onto a module 100 × 120 mm which will fit neatly inside the BBC Microcomputer and with careful mounting and suitable connectors the connector can be accessed from the gap at the rear of the BBC machine. The RECORD SET button can be mounted neatly next to the row of LEDs on the front panel. The power can, of course, be taken direct from the power supply's external output and the cables routed back into the machine via the gap above the port access recess underneath.



Capacitor Tester

Andy D'Rozario,
Manchester.

During circuit development, situations often arise which call for a capacitor to be checked to ascertain whether or not it is functioning. The circuit shown here gives a quick audio and visual indication of the state of the capacitor by using its most basic property — that of DC blocking.

Half of the NE556 oscillates at approximately 200 kHz and is used to provide a train of positive pulses. These pulses are passed through the device under test to the two LEDs and an audio oscillator formed by the other half of the NE556.

The resultant pulses appearing at point X will vary with the device under test as follows:

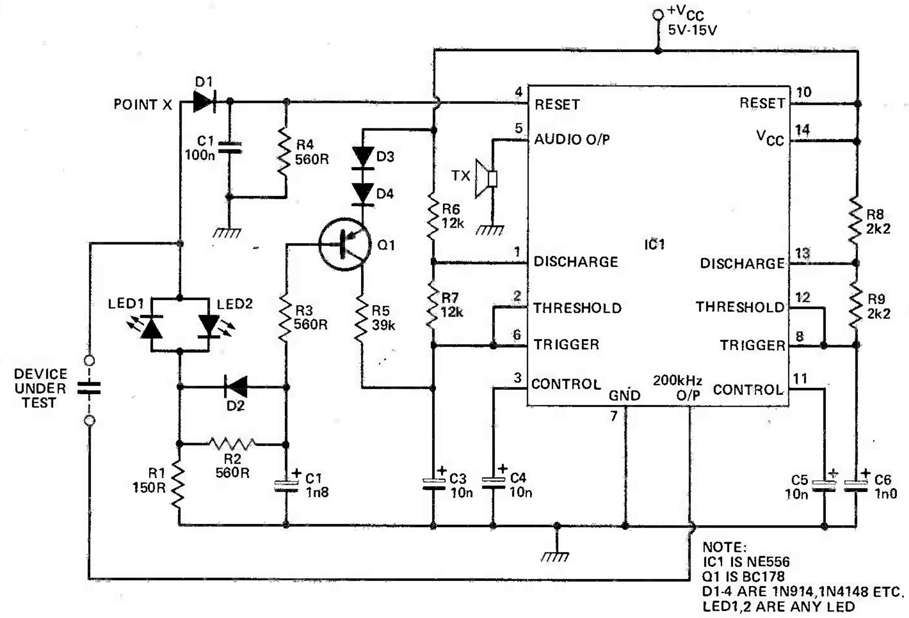
Capacitor OK — positive and negative pulse train at point X, both LEDs illuminated; Q1 conducts and an audio tone is produced.

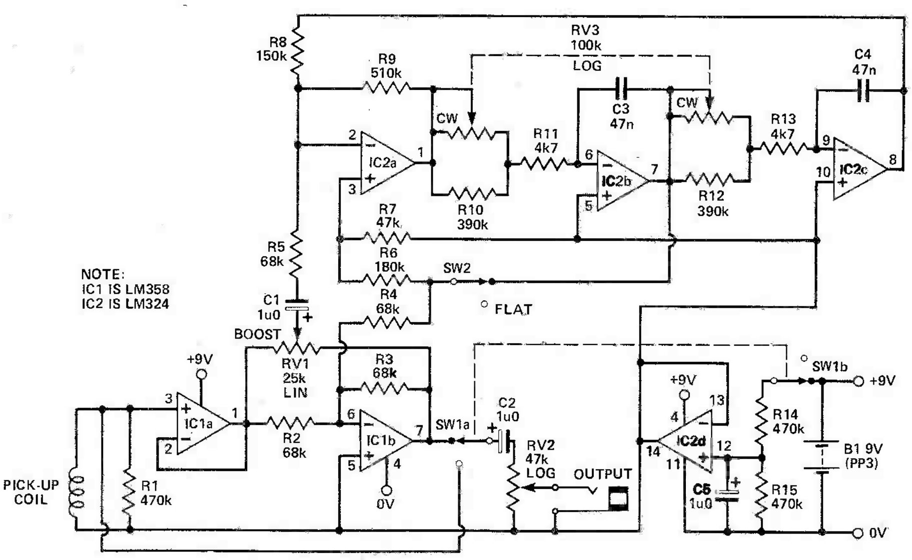
Capacitor S/C — only a positive pulse train at point X, only one LED illuminated, C1 charges up and a lower tone produced.

Capcitor O/C — no pulse train, neither LED illuminated, C2 discharges and the audio oscillator is reset.

A PB2720 piezoelectric transducer was used at the output of the audio oscillator, but a high impedance speaker or earpiece should do just as well.

The tester needs the capacitor under test to be greater than 30nF to produce an audio output reliably, however the LEDs will indicate the correct condition down to 100pF at 5 V supply voltage, and 50pF at 12 V.





Active Bass Tone Control

Ian Willats, Worcester

The circuit was designed to improve the tonal variation of a bass guitar, being physically small enough to replace the passive tone controls in the guitar body. Low power consumption is achieved by the use of LM324 type op-amps (the LM358 is 'half an LM324'), allowing battery operation from a PP3. Current drain is about 1 mA.

Operation of the tone control is as follows: the pickup signal is buffered by IC1a and fed via R2 to mixer IC1b. The boost/cut control RV1 allows a combination of signals to enter the state-variable filter formed by IC2a,b,c, whose centre frequency can be varied by means of RV3 between 40 and 700 Hz (with the given components). The output of the filter is then fed back into the mixer via R4.

In this manner, the selected frequency can be boosted or cut by up to ± 10 dB. If SW2 is opened, however, R4 is grounded via R6 and R7 so that a flat frequency response results. This allows a preset effect to be easily applied to the guitar.

The Q of the filter is set at about 1.4 by R6 and R7. This rather broad peak was found to be musically more useful than a very 'peaky' filter response. Note that the frequency control RV3 is wired so that low frequency effects are obtained when it is turned fully clockwise, giving a subjectively linear control.

IC2d simply provides a low impedance signal ground at half the supply voltage. Switch SW1 is provided to simultaneously switch off the active circuitry and bypass it, for operation in the event of battery failure. In the passive mode only the volume control RV2 is used.

None of the component values given are critical, and some experimentation is useful to match the circuit to a particular guitar. There is no reason why the circuit should not be used in a lead guitar if C3 and C4 are changed to, say, 22nF, to suit the higher frequency range.

Finally, a note about construction — as space is generally very limited inside a guitar body, the circuit can be built directly onto the undersides of the IC sockets and the pots, allowing for easy mounting. The smallest available components should be used. SW2 can be incorporated as a push-pull switch on pot RV1, which makes pre-setting effects very easy to accomplish. **ETI**

DAC/ADC FILTER/AMPLIFIER

ETI supplies the missing link for all your analogue to computer interface circuits. Design by C. D. Oddy.

Anyone who has ever seriously experimented with analogue interfaces to home computers must be all too aware of the problems involved — if you're not too careful you wind up with op-amps everywhere in a variety of hastily concocted amplifier, buffer, and filter circuits. And some of them won't even be hastily concocted; some of them will have taken up a considerable amount of your precious time in the designing. What you need is a handy little unit that will perform any or all of the functions of amplifer, buffer, and filter at the mere twiddle of a control or two. What you need is the ETI filter-amplifier.

The filter-amplifier consists of two active blocks together with input and output buffers and switchable AC or DC coupling. The two active blocks are an amplifier with a variable gain of 0 to 100 and a plus or minus five volt variable offset followed by a low pass filter whose cutoff frequency may be varied over the range 16 Hz to 30 kHz and which may be switched out of circuit when not required. It can be used as an amplifier to match low level signals to the input of an ADC, as a buffer to correct mismatching of signal sources, as a filter to smooth the stepped output of a DAC, and for a multitude of other similar purposes.

Construction

Assembly is simplified by the use of a single quad op-amp for the

PARTS LIST

RESISTORS (all ¼W, 5%)	
R1	1M0
R2	1k0
R3	33k
R4	47k
R5, 6	560R
R7	39k
R8	10k
R9, 11	120k
R10	150k
RV1	20k horizontal skeleton preset
RV2	50k linear with centre click-stop
RV3	100k linear
RV4	100k dual gang log
CAPACITORS	
C1, 4, 5, 7	100n polyester
C2, 3	10u 35V tantalum
C6, 8	10n polyester
SEMICONDUCTOR	
IC1	TL074
MISCELLANEOUS	
SW1	SPST
SW2	DPDT
SW3	SPDT
PCB; case, input and output sockets, knobs, etc as desired.	

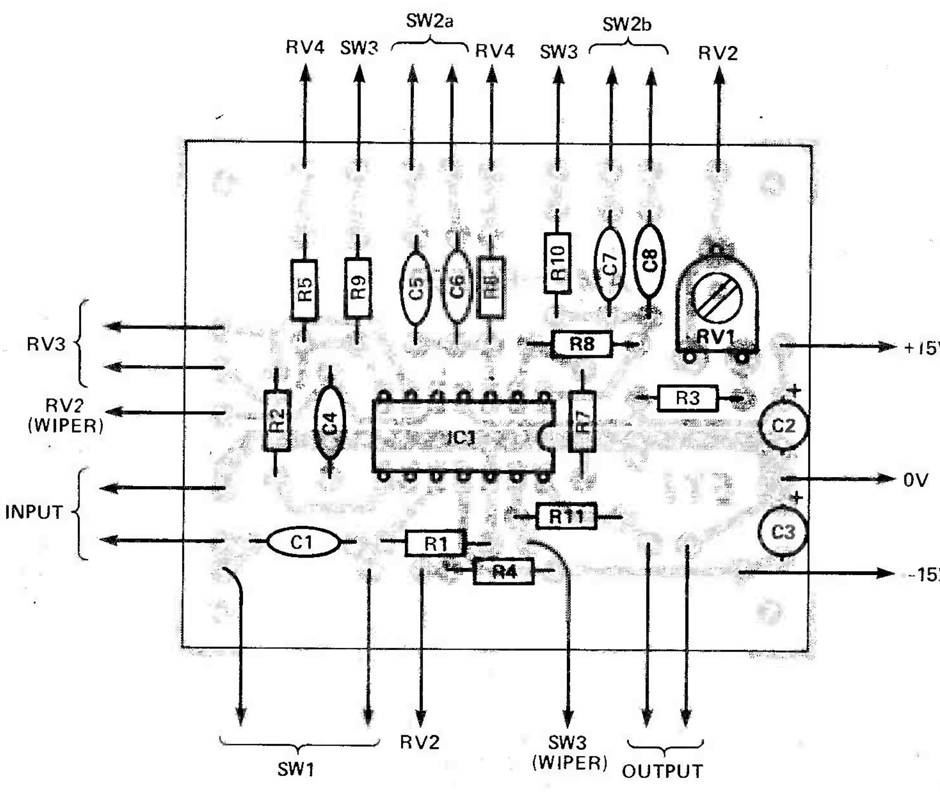
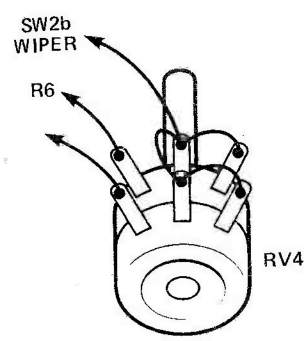


Fig. 1 (left) Component overlay for the PCB

Fig. 2 (below) Connections to RV4



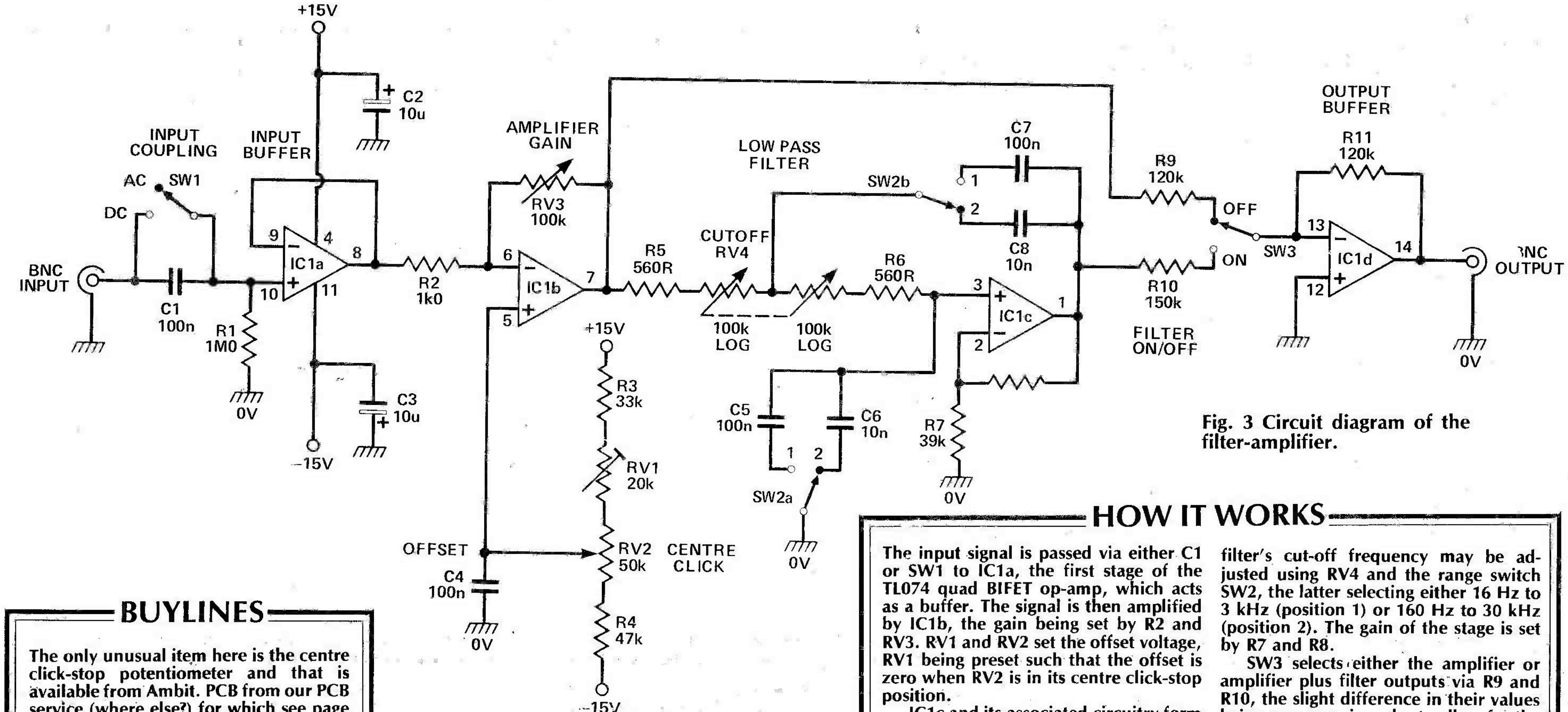


Fig. 3 Circuit diagram of the filter-amplifier.

HOW IT WORKS

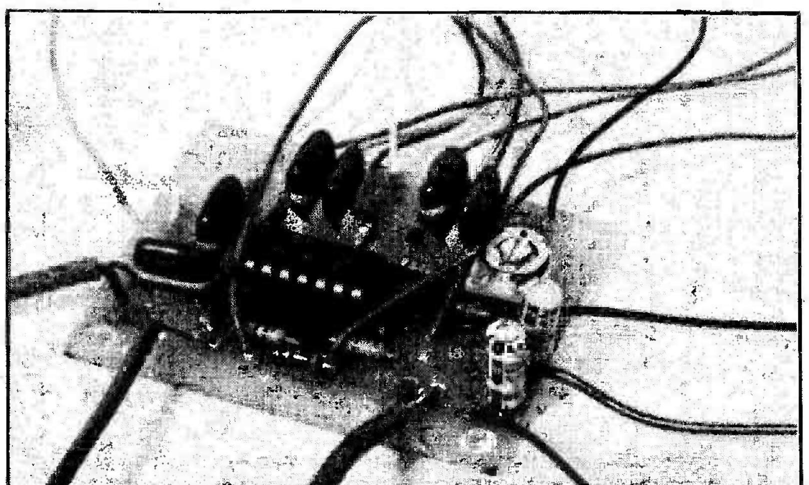
The input signal is passed via either C1 or SW1 to IC1a, the first stage of the TL074 quad BIFET op-amp, which acts as a buffer. The signal is then amplified by IC1b, the gain being set by R2 and RV3. RV1 and RV2 set the offset voltage, RV1 being preset such that the offset is zero when RV2 is in its centre click-stop position.

IC1c and its associated circuitry form a low pass filter of the second order Bessel type which is well suited to the smoothing of stepped signals, such as those obtained from DAC outputs. The filter's cut-off frequency may be adjusted using RV4 and the range switch SW2, the latter selecting either 16 Hz to 3 kHz (position 1) or 160 Hz to 30 kHz (position 2). The gain of the stage is set by R7 and R8.

SW3 selects either the amplifier or amplifier plus filter outputs via R9 and R10, the slight difference in their values being necessary in order to allow for the gain (approx. 2.3 db) of the filter. The signal then passes through IC1d, the final buffer stage, to the output.

BUYLINES

The only unusual item here is the centre click-stop potentiometer and that is available from Ambit. PCB from our PCB service (where else?) for which see page 89.



four stages, and the only point to check on the PCB itself is that this IC and the two electrolytic capacitors (C2, C3) are inserted the right way around. Take care with the wiring of the potentiometers and switches, especially SW2 which has two separate elements whose wiring must be in agreement if the filter is to work correctly. Note also the wiring around RV4 and the connection between this potentiometer and SW2, as shown in **Fig. 2.**

We have not shown either a case or a power supply for this project because it is intended more as a building block than as a complete, self-contained unit. For the really serious experimenter there is obviously a lot to be gained from having several of these filter-amplifiers built into a single unit and equipped with a common power supply, whereas for others, one would probably be sufficient and could be powered from whatever you're using to supply the ICs you're experimenting with.

ETI

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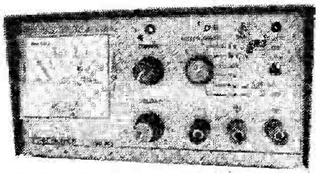

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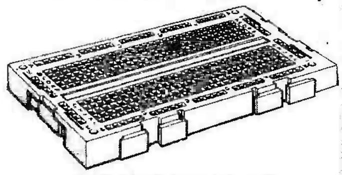

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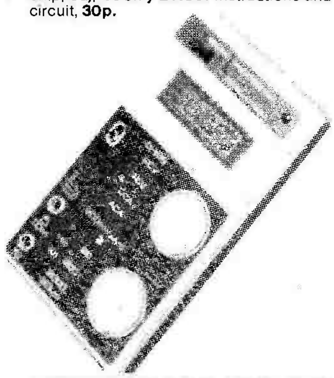

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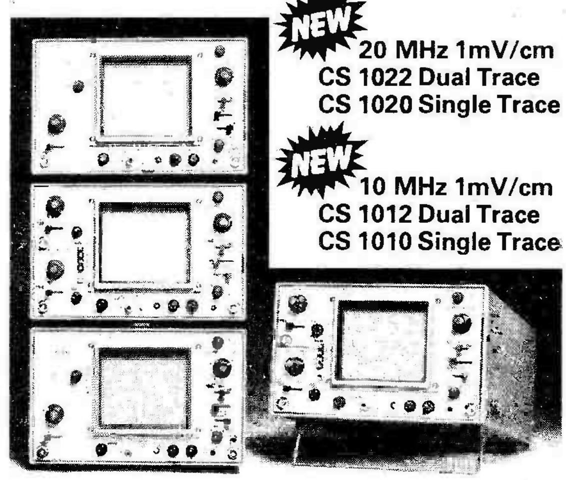

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IC UPDATE

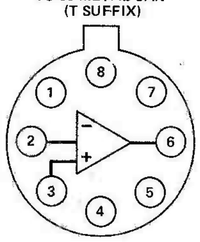
The world of op-amps never stands still, as a glance at the specifications of these devices will testify. No sooner have we got used to the third (or fourth, depending on which manufacturer's literature you've been reading) than the next one comes along.

