An Argus Specialist Publication

electronics today

INTERNATIONAL FEBRUARY 1984 90p

CHAT WITH YOUR COMPUTER!

Versatile allophone speech synthesis board with:

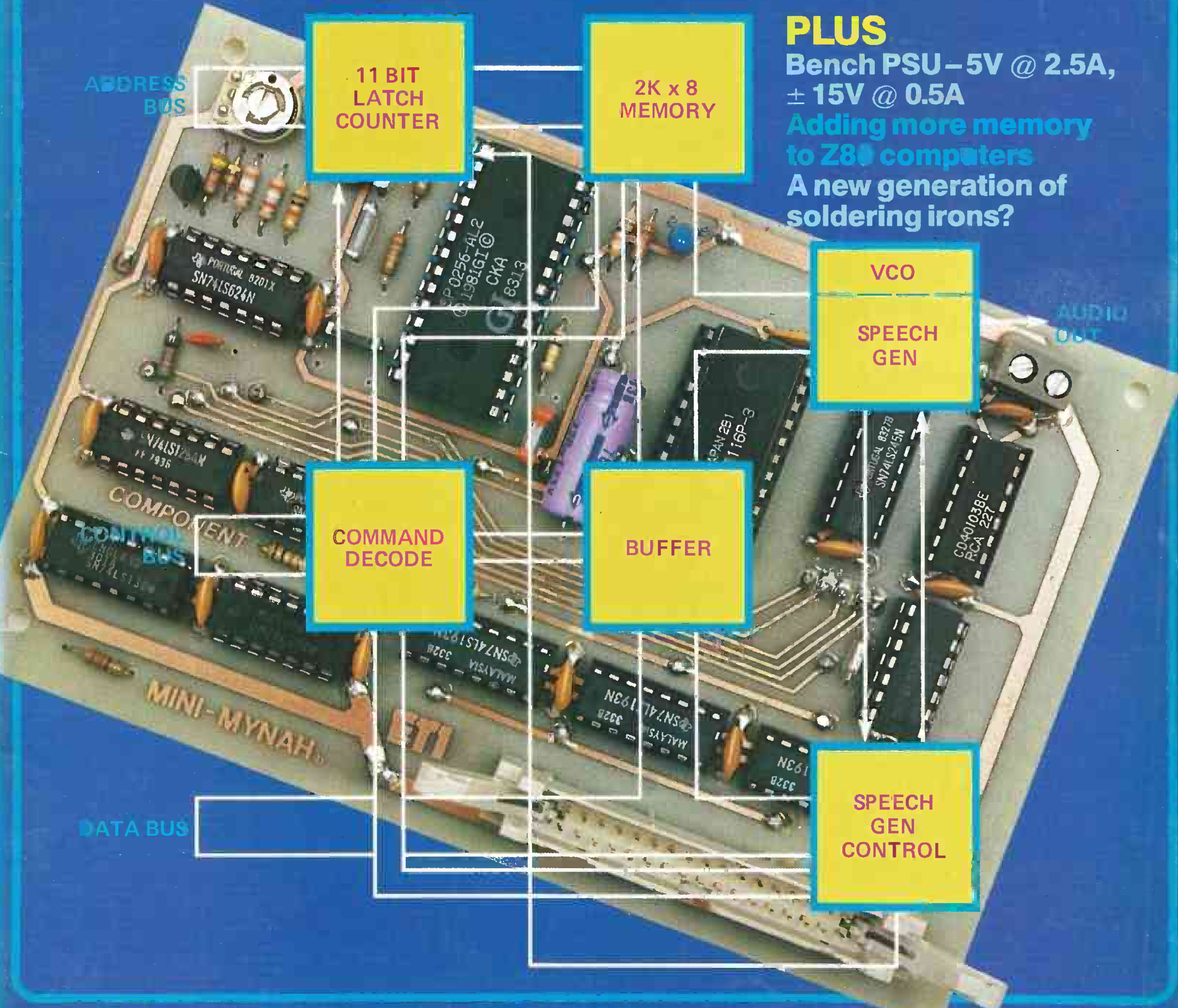
- four levels of inflection
- 2K of on-board RAM storing 100+ words
- speech reproduced as words, phrases or sentences
- simple interface requirements
- low software overhead

PLUS

Bench PSU – 5V @ 2.5A, ± 15V @ 0.5A

Adding more memory to Z80 computers

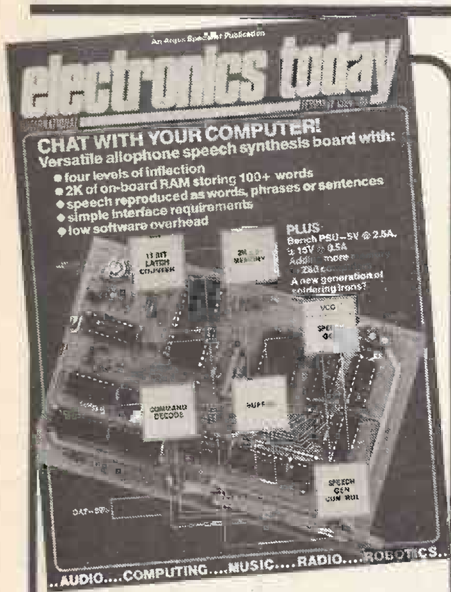
A new generation of soldering irons?



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

electronics today INTERNATIONAL

FEBRUARY 1984 VOL 13 NO 2



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FEATURES

PROJECTS

INFORMATION

SWITCHES

TOGGLE: 2A 250V	
SPST	35p
DPDP	48p

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 ½A	13p

PUSHBUTTON 6A
with 10mm Button

SPDT latching	110p
DPDT latching	160p
SPDT moment	110p
DPDT moment	160p

Mini Non Locking

Push to Make	15p
Push to Break	25p

ETI PROJECTS
We stock most of the parts

DIP SWITCHES

(SPST) 4 way **65p**; 6 way **80p**; 8 way **85p**; 10 way **125p** (SPDT) 4 way **190p**

ROTARY SWITCHES

(Adjustable Stop type)
1 pole/2 to 12 way; 2 pole/2 to 6 way; 3 pole/2 to 4 way; 4 pole/2 to 3 way **48p**

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; 6p/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	250p
B.C.D. Switch Module	278p
Mounting Cheeks (per pair)	75p

JUMPER LEADS (Ribbon Cable Assembly)

Length	14 pin	16 pin	24 pin	40 pin
Single ended DIP (Header Plug) Jumper				
24 inches	145p	185p	240p	380p
Double ended DIP (Header Plug) Jumper				
6 inches	185p	205p	300p	485p
12 inches	198p	215p	315p	480p
24 inches	210p	235p	345p	540p
36 inches	290p	370p	480p	525p

IDC Female Header Socket Jumper Leads 36"

	20 pin	26 pin	34 pin	40 pin
Single ended	160p	200p	260p	300p
Double ended	290p	370p	480p	525p

VEROBOARD 0.1in

2½ x 3¾	95p
2½ x 5	110p
3¾ x 3¾	110p
3¾ x 5	125p
3¾ x 17	420p
4¾ x 17	495p
Pkt of 100 pins	55p
Spot face cutter	150p
Pin insertion tool	185p

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

PROTO DECs

Veroblock	405p
S-Dec	395p
Eurobreadboard	520p
Bimboard 1	575p
Superstrip SS2	1350p

VERO WIRING PEN

+ spool	340p
Spare spool	75p
Combs	8p

DALO ETCH RESIST PEN
Plus spare tip **100p**

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

ULTRASONIC TRANSDUCER
40KHz **350 pr**

COPPER CLAD BOARDS

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

DILL SOCKETS

	Low Prof	Wire Wrap
8 pin	8p	25p
14 pin	10p	35p
16 pin	10p	42p
18 pin	16p	52p
20 pin	20p	60p
22 pin	22p	65p
24 pin	25p	70p
28 pin	28p	80p
40 pin	30p	90p

EDGE CONNECTORS

	.1	.156
2x15 way	—	140p
2x18 way	180p	145p
2x22 way	180p	200p
2x23 way	175p	—
2x25 way	225p	220p
2x28 way	190p	—
2x30 way	245p	—
2x36 way	295p	—
2x40 way	315p	—
2x40 way	315p	—
2x75 way	550p	—

ANTEX Soldering IRONS

C-15W	510p	Spare Bits	85p
CS17W	510p	Elements	230p
C18W	525p	Iron Stand	175p
xS25W	530p	Heat Shunt	30p

SIL SOCKET
0.1" pitch
20 way
65p

IDC CONNECTORS

	PCB with Pins Strt	Plugs latch Pins Angle	Female Header Plug	Female Card Edge Conct
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	180p	340p
50 way	235p	270p	200p	395p
60 way	—	—	230p	495p

EURO CONNECTORS

Gold Flashed Contacts	Female Strt Pins	Socket Angle Pins	Male Strt Pins	Plug Angle Pins
DIN41617 31 way	170p	—	—	175p
DIN41612 2 x 32 A + B	275p	320p	220p	285p
DIN41612 2 x 32 A + C	295p	340p	240p	300p
DIN41612 3 x 32 A + B + C	360p	385p	280p	395p

DIL PLUG (Header)

	Solder	IDC
14 pin	40p	90p
16 pin	48p	105p
24 pin	68p	178p
28 pin	290p	395p
40 pin	250p	255p

ZIF DIL SOCKETS

24 pin	565p
28 pin	799p
40 pin	799p

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	100p	135p
64 way	120p	160p

'D' CONNECTORS

miniature

	9 way	15 way	25 way	37 way
Male				
Solder lugs	80p	105p	180p	250p
Angle pins	150p	210p	250p	355p
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	80p	75p	75p	90p

IDC 25 way 'D' Plug **385p**; Socket **450p**

25 way 'D' CONNECTOR (RS232)
Jumper Lead Cable Assembly

18" long, Single end, Male	475p
18" long, Single end, Female	510p
36" long, Double Ended, M/M	995p
36" long, Double Ended, F/F	£10
36" long, Double Ended, M/F	995p

● SPECIAL OFFER ●
2764-250 ns 399p

PANEL METERS

FSD
60 x 46 x 35mm
0–50mA
0–100mA
0–500mA
0–1mA
0–5mA
0–10mA
0–50mA
0–100mA
0–500mA
0.5A
0.2A
0.25V
0.50V AC
0.300V AC
"S"
"VU" **490p each**

CRYSTALS

32.768KHz	100
100KHz	235
200KHz	265
455KH	370
1MHz	275
1.008M	275
1.28MHz	390
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
4.19430M	200
4.433619M	100
5.0MHz	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	225
7.0MHz	150
7.168MHz	250
7.7328MHz	250
7.68MHz	200
8.0MHx	150
8.089333M	395
8.86723M	175
9.00MHz	200
10.0MHz	175
10.24MHz	200
10.7MHz	150
12.0MHz	175
12.528M	300
14.31814M	170
16.0MHz	200
18.0MHz	180
18.432M	150
19.968MHz	150
20.0MHz	200
24.0MHz	170
24.930MHz	325
26.69M	150
27.648M	170
27.145M	180
38.6667M	175
48.0MHz	170
100.0MHz	295
116.0MHz	300

RELAYS

Miniature, enclosed, PCB mount

SINGLE POLE Changeover
RL-91 205R Coil, 12V DC, (10V5 to 19.5V), 10A at 30V DC or 250V AC **195p**

DOUBLE POLE Changeover, 6A 30V DC or 250V AC
RL-100 53R Coil, 6V DC (5V4 to 9V9) **190p**
RL6-111 205R Coil, 12V DC (10V7 to 19V5) **195p**
RL6-114 740R Coil, 24V DC (22V to 37V) **200p**

AMPHENOL PLUGS

IEEE 24 Way	475
Centronics Parallel 36 Way solder	485
Centronics Parallel 36 Way IDC	480
Centronics 36 Way IDC Female	520p

ASTEC UHF MODULATORS

Standard 6MHz	325p
Wideband 8MHz	450p

BUZZERS

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

LOUDSPEAKERS

Miniature, 0.3W- 8	
2in, 3¼in, 2½in, 3in	80p
2½in 40, 64 or 80	80p

MONITORS

- ZENITH — 12" Green, Hi-Resolution Popular **£75**
- MICROVITEC 1431. 14" Colour RGB input. Connecting cable incl **£215**
- KAGA 12". Med-res. RGB Colour. Has flicker-free characters. Ideal for BBC, Apple, VIC, etc **£219** (car £7)
- KAGA 12". As above but Hi-Resolution **£259** (car £7)
- Connecting Lead for KAGA **£5**

BROTHER 8300 DAISY WHEEL PRINTER/TYPEWRITER

This world famous printer connects directly to BBC Micro. Available from stock at:
ONLY £399 (car £7)

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 **250p**
12VA: 2x4.5V-1.3A; 2x5V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A **345p** (35p p&p)
24VA: 2x6V-1.5A; 2x9V-1.2A; 2x12V-1A; 2x15V-0.8A; 2x20V-0.6A **365p** (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-1A; 2x30V-0.8A **520p** (60p p&p)
Specially wound for Multirail computer PSUs
50VA: Outputs +5V/5A; +12V, +25V, −5V, −12V at 1A **620p** (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x25V-2A; 2x30V-1.5A; 2x50V-1A **965p** (75p)

P&P charge to be added over and above our normal postal charge

VOLTAGE REGULATORS

1A TO220 Plastic Casing

	+ ve		− ve	
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	78LO5	30p	79LO5	50p
6V	78LO6	30p	—	—
8V	78LO8	30p	—	—
12V	78L12	30p	79L12	50p
15V	78L15	50p	79L15	60p

ICL7660	248p	TAA550	50p
RC4194	375p	TDA1412	150p
RC4195	160p	78H05 + 5V/5V	550p
LM309K	135p	78H12+12V/5A	640p
LM317K	250p	78HG + 5V to + 25V 5A	500p
LM317KP	450p	79HG + 2.25V to 24V 51	685p
LM323K	450p		
LM337	175p		
LM723 Var	30p		

SOLDERCON PINS
Ideal for making SIL or DIL Sockets

100 pins	75p
500 pins	350p

ALUM BOXES

3 x 2 x 1"	85p
4 x 2½ x 2"	100p
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 2¾ x 1½"	90p
5 x 2¾ 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

CMOS

		4072	20	4536	275
		4073	22	4538	80
4000	14	4075	20	4539	90
4001	14	4076	55	4541	140
4002	14	4077	20	4543	70
4006	60	4078	20	4544	150
4007	15	4081	20	4548	40
4008	32	4082	20	4549	375
4009	24	4085	55	4553	245
4010	24	4086	60	4554	180
4011	15	4089	125	4555	35
4012	18	4093	20	4556	35
4013	20	4094	70	4557	320
4014	48	4095	95	4558	120
4015	40	4096	70	4559	395
4016	20	4097	275	4560	180
4017	32	4098	75	4561	104
4018	45	4099	110	4562	485
4019	25	4160	95	4566	165
4020	42	4161	96	4568	250
4021	40	4162	96	4569	175
4022	40	4163	96	4572	36
4023	15	4174	96	4580	460
4024	32	4175	105	4581	25
4025	16	4194	105	4582	99
4026	80	4408	790	4583	90
4027	22	4409	790	4584	40
4028	45	4410	725	4585	70
4029	47	4411	675	4597	330
4030	20	4412	775	4599	29
4031	125	4415	480	40085	90
4032	80	4419	280	40097	45
4033	125	4422	770	40098	42
4034	140	4435	850	40100	215
4035	48	4440	900	40101	130
4036	275	4450	380	40102	140
4037	115	4451	350	40103	175
4038	110	4490	380	40104	96
4039	280	4500	675	40105	106
4040	40	4501	28	40106	36
4041	40	4502	60	40107	60
4020	40	4503	40	40108	198
4043	40	4504	75	40109	100
4044	40	4505	185	40110	225
4045	105	4506	36	40114	240
4046	48	4507	36	40161	194
4047	40	4508	130	40163	50
4048	40	4510	46	40174	40
4049	30	4511	45	40175	50
4050	30	4512	45	40181	220
4051	45	4513	198	40182	80
4052	60	4514	115	40192	75
4053	50	4515	115	40193	95
4054	85	4516	55	40194	70
4055	85	4517	275	40195	75
4056	85	4518	40	40244	196
4057	1915	4519	30	40245	196
4059	435	4520	50	40257	196
4060	45	4521	90	40373	180
4061	1195	4522	125	40374	180
4062	986	4526	60	45106	586
4063	86	4527	65		
4066	27	4528	50	OCP71	120
4067	245	4529	150	ORP12	85
4068	20	4530	90	ORP61	86
4069	20	4531	130	BPX25	250
4070	20	4532	50	BPW21	320
4071	22	4534	400	TIL139	225

OPTO ELECTRONICS

LEDs with clips

TIL209	10
TIL211 GRN	14
TIL212 Yel	14
TIL220 2" Red	12
2" Green, Yellow or Amber	14
0.2" Bi colour Red/Green	65
Green/Yellow	78
0.2" Tri colour Red/Green/Yellow	85
Hi-Brightness Red	58
High-Bri Green or Yel	68
Flashing red 0.2" red	55
Square LEDs, Red, Green, Yellow	30
Rectangle Stackable LEDs Red, Green or Yellow	18
Triangular LEDs Red	18
Green or yellow	22
LD271 Infra Red	48
SFH205 Detector	118
TIL32 Infra Red	52
TIL78 Detector	55
TIL38	50
TIL100	75
BARGRAPH, Red 10 segments	250

ISOLATORS

IL74	65
ILD74	115
ILQ74	220
TIL11/2/4	70
ILCT6 Darlington	135
4N33 Photo Darlington	136

7 Segment Displays

TIL312 .3" CA	105
TIL313 .3" CC	105
TIL321 .5" CA	120
TIL322 .5" CC	120
DL704 .3" CC	125
DL707 .3" CA	125
FND357 Red	120
FND500	130
.3" Green CA	150
.6" Green CA	215
.3" ± Red CA	150
.3" ± Green CA	150
LCD 3½ Digits	496
LCD 4 Digits	530
LCD 6 Digits	625
Reflective Switch	170
SLOTTED Optical Switch similar to RS Comp.'s	186

COMPUTER CORNER

- **EPSON RX80 PRINTER: 100 CPS**, 9 x9 matrix, dot addressable graphics, condensed & double width printing, Normal, Italics & Elite Char., Tractor Feed, Bidirectional, Logic seeking £349
- **RX80 F/T Epson Printer.** As above but has both Tractor and Friction feed facilities £279
- **EPSON FX80 PRINTER 10"** Tractor & Friction Feed, 160 CPS, bi-directional Logic seeking, 9 x 11 matrix, hi-res bit image, Normal, Italic & Elite Char. Super & Subscript. Proportional spacing £249
- **SEIKOSHA GP100A.** 10" Tractor Feed, 80 Colmn, 30CPS, Normal and Double width Char. Dot Res Graphics £155
- **SEIKOSHA GP250X.** 10", 50 CPS, Normal and Double width and height Char. RS232 and Centronix Intrf. standard .... **£199 (£7 car)**
- Printer Cable for our printers and BBC MICRO £12
- **TEX** EPROM ERASER. Erases up to 32 ICs in 15-30 minutes £33
- **TEX** EPROM ERASER with a safety switch £35
- **SPARE** 'UV' Lamp bulb £8
- **C12** COMPUTER GRADE CASSETTES in library cases 40p
- 8½" & 9½" Fan Fold paper (1000 sheets) .... £7 + 150p carr

Call in at our shop for demonstration. Be satisfied before you buy or write in for our descriptive Micro Peripherals Leaflet.