OP-27, OP-37 Very Low Noise Op-Amps

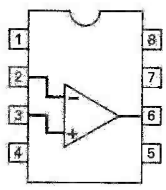
Features

- Very low noise;
  spectral noise density: 3nV/√Hz
  1/f noise corner frequency 2.7Hz
- Very low Vos drift:
  0.2μV/month
  0.2μV/°C
- High gain: 1.8×10^6V/V
- High output drive capability: ±12V into 600Ω load
- High slew rate: 2.8V/μS(17V/μS, OP37)
- Wide gain bandwidth product: 8MHz(63MHz, OP37)
- Good common mode rejection radio: 126dB
- Low input offset voltage: 10μV
- Minimum low frequency noise: 0.08μV_{p-p}0.1Hz to 10Hz
- Low input bias and offset currents: 10nA

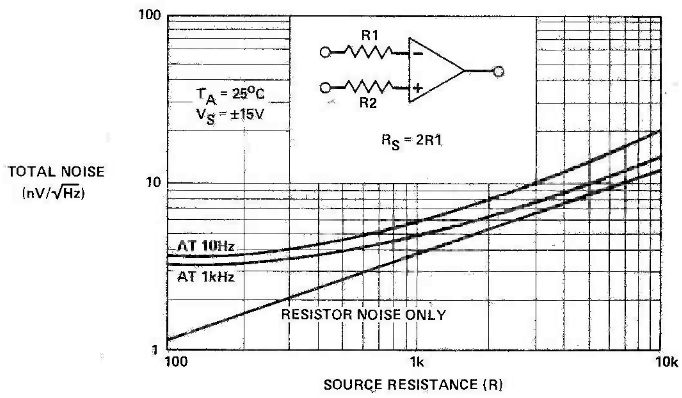
TO-99 METAL CAN
(T SUFFIX)

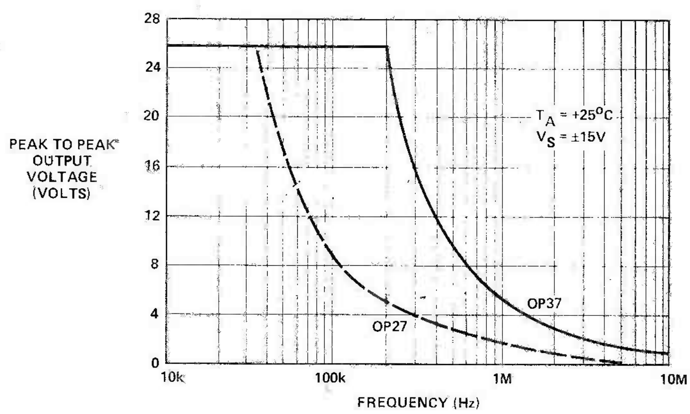


8 LEAD CERAMIC
DUAL-IN-LINE
(D,E SUFFIX)



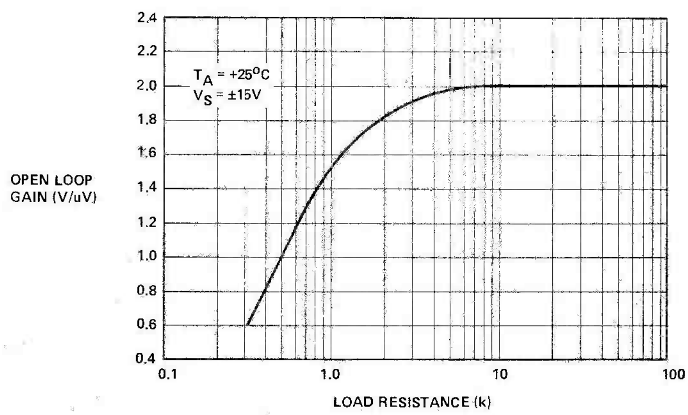
PIN	FUNCTION
1	V_{OS} TRIM
2	INVERTING INPUT
3	NON-INVERTING INPUT
4	V–
6	OUTPUT
7	V+
8	V_{OS} TRIM





Absolute Maximum Ratings

Supply Voltage.. +22V
Input Voltage[1].. ±22V
Differential Input Voltage.............................. ±0.7V
Internal Power Dissipation..............................500mW
Output Short Circuit Duration.....................Indefinite
Storage
  Temperature Range........................ −65°C to +150°C
Operating Temperature Range
  OP-37A/B/C.................................. −55°C to +125°C
  OP-37E/F/G.................................... −25°C to +85°C



Description

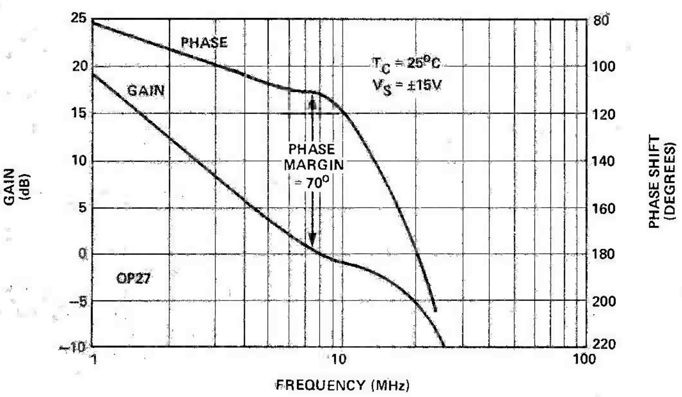
The OP27 and OP37 are designed for use where low noise (both spectral density and burst), wide bandwidth, and high slew rate are required along with low input offset voltage, low input offset temperature coefficient, and low input bias currents in gains greater than or equal to ten. Digital nulling techniques performed at wafer sort make it

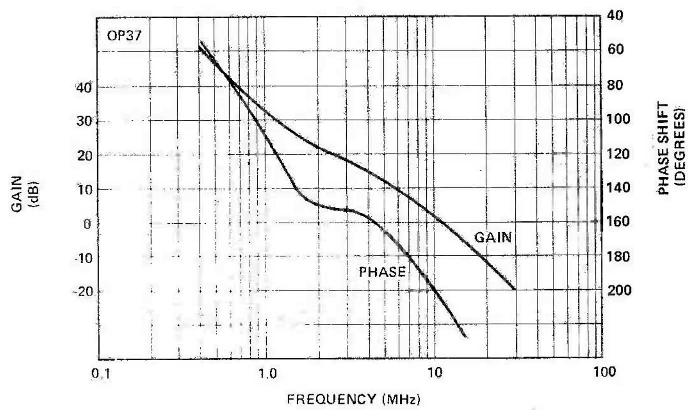
Electrical Characteristics

(V_S = ±15V and T_A = 25°C unless otherwise stated)

Parameters	Test Conditions	OP-27A/E OP-37A/E Min	Typ	Max	OP-27B/F OP-37B/F Min	Typ	Max	OP-27C/G OP-37C/G Min	Typ	Max	Units
Input Offset Voltage[5]			10	25		20	60		30	100	μV
Input Offset Current			7.0	35		9.0	50		12	75	nA
Input Bias Current			±10	±40		±12	±55		±15	±80	nA
Input Noise Voltage[2]	0.1Hz to 10Hz		0.08	0.18		0.08	0.18		0.09	0.25	μVp-p
Input Noise Voltage Density[2]	fo = 10Hz		3.5	5.5		3.5	5.5		3.8	8.0	nV/√Hz
	fo = 30Hz		3.1	4.5		3.1	4.5		3.3	5.6	
	fo = 1000Hz		3.0	3.8		3.0	3.8		3.2	4.5	
Input Noise Current Density[2]	fo = 10Hz		1.7	4.0		1.7	4.0		1.7		pA/√Hz
	fo = 30HZ		1.0	2.3		1.0	2.3		1.0		
	fo = 1000Hz		0.4	0.6		0.4	0.6		0.4	0.6	
Input Resistance (Diff. Mode)[4]		1.5	6.0		1.2	5.0		0.8	4.0		MΩ
Input Resistance (Com. Mode)			3.0			2.5			2.0		GΩ
Input Voltage Range[3]		±11	±12.3		±11	±12.3		±11	±12.3		V
Slew Rate[4] (OP27)	$R_L \geq 2k\Omega$	1.7	2.8		1.7	2.8		1.7	2.8		V/μS
Slew Rate[4] (OP37)	$R_L \geq 2k\mu$	11	17		11	17		11	17		V/μS
Gain Bandwidth Prod.[4] (OP27)		5.0	8.0		5.0	8.0		5.0	8.0		MHz
Gain Bandwidth Prod.[4] (OP37)	fo = 10kHz	45	63		45	63		45	63		MHz
	fo = 1MHz		40			40			40		
Open Loop Output Resistance	Vo = 0, Io = 0		70			70			70		Ω
Power Consumption			90	140		90	140		100	170	mW
Offset Adjustment Range	R_P = 10kΩ		±4.0			±4.0			±4.0		mV

Notes: 1. For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.
2. This parameter is tested on a sample basis only, and guaranteed to an LTPD of 10.
3. Caution the common mode input range is a function of supply voltage, see typical performance curves. Also, the input protection diodes do not allow the device to be removed or inserted into the circuit without first removing power.
4. Parameter is guaranteed by design.
5. Input offset voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power.



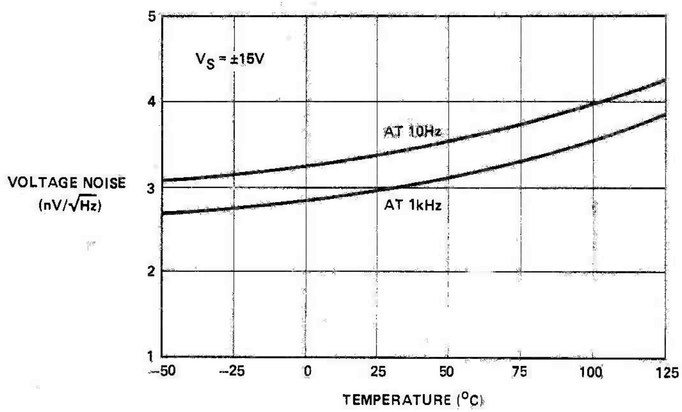


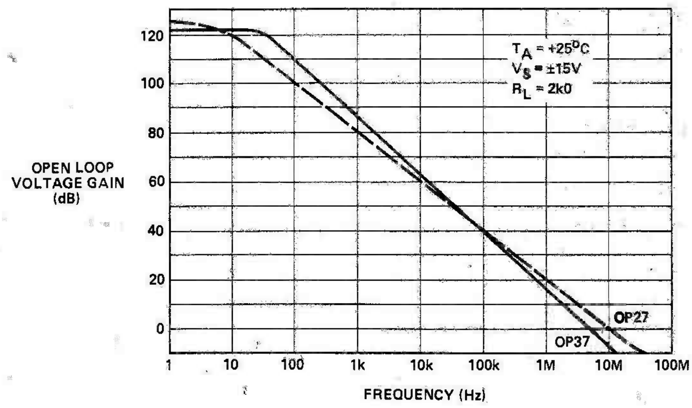
feasible to guarantee temperature stable input offset voltages as low as 25 μV. Input bias current cancellation techniques are used to obtain 10 nA input bias currents.

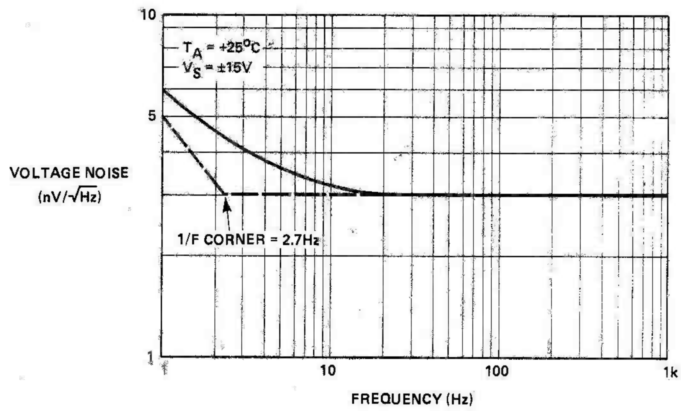
These op-amps are especially useful for instrumentation and professional quality audio systems. Applying the slew rate — power bandwidth equation ($f_p = SR/2\pi V_p$) the OP27 will have an undistorted output up to its power bandwidth frequency of 34 kHz, and an undistorted output of $8V_{p-p}$ at 100 kHz. The same equation applied to the OP37 gives a power bandwidth frequency of 208 kHz, with an undistorted output of 8 V_{p-p} at 338 kHz. This performance is adequate for the most demanding high fidelity applications.

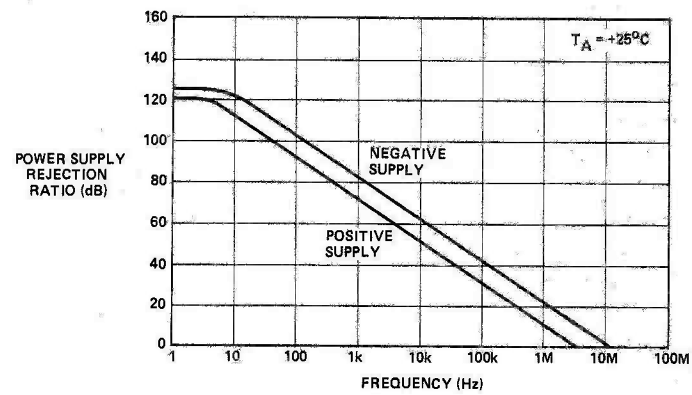
In addition to providing superior performance for the professional audio market the design of these op-amps uniquely addresses the needs of the instrumentation designer. Power supply rejection and common mode rejection are both typically 120dB. Input offset voltage can be externally trimmed without affecting input offset voltage drift with temperature or time.

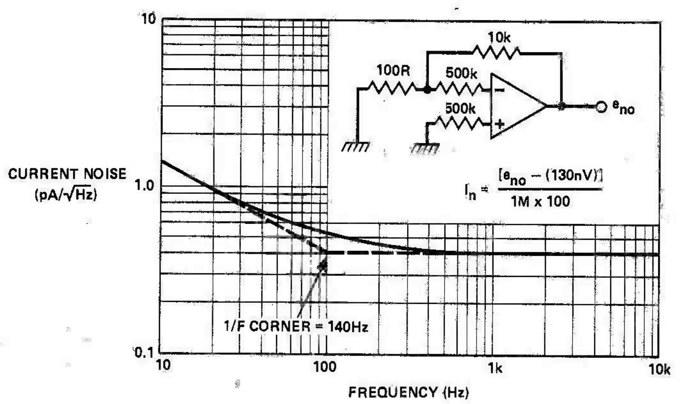
The OP27 has a phase margin of 70° at unity gain, which guards against peaking (and ringing) in low gain feedback circuits. Stable operation can be obtained with capacitive loads up to 2000pF. By decoupling the load











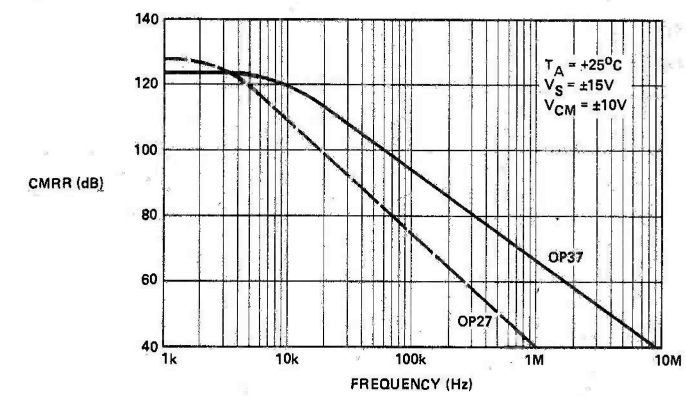
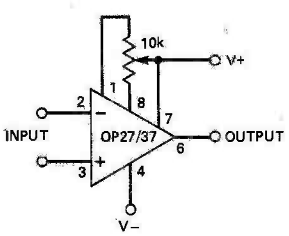


Fig. 1 (left) Offset nulling
Fig. 2 (right) Large signal transient response of OP37



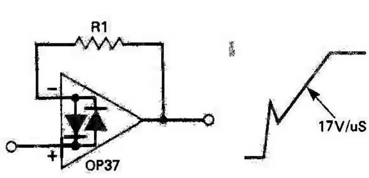
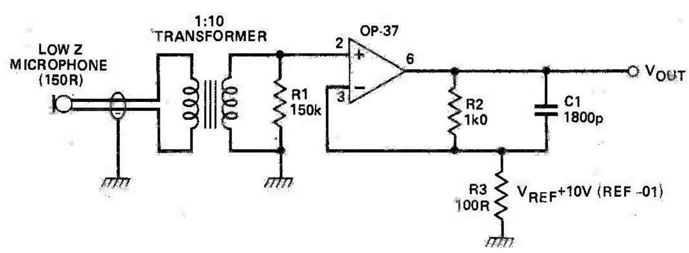


Fig. 3 Low-Z microphone preamp.



capacitance with a series resistor of 50R or more load capacitances larger than 2000pF can be accommodated. Input offset voltage can be externally trimmed without affecting input offset voltage drift with temperature or time.

Low Impedance Microphone Preamp

In this preamp the transformer converts the low microphone impedance up to a value that is close to the optimum source impedance required by the OP37 for best noise performance. The optimum source impedance can be calculated as the ratio of e_n/i_n which for the OP37 is approximately 7000R. Fortunately the noise performance does not degrade appreciably until the source impedance is four or five times this optimum value. The source impedance at the output of this transformer of 15k still provides near optimum noise performance. C1 rolls off the high frequency response at 90 kHz giving a noise power bandwidth of 140 kHz.

Instrumentation

The OP27 and OP37 are particularly adaptable to instrumentation applications. When wired into a single op-amp difference amplifier configuration, they exhibit outstanding common mode rejection ratio. The spot voltage noise is so low that it is dominated almost entirely by the resistor Johnson noise.

The three op amp instrumentation amplifier of Figure 8 avoids the low input impedance characteristics of difference amplifiers at the expense of two more operational amplifiers and a slight degradation in noise performance. The noise increases because two amplifiers are contributing to the input voltage spectral noise instead of one. Thus the noise contribution, exclusive of resistor Johnson noise, increases by slightly more than the √2. The spectral noise voltage increases from approximately 3 nV/√Hz to approximately 4.9 nV/√Hz, with the third amplifier contributing about 10% of the noise.

The gain of the input amplifier is set at 25 and the second stage at 40 for an overall gain of 1000. R7 is trimmed to optimize the common mode rejection (CMRR) with frequency. With balanced source resistors a CMRR of 100dB is achieved. With a 1k source impedance imbalance CMRR is degraded to 80dB at 5 kHz due to the finite (3GΩ) input impedance.

RIAA Phono Preamplifier

The new moving coil magnetic phono cartridges have sensitivities that are an order of magnitude lower than the sensitivity of a typical moving magnet cartridge (0.1 mV per cm/S versus 1.0 mV per cm/S). This places a greater burden on the preamplifier to achieve more gain and less noise. The OP27 is ideally suited for this task. The object in designing an RIAA phono preamp is to achieve the RIAA gain-frequency response curve while contributing as little noise as possible to avoid masking the very small signal generated by the cartridge. The circuit shown is adjusted to match a 40dB RIAA curve. Note that by convention the RIAA gain is specified at 1 kHz. With the "break points" of the curve specified at 50, 500 and 2.1 kHz respectively the entire curve is fixed by the specified gain at 1 kHz.

The circuit is designed to operate with a 3/4000 step up transformer to present the optimum source impedance to the amplifier for best noise figure. The optimum source impedance is obtained as the ratio of the spectral noise voltage e_n to the spectral noise current i_n (when e_n has dimensions of nV/√Hz and i_n has dimensions of pA/√Hz and the ratio has dimensions of kΩ). The circuit is designed to be tested and adjusted independent of the transformer; for this purpose introduce a very low level signal around 1mV at test point TP – 1. The first stage is a wideband stage which provides a small amount of gain (1 + R4/R5) approximately equal to 10dB. Low value feedback resistors must be used to prevent additional noise due to the spectral current noise or excessive Johnson noise. The gain of the first stage reduces the noise contribution of the second stage. The RIAA transfer curve poles and zeros are due entirely to the feedback network of the second stage.

The poles and zeros of the RIAA feedback network are sufficiently separated in frequency that they may be estimated with the following equations:

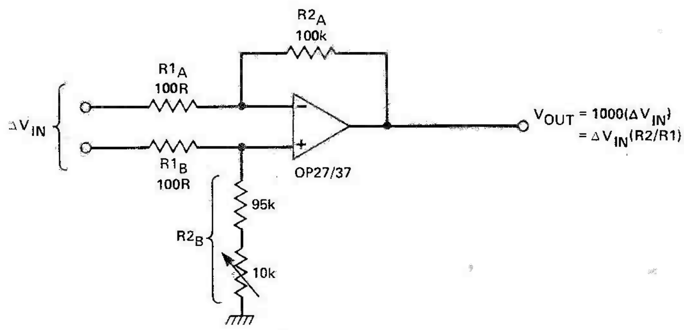
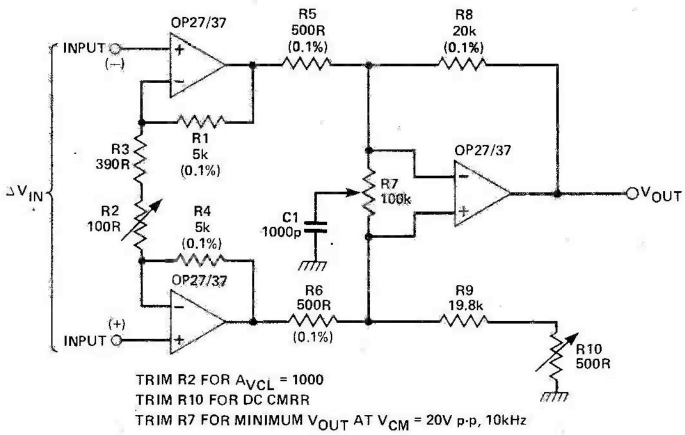


Fig. 4 Single op-amp difference circuit.

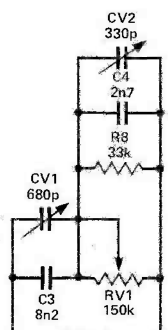
Fig. 5 Three op-amp difference amplifier.



$$f_1(50Hz) \approx \frac{1}{2\pi R7C3} \qquad f_2(500Hz) \approx \frac{1}{2\pi R8C3}$$

$$f_6(2100Hz) \approx \frac{1}{2\pi R8C2}$$

These equations are only approximations. Final tuning is performed with the adjustable capacitors and potentiometers; by successfully injecting 100 Hz, 1000Hz and 21 kHz at TP1 and adjusting CV1, RV1 and CV2 for –6dB, –20dB, and –40dB (relative to LF response).