FLOPPY DISC DRIVES TEAC

(BBC Compatible)

- **FD50A** — Uncased Single, 40 track, 5¼", S/S, 100K £180
- **CS50A** — Single Cased with PSU, 40 track, 5¼" S/S 100K £350
- **CD50A** — Twin Cased with PSU, 40 Track, 5¼" S/S 200K £250
- **CS50E** — Single Cased with PSU, 80 Track, 5¼" S/S 200K £475
- **CO50E** — Twin Cased with PSU, 80 track, 5¼" S/S 400K £475
- **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) £295
- **MITSUBISHI Twin Slimline,** 5¼" Cased with PSU DSDD, 2 Megabyte, (800 K with BBC) £535
- **10 Verbatim or 3M Diskettes** 5¼" S.S.S.D. (5 yrs warranty) £20
- **10 Verbatim or 3M Diskettes** 5¼" D.S.D.D. (5 yrs warranty) £35
- **10 Verbatim or 3M Diskettes** 8" S.S.D.D. (5 yrs warranty) £28
- **10 Wabash Diskettes** 5¼" S/S (2 yrs waranty) £15
- **10 Wabash Diskettesiskettes** 5¼" S/S (2 yrs warranty) £25

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

SPECTRUM 32K UPGRADE

Upgrade your 16K Spectrum to full 48K with our RAM Upgrade Kit. Very simple to fit. Fitting instructions supplied.
£19.50

SPECTRUM FOURTH — I/O Unit

12k 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**
(Send SAE for full details)

BBC & MICROCOMPUTER & ACCESSORIES

Model A .... **£299** Model B **£399** (incl VAT)

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

CRICKLEWOOD ELECTRONICS LTD

Stocking parts other stores cannot reach!

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ALL PRODUCT FIRST GRADE FRANCHISED SOURCE

All advertised items are guaranteed to conform with, or surpass manufacturer's current data sheets. This list represents a fraction of our stock. New items are constantly being brought into stock. Cricklewood Electronics keep up with the times. Please phone about all your electronic needs.

HOW TO ORDER: 1 Mail order with cheque, P.O., Bank Draft, Registered Cash, or write Credit Card* number on order with signature. Please add 60p post, packing and insurance, more for heavy goods, Securicor available. 2 Phone your order quoting Credit Card* number. 3 Call in. You will be more than welcome. 4 Official orders accepted from Govt. Depts., Schools, Colleges, Armed Service Establishments, P.L.C.s and approved accounts. 5 Overseas orders by Bank Draft in Sterling and £2.00 minimum post and packing. DHL plus £65.00 no V.A.T.

* ACCESS
* BARCLAY CARD
* VISA
* AMERICAN EXPRESS

V.A.T. applicable to U.K. only. Please add 15% after adding P&P to order. No V.A.T. on books and datasheets.

DELIVERY all in stock items despatched same day (95% of all advertised items are in stock), items out of stock in a few days — any problems and you will be informed immediately.

- BF246B 70p
- BF247A 75p
- BF247B 75p
- BF254 39p
- BF255 42p
- BF256A 58p
- BF256B 58p
- BF256C 65p
- BF257 30p
- BF258 32p
- BF259 35p
- BF262 80p
- BF263 90p
- BF270 65p
- BF271 68p
- BF324 38p
- BF336 36p
- BF337 42p
- BF338 48p
- BF355 60p
- BF362 85p
- BF363 85p
- BF457 46p
- BF458 56p
- BF459 62p
- BF469 86p
- BF470 88p
- BF494 29p
- BF495 29p
- BF900 1.09
- BFR39 25p
- BFR40 25p
- BFR41 25p
- BFR79 25p
- BFR80 25p
- BFR81 28p
- BFR90 2.11
- BFS28 2.95
- BFS61 30p
- BFS98 1.10
- BFT19 1.65
- BFT66 2.48
- BFW10 1.48
- BFW11 1.48
- BFX29 28p
- BFX30 27p
- BFX34 1.00
- BFX37 70p
- BFX43 70p
- BFX84 27p
- BFX85 28p
- BFX86 28p
- BFX87 25p
- BFX88 28p
- BFX89 1.75
- BFY19 1.10
- BFY37 1.20
- BFY50 23p
- BFY51 23p
- BFY52 23p
- BFY53 31p
- BFY56 31p
- BFY56A 68p
- BFY90 79p
- BLY83 11.80
- BSV81 2.30
- BSX19 24p
- BSX20 24p
- BSX21 40p
- BSX27 78p
- BSX28 86p
- BSX29 34p
- BSY95A 28p
- BU104 2.22
- BU105 1.70
- BU108 3.95
- BU109 3.29
- BU126 1.47
- BU204 2.25
- BU205 1.78
- BU206 1.89
- BU208 1.98
- BU226 3.95
- BU326S 2.35
- BU406 1.45
- BU407 1.45
- BU408 1.35
- BU409 1.25
- BU500 2.95
- BUV20 11.00
- BUV21 10.90
- BUV23 13.60
- BUV24 12.10
- BUV25 15.00
- BUW81A 4.49
- BUX20 17.00
- BUY18S 3.95
- E430 5.95
- J300 70p
- J310 70p
- ME0401 55p
- ME0402 55p
- ME0404 55p
- ME0411 55p
- ME0412 55p
- ME0413 55p
- ME0414 55p
- ME0481 55p
- ME0482 55p
- ME1001 55p
- ME1002 55p
- ME1075 55p
- ME1100 55p
- ME1120 55p
- ME3002 55p
- ME4001 55p
- ME4002 55p
- ME4003 55p
- ME4101 55p
- ME4102 55p
- ME4103 55p
- ME4104 55p
- ME6001 55p
- ME6002 55p
- ME6003 55p
- ME6101 55p
- ME6102 55p
- ME8001 75p
- ME8002 75p
- ME8003 75p
- ME9001 75p
- ME9002 75p
- MJ481 1.69
- MJ491 1.72
- MJ802 3.99
- MJ900 2.90
- MJ901 3.10
- MJ1000 2.50
- MJ1001 3.00
- MJ1800 3.60

- MJ2500 2.19
- MJ2501 2.25
- MJ2955 1.00
- MJ3000 2.19
- MJ3001 2.25
- MJ4032 3.25
- MJ4035 3.65
- MJ4502 3.99
- MJ15003 4.85
- MJ14004 5.55
- MJ15015 2.45
- MJ15016 3.34
- MJE340 53p
- MJE370 97p
- MJE371 99p
- MJE520 92p
- MJE521 94p
- MJE2955 99p
- MJE3055 69p
- MP8111 1.20
- MP8112 1.68
- MP8121 1.62
- MP8122 1.68
- MP8512 1.89
- MPF102 39p
- MPF103 29p
- MPF104 29p
- MPF105 29p
- MPF112 59p
- MPF121 1.68
- MPS6518 47p
- MPS6530 45p
- MPS6560 45p
- MPS5562 45p
- MPSA05 23p
- MPSA06 25p
- MPSA10 28p
- MPSA12 29p
- MPSA13 48p
- MPSA14 49p
- MPSA16 30p
- MPSA18 65p
- MPSA20 48p
- MPSA42 49p
- MPSA43 49p
- MPSA55 28p
- MPSA56 30p
- MPSA65 40p
- MPSA66 47p
- MPSA70 45p
- MPSA92 39p
- MPSA93 39p
- MPSL01 46p
- MPSL51 49p
- MPSU01 84p
- MPSU04 1.32
- MPSU05 55p
- MPSU06 56p
- MPSU07 75p
- MPSU51 88p
- MPSU55 58p
- MPSU56 59p
- MPSU57 1.20
- MRF475 6.50
- OC20 2.30
- OC22 2.00
- OC23 2.00
- OC25 2.50
- OC28 1.70
- OC29 2.95
- OC35 2.35
- OC41 80p
- OC43 70p
- OC44 82p
- OC70 50p
- OC71 50p
- OC72 50p
- OC82 50p
- OC820 70p
- OC83 75p
- P346A 58p
- R2008B 2.14
- R2010B 1.88
- TIP29A 29p
- TIP29C 38p
- TIP30A 35p
- TIP30C 38p
- TIP31A 35p
- TIP31C 34p
- TIP32A 38p
- TIP32C 42p
- TIP33A 65p
- TIP33C 78p
- TIP34A 74p
- TIP34C 88p
- TIP35A 1.09
- TIP35C 1.28
- TIP36A 1.28
- TIP36C 1.39
- TIP41A 49p
- TIP41C 55p
- TIP42A 55p
- TIP42C 59p
- TIP49 1.20
- TIP50 1.40
- TIP53 1.57
- TIP54 1.59
- TIP110 74p
- TIP112 90p
- TIP115 81p
- TIP117 96p
- TIP120 89p
- TIP122 73p
- TIP125 84p
- TIP127 84p
- TIP130 93p
- TIP132 93p
- TIP135 99p
- TIP137 99p
- TIP140 1.04
- TIP142 1.04
- TIP145 1.15
- TIP147 1.15
- TIP162 4.95
- TIP2955 77p
- TIP3055 70p
- TIS43 50p
- TIS45 40p
- TIS46 40p
- TIS47 49p
- TIS48 50p
- TIS88A 80p
- TIS90 28p
- TIS91 30p
- TIS92 30p
- TIS93 54p
- VN10KM 60p
- VN46AF 95p
- VN66AF 99p
- ZTX107 10p

- ZTX108 10p
- ZTX109 12p
- ZTX300 13p
- ZTX301 15p
- ZTX302 15p
- ZTX303 23p
- ZTX304 15p
- ZTX310 35p
- ZTX311 32p
- ZTX312 35p
- ZTX313 38p
- ZTX314 24p
- ZTX320 35p
- ZTX330 35p
- ZTX341 28p
- ZTX500 14p
- ZTX501 14p
- ZTX502 14p
- ZTX503 17p
- ZTX504 24p
- ZTX510 24p
- ZTX530 24p
- ZTX531 25p
- ZTX550 45p

MANY MORE TRANSISTORS IN STOCK

DIODES

- 1N34A 30p
- 1N821 70p
- 1N823 92p
- 1N914 4p
- 1N916 6p
- 1N1184 2.95
- 1N1190 1.47
- 1N1192 1.75
- 1N1194 1.65
- 1N1194A 1.80
- 1N1196A 2.41
- 1N1198A 2.65
- 1N1201A 97p
- 1N1204A 1.00
- 1N1206 1.20
- 1N4001 4p
- 1N4002 4½p
- 1N4003 5p
- 1N4004 5½p
- 1N4005 6p
- 1N4006 6½p
- 1N4007 7p
- 1N4009 20p
- 1N4148 3p
- 1N4150 18p
- 1N4448 22p
- 1N5400 12p
- 1N5401 13p
- 1N5402 14p
- 1N5404 16p
- 1N5406 18p
- 1N5407 19p
- 1N5408 20p
- 1S44 10p
- 1S131 40p
- 1S134 58p
- AA119 28p
- BA102 25p
- BA115 26p
- BA133 40p
- BA138 30p
- BA142 20p
- BA144 15p
- BA155 15p
- BA156 38p
- BA182 40p
- BA201 18p
- BA202 26p
- BA316 25p
- BA317 25p
- BA318 30p
- BAV10 16p
- BAV19 15p
- BAV20 15p
- BAV49 15p
- BAX13 10p
- BAX16 11p
- BAY38 20p
- BAY44 15p
- BAY93 20p
- BB103 70p
- BB104B 80p
- BB104G 80p
- BB105 57p
- BB105A 57p
- BB105B 58p
- BB109G 65p
- BY126 11p
- BY127 12p
- BY134 52p
- BY182 1.26
- BY188A 65p
- BY206 36p
- BY207 36p
- BY223 1.29
- BY297 48p
- BY299 55p
- BYX10 38p
- BYX55 350 62p
- BYX71 350 1.10
- BYX71 600 1.52
- ITT44 10p
- ITT921 15p
- ITT923 15p
- ITT2002 27p
- MZ2361 1.80
- OA10 70p
- OA47 20p
- OA90 10p
- OA91 10p
- OA95 20p
- OA200 20p
- OA202 20p
- SPD9000 75p
- SPD9002 95p

GRAPHIC PROCESSOR

- EF9365 35.00
- EF9366 35.00

BRIDGE

1 amp type
- W01 (100) 28p
- W02 (200) 34p
- W04 (200) 38p
- W08 (800) 50p

2 amp type Square with hole
- S01 (100) 46p
- S02 (200) 50p
- S04 (400) 55p
- S08 (800) 68p

6 amp type Square with hole
- PW01 (100) 95p
- PW02 (200) 99p
- PW04 (400) 1.30
- PW06 (600) 1.39

25 amp type Metal clad with hole
- K01 (100) 2.62
- K02 (200) 2.75
- K04 (400) 3.25
- K06 (600) 4.10
- BYW64 35A 400V 4.50

Proprietory Bridges
- B40C1500 1.20
- B80C1700 1.80
- BY164 55p
- BY179 92p

DIACS

- BR100 29p
- ST2 29p

THYRISTORS

Sensitive Gate Small Signal
- 2N5060 30p
- 2N5061 32p
- 2N5062 35p
- 2N5063 37p
- 2N5064 40p
- BR101 75p
- BR103 69p
- BRY39 60p
- BRY55-100 60p
- BRY55-300 67p
- BRY56 50p
- TIC44 35p
- TIC47 50p

4, 8 & 12 Amps Texas TO220
Suffix: A = 100V, B = 200V, C = 300V, D = 400V, M = 600V

4A
- TIC106A 46p
- TIC106B 47p
- TIC106C 48p
- TIC106D 49p
- TIC106M 68p

8A
- TIC116A 66p
- TIC116B 68p
- TIC116C 71p
- TIC116D 73p
- TIC116M 80p

12A
- TIC126A 72p
- TIC126B 72p
- 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(6A) 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, 82V, 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 26p
- 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
- ILD74 1.19
- ILQ74 2.50
- LD271 50p
- LD461 25p
- LD466 1.45
- LD468 1.65
- LD471 27p
- LD476 1.20
- LD478 1.45
- LD479 1.65
- LD481 27p
- LD486 1.25
- LD488 1.30
- LD489 1.89
- LD599 81p
- MOC3020 1.49
- ORP12 95p
- TIL32 71p
- TIL38 44p
- TIL78 60p
- TIL81 1.30
- TIL100 72p
- TIL116 1.10
- TIL138 2.40
- TIL139 2.40
- TIL209 9p
- TIL211 14p
- TIL212 14p
- TIL311 [illegible]
- TIL313 1.02
- TIL401 3.50
- TIL403 3.80
- TIL406 4.10
- TIL722A 49p

LIN IC'S

- AY1-5050 95p
- AY3-8910 3.99
- AY3-8912 4.95
- CA3018A 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
- CA3035 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 2.35
- CA3140E 39p
- CA3140T 1.40
- CA3160AE 99p
- CA3161E 1.59
- CA3162E 4.49
- CA3240E 1.04
- HA1366W 2.40
- HA388 2.54
- ICL7106 7.50
- 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 1.30
- LF398 4.62
- LF13201 2.99
- LF13331 3.30
- LF13741H 68p
- LF13741N 59p
- LM10CH 4.50
- LM11CH 4.50
- LM114 7.50
- LM301AH 95p
- LM301AN 35p
- LM305AH 2.90
- LM307N 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 89p
- LM317H 2.80
- LM317T 1.75
- LM318H 2.40
- LM318N 1.49
- LM319H 2.48
- LM319N 2.10
- LM324N 39p
- LM335Z 1.60
- LM337K 4.39
- LM337MP 1.85
- LM337T 1.75
- LM339N 1.80
- LM340 44p
- LM345K 8.60
- LM348N 62p
- LM349N 1.09
- LM350K 4.60
- LM359N 1.44
- LM360N 3.88
- LM361N 65p
- LM377N 1.69
- LM378N 3.40
- LM379S 5.50
- LM380N 75p
- LM380N8 1.50
- LM381AN 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 2.10
- LM391N80 2.40
- LM392N 95p
- LM393N 1.20
- LM394H 3.80
- LM396K 14.95
- LM709N8 64p
- LM709CH 1.00
- LM710CH 1.44
- LM710CN 52p
- LM711CH 1.38
- LM711CN 70p
- LM723CH 95p
- LM723CN 35p
- LM725CH 3.40
- LM725CN 3.19
- LM733CN 69p
- LM741CH 96p
- LM741CN 18p
- LM741CN14 80p
- LM747CN 69p
- LM748CH 1.00
- LM748CN 35p
- LM748C14 70p
- LM1011 8.60
- LM1303N 2.25
- LM1304N 2.50
- LM1305 3.10
- LM1307 2.75
- LM1310N 1.45
- LM1330N 2.25
- LM1458 44p
- LM1496 75p
- LM1800 3.95
- LM1801 2.99
- LM1812 8.00
- LM1818 5.95
- LM1820 3.95
- LM1828 4.79
- LM1830 3.67
- LM1845 4.12
- LM1848 2.89
- LM1850 2.75
- LM1871 3.25
- LM1872 4.39
- LM1877 5.95
- LM1886 7.44
- LM1889 3.77
- LM2907N 2.75
- LM2907N8 2.60
- LM2917N 2.40
- LM2917N8 2.40
- LM3301 1.60
- LM3302 74p
- LM3401 65p
- LM3404 75p
- LM3405 1.45
- LM3524 6.77
- LM3900 48p
- LM3905 1.25
- LM3909 79p
- LM3911 1.20
- LM3914 3.25
- LM3915 3.25
- LM3916 3.25
- LM4250CH 2.63
- LM4250N 2.38
- LM13600 1.15
- MB3712 2.18
- MB3756 3.80
- MB8719 7.95
- MC1303 2.25
- MC1304 2.50
- MC1305 3.10
- MC1307 2.75
- 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 11.80
- NE529 2.25
- NE531N 1.36
- NE540L 4.95
- NE543N 2.50
- NE544N 1.95
- NE555 18p
- NE556 65p
- 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 1.45
- 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
- TCA160C 2.67
- TCA210 2.75
- 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
- TCA800Q 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 2.76
- TDA3300 15.60
- TDA7000 3.45
- TL061 40p
- TL062 80p
- TL064 95p
- TL071 34p
- TL072 45p
- TL074 99p
- TL081 29p
- TL082 45p
- TL083 75p
- TL084 89p
- TL170 49p
- TL430 69p
- UAA170 2.49
- UAA180 2.49
- ULN2003 75p
- UPC575C2 2.00
- UPC1024H 99p
- UPC1025H 3.95
- UPC1032H 1.50
- 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 3.95
- XR2207 4.00
- XR4212 1.80
- ZN409 2.25
- ZN414 1.00
- ZN1034 1.99
- ZNA134E 29.95
- ZNA234E 8.47

74 TTL

- 7400 19p
- 7401 19p
- 7402 19p
- 7403 19p
- 7404 19p
- 7405 19p
- 7408 19p
- 7409 19p
- 7410 19p
- 7411 19p
- 7412 19p
- 7413 25p
- 7414 50p
- 7416 40p
- 7417 40p
- 7420 19p
- 7421 19p
- 7422 19p
- 7423 19p
- 7425 19p
- 7426 19p
- 7427 19p
- 7428 26p
- 7430 19p
- 7432 24p
- 7433 24p
- 7437 25p
- 7438 36p
- 7440 22p
- 7441 55p
- 7442 32p
- 7443 89p
- 7444 89p
- 7445 69p
- 7446 59p
- 7447 70p
- 7448 70p
- 7450 15p
- 7451 15p
- 7453 15p
- 7454 14p
- 7460 29p
- 7470 34p
- 7472 29p
- 7473 56p
- 7474 55p
- 7475 56p
- 7476 55p
- 7480 49p
- 7481 1.19
- 7482 90p
- 7483 38p
- 7484 90p
- 7485 90p
- 7486 30p
- 7489 1.68
- 7490 19p
- 7491 44p
- 7492 44p
- 7493 44p
- 7494 72p
- 7495 36p
- 7496 48p
- 7497 1.19
- 74100 1.25
- 74104 49p
- 74105 55p
- 74107 26p
- 74109 30p
- 74110 35p
- 74116 90p
- 74118 90p
- 74119 75p
- 74120 99p
- 74121 30p
- 74122 40p
- 74123 40p
- 74125 35p
- 74126 34p
- 74128 35p
- 74132 39p
- 74136 39p
- 74141 55p
- 74142 1.95
- 74143 2.08
- 74144 2.08
- 74145 70p
- 74147 88p
- 74148 75p
- 74150 1.20
- 74151 39p
- 74153 39p
- 74154 1.20
- 74155 45p
- 74156 45p
- 74157 45p
- 74159 1.50
- 74160 59p
- 74161 59p
- 74162 49p
- 74163 49p
- 74164 56p
- 74165 76p
- 74166 99p
- 74170 1.25
- 74172 2.49
- 74173 59p
- 74174 54p
- 74175 49p
- 74176 39p
- 74177 45p
- 74178 79p
- 74180 40p
- 74181 1.40
- 74182 80p
- 74184 89p
- 74185 69p
- 74186 4.69
- 74188 2.48
- 74190 60p
- 74191 60p
- 74192 60p
- 74193 60p
- 74194 60p
- 74195 60p
- 74196 45p
- 74197 45p
- 74198 1.50
- 74199 1.50
- 74221 73p

TTL & CMOS Pls phone for latest prices

74LS TTL

- 74LS00 19p
- 74LS01 19p
- 74LS02 19p
- 74LS03 19p
- 74LS04 19p
- 74LS05 19p
- 74LS08 19p
- 74LS10 19p
- 74LS11 19p
- 74LS12 19p
- 74LS13 39p
- 74LS14 39p
- 74LS15 15p
- 74LS20 19p
- 74LS21 19p
- 74LS22 19p
- 74LS27 19p
- 74LS28 19p
- 74LS30 19p
- 74LS32 19p
- 74LS33 19p
- 74LS37 19p
- 74LS38 19p
- 74LS40 19p
- 74LS42 35p
- 74LS47 60p
- 74LS51 19p
- 74LS54 19p
- 74LS55 19p
- 74LS73 28p
- 74LS74 28p
- 74LS75 28p
- 74LS76 28p
- 74LS78 35p
- 74LS83 40p
- 74LS85 60p
- 74LS86 22p
- 74LS90 32p
- 74LS92 45p
- 74LS93 24p
- 74LS95 39p
- 74LS96 93p
- 74LS107 35p
- 74LS109 35p
- 74LS112 35p
- 74LS113 36p
- 74LS114 36p
- 74LS122 35p
- 74LS123 60p
- 74LS124 1.60
- 74LS125 24p
- 74LS126 25p
- 74LS132 40p
- 74LS136 29p
- 74LS138 39p
- 74LS139 39p
- 74LS145 99p
- 74LS147 99p
- 74LS148 1.19
- 74LS151 47p
- 74LS153 49p
- 74LS154 1.50
- 74LS155 39p
- 74LS156 46p
- 74LS157 40p
- 74LS158 35p
- 74LS160 50p
- 74LS161 50p
- 74LS162 50p
- 74LS163 50p
- 74LS164 60p
- 74LS165 60p
- 74LS168 1.40
- 74LS169 1.09
- 74LS170 1.19p
- 74LS173 90p
- 74LS174 40p
- 74LS175 40p
- 74LS181 1.20
- 74LS183 1.20
- 74LS190 60p
- 74LS191 60p
- 74LS192 60p
- 74LS193 60p
- 74LS194 50p
- 74LS195 50p
- 74LS196 59p
- 74LS197 59p
- 74LS221 95p
- 74LS240 1.40
- 74LS241 1.40
- 74LS242 1.40
- 74LS243 1.40
- 74LS244 1.40
- 74LS245 1.40
- 74LS247 1.40
- 74LS248 1.40
- 74LS249 1.40
- 74LS251 45p
- 74LS253 45p
- 74LS257 45p
- 74LS258 45p
- 74LS259 80p
- 74LS261 99p
- 74LS266 25p
- 74LS273 75p
- 74LS276 1.25
- 74LS279 33p
- 74LS280 1.80
- 74LS283 49p
- 74LS289 4.70
- 74LS290 55p
- 74LS293 49p
- 74LS295 74p
- 74LS298 79p
- 74LS299 1.95
- 74LS323 1.95
- 74LS324 1.95
- 74LS325 3.50
- 74LS326 3.50
- 74LS327 3.50
- 74LS347 1.35
- 74LS348 1.40
- 74LS352 71p
- 74LS353 71p
- 74LS362 7.25
- 74LS365 40p
- 74LS366 40p
- 74LS367 40p
- 74LS368 40p
- 74LS373 99p
- 74LS378 99p
- 74LS386 1.14
- 74LS390 46p
- 74LS393 99p
- 74LS395 89p
- 74LS396 1.90
- 74LS398 2.70
- 74LS399 1.59
- 74LS445 1.40
- 74LS490 1.40
- 74LS540 89p
- 74LS541 79p
- 74LS640 2.00
- 74LS641 2.00
- 74LS643 2.00
- 74LS644 2.00
- 74LS669 99p
- 74LS670 1.19
- 74LS673 6.50
- 74LS674 9.99
- 74LS688 3.40

74S TTL

- 74S00 35p
- 74S02 35p
- 74S04 35p
- 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
- 74S281 3.00
- 74S262 8.50
- 74S287 2.19
- 74S288 1.99
- 74S289 1.57
- 74S301 3.20
- 74S470 3.26
- 74S471 6.25
- 74S473 12.50
- 74S474 3.99
- 74S475 7.95
- 74S571 6.09
- 74S573 9.00

74 CMOS TTL

- 74C00 37p
- 74C02 37p
- 74C04 37p
- 74C08 37p
- 74C10 37p
- 74C14 37p
- 74C20 37p
- 74C30 37p
- 74C32 37p
- 74C42 1.25
- 74C48 1.70
- 74C73 99p
- 74C74 99p
- 74C76 78p
- 74C83 1.60
- 74C85 1.60
- 74C86 1.60
- 74C89 4.75
- 74C90 1.36
- 74C93 1.36
- 74C95 1.60
- 74C107 95p
- 74C151 2.60
- 74C154 3.50
- 74C157 2.60
- 74C160 1.50
- 74C161 1.50
- 74C162 1.50
- 74C163 1.50
- 74C164 1.50
- 74C165 1.50
- 74C173 65p
- 74C174 1.88
- 74C175 1.50
- 74C192 1.50
- 74C193 1.50
- 74C194 4.50
- 74C195 1.50
- 74C200 7.70
- 74C221 1.95
- 74C901 90p
- 74C902 90p
- 74C903 90p
- 74C904 90p
- 74C905 9.25
- 74C907 90p
- 74C908 1.35
- 74C911 9.95
- 74C912 9.95
- 74C914 1.50
- 74C915 2.00
- 74C918 1.90
- 74C920 12.50
- 74C922 6.75
- 74C923 5.75
- 74C925 6.80
- 74C926 6.80
- 74C928 7.50
- 74C929 13.00
- 74C930 5.50
- 74C932 2.45

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 69p
- 4048 39p
- 4049 22p
- 4050 23p
- 4051 44p
- 4052 58p
- 4053 49p
- 4054 79p
- 4055 83p
- 4056 83p
- 4059 4.36
- 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
- 4086 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 3.98
- 4536 2.69
- 45.38 78p
- 4539 89p
- 4543 68p
- 4553 2.25
- 4555 36p
- 4556 36p
- 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
- Z80A 2.98
- Z80B 8.80

MEMORIES

- 2102AL2 1.35
- 2111-1 3.00
- 2114 (200ns) 99p
- 2532 3.25
- 2564 8.25
- 2708 3.50
- 2716 (5v) 2.85
- 2764 4.25
- 4027 3.00
- 4060 9.50
- 4116 (200ns) 99p
- 4118 3 3.25
- 4164 4.55
- 5204 7.50
- 6116P3 3.85
- 6514 3.30
- 6810 1.45
- 7489 1.65
- 74189 4.00

- 75LS289 3.25
- 74LS289 3.25
- 74LS287 3.05
- 74LS288 2.25

LOG IC'S inc COMP SUPPORT

- ADC0804 4.40
- ADC0816 14.95
- ADC0817 10.39
- AY5-1013A 3.00
- AY5-1015 2.99
- INS1671 20.00
- INS1771 14.50
- MC1466L 6.95
- MC1488 59p
- MC1489 59p
- MC4024 3.25
- MC4044 3.25
- MK50250 10.00
- MK50398 6.35
- MM5303 6.25
- MM5307 12.75
- MM5357 22.50
- MM57105 14.00
- MM57109 12.00
- MM57160 12.00
- MM57161 12.00
- MM58174 11.80
- RO2513LC 7.50
- RO2513UC 7.50
- SAA5000 3.00
- SAA5010 7.10
- SAA5012 7.10
- SAA5020 5.50
- SAA5030 9.00
- SAA5040 15.00
- SAA5041 15.00
- SAA5050 8.50
- SAA5052 8.50
- 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 1.45
- 6845 6.50
- 6847 6.50
- 6850 1.66
- 6852 2.40
- 6875 4.99
- 8131 3.75
- 8154 9.00
- 8155 3.60
- 8212 1.70
- 8216 98p
- 8223 1.80
- 8224 1.95
- 8226 2.50
- 8228 2.19
- 8238 6.75
- 8243 2.80
- 8250 8.40
- 8251 2.50
- 8253 3.95
- 8254 10.00
- 8255 2.25
- 8257 4.00
- 8259 3.82
- 8279 4.10
- 8601 1.20
- 9062 2.50
- Z80ACTC 2.80
- 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 65p
- 7812M 65p
- 7815M 65p
- 7842M 65p

1 Amp TO220
- 7805T 45p
- 7812T 45p
- 7815T 45p
- 7824T 45p

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 80p
- 7912M 80p
- 7915M 80p
- 7924M 80p

1 Amp. TO220
- 7905T 57p
- 7912T 57p
- 7915T 57p
- 7924T 57p

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

NEXT MONTH

AN ARGUS SPECIALIST PUBLICATION
electronics today INTERNATIONAL

CABLE TELEVISION — ALL IT'S SUPPOSED TO BE?

A couple of years ago, cable television was described as a 'licence to print money' — exactly the same description that was applied to commercial television. Now the picture doesn't look nearly so bright. ETI will have a special report on cable television, taking the technical and financial issues that are deciding the future of our entertainment.

STEREO POWER METER

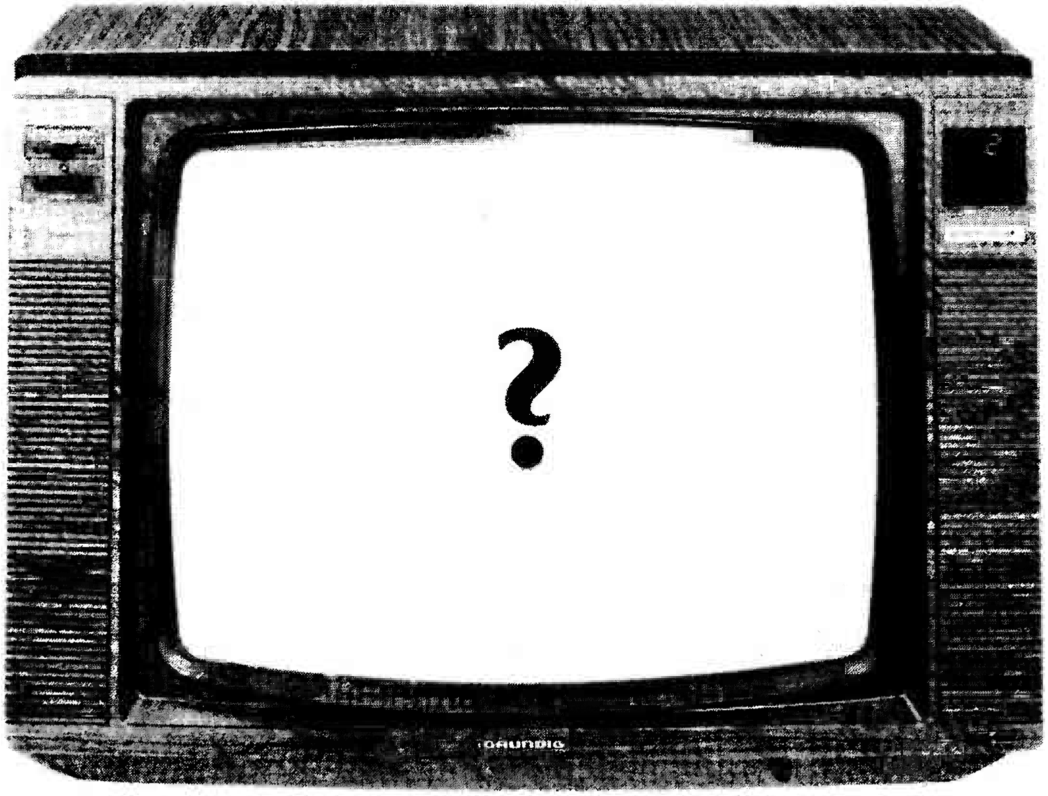
This device will give you a true indication of power, as it measures the current going to the load and multiplies it by the voltage to obtain the power — none of these cheats where you measure just the voltage and hope the impedance is what it says on the case! And once you know the power, and you've measured the voltage, you could work out the impedance. If you can also measure the current, you can then work out the phase angle as well . . .

Z80 DRAM CARD

Following on from this month's article on how to replace one set of DRAMs with a larger capacity set still within an existing system, here is a whole board full of memory, all for your Z80 system.

COMPLEX NUMBERS

Complex numbers are not as complicated as you think — in fact, once you get over your initial trepidation, you'll find that they make circuit calculations very much easier than they ever are by other means!



ALL THIS AND MUCH MORE IN THE MARCH ISSUE OF ETI ON SALE FEBRUARY 3rd — PLACE YOUR ORDER NOW OR RISK MISSING OUT!

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

THE NEW MPF1 PLUS...

... LOWEST COST
Z80 SINGLE BOARD COMPUTER
AVAILABLE WITH ALL THESE FEATURES!

BUILT-IN ASSEMBLER

The MPF1 PLUS incorporates the Z80 – the most widely used 8-bit microprocessor in the world, to form a Single Board Computer (SBC). Packed in a plastic bookcase together with three comprehensive manuals and power supply (to BS3651 standard), the MPF1 PLUS is a microprocessor learning tool for every application.

Teaching you in a step-by-step method the MPF1 PLUS helps the user fully understand the Software and Hardware of a microprocessor easily and conveniently – as opposed to micro-computers that aim to teach high-level languages instead of microprocessor systems fundamentals.

Not only is the MPF1 PLUS a teaching tool but with the available accessories it can also be used as a low-cost development tool or simply for OEMs.

FLIGHT Electronics Ltd.

Quayside Rd, Southampton, Hants SO2 4AD Telex 477793 Tel (0703) 34003/27721

Micro-Professor is a trade mark of Multitech Industrial Corporation. Z80 is a trade mark of Zilog Inc.

THE MPF1 PLUS

Just look at the specification:-

Technical Specification

CPU: Z80A – 158 instructions
Software:
- Z80/8080/8085 machine code
- Z80 Assembler, line and 2 pass.
- 8K BASIC interpreter (Extra)
- 8K FORTH (Extra)

ROM: 8K Monitor (full listing and comments)
RAM: 4K CMOS (2 x 6116)
Input/Ouput: 48 system I/O lines
Speaker: 2.25" coned linear
Display: 20 character 14 segment green phosphorescent
Expansion:
- Socket for 8K ROM
- Cassette interface
- Connectors 40 way, complete CPU bus

Keyboard: 49 key. Full "QWERTY" real movement good tactile feedback
Batteries: 4 x U11 for memory back-up (batteries not included)
Serial Interface: 165 baud for read/write via audio cassette

Manuals

1. User's Manual. 8 chapters.
   1. Over view and Installation.
   2. Specification (hardware and software). 3. Description of Operation. 4. Operating the MPF-1 Plus. 5. 44 Useful Sub-Routines.
   6. The Text Editor.
   7. Assembler and Disassembler.
   8. System Hardware Configuration.
2. Experiment Manual. 16 experiments.
3. Monitor Program Source Listing with full commenting.
4. Also available the MPF-1 Plus Student Work Book (self-learning text).