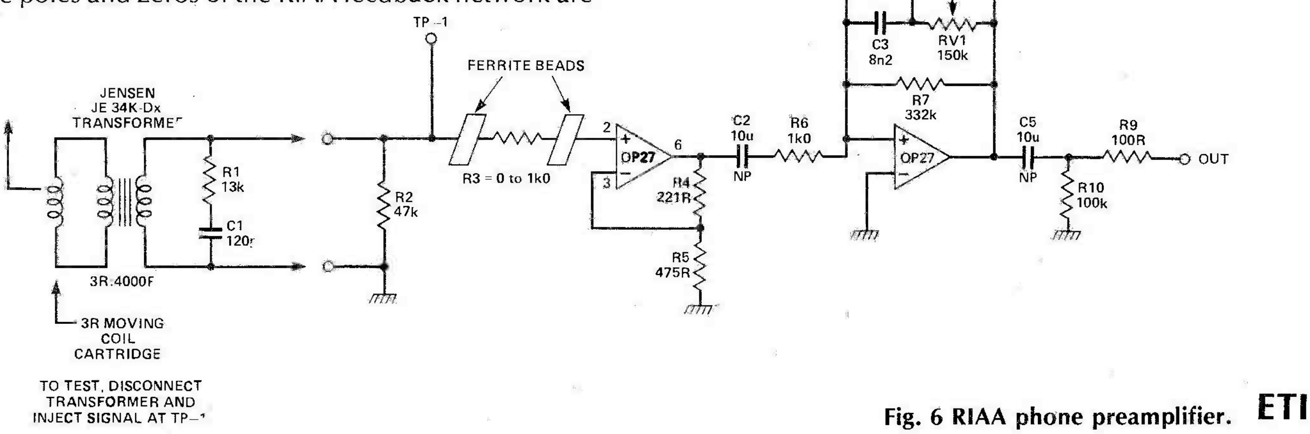


Fig. 6 RIAA phone preamplifier.

ETI

ACTIVE LOUDSPEAKER

In the halycon days of the hi-fi boom, DIY loudspeakers were published at a rate of several a month. However, it's now been over a year since we last published a design in ETI. Jeff Macaulay takes a fresh look!

There is confusion reigning in the hi-fi world at the moment, and reading some hi-fi magazines you might well be convinced that the only apporach is to spend all your money on just the record deck and make do with whatever amp and speakers you can afford on the little change you have left from your life's savings.

The alternative is to make do with the latest chrome-plated wonder with built-in obsolescence (though, thankfully, hi-fi rack systems seem to have gone out of fashion). To read the advertising blurb that accompanies these units, one could be forgiven for thinking that products launched as recently as the previous week were junk

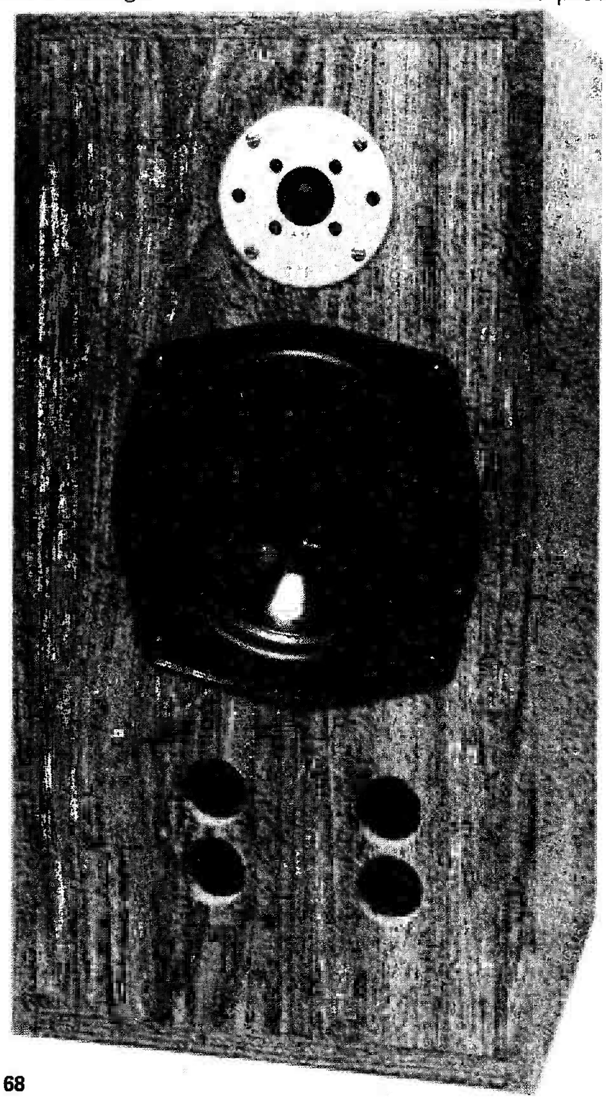
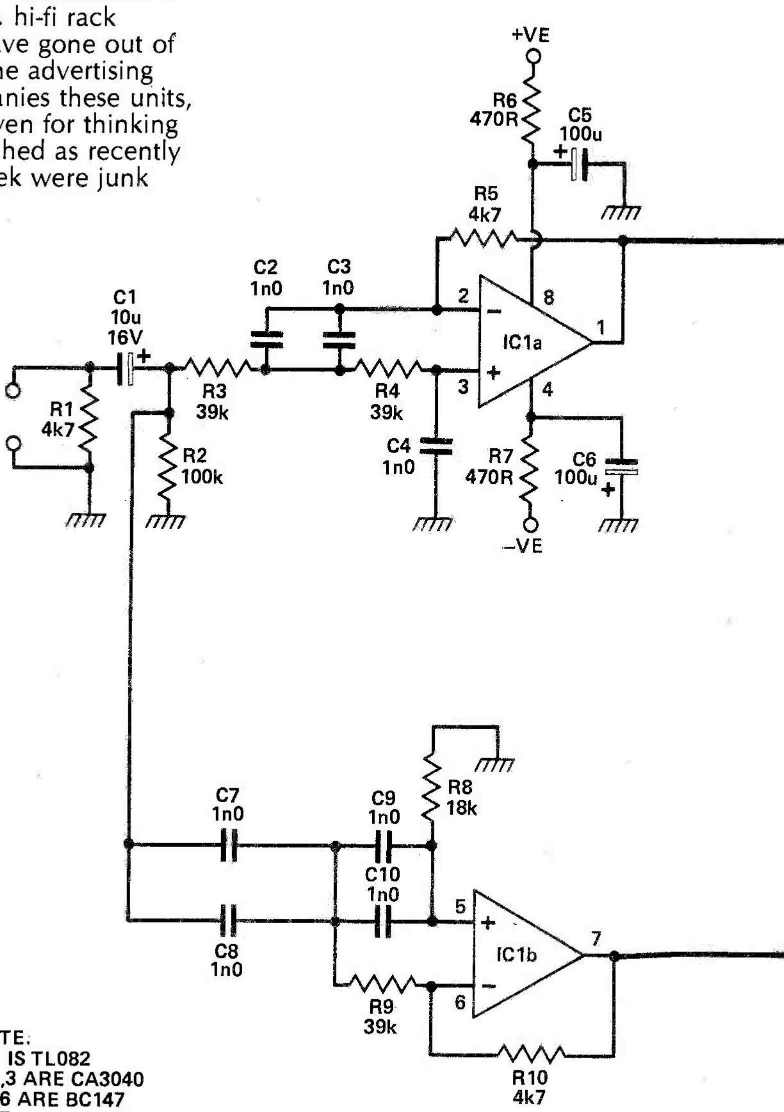


Fig. 1 (below and page facing) Circuit diagram of the active loudspeaker.



NOTE.
IC1 IS TL082
IC2,3 ARE CA3040
Q1,6 ARE BC147
Q2,7 ARE BC142
Q3,5,8,9 ARE 2N3055
Q4,9 ARE BC143
LS1 IS B200 8R
LS1 IS HD100/25 8R

*Q3,5,8,10 ARE MOUNTED ON A HEATSINK

compared to the current 'flavour of the month'.

This situation has been compounded by the introduction of compact disc — is it worth spending money on analogue systems when digital is just around the corner? One can already hear the cries of anguish from certain highland-dwelling turntable manufacturers.

While we'll admit that it is a truism that if you degrade the sound at the start of its journey through your hi-fi, there is absolutely nothing you can do to improve it, there is still a case for having a good speaker system to do the final conversion of electrical energy into sound energy.

Unfortunately no currently available drive unit can be made to cover the whole audio spectrum properly. For good bass response a heavy large diameter cone is required. The acual amount of bass that can be radiated by the speaker is directly proporitonal to both the cone area and the maximum cone excursion. For good treble, though, the converse is true. A small light cone, or dome, with low mass is required to give good transient response.

As a consequence, almost all practical speaker systems that merit the title "hi-fi" contain two or more drive units connected to the power amplifier through a crossover. To work properly (or even at all) the crossover has to be designed for the specific drive units it is to be used with, to take account of the very complex (in both senses of the word) load that an audio drive unit presents on its terminals. Standard filter equations just don't work when you're dealing with a circuit component that defies any sort of simple representation.

HOW IT WORKS

For the purposes of analysis, the circuit can be split up into four sections: the low-pass filter around IC1a, the high-pass filter around IC1b and the two power amplifiers around IC2 and IC3

The two filters are based on the well-known Sallen and Key configurations, and both have component values such as to give a Butterworth type response with a Q of 0.7. All that this means is that the values are chosen so as to give a minimum of response ripples in the pass-band whilst giving a maximum roll-off outside the pass-band that a two-pole filter can deliver.

It is usual to include some compensation for the uneveness of the responses of the drive units at this stage. However, as we've already explained, both the drive units selected have very good flat responses, and this was judged to make compensation superfluous.

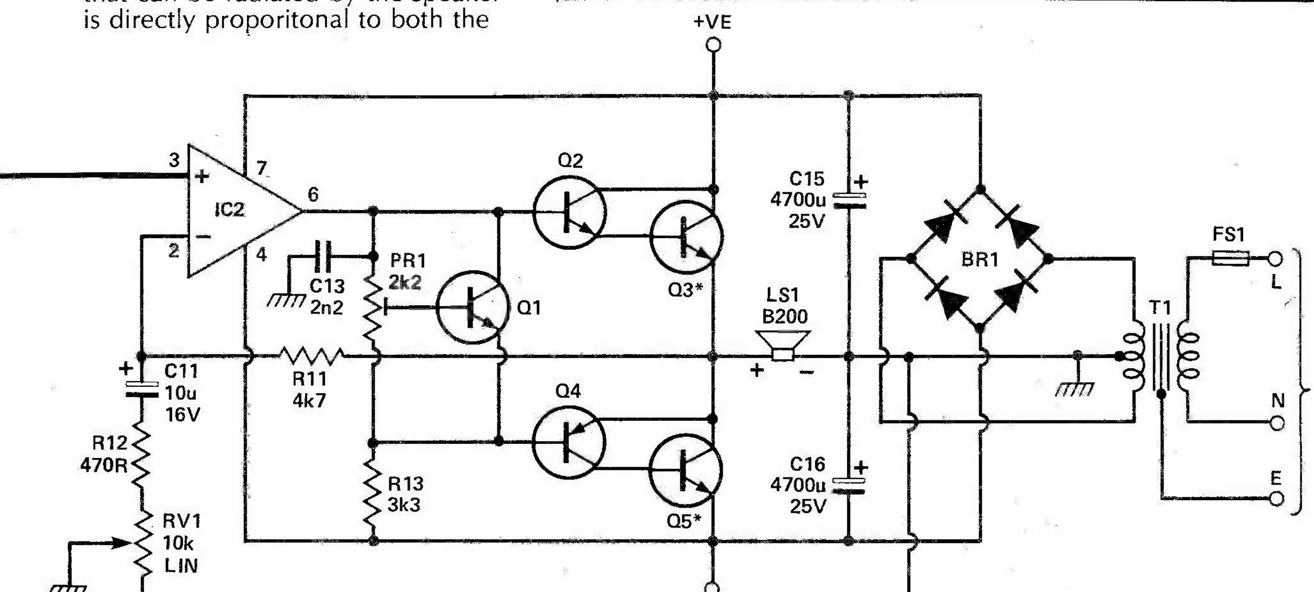
Both the power amplifiers are the same (with the minor difference of the connection C13 and C14), and are based on the 'brains and brawn' principle. In this, the op-amps IC2 and IC3 provide the open-loop gain for the system, while the transistors simply provide a current sourcing capability well beyond that of the op-amps.

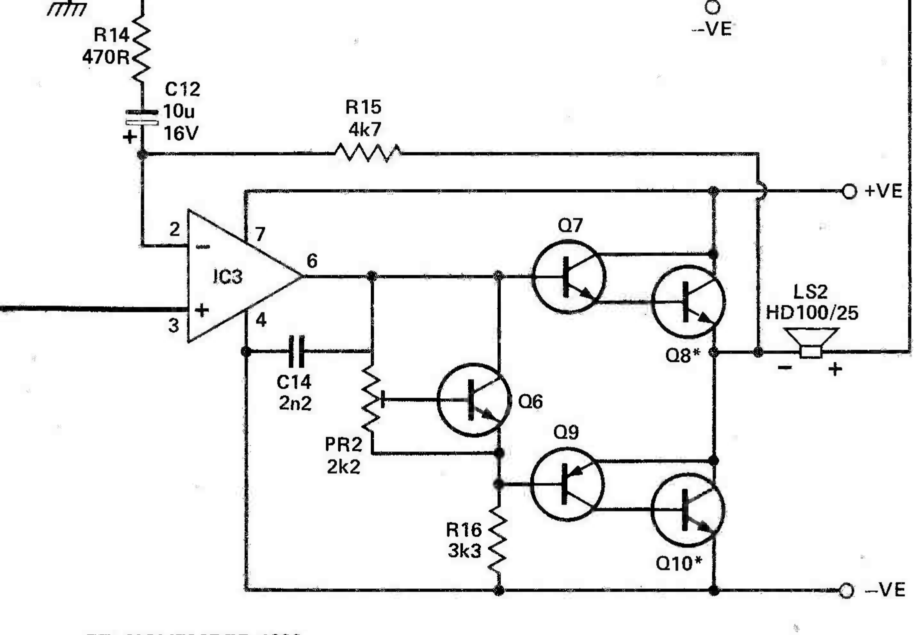
Taking a close look at the bass amplifier circuit, IC2 is a CMOS type op-amp which offers very low noise and a very good slew rate. The output from this is fed to the quasi-complementary output stage built around Q1 to 5.

To avoid serious distortion at the cross-over between the lower and upper sets of driver transistors, a bias voltage is provided between the 'bases' of the compound output transistors (Q2/3 and Q4/5) by Q1 which is, with PR1, wired as a V_{be} multiplier.

Because of the high input signal, very low gain is needed from the power stage, so the feedback level can be very high. R12 and RV1 in one arm and R11 in the other set the level of feedback, so RV1 can be used to adjust the level of the bass output — in fact, it's wired as a balance control, so it simultaineously adjusts the treble output.

Finally, note that the treble and bass units are connected in the opposite phases. This is to keep the reponse level at crossover; without this the two units would be in antiphase at the crossover point (this is due to the inevitable phase alteration caused by the filters).





Another problem is that crossovers, being passive components, absorb power intended for the audio drive units. As a result, a 100W amplifier may be needed to drive a speaker system whose drive units would require only a few watts without the crossover in the way.

Using active (or passive if you prefer) filters before the power amplifier has the potential to solve all these problems. For a start, the filters are built using standard components and will produce near-perfect text-book responses; the impedance variations of the drive units will have no effect at all.

A hidden benefit is that if the bass unit is driven into clipping, the ill effects are not transmitted to the high frequency unit. in a conventional cross-over system, the high-frequency harmonics caused by clipping are directly coupled to the tweeter and this can have destructive consequences.

Amongst the many other benefits from this approach is that the speakers wil be much better damped, because they see the low imedance of the amplifier, and this leads to a much lower Q figure for any resonances.

Unfortunately, all commercially made active speakers are very expensive — doubly so because you will have to change the amplifier to use them. We've already published one active design, ourselves, back in September 1982, which, although very much cheaper than commercial units, was still rather expensive and large. We felt that there was room for an active design towards the bottom end of the market, so here it is!

To make a simple but effective design, it was decided to restrict the drive unit count to two, and to use two fairly well known units — the KEF B200 and the Audax HD100/25.

The first of these units must be just about the best known bass drive unit of all time! It features an exceptionally flat response up to about 3 kHz and gives an excellent neutral sound. Driven directly, 12 W RMS will produce 96 dB of sound pressure. The B200 also has quite a nice low bass resonance.

The HD100/25 is a soft dome unit, which delivers a response within ± 3dB of flat within the range 1.5 kHz to 20 kHz. Soft domes have the advantage over hard domes of not having a resonance within their working range.

Having selected the drive units, the next task is to decide the cross-over characteristics, namely the cross-over frequency, and the roll-off rates.

The choice of these parameters is rather more limited than you might at first think. The B200 has a mechanical roll-off at 3 kHz, and this sets the absolute maximum frequency that you can use this unit to. The HD100 has a fundamental resonance at 800 Hz, so the cross-over point has to be somewhere between these limits. After quite a lot of experimentation and listening tests, 2.5 kHz was found to produce the best results.

Choosing the rate of roll-off was the next task. In theory, higher order filters with steep cut-offs are attractive, as they will limit the range of frequencies over which both the drive units are operating. In practice, such filters give problems with transient response and in the end, second-order filters were chosen.

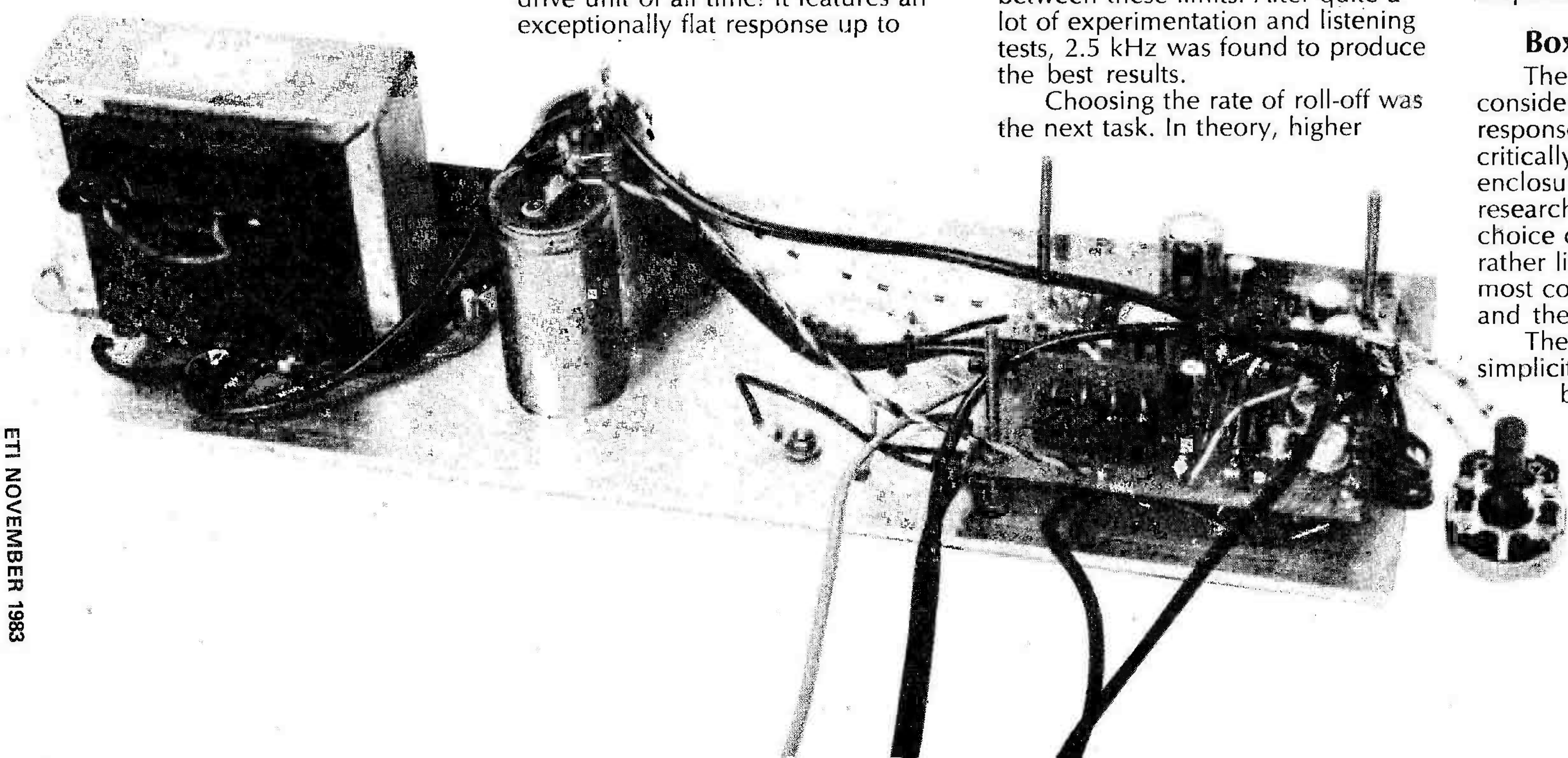
Here comes the clever bit: to make the loudspeakers directly compatible with existing equipment (we assumed that potential constructors would have a power amplifier already), the gain of the driver amplifirs was set at close to unity. The consequence of this is that they operate in very low distortion and negligible noise regimes, even with a comparatively simple circuit. The measured distortion from the power amps was found to be well below 0.1% at all output levels short of overload.

This approach has the additional advantage that the active speaker can be hooked directly up to the back of your existing power amplifier.

Boxing It Up

The last part of the design to be considered is the enclosure. The response of any speaker system is critically dependent upon the enclosure. Despite over 50 years of research and development the choice of enclosure type is still rather limited. At present the two most common are the infinite baffle and the reflex.