Accessories

- **PRT-MPF-1P:** 20 character printer. Ready to plug in. Memory dump.
- **EPB-MPF-1P:** Copy/list/verify 1K/2K/4K/8K ROMS. Ready to plug in.
- **SSB-MPF-1P:** Speech Synthesizer. Inc. 20 words and clock program. 1200 words available.
- **SGB-MPF-1P:** Sound Synthesizer Board.
- **I/O – MPF-1P:** Input/output board

Yes! I now realise that I need an MPF1 PLUS and that it is the lowest cost Z80 SBC available with all these features.

I enclose £165.00 (£140.00 + £21 VAT plus £4 carriage). Overseas P.O.A.

Cheques payable to FLIGHT ELECTRONICS LTD.

Please debit my Barclaycard/Access VISA ☐ Access ☐

Account No. ____________________

An invoice will automatically be sent.

Name ____________________

Address ____________________

Signature ____________________

Date ____________________

ETI

DIGEST

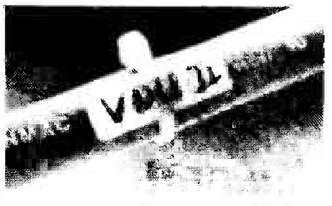
Portable Projection TV

For those who find Clive Sinclair's 2" marvel a mite too small, Matsushita might just have the answer. Their latest addition to the portable TV market is a fold-flat projection colour television with a 6.5" screen.

The TV has been developed from Matsushita's large screen projection systems and uses three 5cm projection tubes for red, green and blue instead of the single CRT found in conventional TVs. When folded for carrying it measures 250 x 85 x 310 mm and it weighs just 3 kg, about half the size and weight of currently available 7" screen televisions. It is also claimed to use only about a third as much power.

Matsushita have released very little other information on the new TV and when we telephoned their UK press office they stressed that there are no plans as yet to introduce it here at all. Disappointed would-be purchasers will have to make do with either a Sinclair and a magnifying glass or a conventional 7" TV and a body-building course.

Also new from Matsushita is a more normally-sized TV (screen size is not stated) which is described as digital and multi-functional. Again, very little information is given on the circuitry, etc, but it apparently incorporates a microprocessor and several other LSI devices and thereby reduces the component count by 30% compared with conventional sets. Features include an 11-bit digital remote infra-red control unit which is theoretically capable of controlling up to 2,048 functions, allowing it to cope with additions such as a VTR, video disc, personal computer, etc. The set is equipped to handle Viewdata and Teletext and incorporates a special facility whereby a picture from one source may be inserted into a larger main picture, allowing simultaneous viewing of, for example, a programme and an information service. As with the projection TV, Matsushita say they have no plans to introduce the new model into the UK as yet. National Panasonic UK Ltd, 300-318 Bath Road, Slough, Berks S11 6JB, tel Slough 34522.



Spaghetti Eater

If your office, workbench, or audio system is fast being swallowed up by a writhing mass of unidentified cables, Inmac's new cable tidies could be just what you need. Not only do they neatly group cables into bundles, they also allow you to indicate each cable's function, making it instantly identifiable.

The ties are available in both permanent and releasable form, and will hold up to six cables in a 35mm diameter bunch. They cost £5.00 for a packet of 35. A releasable tie is also available with a self-adhesive pad so that a bundle of cables may be secured to any suitable surface. This type secures three or more cables in a bundle of up to 19mm diameter and costs £5.50 for a pack of six. Lastly, there are identity ties, small ties which attach permanently to an individual cable and which have a 25mm wide area on which you can write. These cost £5.00 for a pack of 35. Inmac UK Ltd, Davy Road, Astmoor, Runcorn, Cheshire WA7 1QF, tel 09285 67551.

Exhibitions Galore

You've seen the best, now see the rest! No, but seriously, folks, the exhibition season doesn't end with Breadboard, and there are a lot more people out there waiting to show off their wares and expertise. There are exhibitions of general interest, exhibitions aimed just at the chosen few, big exhibitions, small exhibitions, conferences, seminars, the lot. So get out your diaries and make a note of some of the following.

First off is the Acorn Education Exhibition which will take place in the Central Hall, Westminster, London, from the 25th to the 27th January. As its title suggests, the exhibition is aimed at those involved in education, teachers, lecturers, administrators, etc, and will bring together some of the many companies offering educational software, peripherals, and services for Acorn's BBC microcomputer. Interested readers should contact Tim Collins, Computer Marketplace Ltd, 20 Orange Street, London WC2H 7ED, tel 01-930 1612. The same people are also organising a Sinclair Education Exhibition in March, the second Acorn User Exhibition in August, and a robotics exhibition in November, and information on these can be obtained from the above address.

IFSSEC '84, the International Fire Security and Safety Exhibition and Conference, will take place at Olympia, London, from the 9th to the 13th April. Over 65,000 people are expected from all over the world to inspect the latest fire control and intruder detection products and services offered by the anticipated 700 exhibiting companies. There will also be seminars on such topics as the requirements of fire safety regulations and police policies toward intruder alarm installations. Details, conference programmes, etc, are available from IFSSEC Ltd, Cavendish House, 128-134 Cleveland Street, London W1P 5DN, tel 01-387 5050.

The British Robot Association are holding their 7th annual conference in Cambridge (no single venue mentioned) from the 14th to the 16th May. Representatives from both Eastern and Western countries will be taking part and the organisers expect it to be their biggest yet. They are still considering papers for presentation at the conference and would welcome contributions from the industrial/applications viewpoint submitted within the next month or so. Details from the Conference Organiser, B.R.A.7, British Robot Association, 28-30 High Street, Kempston, Bedford MK42 7AJ, tel 0234 854477.

Micro City is described as an exhibition of computers, business systems and communications and will take place at the Bristol Exhibition Complex from the 15th to the 17th May. A major feature is the Offices Of The Future exhibition-within-an-exhbition which will occupy an entire hall. Details from Steve Hybs, Tomorrow's World Exhibitions Ltd, 9 Park Place, Clifton, Bristol BS8 1JP, tel 0272 292156.

Interconnection '84 is a new conference and exhibition which aims to cover the entire field of interconnection under four main headings; board level interconnection, interboard connections, equipment-to-equipment, and techniques and board materials. It will be held at the Park Lane Hilton, London, on the 6th and 7th June. The organisers welcome papers for presentation at the conference, preferably concentrating on one of the above headings. For further details contact Brian Morgan, Marketing Manager, Benn Electronics Publications Ltd, 146 Midland Road, Luton LU2 0BL, tel 0582 417438.

Finally, and moving a little further afield, the second Electronic Displays exhibition and conference will be held at Frankfurt Fairgrounds from the 5th to the 7th September, and will concentrate as before on display devices, display drivers, CRT monitors and other devices used in modern information systems for text and graphic display. Again papers for presentation will be welcomed and information on this and other aspects of the event can be obtained from Network GmbH, An der Friedenseiche 10, 3050 Wunstorf 2, West Germany.

HOME LIGHTING KITS

These kits contain all necessary components and full instructions & are designed to replace a standard wall switch and control up to 300w. of lighting

TDR300K	Remote Control Dimmer	£14.95
MK6	Transmitter for above	£4.50
TD300K	Touchdimmer	£7.75
TS300K	Touchswitch	£7.75
TDE/K	Extension kit for 2-way switching for TD300K	£2.50
LD300K	Rotary Controlled Dimmer	£3.95

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It's packed with details of all our KITS plus large range of SEMICONDUCTORS including CMOS, LS TTL, linear, microprocessors and memories; full range of LEDs, capacitors, resistors, hardware, relays, switches etc. We also stock VERO and Antex products as well as books from Texas Instruments, Babani and Elektor
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DISCO LIGHTING KITS

DL 1000K
This value for money kit features a bi-directional sequence, speed of sequence and frequency of direction change, being variable by means of potentiometers and incorporates a master dimming control. **£15.95**

DLZ1000K
A lower cost version of the above, featuring undirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum. **£8.95**

Optional opto input DLA1
Allowing audio ("beat") – light response. **60p**

DL3000K
This 3 channel sound to light kit features zero voltage switching, automatic level control and built in mic. No knobs to adjust – simply connect to mains supply and lamps. (1Kw channel) **£12.95**

ELECTRONIC LOCK KIT XK101

This KIT contains a purpose designed lock IC, 10-way keyboard, PCBs and all components to construct a Digital Lock, requiring a 4-key sequence to open and providing over 5000 different combinations. The open sequence may be easily changed by means of a pre-wired plug. Size: 7 x 6 x 3 cms. Supply: 5V to 15 V d.c. at 40uA. Ouput: 750mA max. Hundreds of uses for doors and garages, car anti-theft device, electronic equipment, etc. Will drive most relays direct. Full instructions supplied. **ONLY £11.50**

Electric lock mechanism for use with latch locks and above kit **£14.95**

MINI KITS

MK1 ELECTRONIC THERMOSTAT
Uses LM3911 IC to sense temperature (80°C max) and triac to switch heater (1KW). Mains powered. £4.60

MK2 SOLID STATE RELAY
Switches 240V ac motors, lights, heaters from logic/computer circuits. Zero voltage switching, opto-isolated. Supplied without triac £2.60

MK4 PROPORTIONAL TEMPERATURE CONTROLLER
Uses "burst fire" technique to maintain temperature to within 0.5°C. Ideal for photography, incubators, wine making, etc. Max load 3KW (240V ac). Temp. range up to 90°C £6.50

MK5 MAINS TIMER
Mains powered timer enabling a load up to 1KW at 240V ac to be switched on (or off) for a variable time from 20 mins. to 35 hrs. Longer or shorter periods possible with minor component changes. £6.50

MK15 DUAL LATCHED SOLID STATE RELAY
Comprises two MK2s with latch circuit enabling the MK12 kit to control two mains loads independently. Two output triacs not supplied. (See remote control kits.) £4.50

NEW! MK19 DC CONTROLLED AUDIO AMPLIFIER
May be used with virtually any stereo audio amplifier to control bass, volume, treble and balance remotely either using a wire link or the MK11 infra red receiver. A 1 of 10 decoder with LEDS is also included for remote input selection/display. (See remote control kits.) £10.70

COMPONENTS
a wide range in stock including:

LINEAR ICs

555	17
556	40
741	15
748	35
AD590	3 30
AY 3-1270	7.20
CA3080	72
CA3130	75
CA3140	43
ICL7106	7 00
ICL7107	9 00
ICL7126	8 00
ICL8038	3 10
CMOS555	79
LF351	44
LF353	80
LF356	90
LM324	35
LM334Z	90
LM335Z	1 20
LM339	50
LM348	63
LM358	45
LM377	1 45
LM380	80
LM381	1 15
LM382	1 00
LM386	75
LM1458	35
LM1830	1 50
LM2917	1 60
LM3900	48
LM3909	60
LM3911	1 20
LM3914	2 10
LM3915	2 20
LM13600	1 10
LS7220	2 75
LS7225	2 60
MF10C	3 30
ML922	4 10
ML924	1 95
ML925	2 10
ML926	1 40
ML927	1 40
ML928	1 40
ML929	1 40
MM74C911	6 50
MM74C915	96
MM74C922	2 90
MM74C926	4 50
NE566	1 40
NE567	97
S566B	2 15
S576D	2 15
SAB0600	2.50
SL440	1 75
SL441	1 35
SL480	1 70
SL490	2 40
TBA800	68
TBA810AS	1 00
TMS1121	8 50
TMS1601	10 00
TDA1024	1 20
TDA2020	2 85
TDA4290	1 98
TL061	40
TL062	60
TL064	98
TL071	30
TL072	50
TL074	95
TL081	25
TL082	45
TL084	95
TL170	50
TL507C	1 80
UA2240	1 20
ULN2003	80
ULN2004	85
ZN414	98
ZN425	3 40
ZN427	5 70
ZN428	4 10
ZN1034E	1 80

TRIACS

400V Plastic

1 6A	42
4A	49
8A	58
12A	85
16A	95
25A	1 90
Q4006LT	85
MOC3020	1 10
Diac	18

REGULATORS

78L05 12 15	26
79L05 12 15	60
7805 12 15	35
7905	40
LM317T	1 80
LM338K	4 60
LM723	40

CMOS

4000	11
4001	11
4002	11
4007	12
4011	11
4012	12
4013	20
4015	39
4016	20
4017	29
4019	24
4023	15
4025	15
4026	72
4027	20
4028	38
4040	39
4043	38
4046	46
4049	21
4050	21
4060	42
4069	13
4070	13
4071	13
4077	16
4081	12
4093	20
4501	24
4511	55
4514	1 15

MEMORIES

2114	80
6810	1.25
2716	2 00
2732	4 80

MICROS

Z80A cpu	2.85
Z80A ctc	2.60
Z80A pio	2 50
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LEDs 3mm & 5mm

Red	9p
Green or Yellow	12p
Flashing Red	49p
Flashing Continuous Red	52p
Tri Colour 5mm Round	50p
Rectangular	55p

DISPLAYS

3" cc Red	75p
5" cc ca Red	85p

LCD 3½ DIGIT MULTIMETER

16 ranges including DC voltage (200 mv-1000 v) and AC voltage, DC current (200 mA-10 A) and resistance (0-2 M) + NPN & PNP transistor gain and diode check. Input impedance 10M. Size 155 x 88 x 31 mm. Requires PP3 9v battery. Test leads included. **ONLY £29.00**

HOME CONTROL CENTRE

This kit enables you to control up to 16 different appliances anywhere in the house from the comfort of your armchair. The transmitter injects coded pulses into the mains which are decoded by receiver modules connected to the same mains supply and used to switch on the appliance addressed. The transmitter also includes a COMPUTER interface so you can programme your favourite micro (eg. ZX81) to switch lights, heating, electric blanket, make your morning coffee, etc., automatically without rewiring your house. **JUST THINK OF THE POSSIBILITIES.** The kit includes all PCBs and components for one transmitter and two receivers, plus a pre-drilled box for the transmitter.

Order as XK112. £42.00

Additional Receivers XK111 £10.00

"OPEN-SESAME"

The XK103 is a general purpose infra-red transmitter/receiver with one momentary (normally open) relay contact and two latched transistor outputs. Designed primarily for controlling motorised garage doors and two auxiliary outputs for drive/garage lights at a range of up to 40 ft. The unit also has numerous applications in the home for switching lights, TV, closing curtains, etc. Ideal for aged or disabled persons.
The Kit comprises a mains powered receiver, a four button transmitter, complete with pre-drilled box, requiring a 9V battery and one opto-isolated solid state switch kit for interfacing the receiver to mains appliances. As with all our kits, full instructions are supplied.

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XK113 MW RADIO KIT

Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5.5 × 2.7 × 2cms. Requires PP3 9V battery. IDEAL FOR BEGINNERS. **£5.50**

REMOTE CONTROL KITS

FOR A DETAILED BOOKLET ON REMOTE CONTROL – send 30p + 6" × 9" S.A.E.

MK6 SIMPLE INFRA RED TRANSMITTER
Supplied with hand-held plastic box. Requires 9V (PP3) battery £4.50

MK7 INFRA RED RECEIVER
Mains powered with triac output to switch up to 500W at 240V ac. Range approx. 20 ft. on/off or momentary control. £10.50
(RC 500K – special price for MK6/MK7 £13.95

MK9 4-WAY KEYBOARD
For use with MK 18/MK 12 transmitter receiver where only 4 channels are required £1.90

MK10 16-WAY KEYBOARD £5.40

MK11 10 channel + 3 analogue o/p receiver
A mains powered I.R receiver providing control signals to 10 on/off and 3 analogue circuits. May be used for controlling the volume of an amplifier, brightness of a lamp, etc. £13.50

MK12 16-CHANNEL I.R RECEIVER
A mains powered I.R Receiver providing up to 16 outputs for switching. 13.50

MK18 based on the SL490. This kit includes all components to make a coded transmitter. Requires a PP3 battery and keyboard (MK9, MK10 or MK13) size 8 × 2 × 1.3cm Range approx. 60 ft. £6.80

MK13 11 way keyboard for use with MK18 and MK11 kits £4.35

3-NOTE DOOR CHIME

Based on the SAB0600 IC the kit is supplied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 × 71 × 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete. AN IDEAL PROJECT FOR BEGINNERS. Order as XK 102. **£5.50**

ALL PRICES EXCLUDE VAT

COMPONENT PACKS

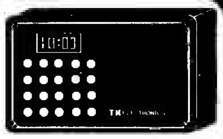
- **PACK 1** 650 Resistors 47 ohm to 10 Mohm – 10 per value **£4.00**
- **PACK 2** 40 × 16V Electrolytic Capacitors 10µF to 1000µF – 5 per value **£3.25**
- **PACK 3** 60 Polyester Capacitors 0.01 to 1µF/250V – 5 per value **£5.55**
- **PACK 4** 45 Sub-miniature Presets 100 ohm to 1 Mohm – 5 per value **£2.90**
- **PACK 5** 30 Low Profile IC Sockets 8, 14 and 16 – pin – 10 of each **£2.40**
- **PACK 6** 25 Red LEDs (5mm dia.) **£1.50**

DVM/ULTRA SENSITIVE THERMOMETER KIT

This new design is based on the ICL7126 (a lower power version of the ICL7106 chip) and a 3½ digit liquid crystal display. This kit will form the basis of a digital multimeter (only a few additional resistors and switches are required—details supplied), or a sensitive digital thermometer (–50°C to +150°C) reading to 0.1°C. The basic kit has a sensitivity of 200mV for a full scale reading, automatic polarity indication and an ultra low power requirement—giving a 2 year typical battery life from a standard 9V PP3 when used 8 hours a day, 7 days a week.

Price £15.50

MICROPROCESSOR CONTROLLED MULTI-PURPOSE TIMER



Now you can run your central heating, lighting, hi-fi system and lots more with just one programmable timer. At your selection it is designed to control four mains outputs independently, switching on and off at pre-set times over a 7 day cycle, e.g. to control your central heating (including different switching times for weekends), just connect it to your system programme and set it and forget it—the clock will do the rest.

FEATURES INCLUDE:-

* 7mm LED 12 hour display
* Day of week, am/pm and output status indicators
* 4 open collector outputs for driving relays, triacs, etc.
* 50/60Hz mains operation
* Battery backup saves stored programmes and continues time-keeping during power failures. (Battery not supplied)
* Display blanking during power failure to conserve battery power
* 18 programme time sets
* Powerful 'Everyday' function enabling output to switch every day but use only one time set
* Useful 'sleep' function — turns on output for one hour
* Direct switch control enabling output to be turned on immediately or after a specified time interval
* 20 function keypad for programme entry
* Programme verification at the touch of a button
* Plastic box with attractive screen printed front panel 15 × 10 × 5.5cm

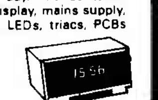
Now only £39.00
(Kit includes all components, PCB, box, assembly and programming instructions)
Order as CT6000

XK114 OPTIONAL RELAY KIT
Kit includes one relay, PCB to accommodate up to four relays, terminal blocks, etc., to fit inside CT6000 box. Provides up to four 3amp 240V AC changeover contacts.
£3.90
Additional relays £1.65 each.

24 HOUR CLOCK/ APPLIANCE TIMER KIT

Switches any appliance up to 1kW on and off at preset times once per day. Kit contains: AY-5-1230 IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triacs, PCBs and full instructions.

CT1000K Basic Kit **£14.90**
CT1000K with white box (56/131 × 71mm)....**£17.40**
(Ready Built).......**£22.50**



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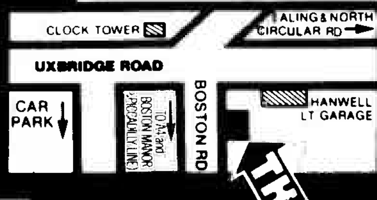

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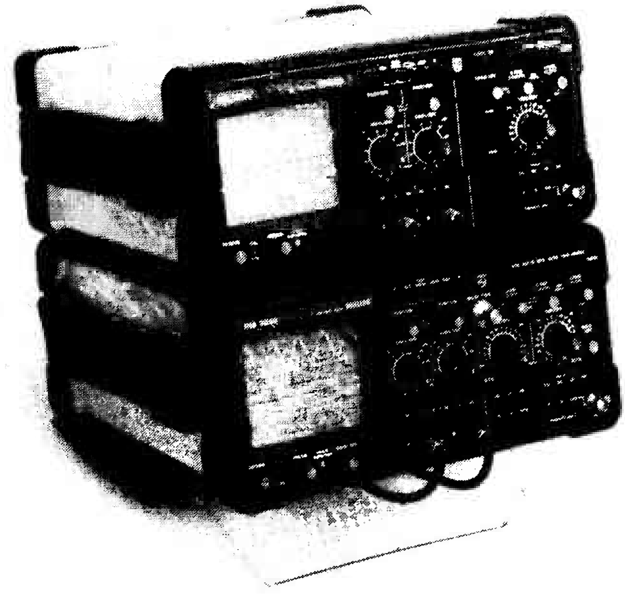


Portable Oscilloscopes

Electronic Brokers is introducing into its range a pair of laboratory performance, portable oscilloscopes which are purpose-designed for tough operating conditions. They are both dual trace instruments, the PM3254 with single timebase and the PM3256 with added delayed timebase.

The triger and timebase circuits have been developed to give over 100MHz bandwidth, with vertical amplifier bandwidth 75MHz over a wide temperature range. The ruggedised CRT generates an extremely bright, small spot which produces accurate traces even in high ambient light conditions. Operational capabilities included are separate variable control of main and delayed timebases, variable hold-off, X-Y display facilities and TTL triggering as standard. The trigger-view function can also be used as a third channel. Both oscilloscopes can be operated from either AC or DC power supplies.

The oscilloscopes are constructed around a strong tubular chassis. Front and rear panels are rigid plastic mouldings, the side panels are tough ABS and thick rubber bumpers offer protection to the corners. A shoulder strap is provided for easy transportation from laboratory to alternative locations.

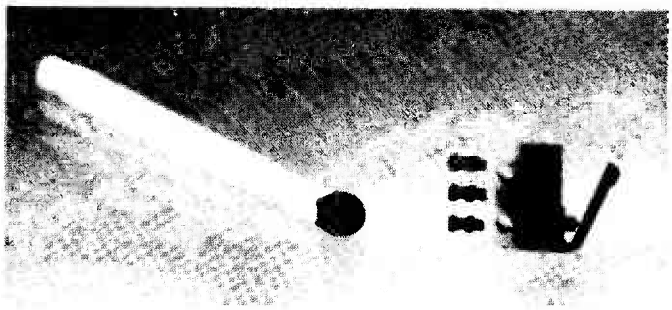
The PM3254 costs £1,096 and the PM3256 costs £1,196. For further information contact Electronic Brokers Limted, 61/65 Kings Cross Road, London WC1X 9LN, tel 01-278 3461.

Musical Spectrum

Ricoll have introduced an add-on for the Spectrum which, they claim, allows a sound to be stored in memory and then replayed at any pitch. The "Action Replay" will accept an input from a microphone or other audio source and after storing it allows real-time replay using the Spectrum keyboard or an external keyboard and an external amplifier and speaker.

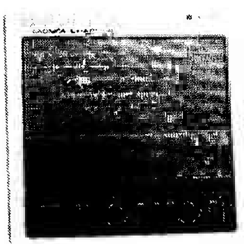
The unit comes in a box which plugs directly into the Spectrum and has sockets for audio input and output. The input signal is sampled at 32 kHz and stored in 32k of RAM in the unit. The pitch of the stored sound can then be controlled from the keyboard, Ricoll claiming four octaves upward shift and no limit to the downward shift. Using various software options, the sound can be reversed, reproduced continuously to form a sort of glitch-free tape loop, and have effects such as echo and vibrato added. Audio bandwidth is 12 kHz, signal-to-noise ratio 66 dB, quantisation noise -72 dB, and the manufacturers claim that distortion is undetectable and that the audio quality generally compares favourably with that of a good hi-fi cassette recorder. The unit is intended to be used in conjunction with a monitor which displays such factors as input level/overload, and with some of the other software options available allows Fourier analysis and synthesis.

The complete unit with a set of demonstration software costs £99.00 including VAT and should be available from the beginning of January. A few fingers here at ETI got a bit itchy at the thought of playing with such a device, and so we have persuaded Ricoll to let us have a sample to evaluate as soon as the first production units are ready. Watch this space! Ricoll Electronics Ltd, 48 Southport Road, Ormskirk, Lancashire L39 1Qr, tel 0695 79101.



Unmatched?

It certainly won't be easy to find another microswitch which can match this one for size. Height, from the bottom of the pins to the top of the (depressed) lever is just 10mm, width is 8mm and thickness 3mm. The switching operation is single pole change-over and the contacts are rated at 300 mA, 50 V (not, we suspect, 300 mega-amps as stated in the press release!) The actuating lever is designed for both simple compression and cam follower applications and the suppliers envisage it being used in scale models and for anti-tamper switching in small equipment. The switches are available in packs of ten for £4.00 including post and packing from Semiconductor Supplies International Ltd, Dawson House, 128-130 Carshalton Road, Sutton, Surrey SM1 4RS, tel 01-643 1126.



Free Of Charge

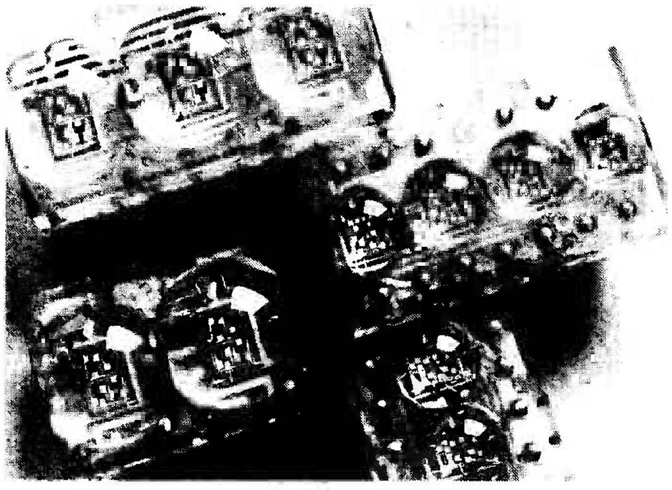
Taking the idea of low battery costs through the use of Ni-Cads to its logical conclusion, Sanyo have introduced a charging unit which doesn't need a supply of electricity. Their NC-AMI charger for AA (HP7) size cells is solar powered.

Sanyo have used what they call amorphous silicon semiconductor technology, or AMORTON for short, to produce the solar panel which has made the new charger possible. They do not say just how much output the new panel gives nor how long the unit will take to fully charge batteries. The charger, complete with four AA size Cadnica cells, should be on sale in the UK soon at a price which Sanyo say will be 'within easy reach of the average customer'.

New Maplin Catalogue

The 1984 Maplin Electronic Supplies catalogue arrived at the ETI offices the other day — and kept on arriving! We don't know exactly how many copies they've sent us but if any more arrive we'll have enough to build our new offices with. The new catalogue has nearly 500 pages, 20% more than the 1983 edition, and includes a section on the Heathkit range of electronics kits. For the first time, Maplin's prices appear on the page rather than in a separate supplement. The prices will hold until at least February when an update leaflet will be issued. The new catalogue costs £1.35 and can be purchased from branches of W.H. Smiths, from Maplin's own stores, or by post from Maplin's Rayleigh address for £1.65 including postage.

The Maplin stores mentioned above continue to increase in number. In addition to their stores in Birmingham, Manchester, London and Southend, they have recently opened a new one in Southampton. The shop is at 46-48 Bevois Valley Road, which is quite close to the City University. The existing premises had previously been used for the sale of electronic components for over forty years, and will now stock the extensive Maplin range. Maplin Electronic Supplies Ltd, P.O. Box 3, Rayleigh, Essex SS6 8LR, tel 0702 554155.



Red-uced!

Siemens have introduced four red LED digital displays which offer a considerable reduction in operating power over conventional types. Dissipation is only 80 mW per digit and Siemens claim that they are ideal for use with MOS devices and in CMOS circuitry.

The low power dissipation is achieved through the use of gallium arsenide phosphide as the semiconductor material. The luminosity is 1500 millicandela at 5mA forward current and the forward voltage reaches a maximum of 2V at 20mA. The rated temperature range is −20 to +70 C and the wavelength of the emitted light is stated to be 650 nm.

The new displays come in two, three and four digit versions and the tiny substrate area is viewed through an integral plastic magnifying lens to give a digit height of either 2.8 or 3.8 mm. They are available in 12 or 14 pin plastic packages and all types are arranged for common cathode operation.

Siemens envisage applications for the displays in all types of battery operated equipment and particularly in multimeters, digital thermometers, etc. Siemens Ltd, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex TW16 7HS, tel 09327 85691.

Belfast Chips

Scientists at Queen's University, Belfast, have designed a chip which is capable of packing in 25 per cent more circuits and working at least 10 times faster than present types. They have done it using conventional chip manufacturing techniques and their efforts have been recognised by the UK Science and Engineering Research Council who have just given grants of £300,000 to continue their work.

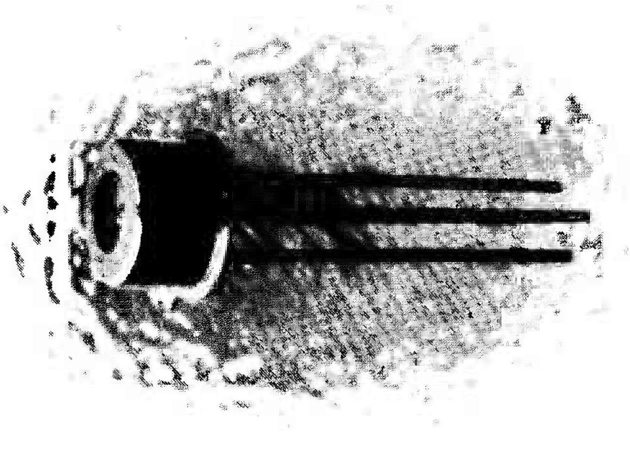
Researchers in the Department of Electrical and Electronic Engineereing say their design holds out the prospect of the most complex chips in the world, operating at the highest possible speed. One of the three-man team behind the new development, lecturer Dr Mervyn Armstrong, said: "Although we have developed a new principle, quite a large amount of development work is still needed before a prototype chip could be successfully produced. It is, however, a major innovation for those creating and marketing tomorrow's chips."

The new approach is based on the ability to align exactly certain essential layers used to make a chip. Until now the alignment of the layers could not be precisely controlled. This has meant the patterns on each essential layer have had to be made a little larger so that even if the overlying layers do not exactly register on top of the previous layer, some part of them would make contact. The penalty is that this wastes valuable space. Exact alignment, which Queen's University say they can now achieve, frees space for more circuitry.

The other problem was speed. An average microprocessor deals with two million pieces of information every second, which are processed through some 30,000 transistors. But as more transistors are put into the chip, the connections between them become smaller and thinner, slowing down the passage of current from one transistor to another, and consequently the response of the computer. These connections are normally made from poly silicon. To restore its efficiency when using thin connections the Belfast team have devised a technique to put a layer of aluminium on top of each part of the chip containing poly silicon.

The Belfast development holds out the promise of medium priced computers which can support many more user terminals than at present and also means that industrial processes now monitored by giant computers could soon come within the range of cheaper, microprocessor-based maci nes.

100MHz Fibre Optic Emitters



Motorola have introduced two new infrared emitters for fibre optic systems which are claimed to be the industry's first planar LEDs capable of data transmission at greater than 100MHz bandwidth. The devices allow fibre optic system operation in areas previously reserved for expensive, edge-emitting LEDs and laser diodes at a significantly lower cost and a much improved operating life.

The new MFOE1201 and MFOE1202 infrared emitters are packaged in a TO-52 metal package which is hermetic, industry standard size and configuration and fits into commercially available fibre optic connectors. The internal lensing enhances coupling efficiency and provides a 250µm diameter optical spot at 0.3 N.A. (numerical aperture) on the emitters. The spectral response peaks at 820nm, which is spectrally matched to the minimum attenuation region of most medium distance fibre optic cable. With a power output of 1.0 to 3.5mW, the devices make short to medium distance, highspeed systems economically feasible. Applications are broad, and include industrial controls, computer systems, CATV and military.

For further information contact Motorola Ltd, European Literature Centre, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP, tel 0908 614 614.

1.5µs, 12-Bit ADC

Burr-Brown have introduced a 12-bit analogue-to-digital converter with a maximum conversion time of only 1.5µSec. Thought to be the fastest successive approximation A/D converter on the market, the ADC803 is accurate to ±0.015% of full scale range, operates with no missing codes over a −25 C to +85 C temperature range and provides both serial and parallel outputs.

The converter incorporates a mix of proven IC and hybrid technologies and utilises state-of-the-art IC and laser trimmed thin-film components to achieve a complete A/D function including voltage reference, clock and comparator. It is packaged in a 32-pin 43x23x5mm hermetically sealed DIP. Input scaling resistors allow internal selection of analogue input range from 0 to −10V, ±5V and ±10V. Output codes are complementary binary for unipolar inputs and bipolar offset binary for bipolar inputs. All digital inputs and outputs are TTL compatible and power supply requirements are +15V and +5V. Because of its differential input comparator design, the ADC803 is very easy to use. The internal DAC drives a comparator input separate from the input signal so that the user's driving circuitry does not have to handle the DAC's large, fast transients.

For further information contact Burr-Brown International Limited, Cassiobury House, 11-19 Station Road, Watford, Herts WD1 1EA, tel 0923 33837.

IEEE Controlled Logic Analyser

The Hawk 3210 logic analyser interfaces with a host of microcomputers to give powerful diagnostic, processing display and hard copy facilities, and at £2495 is claimed to cost only about half as much as other machines offering less facilities.

The 3210 offers 32 channels of 1024 bits depth, with an internal sample clock programmable to 10 MHz. Triggers are programmable in binary, hex, octal, decimal, and ASCII for all 32 channels, including don't care states. Full pre and post trigger capability is provided, using delay of up to 1024 samples.

In timing mode, each screen page displays 128 samples of the 1024 bit storage and from any two of the four pods each carrying eight data probes. Pod 1 carries a dividable external clock input. Glitches are detected to 30MHz, with display detectable on or off. When displayed, glitches are shown as an overlay to data. In parallel state mode binary, parallel, octal, hex, decimal and ASCII displays of 32 channels wide by 16 lines are available, with on-screen command prompt for control.

The unit has fully menu-driven operation and keyboard control for setting trigger words and selecting timing, hex, binary, decimal, octal or ASCII formats. All menus carry prompt instructions at the foot of the display.

Initially, the 3210 analyser is available for use with Apple II machines, a converter card giving the computer IEEE compatability. However, software is now in development to allow the anlayser to be used with Commodore, Sirius and other popular makes of microcomputer and controller. Hawk Electronic Test Equipment, Bircholt Road, Parkwood industrial Estate, Maidstone, Kent ME15 9XT, tel 0622 686811.

Triple Output Power Supply

The Kikusui PWC 0620 is a triple output power supply which offers 0 to 6 volts at up to 3 amps, and 0 to + 20 volts and 0 to − 20 volts, at up to 1 amp. The 20 volt outputs operate in a dual tracking mode and the unit has two large front panel meters, one for current measurement, and the other for voltage. Any of the three outputs can be selected for display on the meter, and there are separate voltage and current controls for the 6 and 20 volts ranges. The power supply is operable either in constant voltage or in constant current modes. Ripple is only 0.5 mV on all outputs, and line and load regulation is within 3 mV. It costs £295 plus VAT, which is a lot more than you will have to pay for the only-slightly-less generously rated instrument which appears elsewhere in this issue. Telonic Instruments Ltd, 2 Castle Hill Terrace, Maidenhead, Berkshire, tel 0628 73933.

SHORTS

● The Scopex Instruments story, part 2: further to our recent report of Scopex' demise, we are now assured that the company's future is secure following the purchase of their assets from the Receiver by Bridage Scientific Instruments Ltd. Bridage say that all existing orders for Scopex products will be fulfilled as soon as possible. The new address for all enquiries is Scopex, 63-65 High Street, Skipton, North Yorkshire BD23 1EF, tel 0756 69511.