The former has the advantage of simplicity since it is merely a closed box. The reflext is also a box but with a tuning port incorporated. The



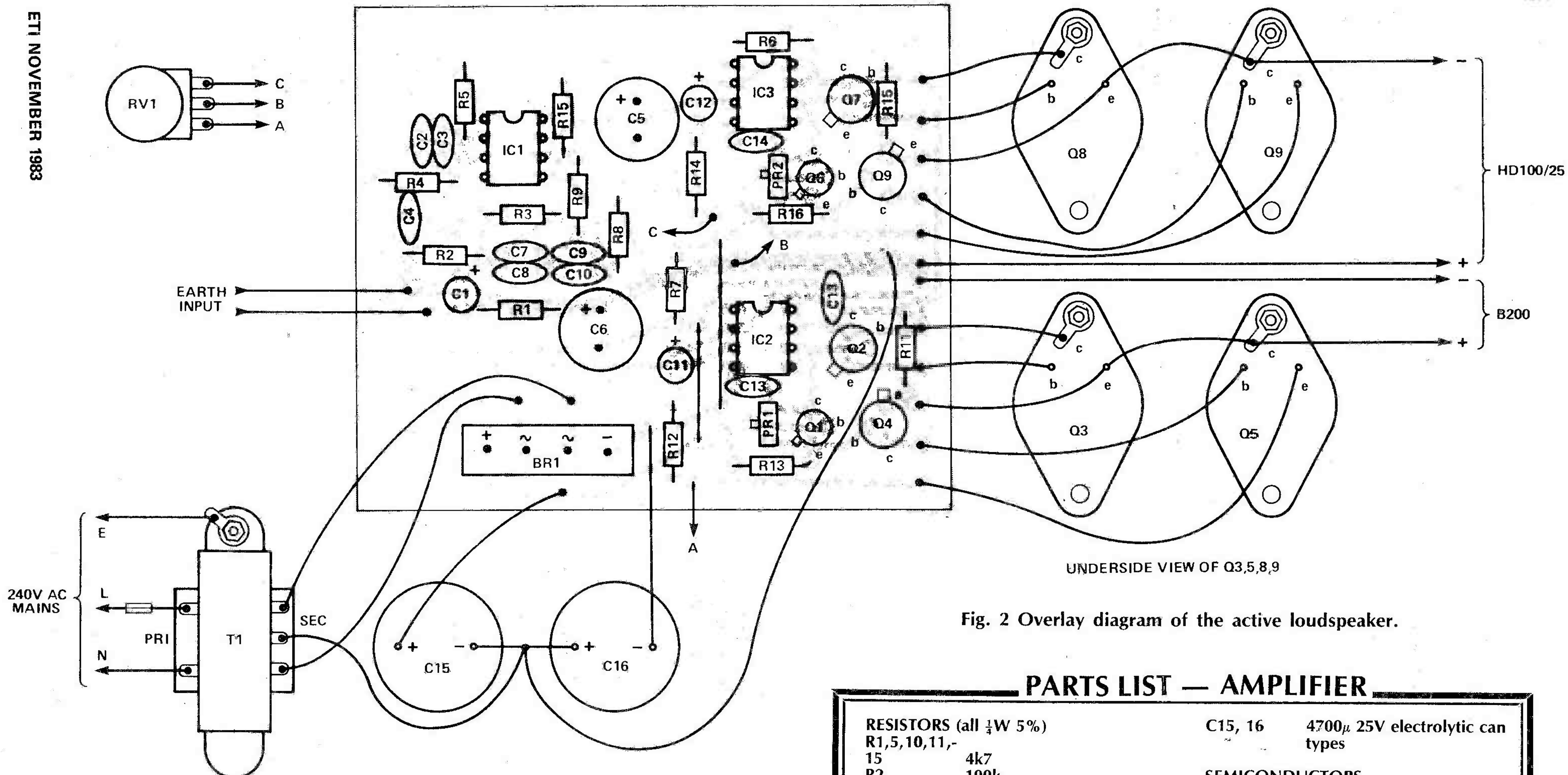


Fig. 2 Overlay diagram of the active loudspeaker.

PARTS LIST — AMPLIFIER

RESISTORS (all ¼W 5%)	
R1,5,10,11,-15	4k7
R2	100k
R3,4,9	39k
R6,7,12,14	470R
R13,16	3k3
R8	18k
RV1	10k linear pot
PR1,2	2k2 linear present pots
CAPACITORS	
C1,11,12	10μ 16V electrolytic, PCB type
C2,3,4,7,8,9-,10	1n0 ceramic or polyester, 5% or better
C5,6	100μ 63V electrolytic, PCB type
C13,14	2n2 ceramic or polyester
C15, 16	4700μ 25V electrolytic can types
SEMICONDUCTORS	
IC1	TL082
IC2,3	CA3040
Q1,6	BC147
Q2,7	BC142
Q3,5,8,10	2N3055
Q4,9	BC143
BR1	100 PIV 2A bridge rectifier
MISCELLANEOUS	
T1	Mains transformer, 24V 1.5A

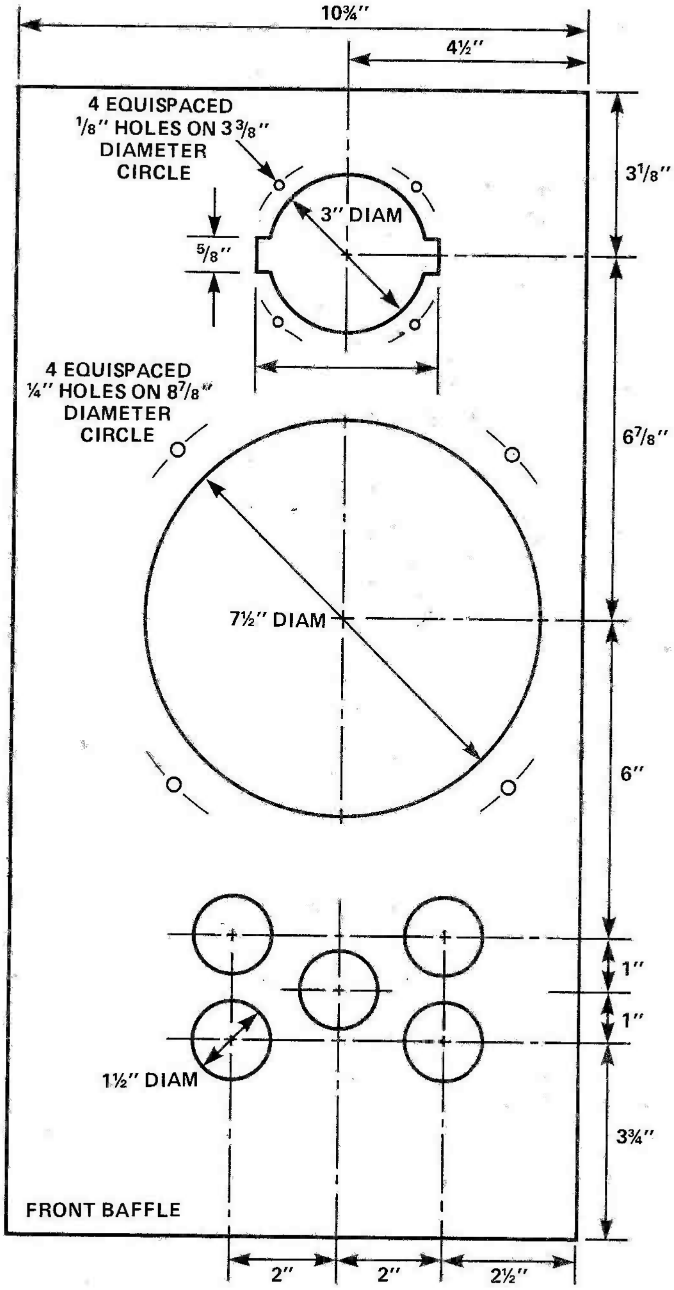
mounting kits for 2N3055s (4 off); heatsink (1.1°C/W total or better); PCB; clips for C15,C16; PCB; audio input socket; mains input socket; 1A fuse and holder; wire; nuts and bolts; etc.

BUYLINES

A full designer-approved kit is available from Bewbush Audio, 26 Hastings Road, Pound Hill, Crawley, Sussex RH10 4AT. The price is £30 per enclosure all-inclusive, for the electronic components, the PCB and heatsink. This does not include the chipboard or the drive units. Please order as kit ETI52.

PCBs are available separately for £10 inclusive per pair, and, for the lazy but affluent, ready-built speakers are available at £200 per pair. Please allow 28 days for delivery, as usual.

Drive Units are available from Wilmslow Audio Ltd, 35/39 Church Street, Wilmslow, Cheshire SK9 1AS.



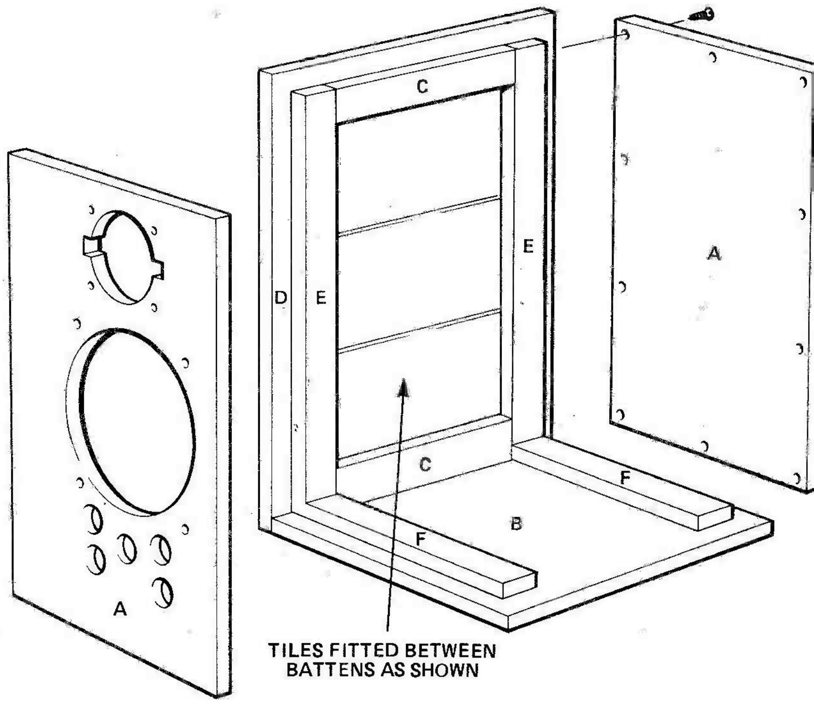


Fig. 3 Construction details of the cabinet and front baffle.

PARTS LIST LOUDSPEAKER

These are the parts required for one speaker.

DRIVE UNITS

Tweeter	Audax HD100/25
Bass Unit	KEFB200

PANELS (all cut from ⅝"/15mm melamine faced chipboard)

A (2 off)*	21¾" by 10¾"
B (2 off)	12" by 10¾"
C (4 off)	6½" by 2⅛"
D (2 off)	23" by 12"
E (4 off)	21¾" by 2⅛"
F (4 off)	9" by 2⅛"

MISCELLANEOUS

Ceramic tiles, 00" by 00", 00 off; BAF acoustic wadding 00" thick, 00" by 00"; wood glue and chipboard screws.

*One of these to form the front baffle, see Fig. 3 for details.

tuning extends the LF response by making the enclosure into a mechanical tuned circuit. However, to operate effectively the enclosure and drive unit have to be matched and adequately damped. This can be difficult for the constructor.

For this design, a resistive port enclosure has been used. This form of loading is similar to the reflex but in this instance the port is fabricated from a series of small holes in the front baffle. This form of loading has one major advantage over both reflex and infinite baffle types. The Q of the speaker resonance is greatly reduced. This renders the enclosure essentially aperiodic at low frequencies. At the same time, deep bass output is augmented by the port whilst the transient response is better than both reflex or sealed box.

Construction

The construction of this project can be neatly divided into two parts, electronic and mechanical. The electronics can be tackled first. As you can see from Fig. 2 most of the components are mounted on the PCB. Very little comment is required about this except to ensure that all the semiconductors and electrolytics are correctly orientated.

The board is mounted on the heatsink along with the power transistors. Before mounting the board, though, be sure to solder the veropins in! To avoid the underside of the board shorting out on the heatsink spacers are used. Alternatively the board can be supported by means of nuts on the retaining bolts.

The power transistors and transformer should now be mounted onto the heatsink. The latter is mounted with self tapping screws into ⅛" pilot holes drilled as shown. The output stage power transistors are mounted on their insulating kits and a check for short circuits between the cases and the heatsink should be made. Last to be mounted are the smoothing capacitors C15 and C16.

Now the interwiring should be attended to. The leads to the drive units, to the collector and emitters of the power transistors, and those between the PCB and the smoothing capacitors should all be in fairly heavy duty wire.

To set the quiescent current, the following procedure should be followed. First, adjust the two presents PR1 and PR2 so that their sliders are shorted to the outputs of IC2 and IC3 respectively. Check that this is the case using a multimeter.

Remove the two wire links (or, if you're very clever, don't fit them in the first place!) and connect up two 100R resistors instead. When you switch on, you should find a 2 V voltage drop across both of these. If you don't find this, there must be a fault somewhere — this will be particularly noticeable if either of the resistors should decide to burn out! Also check that the amplifier outputs are at zero volts.

Next adjust PR1 until the voltage across the 100R resistor near to C11 has risen by a futher 1.0 volts. Adjust PR2 for a further 1.0 volts increase across this resistor.

Switch off, replace the wire links; the amplifier module is now ready for use. Repeat this procedure for the other channel's module.

Cabinet Making

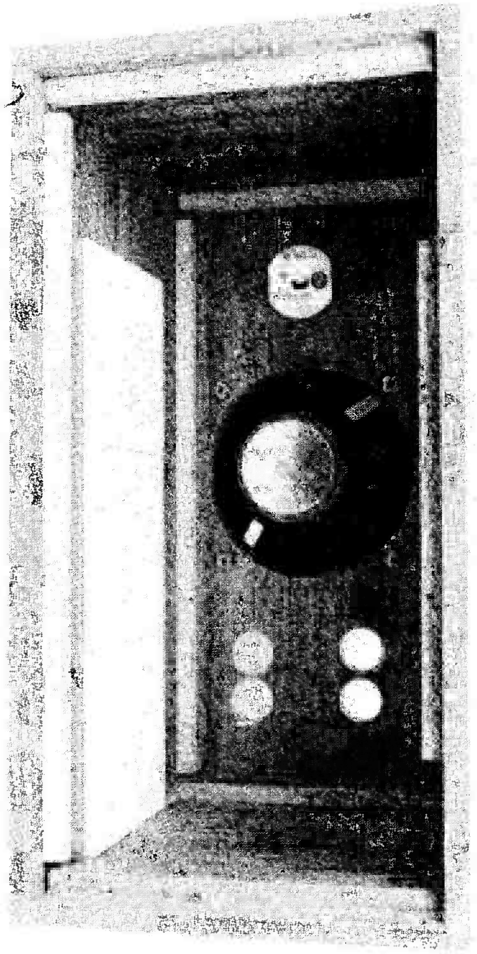
The mechanical work consists of making the cabinet. Fig. 3 shows the plans for this item. It is absolutely vital to ensure that the chipboad is cut accurately to size, or a little over as you can trim it down to the exact size with a Surform or similar.

It's usual to use either high density or mixed density chipboard for loudspeaker construction. We've taken the slightly unusual step of using melamine-veneered type because the high density chipboard tends to have resonances with higher Qs. The mixed density chip could be used instead, but it's not easy to obtain. Before assembly begins, carefully check the sizes of all the panels. Also check the squareness.

Assembly is achieved as follows: first fix the battens in place using chipboard screws and a suitable glue. Assemble the enclosure except for the front panel, using screws and glue again.

Next fit the amplifier module as shown in the rear of the case; drill holes to accommodate RV1's spindle and the wiring to the mains transformer and for the input connections. You can use either a piece of wire (dodgy) or suitable connectors for these, but do be sure not to leave any air gaps.

Damping of the cabinet walls — by adding mass to them in the form of ceramic tiles — will help to prevent radiation from the rear of the drive unit reaching the outside world through the walls. The tiles will reflect the sound back into the wadding (which you'll be putting into the cabinet at a later stage) where it can be absorbed.



One position where it isn't appropriate to use tiles is on the rear panel behind the bass unit: sound would be reflected back to the cone, which would then re-radiate it, resulting in a smeared sound. However, adequate mass loading is achieved by the heatsink, which, because of its shape, doesn't generate the same problems with reflection.

The ceramic tiles should be glued in as shown; they will fit neatly between the battens with a clearance of about ¼″. Many adhesives are suitable for this job, but we've found that Araldite Rapid, applied as a blob on each corner, gives reliable results.

All that now remains is the front baffle (see Fig. 3 for cutting details). Note that the front baffles are made in mirror image pairs, and that the drive units are slightly offset from the centre line to avoid possible diffraction problems.

The B200 is mounted using the template provided with the speaker unit. Note that the 7.5 mm recess is not cut here. Initial experiments with the recess cut showed no discernible audio advantage so the unnecessary complication has been avoided. Note, though, that the foam gasket supplied has been used. Also supplied with the B200 are the mounting screws and T nuts.

The tweeter is fitted with four self-tapping screws; ¾″ No. 6 size is suitable. Note the recesses needed for the tweeter's terminals: these should be cut out with a rasp or similar. Connect the wires to the tweeter before fitting as it can be difficult to manouvre the soldering iron in the confines of the recess.

The last part of the assembly consists of fitting the BAF wadding. This is done in two stages. First cut a section out of the sheet about 12″ square. This is stretched across the rear of the B200 and fixed into place with a few panel pins.

The remainder is now rolled up and placed in the cabinet. Finally screw the front baffle into place with chipboard screws. Now the speaker is ready for use!

We haven't included a mains switch in the speaker; if your amp has one, wire the speakers to a suitable switched outlet socket on the existing amplifer. Connect the input to the loudspeaker to the output of the power amplifier, using screened cable if you wish (though this is probably not necessary), and switch on. **ETI**

USING FIBRE OPTICS

Does copper wire leave you stranded? Is your data missing the bus? L. N. Owen focusses our (tunnel?) vision on a radical alternative.

It is common knowledge that British Telecom and similar organisations now use optical fibres as a transmission medium instead of conventional wiring. This comparatively new technology has been refined to provide a highly efficient system for long-distance telecommunications, but as yet has not been used widely by the experimenter and hobbyist. This is almost certainly because of the high cost and the scale of typical applications (do you really want to build a 10 km transmission line?), but like most new technologies it has produced a number of spin-offs, and some of these do fall within the scope of the humble experimenter.

The main cause of the high cost of transmission systems is the need to use coherent light, that is, light of a specific phase and wavelength. To achieve this, and because of the need for a concentration of high energy to overcome long distance transmission losses, lasers are used. Obviously, if we can do without the laser, things become much cheaper. If we use a much lower energy source, and one which produces incoherent (random) light, we lose the ability to transmit over distances greater than 50m and to use certain phase dependent techniques, but we open up a very broad field of applications indeed.

In all the sample circuits given here, the incoherent light source is a narrow-beam, high-intensity, red LED. These can be bought ready mounted into fibre optic hardware, or, for the painstakingly adventurous, bought loosely and then mounted and polished for the specific application. The former method is strongly recommended for the inexperienced.

When using fibres, signals are transmitted using light. Light is electromagnetic radiation, and thus since it has no electrical charge, it cannot be affected by electric fields. In other words, by using fibre optics, the system is free from electrical noise such as mains or radio interference. Similarly, magnetic fields have no effect on the signal, and two fibres cannot interfere with each other since the light travels longditudinally, any stray photons being absorbed by the fibre jacket material. Thus crosstalk is non-existant, reducing the need for heavy screening and filtering equipment. Furthermore, as light is the carrier, any safety hazards that may arise with warm wires or electrical sparks are eliminated, a considerable advantage in, for example, the petro-chemical industry, where fibre-optic sensors are rapidly replacing all other systems. In addition, most optical fibres are chemically inert, small in size, light in weight, and are sufficiently flexible to be run just about anywhere. And yet, in spite of all these advantages, the single most important factor in the choice of fibre-optics as a transmission system is the range of frequencies it will handle (see Fig. 1).

For optical fibres

$$\text{Bandwidth} \sim 1/\text{length}$$

whereas for electrical cables

$$\text{Bandwidth} \sim 1/(\text{length})^2$$

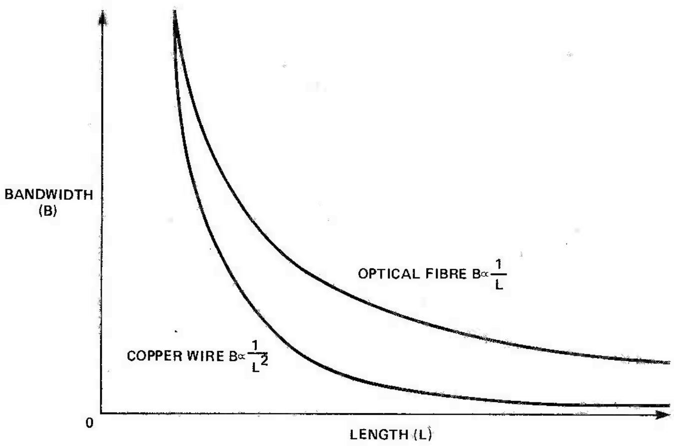


Fig. 1 Comparison of bandwidth over distance for copper wire and optical fibre.

Fibre Physics

Before using fibre a few principles must be understood, the most fundamental being that of the critical angle, or total internal reflection (TIR). Referring to Fig. 2, when light passes from one medium to another of a different density, some light will be reflected and the remainder will be refracted. The angle of emergence of the refracted ray, θ, is found from Snell's Law:

$$n_1 \sin\theta = n_2 \sin\theta$$

where n_1, n_2 are the respective refractive indices and θ is the angle of incidence.