● Regisbrooke have issued a full colour brochure describing their wide range of opto-electronic devices, LED, LCD and vacuum flourescent displays, keyswitches, display driver components, and accessories. The brochure is available free of charge from Regisbrooke Ltd, Unit 5, Horshoe Park, Pangbourne, Berkshire, tel 07357 4841.

● Further doom and gloom. At a meeting of creditors which took place on the 8th November 1983, Jupiter Cantab Ltd, manufacturers of the Jupiter Ace microcomputer, was put into the hands of a liquidator. The business is now being offered for sale, and further details can be obtained from Chater & Myhill, Sussex House, Hobson Street, Cambridge CB1 1NJ, tel 0223 66692.

● The CM200 capacitance meter will measure capacitances between 1pF and 2,500uF, taking three readings per second and giving the result on its 4½ digit LCD to an accuracy of ±0.2%. It is lightweight, will run for several hundred hours from batteries or can be connected to the mains supply, and has a calibration control which allows the user to null out up to 25 pF test lead capacitance. It costs £89 plus VAT. Thurlby Electronics Ltd, New Road, St. Ives, Cambridgeshire, tel 0480 63570.

● In order to combat the shortage of skilled staff in the computing services industry COSIT, the Computing Services Industry Training council has been given £600,000 by the government for its first year of operation. The program will run for five years and the object is to pay firms to help them with their training. For details contact COSIT, 5th Floor, Hanover House, 73-74 High Holburn, London WC1V 6LE, tel 01-242 5049.

● The DPM60 4½ digit LCD module features auto-zero, auto polarity, and logic switched 200 mV or 2V FSD with 10uV resolution. It runs from a 7.5 - 15V supply, has 10 mm high digits, and is available in kit form for £29.95 fully inclusive from Lascar Electronics Ltd, Module House, Whiteparish, Salisbury, Wiltshire SP5 2SJ, tel 079 48 567.

● Galatrek's combined fuse and 13A socket tester is abut the size of a regular 13A plug and has two neons which indicate when connections are absent, reversed or correct. It costs £8.00 including VAT and post and packing from Galatrek International Ltd, Scotland Street, Llanrwst, North Wales.

● Ambit International have opened a new sales counter for their range of electronic components, books, kits, test equipment, etc. The new counter is in the Broxlea building, near the High Street in Broxbourne, Hertfordshire. There is on-site parking and features include an online computer terminal and other advice and information services for customers. Ambit International, 200 North Service Road, Brentwood, Essex CM14 4SG, tel 0277 231616.

● The Beckman CT233 is a clamp-type Hall effect probe which, when used in conjuction with a multimeter, oscilloscope or other voltage indicating device, allows the measurement of AC and DC currents up to 600A. The unit handles conductors up to 45mm diameter, runs from a 9V battery, has an output of 600 mV for FSD, and an accuracy of 3% or better. Beckman Instruments Ltd, Mylen House, 11 Wagon Lane, Sheldon, Birmingham B26 3DU, tel 021-742 7761.

● Motorola have announced the adoption of the SOT-89 package for a broad range of microminiature transistors, initially including general purpose high voltage Darlingtons and RF transistors. The new plastic package is an alternative to the much larger 1 watt TO-92 package, and in addition to the space saving involved Motorola say the preformed leads of the SOT-89 will facilitate pre-assembly testing. Motorola Ltd, 88 Tanners Drive, Blakelands, Milton Keynes, tel 0908 614614.

● Gothic Crellon have published a 64 page catalogue covering their wide rage of resistors, capacitors, semiconductors, valves, relays, switches and the micro and mini computer systems sold by Crellon Microsystems. Copies of the A4 size catalogue are available free from the Sales Department, Gothic Crellon Ltd, 380 Bath Road, Slough, Berkshire SL1 6JE, tel 06286 4300.

● Bulgin are giving away 1984 calendar-cum-posters which illustrate their range of switches, fuse-holders and connectors. Copies are available from Brian Diggle, Advertising Manager, A. F. Bulgin & Co. PLC, Bypass Road, Barking, Essex IG11 0AZ, tel 01-594 5588.

ETI

PROGRAMMABLE SPEECH BOARD

Help your computer to find its voice, with the ETI Mini-Mynah. Teach it words, phrases, sentences or even short stories —then have it repeat them back to you with a single command. Design, development, and awful name by Phil Walker.

The ETI Mini-Mynah is a speech generator with added extras — 100+ words of memory, inflection, and low software overheads are possibly the most important.

At the heart of the system is a General Instruments SP0256-AL2 speech processor IC. This is an NMOS LSI device, containing its own microcontroller, ROM, digital filter and pulse width modulator. The main attractions of this device are that is does not require vast amounts of data to produce understandable speech, it is easy to interface with other devices, its vocabulary is not limited, and it is available to the hobbyist.

The device uses allophone speech synthesis, which means that is provides for the generation of 64 basic speech sounds (including five silences!) from which an unlimited number of words can be assembled. This, however, has the disadvantage that you have to work out exactly which sounds you need to generate to make the words you want to say — more on this later. Other versions of the SP0256 have more, different allophones.

The on-board 2K of RAM can store up to 2048 allophones, which can be in groups of up to 255 in length. The memory is set up by one program, which can then be deleted or over-written. To call up an allophone group thereafter requires only a single instruction within the program — the computer can then get on with other tasks while the sound generator churns out the vocals! However, reproduction is not limited to the set utterances stored by the initial program — individual words, phrases, parts of sentences can be picked out by single commands, and reproduced in any desired order; just because a group of allophones were entered together, they do not have to be reproduced together.

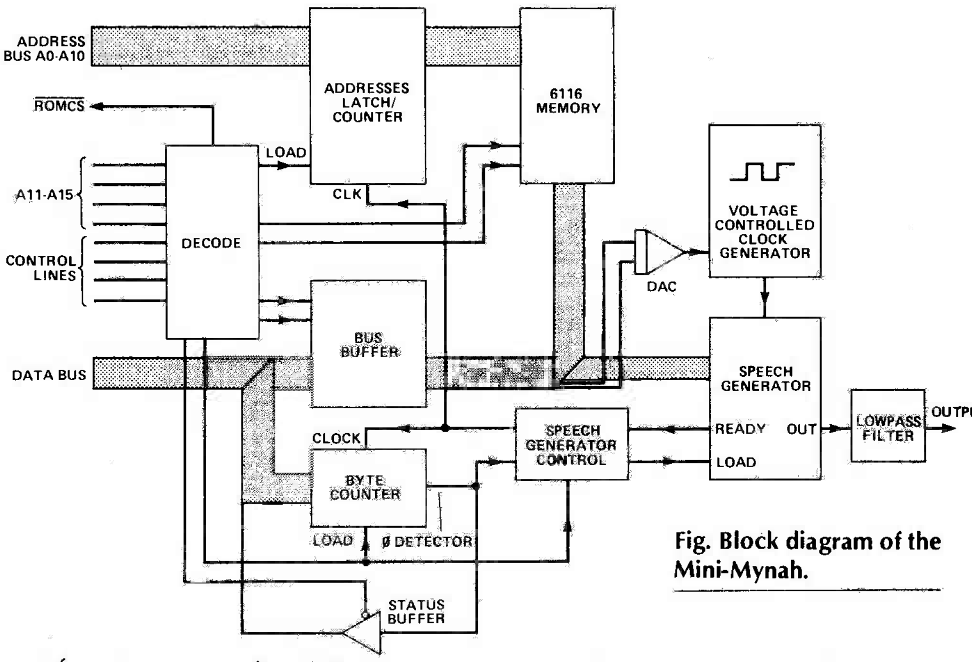


Fig. Block diagram of the Mini-Mynah.

The Circuit

The circuit consists of a 2K block of memory, a speech generator chip, clock generator and output filter together with some control and interface devices.

The main requirements of the system is that data can be put into the memory (and read from it) under control of a common home computer. Having placed the required data in the memory, it is then possible to select a block of data by defining its start address and length. This data block will then be read by the speech generator to produce words, phrases or complete sentences without further action by the controlling computer.

During the design stage, it was noted that only six bits are required to specify one of the 64 allophones provided by the SP0256. For this reason, and because it provides a TTL compatible square-wave output, it was decided to use a 74LS624 VCO to provide the clock frequency for the speech generator; the two spare data bits from the normal eight-bit word are used to provide a four-level control voltage for the VCO. This has the effect of varying the pitch of the reproduced speech as each allophone is being reproduced. The rate of change of the control voltage is slowed down by a large capacitor to give a smooth final result. Adjustment of the 'normal' pitch and of the degree of pitch variation can be made on the board. Additionally, a VCO is rather cheaper than a crystal!

For the following discussion we will assume that the 2K memory block is normally accessed in the address range 8192 to 10239 (decimal) for normal read and write operations and in the range 10240 to 12287 (decimal) for control functions (2000_H to $27FF_H$ and 2800_H to $2FFF_H$ respectively).

By reading and writing from and to addresses in the range 8192 to 10239 the RAM can be loaded with data representing the sounds to be made. The data consists of bytes of eight data bits in which the lower six select which type of sound is to be made while the top two affect the pitch of the preceding allophone. This slight inconvenience is caused by there being no latch on the upper two data bits (this would have necessitated an extra chip had it been included).

In order to start a particular data string being rendered into speech, 2048 (decimal) is added to its starting address and a byte representing its length is written to the resulting address. When this has been done the speech generator will read out the data string in sequence and generate the required sounds. This process will continue until the full number of bytes has been dealt with without any further interference by the controlling computer.

What actually happens is that the write operation loads the address counters with the lower 11 address bits and the byte counter with the data on the data bus. After this operation the speech generator chip is enabled and generates the clock and loading signals by interaction with the byte counter and a simple gate circuit until the byte counter reaches zero. At this point the operation will stop.

If for some reason the controlling computer needs to know the current status of the unit (i.e. whether it is still talking or not) this can be done by a read operation to any address in the range 10240 to 12287 (decimal) and testing the state of data bit 7. This will be high for busy or still talking and low if the Mini-Mynah is ready to accept a new command. Note, however, that a false result may be obtained when the last byte is being processed as the byte counter will be zero before the speech generator has finished sounding (this will not cause a problem if the last byte was a pause).

We have not shown a power supply or audio amp for this project as there are so many simple circuits available. A power supply of 5V at about 300mA should be adequate.

```
PROGRAM LISTING

 10 REM (50 or more characters to take data)
 20 LET K=16514
 30 FOR I=0 TO 50
 40 PRINT I+K
 50 INPUT A
 60 IF A>255 THEN GOTO 100
 70 POKE I+K,A
 80 PRINT PEEK (I+K)
 90 NEXT I
100 FOR J=0 TO I
110 POKE 8192+J, PEEK (16514+J)
150 POKE 10240,I
160 IF PEEK(10240)>127 THEN GOTO 160
170 GOTO 150
```

Fig. 2 Example program for the ZX81.

HOW IT WORKS — PROGRAM

Line 20 sets pointer to data storage start in the REM statement. Lines 30 to 90 take in up to 50 bytes of data and store it in the REM statement. The address at which each byte is to be stored is printed on the screen as is the content of that address after the operation is complete.

The process can be stopped by entering a number greater than 255.

Lines 100 to 120 transfer the data from the REM statement to the memory in the Mini-Mynah. After this, line 150 writes the number of bytes in the data string just loaded to the start address +2048. This action triggers the Mini-Mynah to speak the equivalent of the data string as a string of sounds.

Line 160 tests the status flag and only allows the program to continue when the Mini-Mynah signals that the data string has been processed. Normally line 160 would come before line 150 and other actions would be undertaken by the computer while the Mini-Mynah was speaking (hint — type line 10 in last).

Here is data for a surprise message (don't worry, it's not rude!)

4, 155, 135, 173, 15, 117, 132, 4, 216, 70, 131, 26, 154, 80, 67, 18, 143, 79, 67, 19, 196, 13, 19, 132, 24, 134, 67, 16, 76, 129, 139, 211, 3, 16, 216, 134, 184, 115

Note that although only 64 allophones are available from the basic chip in the Mini-Mynah we have added circuitry which affects the pitch of the reproduced speech. This is activated by the two MSBs of the data byte and is shown in the data by adding 9,64,128 or 192 to the allophone number in the range 0 to 63. Be aware also that the MSBs of one byte affect the pitch of the preceding allophone not the one to which it belongs. To illustrate the effect of not using the pitch inflection, either turn the presets on the PCB to the set-up positions or subtract 64,128 or 192 as necessary from the data bytes and run the program again.

The ZX81 program will run on the basic 1K machine and you should have no problem saving it once you have input the data so that you can store phrases and re-enter them. With 16K + machines or other systems, you will probably find it easier to store the data in arrays or data statements as appropriate.

Interfacing to the 16K or 48K Spectrum should, in theory, be quite simple (but we have not tried it yet) and a possible location in the memory map would be right at the top. Make sure that the area occupied by the Mini-Mynah is not also used by Basic or whatever high level language you use on your system.

Word	Allophone	Code (decimal)
Zero	ZZ/YR/OW	43,60,53
One	WW/AX/AX/NN1	46,15,15,11
Two	TT2/UW2	13,31
Three	TH/RR1/IY	29,14,19
Four	FF/FF/OR	40,40,58
Five	FF/FF/AY/VV	40,40,6,35
Six	SS/SS/IH/IH/PA3/KK2/SS	55,55,12,12,2,41,55
Seven	SS/SS/EH/EH/VV/IH/NN1	55,55,7,7,35,12,11
Eight	EY/PA3/TT2	20,2,13
Nine	NN1/AA/AY/NN1	11,24,6,11
Ten	TT2/EH/EH/NN1	13,7,7,11
Eleven	IH/LL/EH/EH/VV/IH/NN1	12,45,7,7,35,12,11
Twelve	TT2/WH/EH/EH/LL/VV	13,48,7,7,45,35
Thirteen	TH/ER1/PA2/PA3/TT2/IY/NN1	29,51,1,2,13,19,11
Twenty	TT2/WH/EH/EH/NN1/PA2/PA3/TT2/IY	13,48,7,7,11,1,2,13,19
Hundred	HH2/AX/AX/NN1/PA2/DD2/RR2/IH/IH/PA1/DD1	57,15,15,11,1,2,33,39,12,12,0,21
Thousand	TH/AA/AW/ZZ/I H/PA1/PA1/NN1/DD1	29,24,32,43,12,0,0,11,21
Million	MM/IH/IH/LL/YY1/AX/NN1	16,12,12,45,49,15,11

Table 1 Some useful words as allophones.

Construction

Construction should pose no great problem here so long as care and sensible precautions are taken. The first thing to note is that the board is double sided but without plated through the holes. So some of the holes need wire links through them soldered on **both** sides. In other places the leads of decoupling capacitors must be soldered on both sides instead. this is necessary to complete the power supply wiring so make very sure it is done. We recommend the use of IC sockets especially for the more expensive devices. Make sure all polarised components are inserted the right way round.

The order of construction we recommend is:—

1. wire links;
2. IC sockets;
3. decoupling capacitors;
4. resistors, capacitors, diode, transistor, potentiometers;
5. power connector;
6. 34 way connector;
7. ICs into sockets (after checking for shorts, etc.).

Make doubly sure the ICs are the right way round, as they don't all point the same way.

We used a fairly expensive 34-way connector for this project, but it did save us having to solder an awful lot of wires, and

BUYLINES

The SP0256-AL2 is available from Rapid Electronics; the PCB is available from our very own PCB service, and everything else is absolutely standard.

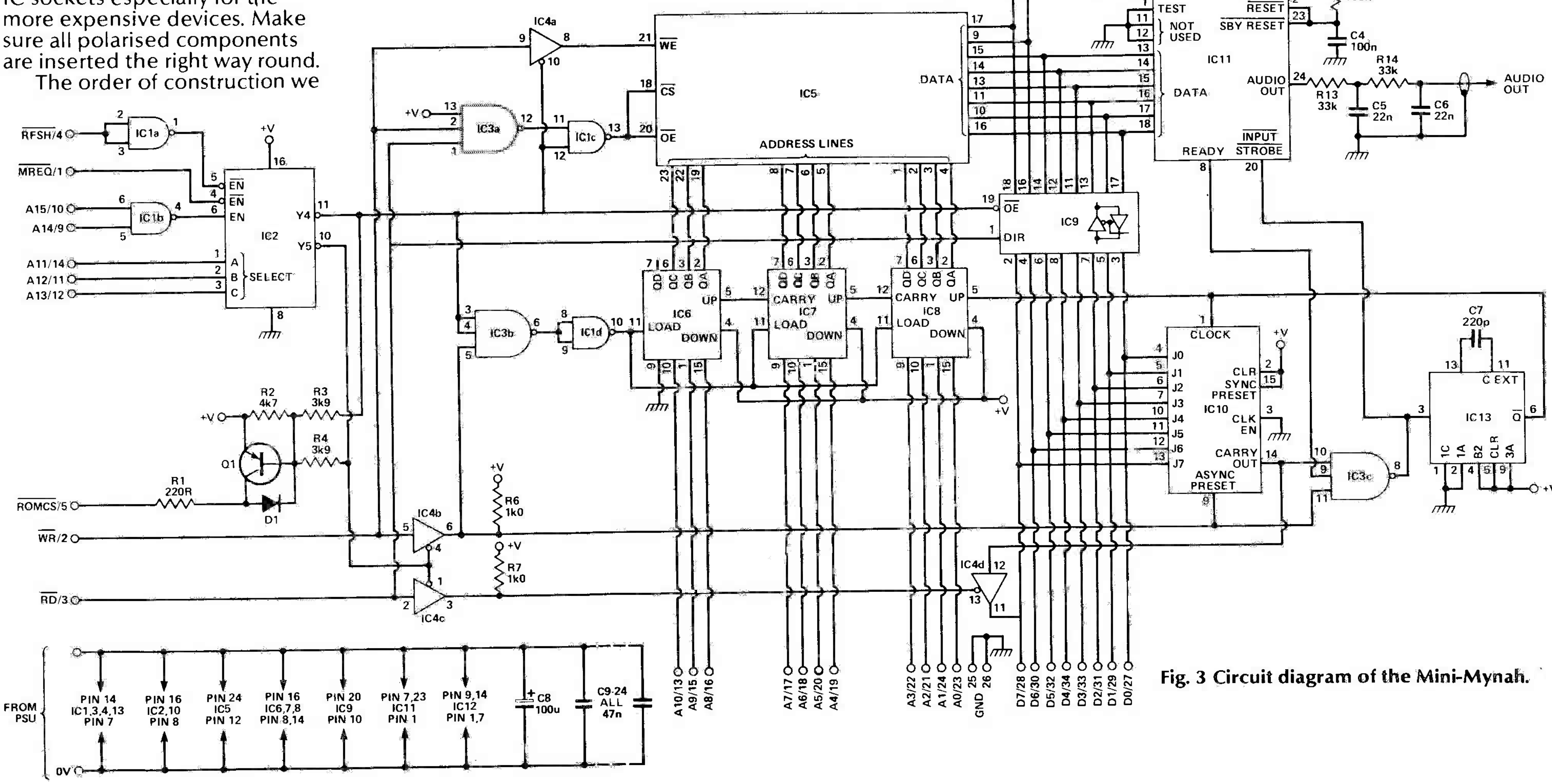


Fig. 3 Circuit diagram of the Mini-Mynah.