If θ is increased, there will be a specific point where the angle of emergence, θ, is 90°. At this angle there is no partial reflection, and this is known as the critical angle, θ. The critical angle can be determined from:

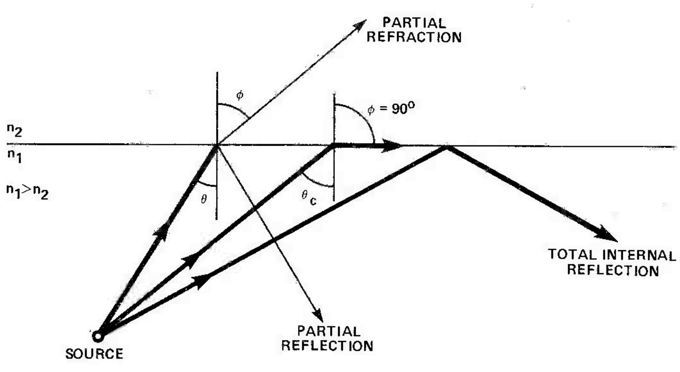


Fig. 2 Illustration of Total Internal Reflection.

$$n_1 \sin\theta_c = n_2 \sin\theta$$
$$\theta = 90° \text{ at the critical angle}$$
$$\sin 90° = 1$$
$$\theta_c = \sin^{-1}(n_2/n_1)$$

If the angle of incidence is further increased, then all the light rays are internally reflected, and this is known as total internal reflection (TIR). Light is transmitted through a fibre by TIR; all other spurious partially reflected, or sub-critical rays dissipate very rapidly.

From this it can be seen that there is a discrete range of angles of valid input. This range is illustrated in Fig. 3 for an air/fibre interface, and is called the acceptance angle, θ_a. Applying Snell's Law again we have:

$$n_0 \sin\theta_a = n_1 \sin(90 - \theta_c)$$
$$= n_1 \cos\theta_c$$
$$= n_1\sqrt{1 - \sin^2\theta_c}$$

but $\sin\theta_c = n_1/n_2$

$$\sin\theta_a = n_1\sqrt{1 - n_2/n_1)^2}$$
$$= n_1 - n_2$$
$$= 0.45 \text{ typically}$$

For the most typical case $n_0 = 1$ (air)

$$\sin\theta_a = n_1\sqrt{1 - (n_2/n_1)^2}$$
$$= \sqrt{n_1^2 - n_2^2}$$
$$= 0.45 \text{ typically}$$

Sin θ_a is known as the numerical aperture, and it is a basic parameter for fibre selection.

Fibre is a three-dimensional media, and as such it supports several modes of propagation, the fundamental two being meridonal and skew. Skew rays follow light paths which never intersect the fibre axis; a special case of the skew mode of travel is that of a ray which travels parallel to the fibre axis, never being reflected throughout the fibre length. Fundamental fibre theory is concerned only with meridonal rays. These, as implied, travel through the fibre axis after each rebound from the fibre/cladding interface.

The final piece of mathematics waiting to be tackled is in calculationg transmission losses. There losses come from three major sources:

i) curvature loss
ii) core/cladding interface
iii) fibre material

The curvature loss is a long-distance phenomena and can be ignored for our purposes. Core/cladding interface losses are due to slight non-uniforimities causing a localised change in c (the speed of light in the fibre body) and subsequent transmission loss. The attenuations in the fibre material are due to two processes. Firstly, impurities in the fibre can cause light to be scattered in a similar manner to the core/cladding interface. Secondly, impurities within the fibre can absorb certain wavelengths. There are two ways around this latter problem: buy an expensive, highly purified cable, or choose a suitable emitter whose peak

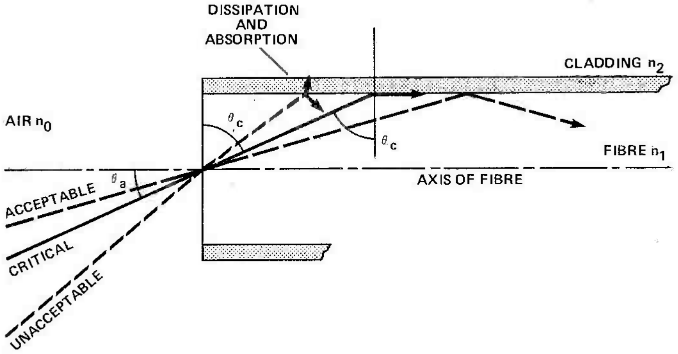


Fig. 3 Acceptable Angle needed to achieve TIR.

wavelength coincides with the maximum transmission spectra of the fibre.

Additional transmission losses come from couplings. The coupling loss is generally given in the respective data sheet (usually in dB/connection). For fibres it is given as dB/km. Thus, for a 1m length of polymer cable with a LED emitter and two bulkhead connectors, the representative calculations are:

Overall attenuation = (emitter coupling loss) + 2*(bulkhead loss) + (fibre attenuation) + (detector coupling loss)
= 2 + 5 + 1 + 2
= 10dB

but the overall attenuation = 10 log(emitter flux/detector flux)
$= 10 \log(\Phi_t/\Phi_r)$
$\log \Phi_r = \log \Phi_t - 1\text{dB}$

We usually know the maximum transmissable power, $\Phi_t = 20\ \mu W$ say

$$\log \Phi_r = \log 20 - 1$$
$$\Phi_r = 2\mu W$$

It is also usual to know the optical sensitivity of the detector,

$$S = 0.44 \text{ A/W, say.}$$

Hence
current = 0.44 or
= 0.88 μA maximum

This example shows the importance of keeping connections to a minimum, especially when using high attenuation fibres, which the cheaper variety tend to be.

Techniques

Optical fibres can be used in one of three ways: illumination, data transmission and sensing.

Taking the simplest case first, fibres can be used very effectively as illuminators, the principle being that of providing a light source channelling it where you will. Any form of optical fibre can be used for this purpose, in fact several types of heavy-gauge fishing line have sufficed for short distances. many cables can use the same source and thus provide a very effective and efficient means of illumination. Typical examples are instrument panels, microscopes, meters, switches, logos, etc.

Transmission of data is, as mentioned earlier, not generally practicable for the hobbyist, but there are exceptions, and a few possibilities are discussed in the section on circuits. Both analogue and digital data may be transmitted, although digital data will have to be handled serially.

Sensing covers an enormous range of fibre-optic applications. Optical sensors must be able to convert an input (pressure, temperature, flow, etc.) into variations of either light intensity, phase spectrum, or polarisation, but within the limitations we have set ourselves only amplitude modulation can be used. This not as great a restriction as it might seem because the majority of sensors use amplitude modulation anyway.

Amplitude can be modulated by absorption, emission, and by changes in refractive index. By juggling with these three parameters, fibre optics can be used for measuring strain, pressure, vibration, liquid and solid levels, gas presence, shaft position, temperature, and much more depending upon the type of end transducer used.

One of the simplest applications of fibres as sensory devices is in position detection (Fig. 4a). A similar system using reflected light could be equally well employed (Fig. 4b). The same system can be extended easily to counting

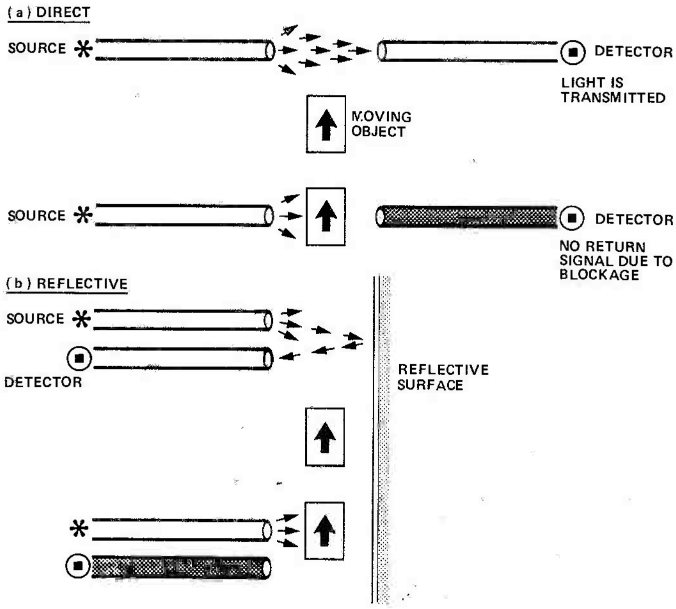


Fig. 4 Position detection using optical fibres.

applications, using pulse counting circuitry, and some forms of quality control. In the reflective mode there is a threshold of surface finish order for the light to be reflected at sufficient intensity, and in the direct mode there are intensity thresholds depending upon the colour density or opacity of thw moving object (eg, testing paper quality).

Taking the principle a stage further why not apply it to a shaft encoder — too late, several systems are already in use, operating both in the reflective and direct modes (Fig. 5). Encoders are also being mechanically coupled to measure pressure. With the same ingenuity, attach fins to

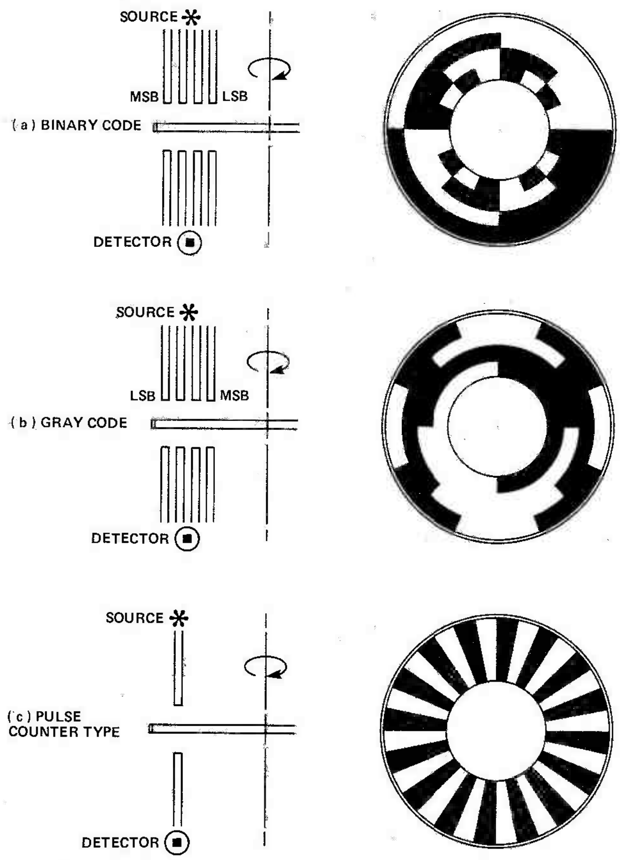


Fig. 5 Shaft encoders and flow meters.

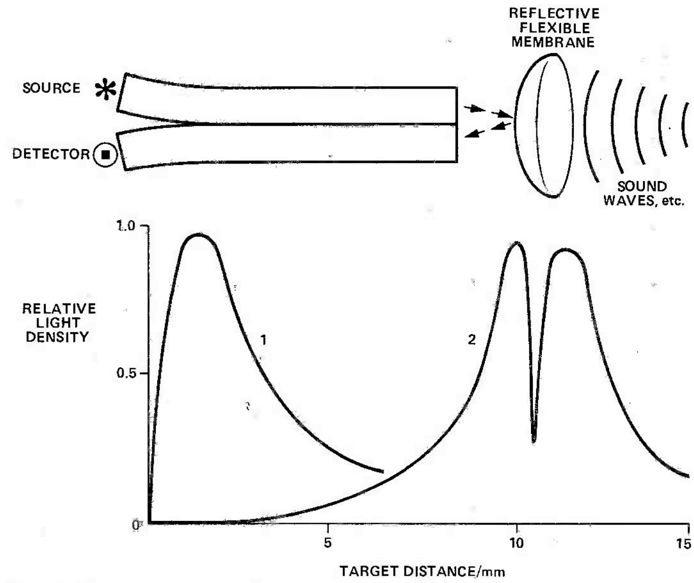


Fig. 6 Measurement of pressure.

another encoded disc (Fig. 5c) and you have a successful form of flow measurement. This particular type operates by counting the number of pulses per unit time and thus calculates the flow rate.

If the reflection method is reconsidered and the polished surface is replaced by a reflective flexible membrane then a form of pressure transducer is realised. Physical arrangement and typical response are shown in Fig. 6. Response 1 is for a single fibre pair whereas trace 2

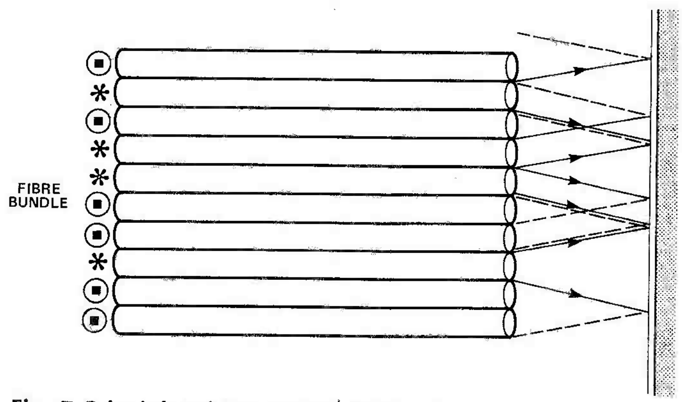


Fig. 7 Principle of the optical level.

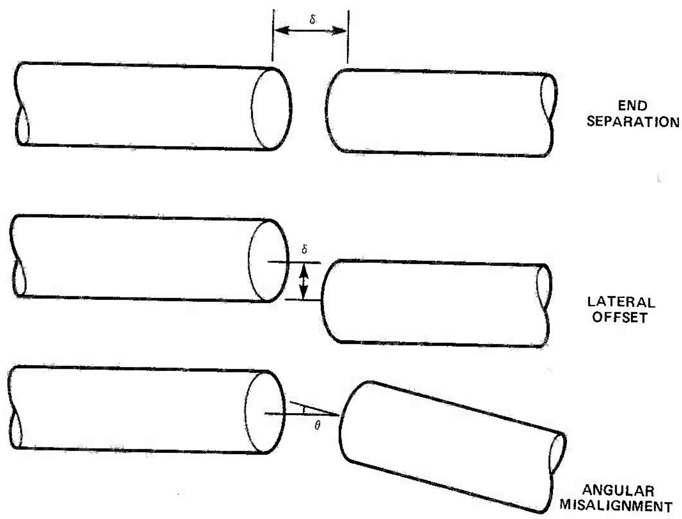


Fig. 8 Transmission loss sensors.

is for a semicircular fibre bundle. This vividly shows that transmission and reception need not be limited to a single fibre, in fact, most cases employ bundles of fibre in various configuraitons. One of the most popular is a random bunch of emitter and receiver fibres in a larger circular or semicircular cable. The reasoning behind this is that light leaves the fibre generating a cone of light rays. Reflecting this cone will disperse the rays even more, thus covering a greater reception area (Fig. 7). This technique is known as an optical lever.

A very sensitive optical sensor can be produced using the principle illustrated in Fig. 8. Two fibres can be made to lose transmission energy in three different ways, according to the distance between the ends, the lateral displacement, and the angular displacement. Using this technique, researchers have managed to measure displacement of as little as 0.005 angstorms. A graph showing typical characteristics for the three methods is given in Fig. 9.

All of the sensors described above work by interfering with the transmission of light between two terminated fibres. This is by no means the only way in which amplitude modulation can be used in sensor applications,

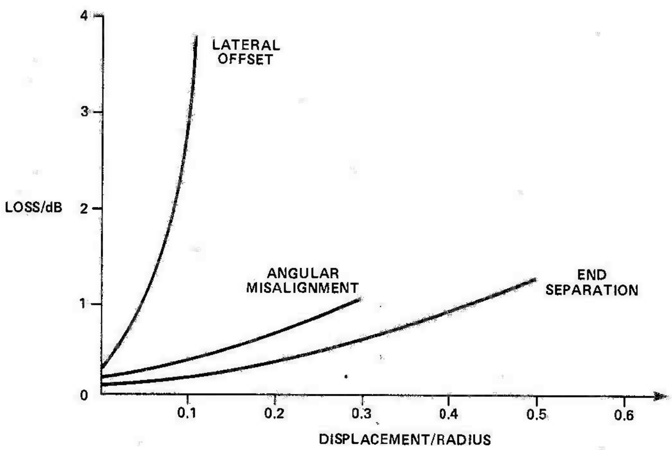


Fig. 9 Characteristics of transmission loss sensors.

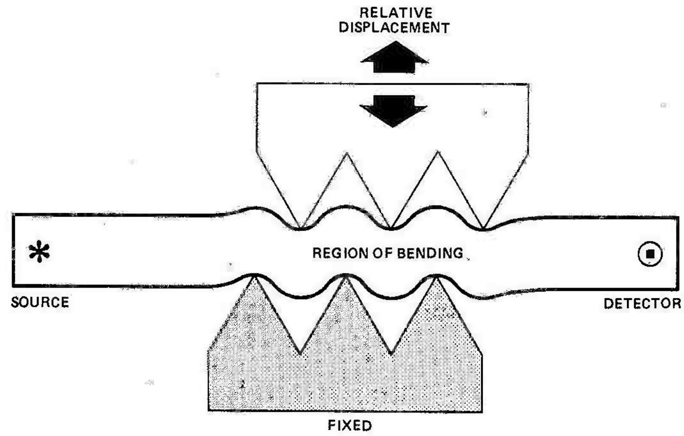


Fig. 10 Fixed/floating microbending transducer.

and a possible alternative is shown in Fig. 10. As mentioned earlier, where the angle of incidence exceeds the critical angle, light is transmitted through the cladding, thus reducing the overall intensity at the detection end. If the critical angle is artificially exceeded by some external excitation, then not only have we another form of displacement sensor, we also have one which modulates an unbroken beam of light. Such microbending transducers can be adapted to measure many different variables, but they are obviously ideally suited to the measurement of pressure. They have been used in microphones, since acoustic signals produce pressure changes, in flow meters (measuring turbulence) and in various other vibrational measuring devices.

Circuits!

The purpose of this section is simply to present a few tested emitter/detector circuits as a guide to further experimentaiton. Design usually revoles around input sensitivity and speed of serial transmission; however, various other factors such as analogue linearity, fitting, etc., do creep in.

The first circuit, Fig. 11, is one of the most useful since

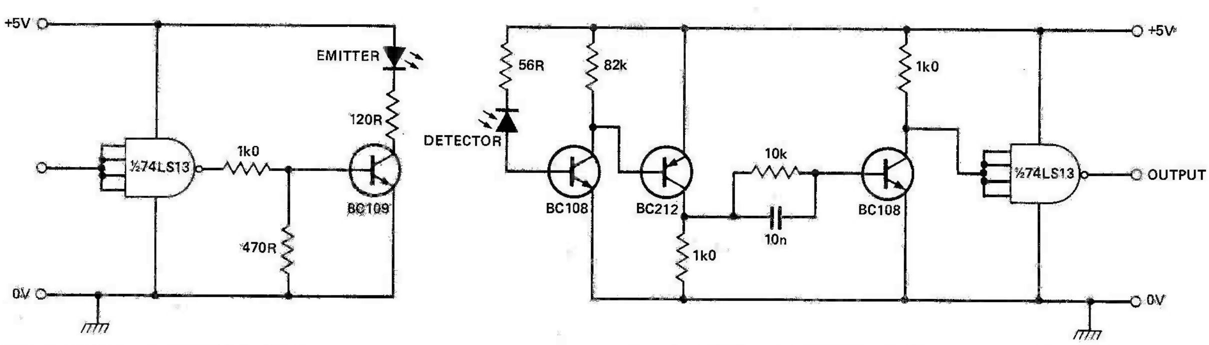
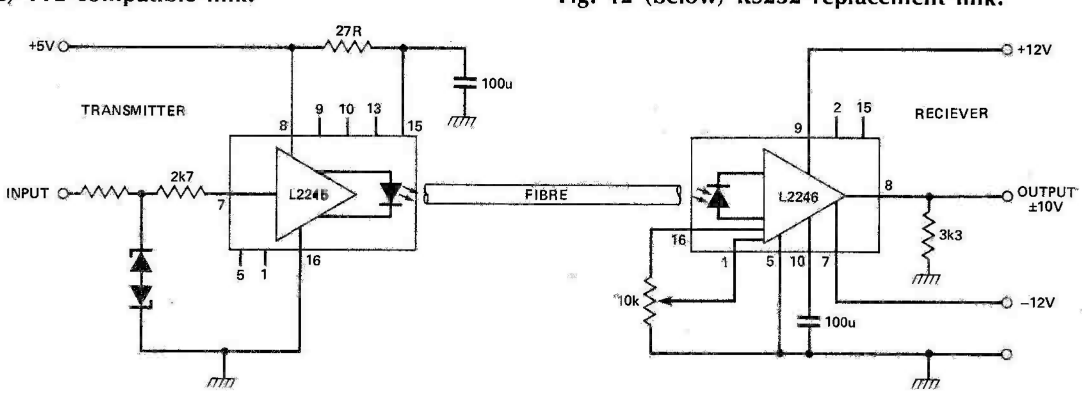


Fig. 11 (above) TTL compatible link.

Fig. 12 (below) RS232 replacement link.



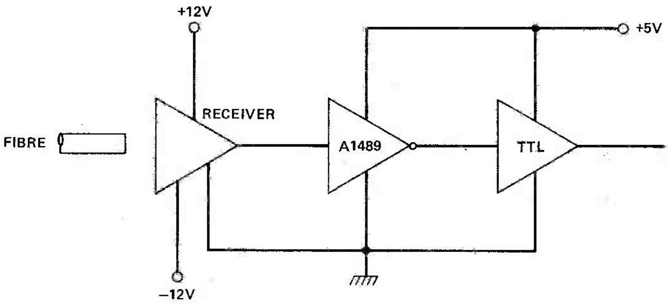


Fig. 13 TTL receiver

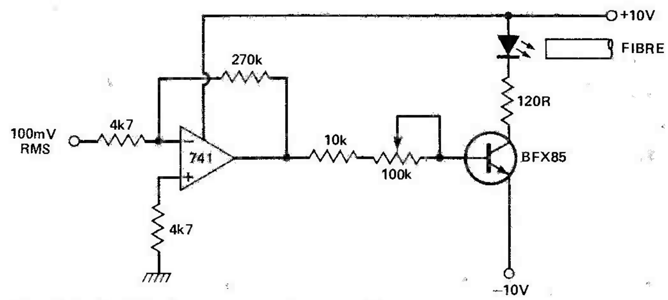


Fig. 14 Audio frequency transmitter.

it provides a medium-distance TTL-compatible link. Using standard polymer cable this circuit can transmit up to 200K bit/s over a distance of 10m.

Figure 12 is a standard transmission line, the RS232. Belling-Lee produce a pair of transmitter/receiver modules designed to directly replace RS232 links. The use of fibres then eliminates all the noise problems, twisted pairs and emitting loops. The modules are made for PCB mounting with screw-on connectors. Primarily they are intended for glass fibres but any type can be used. They provide viable computer/VDU links up to 200m.

The circuit of Fig. 12 can be modified to become a TTL or CMOS transmission system simply by shorting the 2k7 input resistor of the transmitter and modifying the receiver as shown in Fig. 13. The A1489 linear receiver acts as a current buffer and thus provides the RS232 to TTL interface.

Figure 14 is an audio frequency fibre optic transmitter. It is simply an inverting amplifier with a gain of about −60 which drives the emitter via an NPN transistor. The preset, RV1, should be set to give 0V at the collector of Q1.

If power consumption is a problem with transmitters then a series-driven emitter circuit is required (Fig. 15a). This configuration is TTL compatible, gives easy digital control, and high brightness. The driving current in the LED is given by

$$I_f = (V_{cc} - V_f - V_{ol})/R1$$

where V_{cc} = supply voltage
V_f = ON voltage of LED
V_{ol} = low voltage of the open-collector output

If the current step is so high that supply line modulation is occurng, a shunt driven emitter can be used (Fig. 15b). The power consumption is greater than a series circuit but the current step is reduced. The drive current is given by

$$I_f = (V_{cc} - V_f)/R1$$

Receiver design depends on which parameter you want to measure, and whether it is digital or analogue. However, the final signal processing is up to you.

Figure 16 is an audio frequency receiver compatable with the transmitter of Fig. 14. In its base form it is a simple one transistor amplifier driven by a photodiode. Obviously there are many variations on this simple theme: DC/AC amplifiers, A/D convertors, logarithmic or linear, etc.

Finally, for the keen and wealthy, there are several optical communication receiver hybrid circuits available. These provide most of the reception functions on chip, the user being able to control the sensitivity and operating speed. One such chip is the LH0082. This requires only a photodiode and a stable power supply for its basic preparation (Fig. 17a). Add a few minor components and the device can function over a range of 3 nW input sensitivity (@ 100 Kbit/s) to 300 nW input sensitivity (@ 15 Mbit/s). Additionally it can operate in an analogue mode (Fig. 17b).

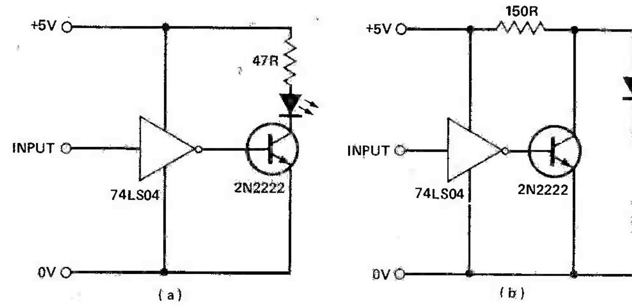


Fig. 15 Series and shunt driven transmitters.

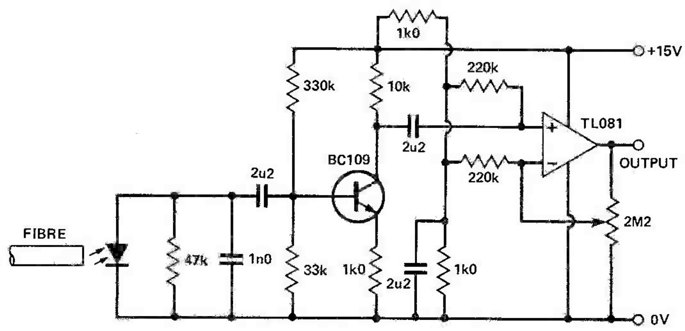


Fig. 16 Audio frequency receiver.

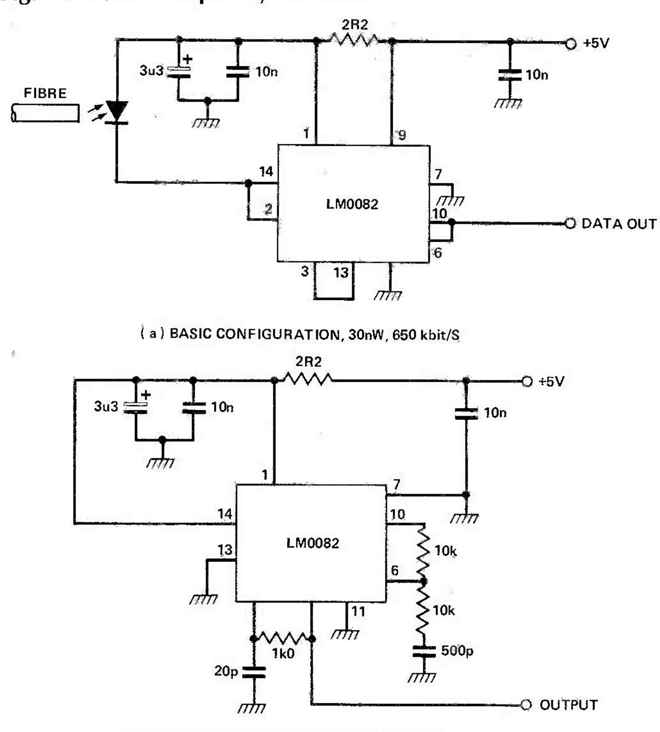


Fig. 17 Optical communcation receiver.

Hopefully these circuits will provide a useful springboard for many projects, as well as making a relatively new technology accessable to the masses! ETI

FAST LIGHT PEN

If you want to use your computer for some real work instead of all these silly games, a light pen can be a useful tool. Design by Martin Postranecky.

This circuit will enable you to build a light pen for use with most home computers, but at a fraction of the price of any commercial unit with comparable performance. Apart from cost, the circuit's main advantages are the very high response speed and the compatability with a large range of TV or monitor brightness and contrast settings.

Going Soft

In order to construct a light-pen system, both software and hardware are needed. This article covers the hardware in some detail, but, apart from giving some hints, leaves the construction of the software largely up to the reader. However, we do hope to be able to give software details in a future issue (no promises, though, so there's no excuse for laziness on your part).

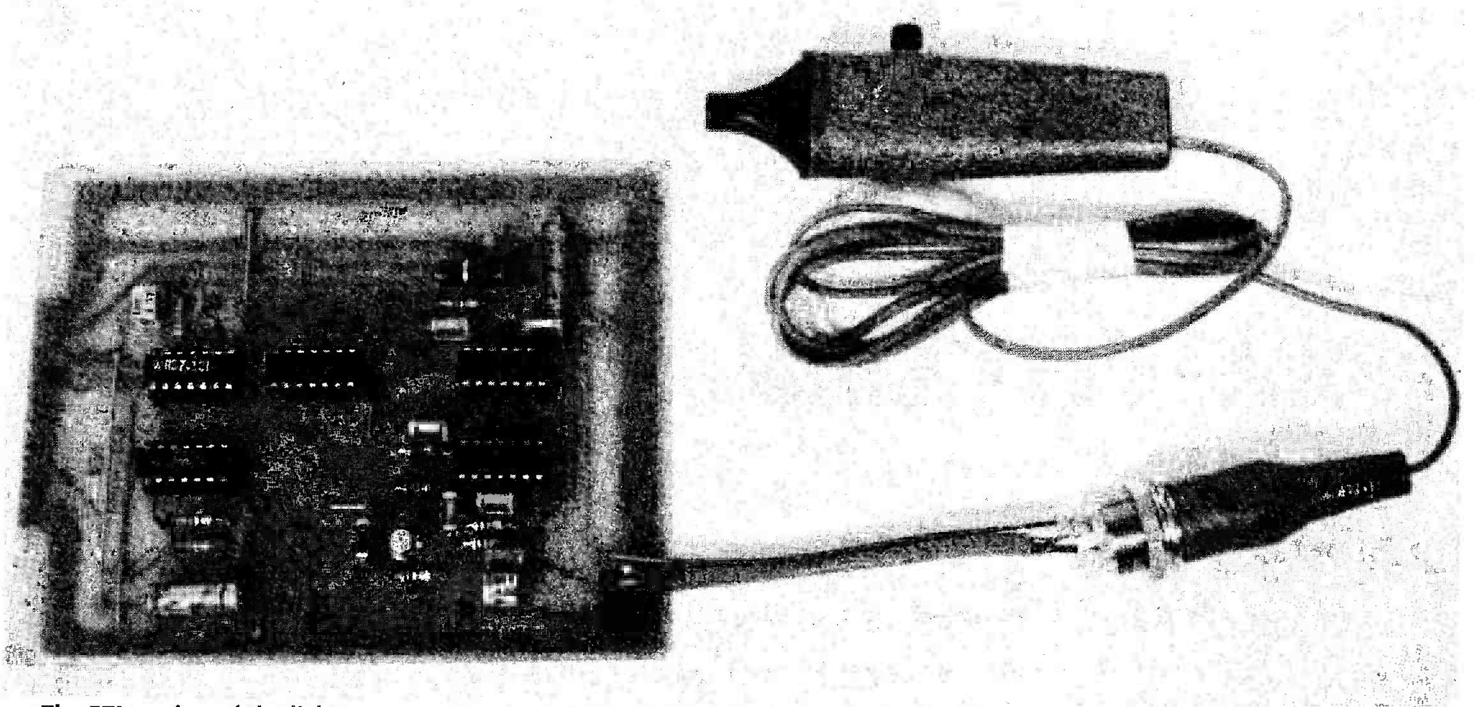
Generally, computers have a dedicated area of RAM that contains the information for the TV display. Words of data are read sequentially, each word being enough information to determine the brightness and colour of an area of screen known as a pixel. The size of the pixel — the number of lines it extends across and how far it extends along them — depends on the computer, but the pixel will be refreshed at a standard rate, every 40 mS in the UK system of two fields of 312½ lines in 20 mS.

When the electron beam "hits" the pixel at which the light pen is pointing the sudden change in phosphor brightness will trigger the light pen circuit. The resultant TTL output pulse can then be used to generate an interrupt which will identify the display file pointer position for that pixel. Your software should then either vary the content of that particular display element or generate an offset vector to move the element to follow (TRACK) the light pen.

Light Hardware

Obviously the response of the light pen must be very fast to enable you to capture the required element. With the photodiode used in this design, the TTL pulse is generated in under 300 nS; if an even faster response is required try a silicon PIN photodiode, eg BPX-65.

The circuit is very easy to build using the PCB layout provided. The only difficult part is the negative supply line, —7.0 V at about 30mA (the Video Amplifier will probably catch fire above ± 8V and the comparator will not work with less than —6V!). But as most computers provide —7V, —12V or —15V line, the simple BZY88 (6V8) Zener regulator should be satisfactory provided the correct



The ETI version of the light pen — unlike the author, we used the body of a highlight pen so that we could fit in the optional switch.

value for the series esistor, R11, is used, as given by Table 1.

The MIXED SYNC line is normally available at the TTL level in any computer somewhere on the video mixer board — most likely as an output of a ZNA134J or an equivalent IC. If all else fails try the cheap and simple circuit shown in Fig. 3 using the VIDEO OUTPUT line of your computer.

Body Building

To form the lightpen body, I used the barrel of a cheap ball-point pen with the photodiode push-fitted in the "sharp" end behind the 1mm 'hole'. But any ball-point / fountain / felt-tip pen /cigar tube / etc would be just as effective — use your imagination! Two points to remember — it is much easier to use a pen barrel where the tip separates or unscrews from the body so that you don't have to work in a 4" long tube. And make sure that the photosensitive element "sees" only a single TV line width. This depends on the size and resolution of the CRT but the aperture in front of the photodiode should not exceed 1 mm diameter. If you like weight-lifting you could even use one of those large 12-colour ball-point pens and build the whole circuit into the body of the pen (though you'll have to re-design the PCB!)

Two suggesions you might like to use are:

- you could mount the main PCB inside your computer case, and connect the pen to the circuit board using a three-pin DIN plug and socket;

HOW IT WORKS

Light falling on the reverse-biased photodiode PD1 increases the leakage current through the diode and R1. The resultant voltage change is AC coupled to the emitter follower Q1 and appears across its emitter load R4. Signal amplification is further provided by the variable-gain Video Amplifier IC1. The SET GAIN potentiometer PR1 is connected between the high gain select pins 4 and 11 and allows the voltage gain to be set between about 50 and 200.

Any small change in the amplifier output (about 10 mV) is detected by the analog voltage comparator, IC2 and appears as a negative-going TTL pulse at the output pin 11. This pulse is inverted by IC3a and clocks out the two complementary output lines LPOUT (Q1, pin 5) and $\overline{\text{LPOUT}}$ ($\overline{\text{Q1}}$, pin 6) of the dual flip-flop, IC4 with its DATA 1 (pin 2) tied high via R8.

The low-going edge of LPOUT also triggers the monostable IC5. After the preset time period — variable by the SET PULSE LENGTH potentiometer PR2 — the high-going edge of the IC5 output Q (pin 1) clocks-out the low-going output $\overline{\text{Q2}}$ (pin 8) of the flip-flop IC4 (DATA 2, pin 12, is again tied high via R7). After passing through gate IC3b and inverter IC3c, this pulse sets the CLEAR 1 (pin 1) of IC4 low and thus clears the flip-flop IC4 outputs, LPOUT and $\overline{\text{LPOUT}}$. The CLEAR 1 will remain low (and so prevent any further triggering of IC4) until the CLEAR 2 (pin 13) is brought low by the next Line Sync pulse of the $\overline{\text{MIXED SYNC}}$ line. This system ensures that only *one* pulse in any TV scan line is passed to the computer and prevents any spurious trigerring caused by the CRT flyback or sync pulses.

The STROBE (pin 13) of IC2 is normally held high by R2. If the optional switch SW1 is used in the LIGHT PEN body the STROBE will normally be low, inhibiting the IC2 output. The operation of the push-to-break switch SW1 allows the STROBE line to swing high enabling the IC2 output. Capacitor C4 removes the worst of the switch bounce from the STROBE line.

BUYLINES

No problems with the components here — NE529A and NE592A are offered by a number of suppliers advertising in this magazine, and the photodiode PD1 (RS Components Stock No. 305-462 used in the prototype) can be any fast response/visible light silicon diode in TO18 can. The PCB is available through our PCB service.

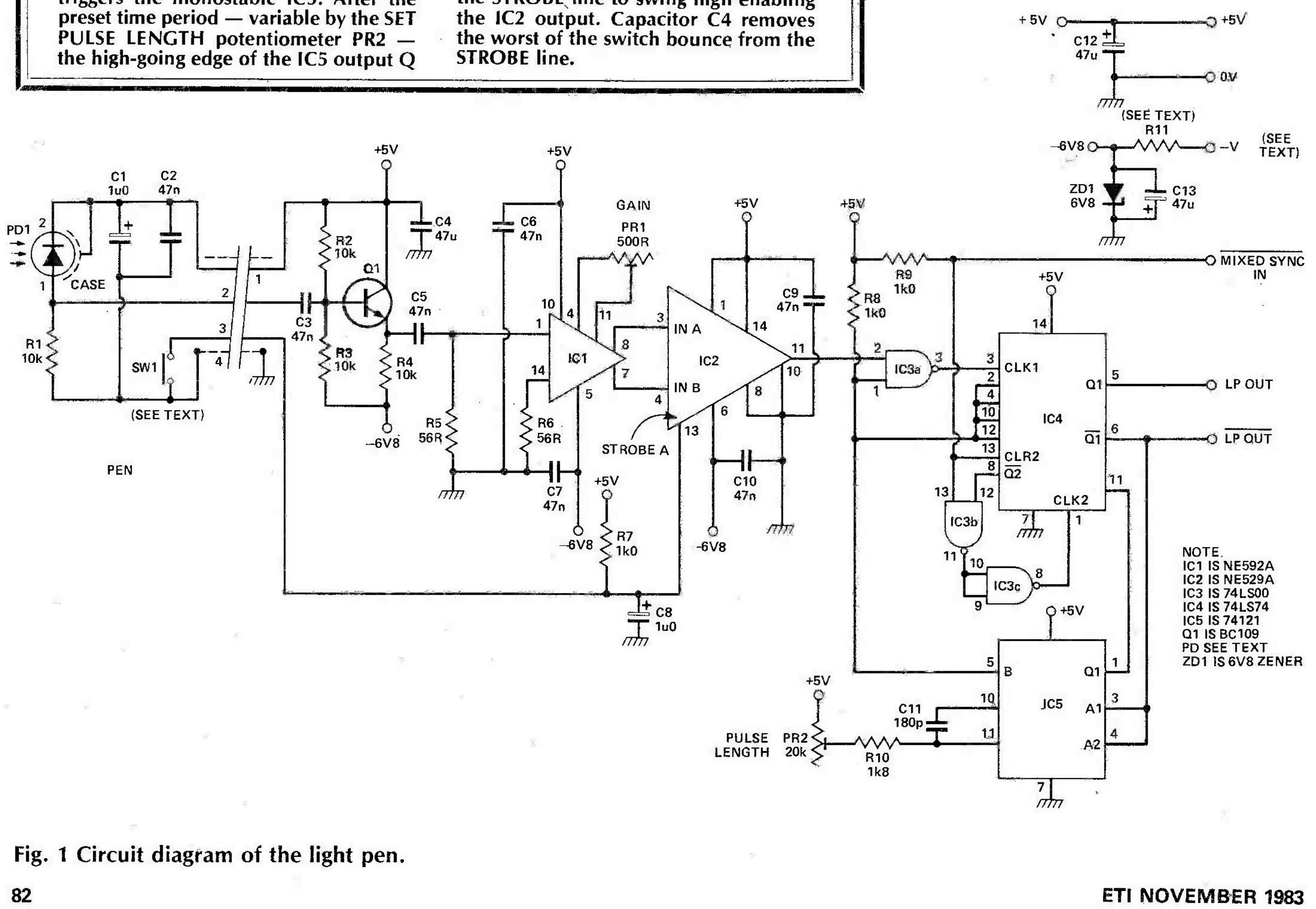


Fig. 1 Circuit diagram of the light pen.

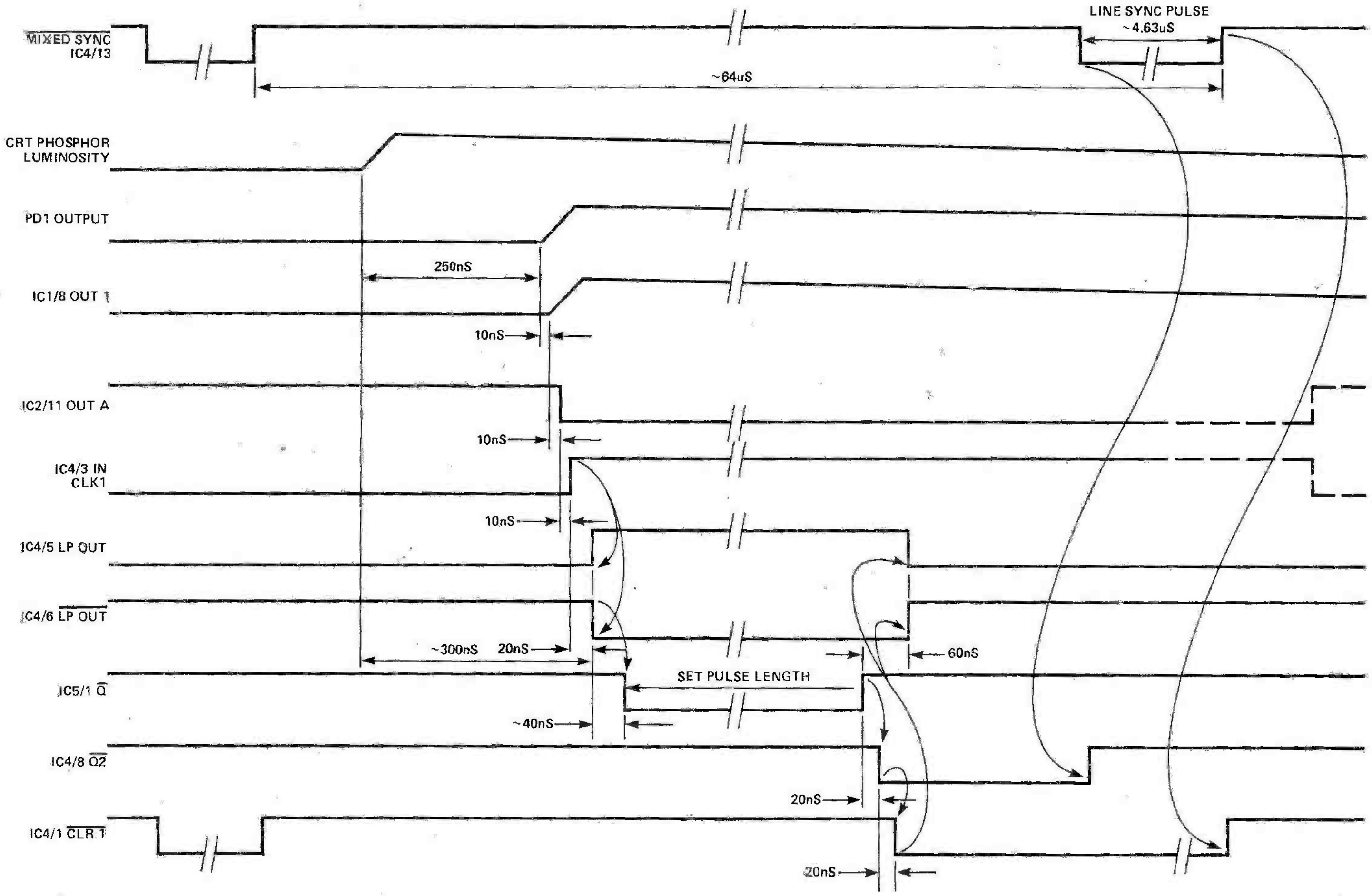


Fig. 2 Timing diagram of the light pen.