HOW IT WORKS

There are two main phases in the operation of this project: the first phase is the loading of the speech information into the memory (IC5); the second phase is the reading of the stored information by the speech pro cessor to generate the required sounds. These two phases will be discussed in order.

In phase one, IC1,2 and 3 a and b are used to decode the control and more significant address lines from the computer interface. In this phase only pin 11 (Y4) of IC2 will be active (low). This enables data to be read from and written into the RAM (IC5) via the data buffer (IC9) and IC6, 7 and 8 which act as address buffers.

When IC1 pin 11 goes low, IC4a is enabled and the signal on the WR line is transferred to the WE input of IC5. Also while IC2 pin 11 is low, the CS and OE pins of IC5 are driven high by the output from IC1 pin 13 until either the WR or RD inputs to IC3a goes low, forcing IC3a pin 12 high and thus IC1c pin 12 low. This disables the RAM until a valid read or write condition is set up but it will keep the RAM in the READ mode when it is not being accessed externally.

The low on IC2 pin 11 enables the bi-directional bus buffer IC9 and also forces the output of IC1d low via IC3b. This condition causes the outputs of IC6,7 and 8 to follow the inputs from the address bus. These devices are actually four-bit binary counters which can be loaded asynchronously by taking their pin 11 low, which is the condition just described.

In phase two, once suitable data has been loaded into IC5, a WRITE operation is performed by the controlling computer such that IC2 pin 10 (75) is sent low and the WR input line is also low. Under these conditions the output of IC4b pin 6 will be low forcing the output of IC1d low via IC3b and thus loading the current contents of the lower 11 address lines into IC6,7 and 8. Also the low on IC4b output causes the contents of the data bus to be loaded into IC10 while holding the output of IC3c high.

At the end of the WRITE operation, the output of IC10 pin 14 (CARRY OUT) will normally be high indicating a non-zero count, the output of IC11 pin 8 (READY) will be high indicating that the speech generator is ready to accept data and since the output of IC4b will now be high the output of IC3c will go low indicating to IC11 that data is available from the RAM (IC5). A short time after this low condition appears at IC11 pin 20, IC11 pin 8 will go low indicating that the data has been accepted. This will cause the output of IC3c to go high until IC11 pin 8 goes high again.

The rising edge of the output from IC3c triggers IC13 which is a monostable set to give a negative going pulse of about 1μs. The output from IC13 drives the clock inputs of IC6,7,8 and 10. These devices act on the rising edge of their clock signal. The purpose of IC13 is in effect to delay the change in the data presented to the IC11 until the correct data has been captured. The first prototype produced some very strange noises without IC13!

The rising edge of the output from IC13 increments IC6,7,8 and decrements IC10. This then sets up the RAM address to the next byte of data, ready for the next sound. When the speech generator is ready for the next data, the process will repeat, and will carry on repeating until the output of IC10 pin 14 goes to the low state to indicate that all the bytes have been read out. At this point the action will stop until new data is written in.

At any time the status of the Mini-Mynah can be tested by doing a READ operation which sets IC2 pin 10 low. This will cause the output of IC4C to go low which will cause the current state of IC10 pin 14 to be transferred to IC4d pin 11 and thus onto the data bus (D7). A high will indicate that speech generation is still in progress while a low level will indicate that a new command can be sent.

As only 64 sounds are available from the SP0256-AL2 device, only six data bits are needed to select them. The remaining two bits are used in this circuit to control a VC0 (IC12) via a crude DAC,R9,R10, with a heavily slugged response. The range of the VCO is about 2.5 to 3.5 MHz and can be varied under program control. This facility allows a certain amount of expression to be put into the generated speech.

C2 and R12 form a power on reset function while R13,14 and C3,4 filter the speech output from the generator to remove unwanted high frequencies.

The circuitry around Q1 is present to allow interfacing to ZX81 computers and generates a signal to disable the ROM in the ZX81 when this device is activated.

it makes a neat and robust connection. There is nothing to stop you soldering ribbon cable direct to the board if you want to economise but make sure you tie it down securely to prevent breakages. Similarly, the power connector could be omitted if you wish.

Interfacing

Making the most effective use of this project requires a memory map space of 4K. If this can be in one block, things are much simpler; however, any method of presenting 8 data bits and 12 address bits together with READ, WRITE and SELECT (or SELECT) signals could be just as effective.

As designed, the project is very easily interfaced with Z80 systems especially the Sinclair ZX81. To assist with the connection to the ZX81, the Mini-Mynah generates a signal on the ROMCS line which pulls high via a 220R resistor when the device is being accessed. This signal temporarily turns off the ZX81 ROM to avoid a conflict between it and the devices we are adding.

Whatever host computer is used, address lines A0 to A10 are used to access the 2K of on-board memory while A11 is low. When A11 is high the same address lines specify the starting address of the speech data string. A12,13,14,15, MREQ and RFSH are all treated as select lines and must be 0,1,0,0,0,1 respectively to enable any action to occur. This does not mean that all of them have to be driven individually, you may find it more convenient to use only one or two of them and connect the rest to +ve or −ve as appropriate. The RD and WR signals must be provided by your control system. If you have only a single R/W line you must provide an inverter for the RD signal.

The data lines, D0 to D7, can be considered as standard except that when doing a READ operation with A11 high (examining the status flag) only D7 will be active (high or low), the others will be floating at undefined levels. Also in this type of operation the address lines A0 to A10 will be irrelevant as the same data is returned whichever address is accessed.

Setting Up

After building up the board and carefully checking it through for wrongly placed components, etc, set RV1 fully clockwise and RV2 fully anti-clockwise, connect an audio amplifier to the output terminal and apply power. You will probably hear a random selection of burbles, hisses and squawks — this means that the Mini-Mynah is working; the noise should stop after a short while. If this does not happen, switch off and try again before carrying out the usual checks for component orientation, broken or shorted tracks, etc.

When it works thus far, connect it to your computer (make very sure of your connections), power up the Mini-Mynah and then power up your ZX81 or whatever you are using. Once the noise has stopped (a momentary short across C4 will clear the last noise of the sequence) you are ready to try it out. Use the demo program or something similar to put data into the RAM and away you go. Try the effect of varying RV1 and RV2 until you find the best result. The sound can vary from a rapid robot voice to a growling monster-from-the-swamp effect.

Speech Synthesis

The spoken word is a very effective way of communicating information in small quantities to and from humans. For many years and for many reasons people have been trying to imitate the sounds of speech. Early attempts used collections of (mechanical) valves, pipes, resonators and noise sources which were thought to approximate to the human vocal tract. Later on these models could be implemented electronically which greatly eased the control problems.

Another system of making machines talk was also tried in which short sections of actual speech were preserved in some recording medium and played back in the sequence required. A notable example of this type of machine was the GPO (as it was then) speaking clock, TIM. This started life with the phrases recorded on glass discs.

With the boom in popularity enjoyed by the home computer has come the demand for speech synthesis systems which allow them to communicate with people. This can be done relatively easily by recording words and phrases in digital form (PCM — pulse code modulation) and playing them back on demand. The trouble with this is that to get good quality speech requires typically 70,000 bits of data per second. Methods have been developed which reduce this requirement (for example, LPC — linear predictive coding) by predicting what happens next partly from what has gone before, but even here the data rate is of the order of one to two thousand bits per second.

The first two methods described often have the feature that speech is available only in pre-set words or phrases; this of course makes them easy to use but on the other hand sets a limit to their applicability. Also, while memory devices are getting cheaper all the time, they take up space and consume power.

The allophone method breaks down speech sounds into individual components, so that a word such as 'zero' would have its sound broken into three parts — one for the z sound, one for the er sound and one for the o; the individual speech components are called allophones.

There are a very large number of potential allophones, as many different sounds as the human voice can generate! However, for any one language, the number of sounds used (or, rather, the number of distinguishably different sounds used) is relatively small. In this case, it is necessary for a speech synthesiser to be told a reference number for each of the three or more allophones it has to produce per second, and this reduces the bit rate to around 100 bits per second. However, the allophones themselves are fairly complex, so

Sound Type	Symbol	Code		Duration	Example	Notes
Silences	/PA1/	00	0	10ms		
	/PA2/	01	1	30ms		
	/PA3/	02	2	50ms		
	/PA4/	03	3	100ms		
	/PA5/	04	4	200ms		
Short vowels	/IH/	0C	12	70ms	sIt	These vowel sounds can be doubled to lengthen them.
	/EH/	07	7	70ms	End	
	/AE/	1A	26	120ms	hAt	
	/UH/	1E	30	100ms	bOOk	
	/AO/	17	23	100ms	AUght	
	/AX/	0F	15	70ms	sUcceed	
	/AA/	18	24	100ms	hOt	
Long Vowels	/IY/	13	19	250ms	sEE	
	/EY/	14	20	280ms	trAy	
	/AY/	06	6	250ms	kIte	
	/OY/	05	5	420ms	vOIce	
	/UW1/	16	22	100ms	tO	
	/UW2/	1F	31	260ms	fOOd	
	/OW/	35	53	240ms	zOne	
	/AW/	20	32	370ms	dOWn	
R-coloured vowels	/ER1/	33	51	160ms	lettER	
	/ER2/	34	52	300ms	fERn	
	/OR/	3A	58	330ms	fORtune	
	/AR/	3B	59	290ms	alARm	
	/YR/	3C	60	350ms	hEAr	
	/XR/	2F	47	360ms	stARe	
Resonants	/WW/	2E	46	180ms	We	(See also /WH/)
	/RR1/	03	14	170ms	Read	
	/RR2/	27	39	130ms	cRane	
	/LL/	2D	45	110ms	Like	
	/EL/	3E	62	190ms	angLE,	squirrEl
	/YY1/	31	49	130ms	cUte,	compUter (Y-sound)
	/YY2/	19	25	180ms	Yes	

Table 2 The allophones that the sound generator IC used offers.

what is needed is a table where the generator can 'look up' the composition of the allophones it is being required to produce. The data that is sent to the speech processor is not, therefore, the actual allophones themselves, but the address (or a pointer to the address) of the code for the allophone, which is stored within the device itself.

The device used here does not use PCM or LPC, as these systems would still require a very large amount of stored data. The data is actually used by the on-board processor which controls noise sources and filters, as well as the basic tone generators. The quality of speech produced is not as good as PCM or LPC systems, but it is quite intelligible.

The device used is the SP0256-AL2 which provides us with a set of 64 allophones. This imposes some restriction on what we can do, but this is not too severe.

It should be understood that in a language such as English, there is no absolute correspondence between what is written and the sounds generated when the same word is spoken. Also, it is often difficult to decide where one sound finished and another starts. To some extent the same basic sound will vary a little depending on its position within a word and also on what sounds are adjacent to it.

When programming the Mini-Mynah it is necessary to decide what sounds you require rather than the letters or words as written. Experiment with alternatives where they are available to get the right sound in the right position. Table 2 shows the 64 speech sounds available from the SP0256-AL2. These are broken down into groups of similar types and are shown with their decimal and hexa-decimal addresses (these correspond to the six LSBs of the data you put into the on-board RAM).

The table also shows the duration of each sound at a nominal 3.12 MHz clock frequency and gives an example or two of the sound in a word context. Notice that alternatives are given for some sounds and that short pauses are recommended before some and after others to make them effective. Try the example words to get a feel for what constructions are needed in different circumstances.

Once you have mastered the allophone set, and can produce understandable speech, you are ready to give it some life. This is where the two MSBs of the data come in. With these you can change the pitch (and duration) of the allophone immediately *preceding* the one whose six LSBs you are setting. By experimenting carefully, you should be able to make much more natural sounding speech rather than the monotonous, flat sound usually associated with computer speech.

Sound Type	Symbol	Code		Duration	Example	Notes
Voiced Fricatives	/VV/	23	35	190ms	Vest	
	/DH1/	12	18	290ms	THis	
	/DH2/	36	54	240ms	baTHe	
	/ZZ/	2B	43	210ms	Zoo	
	/ZH/	26	38	190ms	pleaSure,	aZure
Voiceless Fricatives	/FF/	28	40	150ms	Food	These allophones may be used doubly for initial or singly for final positions.
	/TH/	10	29	180ms	THin	
	/SS/	37	55	90ms	veST	
	/SH/	25	37	160ms	SHip	
	/HH1/	1B	27	130ms	He	
	/HH2/	39	57	180ms	Hoe	
	/WH/	30	48	200ms	WHig	(see also /WW/)
Voiced stops	/BB1/	1C	28	80ms	riB	Usually need 10-30ms silence preceding these.
	/BB2/	3F	63	50ms	Beast	
	/DD1/	15	21	70ms	enD	
	/DD2/	21	33	160ms	Down	
	/GG1/	24	36	80ms	Guest	
	/GG2/	3D	61	40ms	Got	
	/GG3/	22	34	140ms	peG	
Voiceless Stops	/PP/	09	9	210ms	Pow	Usually need 50-80 ms silence preceding these.
	/TT1/	11	17	100ms	parTs	
	/TT2/	0D	13	140ms	To	
	/KK1/	2A	42	160ms	Can't	
	/KK2/	29	41	190ms	speaK	
	/KK3/	08	8	120ms	Crane	
Affricatives	/CH/	32	50	190ms	CHurCH	
	/JH/	0A	10	140ms	JudGe	
Nasal	/MM/	10	16	180ms	Milk	
	/NN1/	0B	11	140ms	thiN	
	/NN2/	38	56	190ms	No	
	/NG/	2C	44	220ms	aNGer	

Table 2 continued.

PARTS LIST

RESISTORS (¼W 5% carbon film)

R1	220R
R2	4k7
R3,4	3k9
R5,6,7,8	1k0
R9	15k
R10,13,14	33k
R11	10k
R12	100k
RV1	22k lin min. horiz. preset
RV2	10k lin min. horiz. preset

CAPACITORS

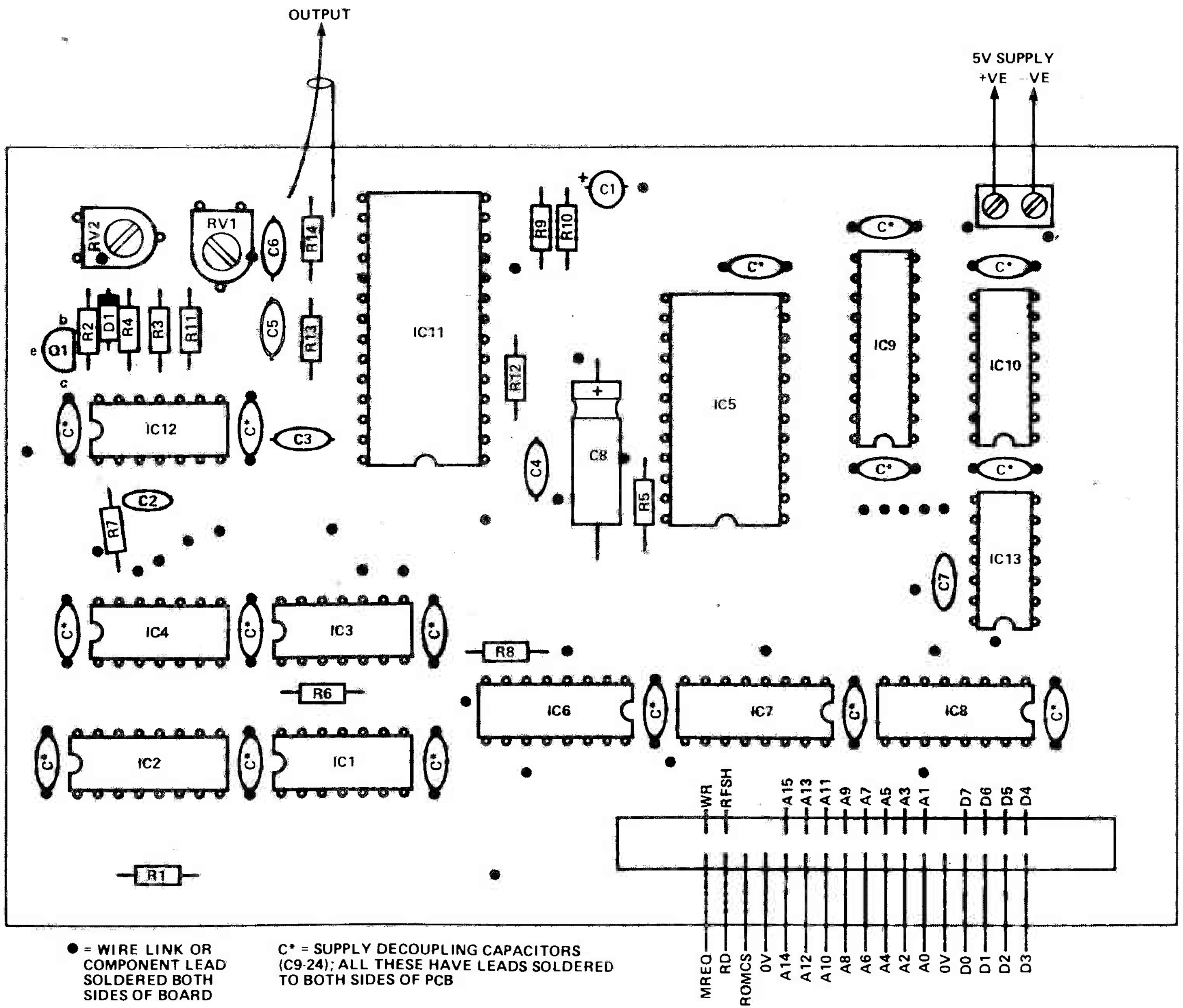
C1	10μF 25V tantalum bead
C2	68pF
C3,5,6	22nF
C4	100nF
C7	220pF
C8	100μF 16V axial electrolytic
C9-24	47nF ceramic

SEMICONDUCTORS

IC1	74LS02
IC2	74LS138
IC3	74LS10
IC4	74LS125
IC5	6116
IC6,7,8	74LS193
IC9	74LS245
IC10	40103
IC11	SP0256-AL2
IC12	74LS624
IC13	74LS122
Q1	BC212L
D1	1N4148

MISCELLANEOUS

34 PCB plug plus socket; ribbon cable to suit; PCB mounting screw terminal, 2-way; IC sockets; PCB; wire, etc.



● = WIRE LINK OR COMPONENT LEAD SOLDERED BOTH SIDES OF BOARD

C* = SUPPLY DECOUPLING CAPACITORS (C9-24); ALL THESE HAVE LEADS SOLDERED TO BOTH SIDES OF PCB

Z80 DRAM

We publish a superb project like Bob Campbell's 64K DRAM board for 6502/6800 systems and instead of gratitude, all we get are hundreds of letters asking for a Z80 version. Here it is then, you ungrateful lot, and don't forget to say "thank you"!