● if the size of the light pen body permits, you might find it useful to mount a small push-to-make switch on it (SW1) connected between the ground (shield) and the third wire. You can use SW1 as a push-to-write switch.

Setting Up

Construction of the main PCB should pose no problems. Please make sure that all the ICs are the right way round — they don't all fit the same way! Don't forget to insert all five links as shown on the PCB overlay and re-check the polarity of the zener ZD1 and the electrolytic capacitors. (If you think all this is superfluous, you don't know your Murphy's law).

Use and oscilloscope or a logic probe to look at the output of IC4 pin 5. Point the light pen at the TV screen with the brightness and contrast setting fully down (ie, dark) and adjust the GAIN present potentiometer PR1 so that the line stays low.

Then set both brightness and contrast back to the usual level and point the light pen at some white display element. Slowly increase PR1 until a single pulse appears on the TTL output line. Because the light pen could cover two or more scan lines depending on the CRT size, you may get two or three pulses repeated at 64 μS interval. You should be able to reduce the gain with PR1 and/or TV brightness control sufficiently to obtain just a single pulse.

Finally set the required pulse duration by the PULSE LENGTH potentiometer, PR2 (adjustable between about 200 nS and 2μS).

All that remains now is to sit down and write your software to actually use the light pen. What about a (computer) game of battleships . . .?

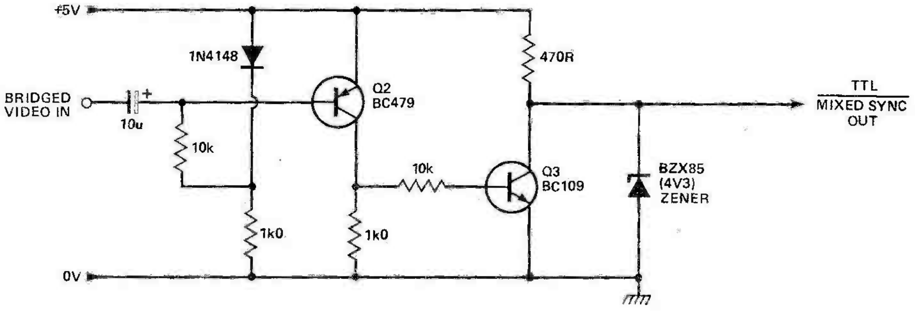
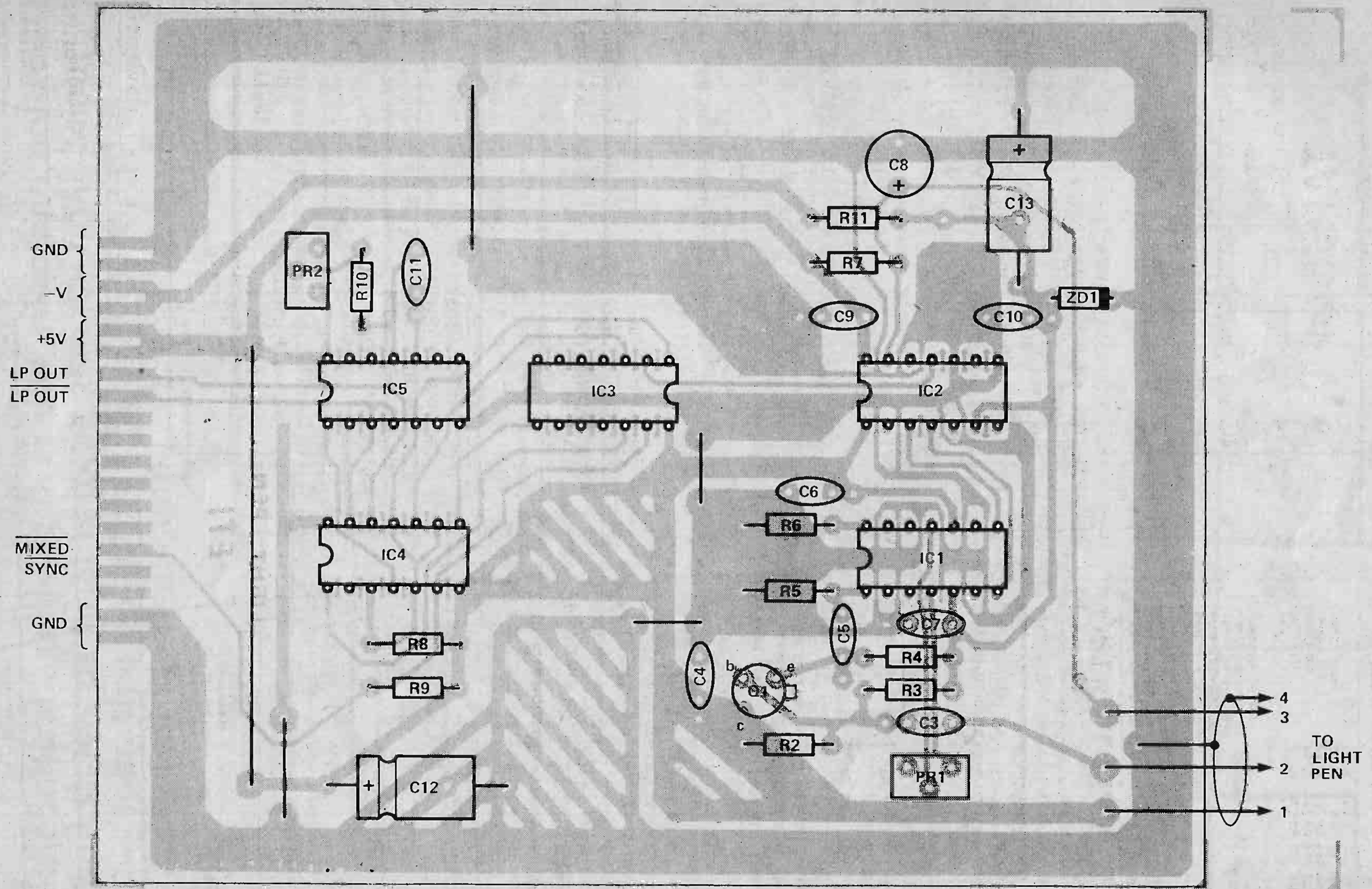


Fig. 3 Circuit to recover the MIXED SYNC pulse from the composite video.

SUPPLY VOLTS	R11 VALUE
−7	10R/1W
−12	120R/1W
−15	220R/1W

Table 1 Values of R11 for various negative host computer supply voltages.



PARTS LIST

RESISTORS (all ¼W 5% unless stated)

R1, 2, 3	10k
R4, 7, 8, 9	1k0
R5, 6	56R
R10	1k8
R11	See Table 1
PR1	500R lin preset
PR2	20k lin preset

CAPACITORS

C1, 8	1u0 10V tant
C2-7, 9, 10	47n polyester
C11	180p ceramic
C12, 13	47u 10V tubular electrolytic

SEMICONDUCTORS

IC1	NE592A
IC2	NE529A
IC3	74LS00
IC4	74LS74
IC5	74121
Q1	BC109
PD1	High-speed visible light photodiode in TO18 can — see text
ZD1	BZX85 (6V8) 1W zener diode

MISCELLANEOUS

PCB; three-core plus shield cable (or two core without SW1); light pen body — see text; SW1; miniature push-to-make switch (optional); three-pin DIN plug and socket (optional).

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READ/WRITE

Component Supplies

Dear ETI,

Your IC Update feature is most interesting, not least for your introductory remark about neither IC being actually available to the hobbyist.

It encapsulates something I've long been feeling — that the home constructor/hobbyist/amateur etc is often regarded as a convenient disposal route for the obsolete, substandard and just plain trashy.

Maybe I'm in a minority, my electronics interests being focused on audio with aspirations to the building of equipment with the sonic qualities of Mark Levinson, Threshold, etc. It's a continual pain to deal with supliers who can't even deliver what they advertise (and what they advertise often lags far behind industrially-available components).

I'd have thought that there was scope for someone, somewhere to get on a platform as a purveyor of genuine quality up-to-date goods as an alternative to the present system of 'bargain packs' and 'just as good only cheaper' (it's never as good and always costs you more to put right in the long run). Not that I condemn the cheapos entirely, many of us started there — but to what extent are we stuck there for the want of an alternative and for the want of a bit of imaginative energy?

Yours
Dick Bowman
London E17

We're very glad that at least one reader concurs with our remarks. We have, ourselves, access to 'professional' sources for components, and frequently we are unable to specify components that we'd like to because they are not available on the hobby market. So what do we do — do we leave out the devices in question, as we've done so far, or do we use them and hope that we can persuade someone, somewhere to sell them to readers?

To a great extent, what actually makes its way on to the hobby market depends on manufacturers' pricing policies — if the 100 (or even 1000) off prices are punitive, none of the advertisers in our magazine will stock bits because no one will buy them. And can you blame them?

We've spent quite a lot of effort trying to get manufacturers to recognise that the hobbyist market is important. It is very frustrating indeed to speak to an engineer who started out as a hobbyist (admittedly, probably before going on to do a formal qualification in electronics) who still doesn't recognise that we're important. It's also surprising how little it is recognised that ETI and (to be generous to the opposition for once!) other hobbyist magazines are widely read by professional engineers.

ZX81 Tape Mod

Dear Sir,

On page 61 of the February issue you publish an article by Mr Ian Ridout concerning modifications to facilitiate recording programs from the ZX81 on to cassette. Talk about a sledgehammer to crack a nut!

A year or so ago I did modify my son's ZX81 — and then quite a few of his friends' got done — to increase the write signal to cassette. Inspection of the Sinclair circuitry had revealed, as Mr Ridout states, that only about 1 millivolt RMS of signal emerged from the '81' at the cassette port, after the double 47 uS filter. Changing Sinclair components R29/C12 to 330K and 150pF worked with some 20 different machines, from metered hi-fi decks to auto-levelled portables. This, of course, tripled the signal to the cassette. 220K/220 PF combinations were also acceptable, giving a fivefold increase approx.

To use an FET as a buffer is a substantial overkill — needless when even a loading of, say, 10k/4n7 would be acceptable to the machine and give over 100 mV of signal, RMS. It is far more likely to create difficulties with the circuit published in your magazine owing to the very high signal level, than the easy and modest change of 1 resistor and 1 capacitor.

Yours sincerely,
P. A. Duvall
Theydon Bois

We don't accept that using *one* transistor is comparable to using a sledgehammer! Certainly, if we'd managed to fit in a couple of ICs, perhaps a dedicated micro to handle the tape signals . . . then that criticism really would be in order. As to difficulties with high signal levels, we've had none reported as yet — and, in any case, it's always far easier to get rid of excessive levels than it is to boost inadequate ones.

Fuel Economy

Dear Sir,

Your comments on the Hyconomiser suggested that readers might be interested in the possible advantages of electronic mpg devices. Mine is a Mobelex Maximiser, giving an instantaneous readout in mpg, and a record of fuel used, to tenths of a gallon. My car is a 1972 Datsun Bluebird (1600cc) which, until a replacement carburettor was fitted a few years ago gave exceptionally economical consumption. I had always suspected that I had been lucky, and when the consumption on a run increased from the early 40s to the late 30s I fitted the meter to check up on the situation.

I had hoped that the meter might indicate places on the performance curve where the carburettor was delivering an economical mixture, and this proved to be the case. Observing the meter readings at steady speeds showed that just above 50mph gave a noticeably low reading. This was a rather lower cruising speed than the one I had found by trial and error to be economical with the previous carburettor, but checks on mileage and fuel put in (which agreed very closely indeed with the meter readings) showed that I could now get an overall consumption very close to 50 mpg, though traffic hold-ups and so on seemed perpetually to conspire to limit me to forty-nine point something and deny the triumphant fifty-plus. Nevertheless, I found the improvement of over ten miles per gallon very satisfying on those unavoidable long runs.

Of course, it is not all joy, and meter watching needs a certain frame of mind, where driving satisfaction comes from saving, rather than the wind in the hair. The meter shows what we all know but prefer not to believe. Hard acceleration can show as little as six or seven mpg, while one *enthusiastic overtaking up hill can more than counteract ten miles of careful driving on the level. Most of the economical methods I already knew, but didn't practise regularly until the meter kept reminding me of my wastefulness. One new — to me — tip is not to let the speed increase as the car breasts a hill. Easing off to keep the speed constant can show startling improvements, which of course follows logically if one considers that if acceleration is costly, acceleration up hill is far worse.*

One doesn't need to watch the meter all the time — in fact, once one has explored the performance envelope with it, if you drive by your findings you don't need to use it at all, yet I personally wouldn't be without one in future. On the other hand the ideal meter would differ in some respects from the one I have fitted. When one is using small quantities of petrol the fuel flow transducer appears to give a signal every second or two, and the combination of this data with the more frequent speed signals gives a display that flickers over some 5-10 mpg. It would be easy to be dismissive about the meaningfulness of the display, but in fact the trend of the figures is quite easily followed — indeed, after some degree of use one can begin to read subtleties into the way the display is operating. Nevertheless, some kind of integrating device that would operate over a second or two would make the device easier to interpret, particularly by the impatient or non-technical. Again, reading the tenths against the mileage enables a quick check on mpg attained over the last five miles or fifty miles, or since the beginning of the journey, but it would be pleasant to do this automatically rather than by mental arithmetic.

Incidentally, the best mpg I have ever attained over a distance was coming eastward on the M4 from the service area on the summit level. A strong tail wind enabled me to display (and check on the mileage/consumption figures) over 80 mpg for some thirty miles. Needless to say, awful rush-hour jams at the London exit reduced my overall figure to about fifty . . .

Unfortunately I lack both the time and the expertise to design my own ideal meter, but I feel that I would now be able to offer quite a lot of useful advice to anybody thinking of obtaining or designing one.

I am sure that a device like the Hyconomiser could improve the consumption of any car that, like mine on its new carburettor, was operating slightly rich. However I don't understand the emphasis on the so-called optimum mixture, where the oxygen and hydrocarbons are present in the exact quantities needed for the theoretical reaction. In real life, some of the petrol and some of the oxygen just can't get together, and both petrol and oxygen are wasted. For some forty or fifty years two mixtures have been aimed at:
1. A rich mixture for maximum power with excess fuel, where all the oxygen is burned, but some petrol is wasted.
2. A weak mixture for cruising, with excess air, where all the fuel is burned, but some oxygen passes off unburned (don't forget that four fifths of the gas in the cylinder is nitrogen, that passes out hot but unchanged, so a little excess oxygen is unimportant). Modern carburettors try to operate in these two regimes, and avoid the 'optimum' mixture like the plague. The problem, leaving aside gross failures to atomize, is that no improvement in mixing arrangements can improve the mixing beyond a certain point determined by the mathematics of probability.

This effect was first noticed, to my knowledge, in connection with the Lumiere 'Autochrome' colour photographic plates circa 1910. The system depended on an intimate mixture of red, green and blue fine transparent powders to produce a mosaic screen with many million elements to the square inch. However aggregations of many grains all of the same colour produced objectionable spots on the plates, and it became apparent that more thorough mixing did nothing to alleviate the problem. In the 1920s E. J. Wall showed that the number and size of these clumps of grains was very close to that predicted by probability theory. Even larger clumps of grains should have been present, but plates with these were presumably rejected by visual inspection.

Anyone who hopes to create an ideal mixture without 'lumps' merely by mixing or agitation is, I am afraid, attempting to evade one of the laws of nature.
Yours sincerely
Michael C. Jones
Harrow

We have considered doing a project for a fuel consumption monitoring system, as the electronics involved would be relatively simple and easy to design. However, the problems come in trying to design the fuel volume and the distance travelled transducers.

Tropical Programming

Dear Editor,

I'm having infinite trouble with my Atari Cassette Programmer and wrote to HE wondering if their EPROM project earlier this year (the magazine takes some time to reach me out here!) would be of use. They say not, but suggested contacting you.

I need some way of storing programs and loading them; my 410 program recorder seems to store them but won't load. There are two of us in Fiji with Ataris and both of us have exactly the same problem. My friend got a disc drive, but that's packed up too, so we are driven to lying on the beach, drinking from a coconut and dreaming of programming.
Any suggestions welcome.
Rob Patterson
Lelan Memorial School
Fiji

This must be the cruellest letter we've received in a long time — how is it possible for anyone to worry about programming when there's important business like lying on the beach to get on with? There's nowt so queer as folk (well known north of England saying No. 42).

So far as we are aware, the 410 programmer is a reliable piece of equipment and should work. However, it's probably the excess heat that's giving the trouble, by causing the timing components in either the recorder or the interface to change value just enough for the two not to be compatible. Have you tried using the computer and recorder in an air conditioned room? Alternatively, we suggest contacting Atari themselves.

ETI welcomes all it's readers (publishable) opinions on the contents of the magazine, and issues related to electronics. Send your letters to The Editor, ETI, 145 Charing Cross Road, London WC2H 0EE. **ETI**

ETI PCB SERVICE

The best way to get a really professional finish to your project is to use a professionally made PCB — look no further, here they are!

In order to ensure that you get the correct board, you must quote the reference number when ordering — if you don't, you may get sent the wrong board. The code can also be used to identify the year and month that a particular project was outlined in: the first two numbers are the year, the third is the month and the number after the hyphen indicates the particular project.

Note that these are all the boards that are available — if it isn't listed, we don't have it.

Our terms are strictly cash with order — we do not accept official orders. However, we can provide a pro-forma invoice for you to raise a cheque against, but we must stress that the goods will not be dispatched until we receive payment.

1979

- ☐ E/794-1 Guitar Effects Unit 2.64
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- ☐ E/796-1 Accented Beat Metronome3.60

1980

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- ☐ E/808-1 CMOS Logic Tester 2.64
- ☐ E/808-3 Ultrasound Burglar Alarm 2.87
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1981

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- ☐ E/812-1 Universal Timer 3.31
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Prices quoted are valid until December 1983

How to order: indicate the boards required by ticking the boxes and send this page, together with your payment, to: ETI PCB Service, Argus Specialist Publications Ltd, 145 Charing Cross Road, London WC2H 0EE. Make cheques payable to ETI PCB Service. Payment in sterling only please. Prices subject to change without notice.

Total for boards	£....................
Add 45p p&p	0.45
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LOGIC CLIP

Ever been frustrated trying to test a digital circuit with only one single-point logic probe? Never fear, ETI comes to the rescue with this 16-point, 4-state CMOS/TTL logic probe.

This logic clip is a very useful addition to a digital test-set, speeding up the tedious testing of MSI devices, such as flip-flops and counters. Such clocked logic requires both stimulus and effect to be observed, and this is difficult to do with a conventional logic probe. The usual solutions of a multi-trace oscilloscope and a logic analyser will be just a bit beyond the means of the average ETI reader. The ETI logic clip provides equivalent facilities at a much more approachable cost.

When built, the logic clip simply clips on top of the IC to be tested (using an IC test clip), showing the logic state (high, low, undefined or pulsing) of all 16 pins of the IC. The probe caters for both TTL and CMOS ICs — the high and low logic levels are selected by a single switch.

Goodbye Tedious Testing

The logic clip is the ideal partner for the ETI Dicrobe logic pulser (September 1982), which can provide suitable stimuli for the IC under test. For example, let us suppose that we wish to test for the proper operation of a binary counter. If we use a normal probe, each counter output must be checked before the next clock pulse can be applied, to make sure that the clock pulse is producing the desired response — a binary count. Contrast this with using the logic clip, which simply fits on top of the counter chip, leaving your hands free. You sit back, push the pulser button and watch the count progress.

Dazzling Dual Colour

The circuit basically consists of two identical logic probes, which compare the input with selectable logic levels for low and high, and drive the display LEDs accordingly. The small size of the clip is achieved by scanning eight pins on either side of the test IC, and feeding the selected test voltage to these two logic probes. Of course, there would be little point in doing this if all the data was displayed on one LED — the result would be a meaningless blur, so the display is made up of two rows of eight multiplexed dual colour LEDs, one row for each logic probe.

These dual colour LEDs are connected between the outputs of the high and low comparators, and give the following indications:
High: green
Low: red
Undefined: off
Oscillating: yellow
With experience, the mark/space ratio of an oscillating mode can be estimated from the degree of red or green in the yellow indication. To make the device easier to read, the LEDs are laid out in the pattern of the IC pins (see Fig. 2a), each LED corresponding to the test pin below it.

The scanning is done by 4051 CMOS one-of-eight analogue selectors for both input and display. These have an on resistance of about 160R, and so will limit the current through the LEDs. The scan address lines are provided by the binary counter IC2, fed by oscillator IC1, which runs at a frequency high enough to maintain persistence of the display (ie, no flicker). The rather odd order in which the pins are scanned is due simply to the constraints of the PCB design.

Construction

The probe consists of two circuit boards attached to an IC test clip, each board displaying the state of the eight pins on it's side of the IC. Start the construction by soldering the wire links above R6 on board 2, then insert the resistors

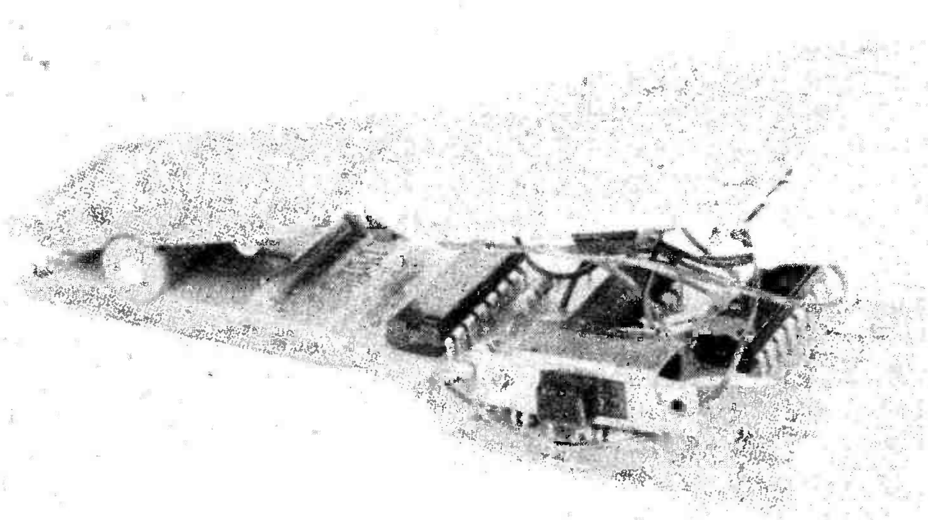


Fig. 1 Construction of the logic clip is on two boards which are then glued onto an IC clip.

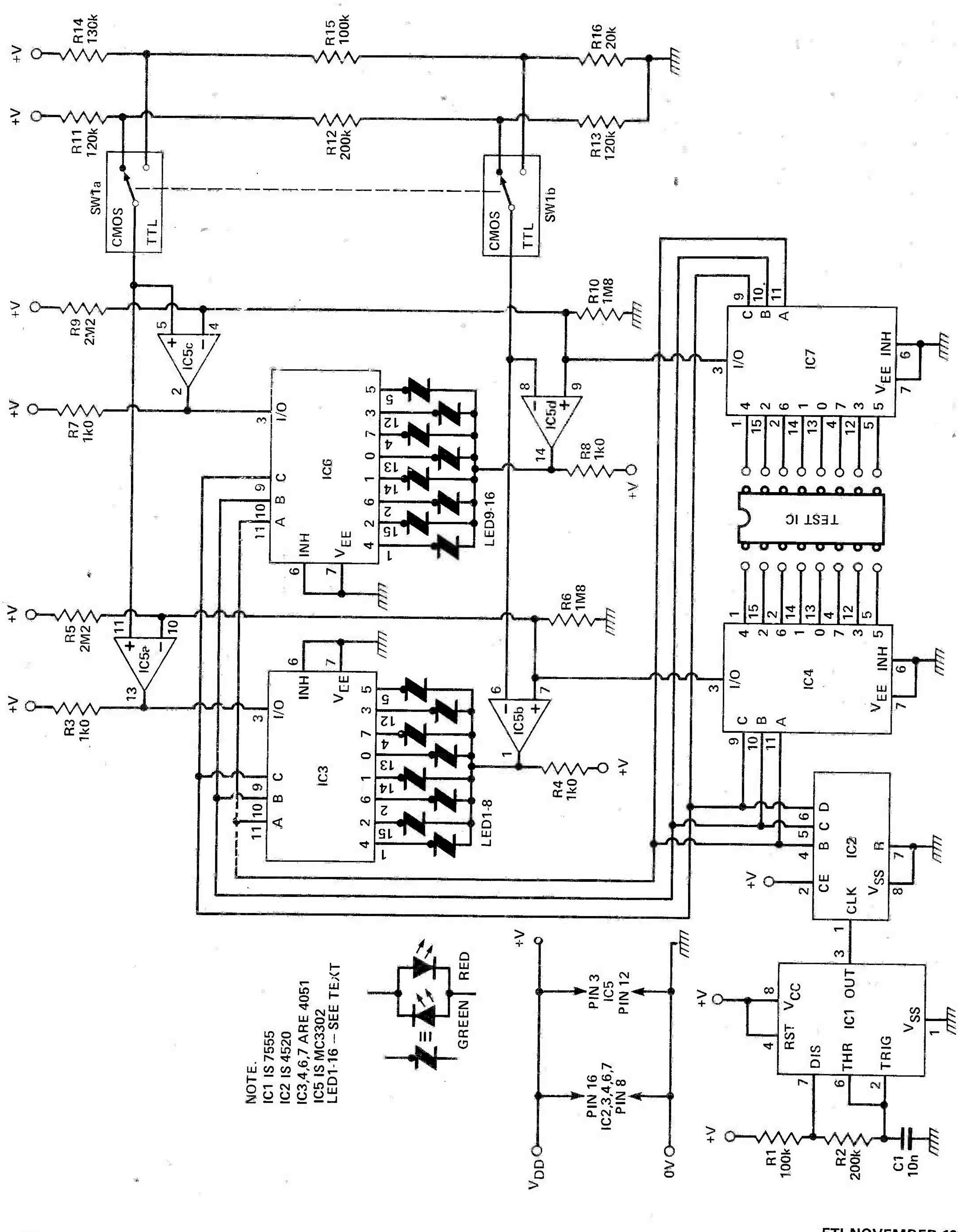


Fig. 2 Circuit diagram of the Logic Clip.

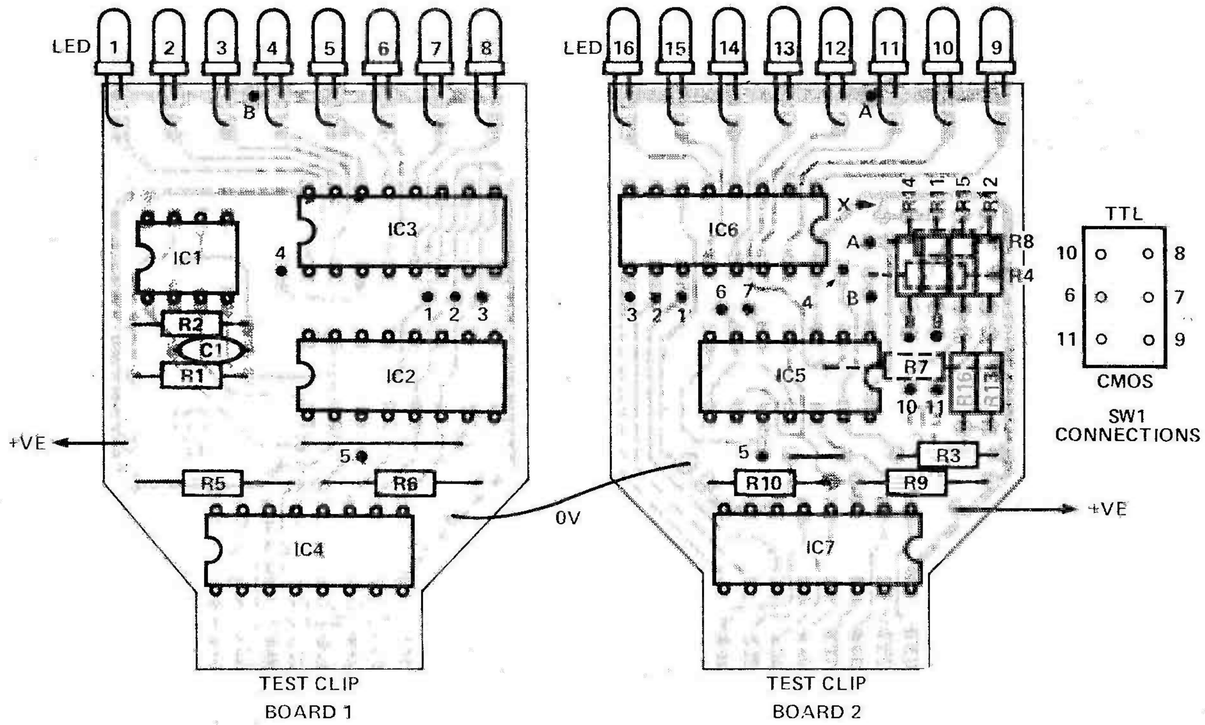


Fig. 3 Overlay diagram of the logic clip. Note that all the numbered points and the points with letters A and B should be joined up (ie, join 1 to 1, 2 to 2, A to A, etc. The point marked 'X' is where the foil may be cut if you want to power the clip from an external source (see Expanda-clip section of text). Note also that resistors R4, R7 and R8 are mounted on the foil side of the PCB, and should be very carefully soldered onto the pads provided to avoid lifting the track.

HOW IT WORKS

The logic clip relies on the multiplexing/demultiplexing action of the 4051 analogue selectors. The scan address is provided by the dual binary counter, IC2. Only one of the counters is used, and the count outputs B, C and D are taken to the 4051s for ease of PCB design. The counter is fed by the 7555 oscillator, IC1. The components used set the oscillation frequency at around 500 Hz, so each of the test IC pins is scanned approximately 30 times a second.

As each of the pins is scanned in turn, the voltage at that pin is fed to the high and low comparators of IC5 (two comparators for each side of the chip). The upper and lower threshold voltages are provided by R11-R16, and are selected by SW1. The outputs of the comparators vary with input as shown in Table 1.

The comparators have uncommited collector outputs, so can sink current, but are passive high, i.e. they just sit there and do nothing when high. Thus, the LEDs have to be driven by resistors R3, 4, 7 and 8. When an output is low, the open collector sinks current to ground, preventing the LED from lighting. When the output is high, the current can flow through the LED. The outputs of the low comparators, IC5b and IC5d, are connected to the commoned green anodes, and the high comparators, IC5a and IC5c, are connected to the demultiplexers, IC3 and IC6. These are fed by the same address lines as the multiplexers, and have a similar PCB layout, so each LED corresponds to the test pin directly below it. The net result of all this is a four-state display of what is happening on the sixteen pins of the IC under the clip.

PARTS LIST

RESISTORS (all ¼W 5%)		CAPACITOR	
R1, R15	100k	C1	10n (B37448)
R2, R12	200k		
R3, R4, R7, R8	1k0		
R5, R9	2M2	SEMICONDUCTORS	
R6, R10	1M8	IC1	7555
R11, R13	120k	IC2	4520
R14	130k	IC3, 4, 6, 7	4051
R16	20k	IC5	MC3302

LED 1-16 — 0.2' two-lead red/green dual colour

MISCELLANEOUS
PCBs, DPDT switch (as small as possible), IC test clip, 2.5mm jack plug and socket, two core lead, red and black croc. clips.

BUYLINES

Problems here are the LEDs and the test clip. Make sure that the LEDs are 2-lead devices, NOT the 3-lead common cathode type sometimes called 'dual colour'. Suitable LEDs are available from Watford Electronics.

Our test clip was obtained from Basic Electronics, but Maplin, GSC and RS stock equally suitable clips (order codes FY74R, 08-0016 and 423-627 respectively)

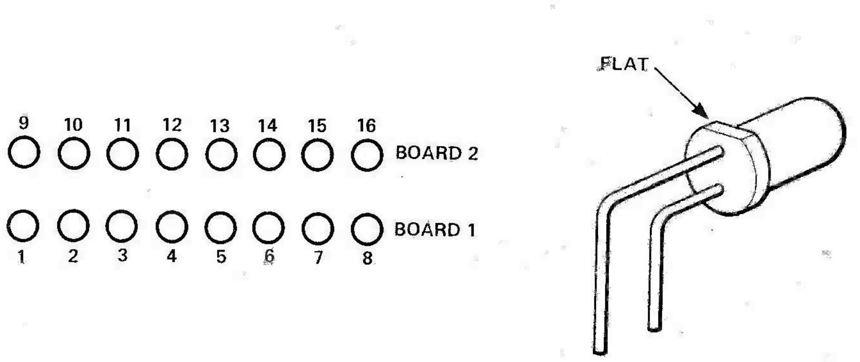


Fig. 4(a) The layout of the indicator LEDs. (b) Mounting details of the two-colour LEDs.

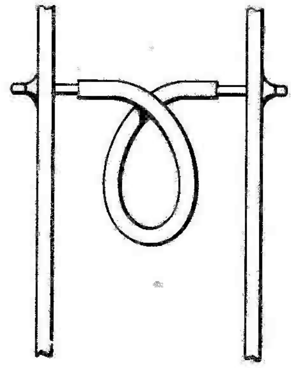


Fig. 5 How we suggest looping the connecting wires between the two boards.

and C1. Next, fit the LEDs: these are dual colour devices, with a flat on the package that indicates the red anode/green cathode lead. Form the LED leads as shown in figure 4b.

Connect SW1 to points 6 to 11, following the layout shown in the overlay diagram. Now solder the ICs in place, noting their orientation and taking care not to make any solder bridges across the many fine tracks. Next, carefully solder the resistors R3, 4, 7 and 8 on the foil side of board 2, keeping the resistors as close to the board as possible. Finally, solder the power jack socket in place, taking both power rails to each board from the socket.

Once the boards have been assembled, it would be advisable to test them before attempting final construction. Temporarily wire the boards together using lengths of insulated wire to join points 1-5. Plug in the power jack and apply suitable test voltages to each of the sixteen inputs (e.g. try V+, 0V and V+/2). Check that the LEDs light correctly for both CMOS and TTL threshold levels. If they do not, check that the LEDs are connected the right way round, and that all the components are inserted correctly.

Tricky . . .

Now for the tricky bit of mounting the boards onto the test clip. Details will depend on the type of clip used, but the method we used for our hinged clip will apply to most types.

First, shape the test contacts so they fit through the holes in the PCB. Bend these pins to make the edge of the board flush with the plastic of the clip. Then solder the boards to the clip with the components facing inwards. This joint may be strengthened by filling between the board and the clip with epoxy resin, such as Araldite. Finally, make the inter board connections 1 to 5 with lengths of fine, flexible insulated wire. These wires will be flexed as the clip is used, so it would be wise to reduce the strain on them. This can be done by making a loop in the wire like that shown in figure 5, and ensuring that the wire is at right angles to the board.

. . . But You Can Do It

The probe is a rather odd shape, so we recommend building a case around the boards, using 60 thou plastic sheet ('Plasticard'), available from most good model shops. This should be cut to size and glued together with polystyrene cement.

If you have never worked with plasticard before, we had better explain how easy it is to use. To cut it, you just score a line with a sharp knife, such as a scalpel (fairly heavily for 60 thou), and snap along the score line. As the clip hinges, there are two halves to the case, which simply shroud the boards, covering the soldering. The logic select switch is glued into a hole in one of the sides, and the power jack socket into the other.

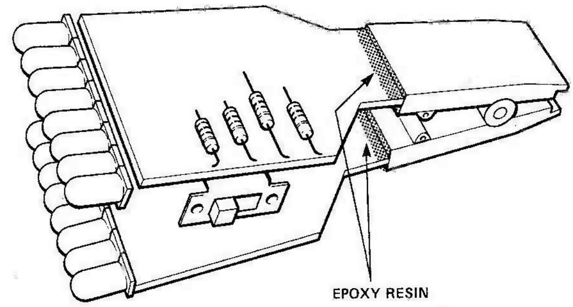
If you feel unable to build the case, then find a suitably sized box to hold both boards, wire the boards firmly together, and connect the test clip to the probe unit via a length of ribbon cable.

Expanda-clip

There are other possible uses of the clip, for instance, a number of similar units could be built on one board (with a different PCB layout), for use on 40-pin devices. Alternatively, the logic clip could be used to monitor bus lines, etc.

Also, it is worth noting that there is facility on the board for the clip to be powered by a supply other than that of the circuit under test, allowing low voltage devices to be tested, whilst keeping the LEDs brightly lit. This can be done by breaking the foil at the point marked 'X' (the connection between the +ve supply and the resistor divider chain) and connecting a voltage sense line to the spare PCB pad just below point X. This line is then connected to the +ve supply rail of the unit under test, with the clip powered by another source. This may be necessary even for TTL circuits, due to the variation in 'on' resistance of the 4051 selectors.

Having struggled through a rather involved construction, you should be left with a very useful and time saving tool. Happy probing!



ETI

SERVICE SHEET

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We receive a very large number of enquiries. Would prospective enquirers please note the following points:

- We undertake to do our best to answer enquiries relating to difficulties with ETI projects, in particular non-working projects, difficulties in obtaining components, and errors that you think we may have made. We do not have the resources to adapt or design projects for readers (other than for publication), nor can we predict the outcome if our projects are used beyond their specifications;
- Where a project has apparently been constructed correctly but does not work, we will need a description of its behaviour and some sensible test readings and drawings of oscillograms if appropriate. With a bit of luck, by taking these measurements you'll discover what's wrong yourself. Please do not send us any hardware (except as a gift!);
- Other than through our letters page, Read/Write, we will not reply to enquiries relating to other types of article in ETI. We *may* make some exceptions where the enquiry is very straightforward or where it is important to electronics as a whole;
- **We will not reply to queries that are not accompanied by an SAE** (or international reply coupon). **We are not able to answer enquiries over the telephone.** We try to answer promptly, but we receive so many enquiries that this cannot be guaranteed.
- Be brief and to the point in your enquiries. Much as we enjoy reading your opinions on world affairs, the state of the electronics industry, and so on, it doesn't help our already overloaded enquiries service to have to plough through several pages to find exactly what information you want.

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ETI should be available through newsagents, and if readers have difficulty in obtaining issues, we'd like to hear about it.

Backnumbers

Below we list the backnumbers that are available from our backnumbers department. Please note that this list will be out of date if you use an old copy of the magazine. Backnumbers cost £1.50 (UK or overseas by surface mail) and are available from: ETI Backnumbers Department, 513 London Road, Thornton Heath, Surrey CR4 6AR (cheques should be made payable to ASP Ltd).

Even if the copy of ETI you need is not listed, all may not be lost, because we run a photocopying service. For £1.50 (UK and overseas) we will photocopy an entire article (note that parts of a series of articles count as separate articles). Your request should clearly state what article you require and the month and year in which it appeared (the index for 1980 and 1981 was published in January 1982, and the index for 1982 appeared in December 1982). Send your request to ETI Photocopies, Argus Specialist Publications Ltd, 145 Charing Cross Road, London WC2H 0EE (cheques should be made out to ASP Ltd).

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Write For ETI

We are always looking for new contributors to the magazine, and we pay a competitive page rate. If you have built a project or you would like to write a feature on a topic that would interest ETI readers, let us have a description of your proposal, and we'll get back to you to say whether or not we're interested and give you all the boring details. (Don't forget to give us your telehone number).

We don't bother with the bureaucracy for Tech Tips — all you do is to send in your idea, stating clearly if you want an acknowledgement of receipt. If possible, please *type* your explanation of why the circuit is different, what it does and how it works, on a separate sheet from the circuit diagram; both sheets should carry your name, address and the circuit title. We'll let you know (within a month or so) if we want to use your Tech Tip.

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OOPS!

We have in the past published small corrections to projects on the letters page, and major corrections separately. From now on corrections will appear on this page, and will be repeated for several months (just to increase our embarrassment). If a correction is too large to fit on here, we will publish it just once, but will note the fact that a correction does exist, and that copies of it can be obtained from us provided you send in an SAE. But please — request copies only if you really do need them; if this service is abused, we may be forced to withdraw it.

Programmable Power Supply (January 1983)
Lascar Electronics have now moved to Module House, White Parish, Salisbury, Wiltshire SP5 2SJ.

Flash Sequencer (July '83)
Q1 should be BC184L; Q2-5 should be BC182L.

Telescope (August 1983)
We had a shower of annotation falling off our diagrams! On Fig. 1, C19 (below IC14) was not labelled nor was Q2 (above R11), and there were two C23s — one should be IC22 and it doesn't matter which. In Fig. 5, IC12 was not labelled. Unfortunately, there was a mistake in the correction (blush!): C14 is the 22µ tant on the −5 V line.

Graphic Equaliser (August 1983)
D2 and D3 are shown the wrong way round in the power supply circuit diagram on page 20.

Universal EPROM Programmer (August 1983)
Quite a few sillies here! On the circuit diagram (page 46), C6 is 100u and C9 is 100n, not the other way round as given. Some bars were omitted from note three of Table 1 on page 48: it should have read "CE/$\overline{PGM}$ (27 series) is equivalent to PD/PGM (not PD/$\overline{PGM}$) (25 series)." The penultimate sentence of the first paragraph on page 50 should read ". . . adjust RV1 for a potential of +25 V at *IC10* output." On the overlay, IC7 is between SK2 and SK1, IC6 is between SK1 and C10, IC11 is between R7 and R10, R3 is between R2 and Q2, and Q7 is between Q6 and Q8. A link is missing between IC7 and SK1, and the unidentified pins at the right hand end of SK3 are the +5V line. Finally, C10 appears twice in the parts list but only the first entry is correct, and the second DIL socket should, of course, be 8, not 80, way.

Z80 Controller Computer (August 1983)
On the overlay, SW1 is the rectangle beside ICs 5 and 6, C6 should be shown between ICs 3 and 7, and a link through has been missed — to the right of pin 18, IC11.

Typewriter Interface (October 1983)
There are two errors in Table 1 on page 24: location 3C should contain E7 and location 3F should contain 5F.

Car Alarm (October 1983)
In the semiconductors section of the parts list, Q1, 2, 5, and 7 should be BC212L, Q3 should be BC182L, and Q4, 6 should be TIP31 or BD131. There was also another (inconsequential) silly but we bet you've already spotted that one!

Tech Tips (October 1983)
Ramped Pulse Generator For Stepper Motors — pin 1 of IC2 should be grounded, the Ramp Up and Ramp Down inputs accept negative, not positive, going pulses, and IC7 should be a 4011 rather than a 4001.

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