When I set out to design the DRAM Board (published in ETI Sept. 83) I had no intention of considering its use with the Z80 processor. However, the question "Can it be done?" provides a good introduction to the many considerations that must be given to the peculiarities of the Z80 when designing almost anything for it, not least a dynamic memory system.

Since this is to be an add-on or an extension to an existing system we must first consider the probable target system and the alternative solutions to the 'maximum memory objective'.

Probable target computers include:
- Z80 Systems with some dynamic memory, 16K eg. TRS-80, Video Genie;
- Z80 systems with little or no memory, eg. Home Brews, μ-Professor;
- ZX80, ZX81, ZX Spectrum, are not worth considering as they already have very comprehensive and cheap support.

There are three distinct solutions to satisfy the first two users. They are:-
1. Modify the DRAM Board to suit the Z80.
2. Design a new board to take in all the advantages of the Z80 using similar techniques and with the same overall objectives.
3. Replace and extend an existing 4116 based system with 64K chips (this applies to the first user only) using the original PCB, with either complete re-decoding using a PROM or modifying the existing TTL decoding on board. This option will probably end up with the system ROM still within the memory map, ie. decoding 16K blocks and upgrading to 48K from 16K.

Modifying the DRAM Board

Consulting the circuit diagram from the original article, it can be seen that only three signals other than the address and data buses are taken from the system. These are R/W, Φ1 and Φ2. To use the board with the Z80 these signals must be mimicked in such a way that they satisfy both the requirements of the board and the processor itself.

Assuming for the moment that the discrete refresh counter, IC1, is to be retained, then the following observations can be used as a guide to the final design:

R/W — this signal is high during a read cycle and low during a write to memory cicle;

Φ1 — this signal, or more accurately, the rising edge of it initiates the refresh cycle, and also clocks the refresh row address counter;

Φ2 — this is slightly more complex as it signifies both a valid address and the start of a memory access cycle, read or write.

Obviously the R/W line is the simplest and in fact WR can be substituted directly in it's place. RFSH, the Z80 signal, performs a similar function to Φ1 although it is inverted, ie negative true, and thus must be inverted before substitution. MREQ is very similar to Φ2 although again it is inverted, ie active low. One other slight complication is that MREQ becomes active during the refresh cycle RFSH. Obviously this situation must be distinguished from a true memory access cycle.

Combining all these conditions, the two necessary logical signals can be arrived at, namely MC and RC Memory and Refresh cycle start; note that both have active rising edges. The two equations are:-

$$\overline{\text{MREQ}} \text{ and } \overline{\overline{\text{RFSH}}} = \text{MC}$$

$$\overline{\text{RFSH}} = \text{RC}$$

These two equations can be resolved into a logical circuit in the usual way, ie, hard slog, copy someone else, intuitively or by guess work. However it is arrived at, it should look something like Fig. 1. The prime (') on any signal indicates that it is a substitute.

This solution will work in principle; however the timing constraints of the board as a whole,

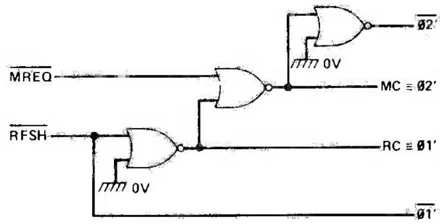


Fig. 1 Generation of Φ1 and Φ2 from RFSH and MREQ.

and particularly those of the 74LS608, are such that it will probably not work without adjusting the timing components around IC17.

A slightly better solution becomes apparent from the timing diagrams of the Z80. Consider the same situation which we have just tried to avoid, MREQ becoming active during RFSH. Taking cycle T3 in Fig. 2,

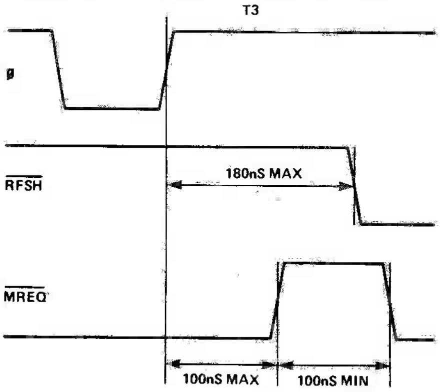


Fig. 2 Diagram showing the timing of the Z80's MREQ and RFSH functions.

only in the worst possible case can MREQ become active before RFSH. Thus MREQ could be used as a cycle start directly, and that means for both refresh and memory access cycles. In fact most systems using dynamic memory use MREQ as RAS and generate ROW/COL and CAS by delay lines from that active edge. Delay lines are to be avoided if at all possible, but unfortunately this is not always so in DRAM design. The second solution now looks like Fig. 3; this is much simpler than all the others and should work very well, in theory at least. The need for the two signals Φ1 and Φ2 to control the address and data buffers means that the circuit is still more complex than it might be.

Further improvements can still be made to the circuit by using the Z80's on chip refresh row address counter.

During RFSH, the CPU puts out on the lower seven address lines a refresh row address which is cycled through 0-128, incrementing once very M1 cycle. Using this address the 393, IC1, can be dispensed with, and the 244 that goes with it, IC2. Since the Z80 refresh address is only seven bits wide, the TMS 4164 cannot be used as it requires an eight bit, 256 cycle refresh. The 4864 64K x 1 bit memory and its derivatives (see Table 1) use a 128 cycle 2ms refresh cycle and thus only require seven refresh address bits, and these should be used instead.

Using the Z80 refresh address counter in this way requires the primary address buffer IC 11 to be enabled on both the refresh and memory access cycles, and the address multiplexers, IC 12 and IC 14, to present the lower 8 bits A0-A7 and the upper 8, A8-A15, of any address separately. In other words, the lower 8 should be on the "a" side and the upper 8 on the "b" inputs to the multiplexers, or vice versa but not intermixed. All these modifications could be made, and the timing corrected to suit and a PROM programme devised etc, but unless there is a pressing reason for the DRAM board to be used in this way for a Z80 application, I would advise against it. There is a great deal more to be gained by using a purpose designed Z80 RAM Board.

Such a design is presented here and the advantages are clear, but first some notes on converting the 16K 4116 system such as that of a TRS-80 or Video Genie.

16-48K Upgrade

Those computers already using the 4116 dynamic RAMs obviously have the necessary circuitry to produce the signals to drive the RAMs properly. Those signals, including the address multiplexing, are usually controlled by the decoding circuitry, by gating either CAS and/or the enable for the output/input buffers. The main difference between a 16K 4116 and a 64K 4864 memory array is the 'width' of the decoding, A7 and the supply rails. Looking at the pin configuration of the two RAM chips reveals that only three pins are different, see Fig. 4. So with the minimum of modifications it is a relatively simple matter to swap the two using the original PCB.

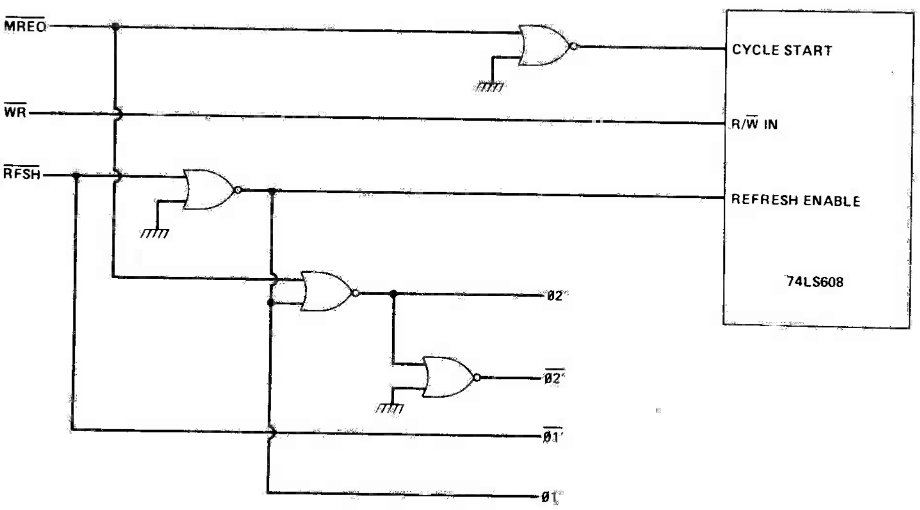


Fig. 3 Using MREQ as a direct start for both refresh and memory access cycles.

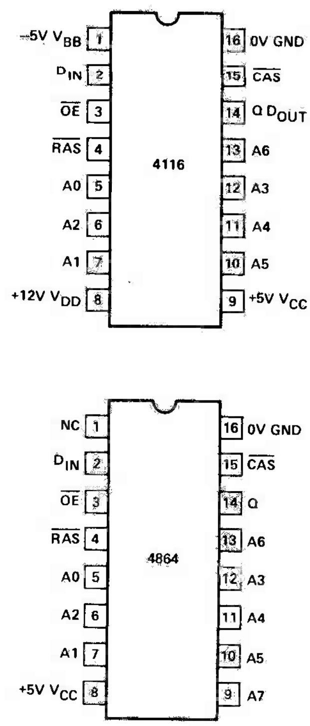


Fig. 4 Pinouts of the 4116 and 4864 DRAMs.

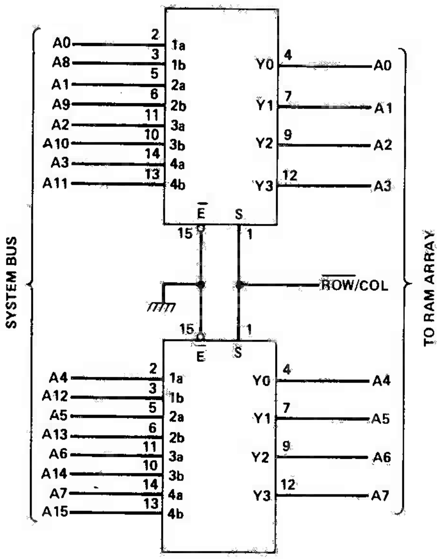


Fig. 5 Modified address multiplexer arrangement.

Modifying the power supply lines is the first and the simplest of the changes necessary:

PIN 1 V_{bb} −5V: this track should be disconnected, at both ends of the RAM array, from the −5V supply; furthermore all the capacitors on this line between it and either ground, +5V or +12V should be removed. The track now takes no further part in the circuit until we upgrade to 256Ks!

PIN 8 V_{dd} +12V: this now becomes the +5V, ie V_{cc}, line on the 4864; thus it should be disconnected from the original +12V supply and reconnected to a suitable point on the computer's +5V circuit. Any capacitors between it and ground should be retained; there is usually one per IC, and if there is not, additional ones should be added; 1µF tants or 0.1 µF MKC will do.

PIN 9 V_{cc} +5V: finally, this track becomes the additional address line A7. It should be disconnected from the +5V supply and all the attached capacitors removed. The now isolated track should be connected to the unused output of the address multiplexers. Normally these are a pair of 74LS157s. The remainder of the circuitry around the RAM array is identical to the original 4116 regime.

The modification to the address multiplexers, which usually consist of two 74LS157s, is dependent upon the specific system. The normal approach is to have only A0-A13 inclusive connected to the inputs of the multiplexers. Both A14 and A15 must now be added to these and should correspond to the new output just connected to A7 pin 9 on the RAMs. Thus the final circuit should look something like Fig. 5. The main thing is that A0-A6 are all on one side of the multiplexer's inputs, ie, all a's or all b's.

Finally, the last modification is to the decoding circuitry, and this is probably the most machine dependent modification of all. Of the numerous systems in use, the most common is to gate the CAS signal to the appropriate RAM block through a tri-state buffer. It is necessary only to increase the decoding to this buffer to enable the new areas of RAM.

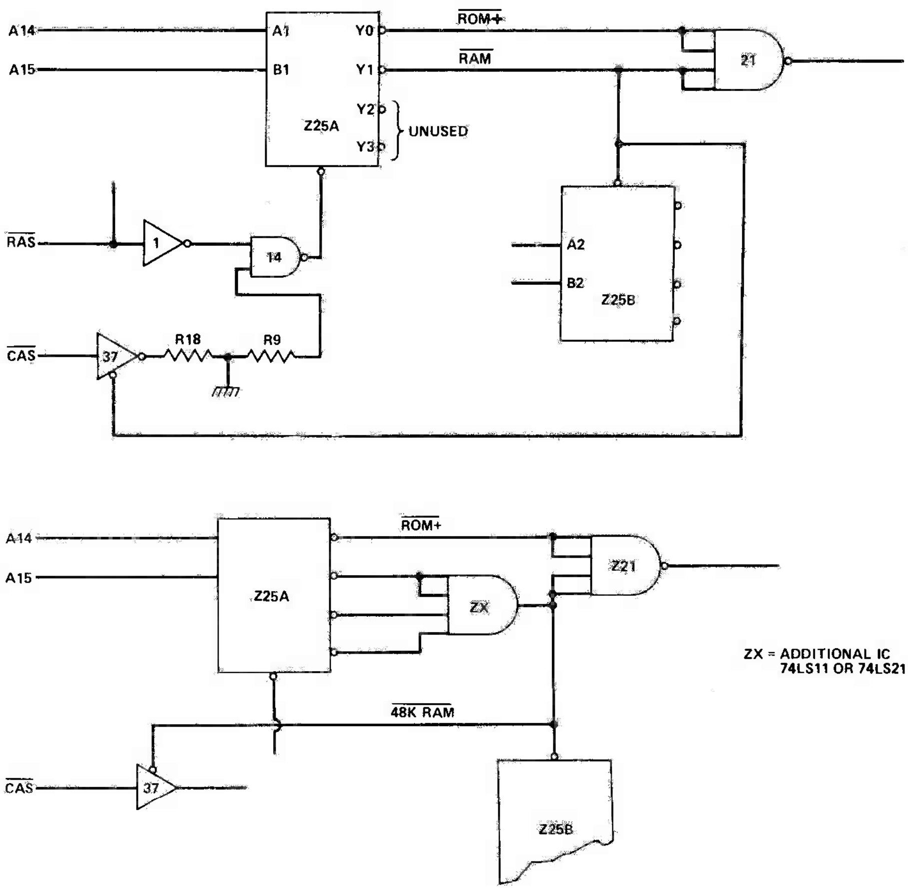


Fig. 6 Decoding circuitry of the Video Genie a) before and b) after modification.

Type No.	Manufacturer	Refresh Cycle		
TMS 4164	Texas Inst.	8 bit	256 cycle	4 ms
TMM 4164	Toshiba	7	128	2
HYB 4164	Siemens	8	256	4
2164	Intel	7	128	2
HM 4864	Hitachi	7	128	2
MCM 6664A	Motorola	7	128	2 or pin 1
MCM 6665A	Motorola	7	128	2
µPD	NEC			
MK	Mostek			
IMS 2600	Inmos	8	256	4
NCM 4164	National Semi.	8	256	4
F 4164	Fairchild	8	256	4
MB 8264	Fujitsu			
MB 8265	Fujitsu	pin 1		
MSM 3764	OKI Semi.			

Table 1 Comparison of 64K DRAMs.

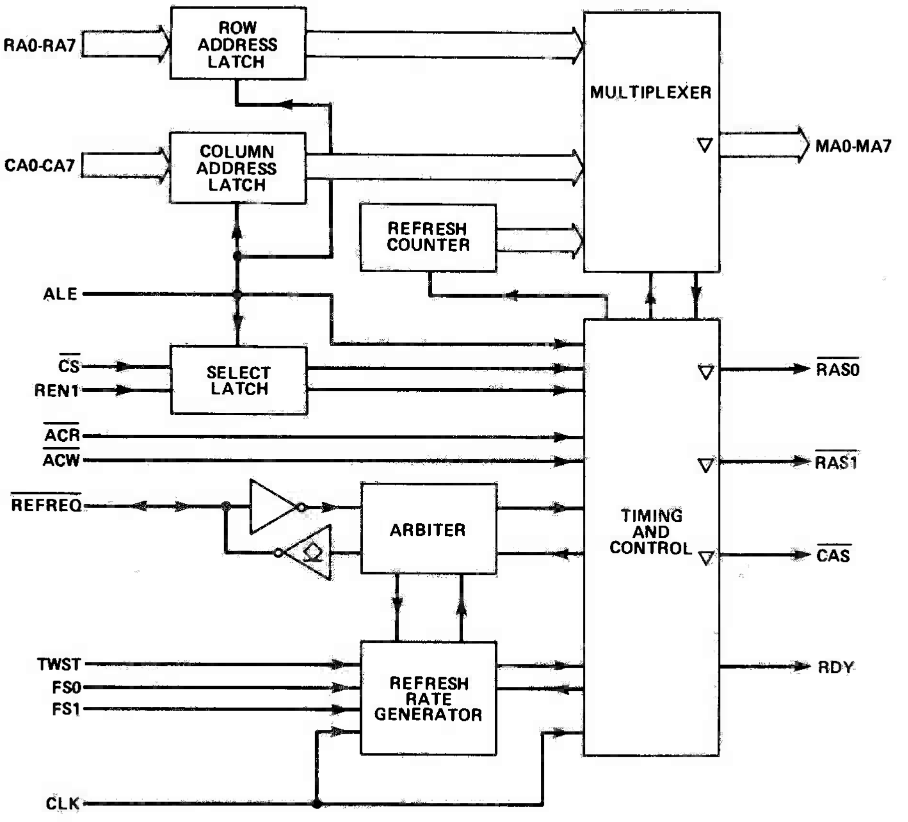


Fig. 7 Block diagram of the TMS 4500A DRAM controller.

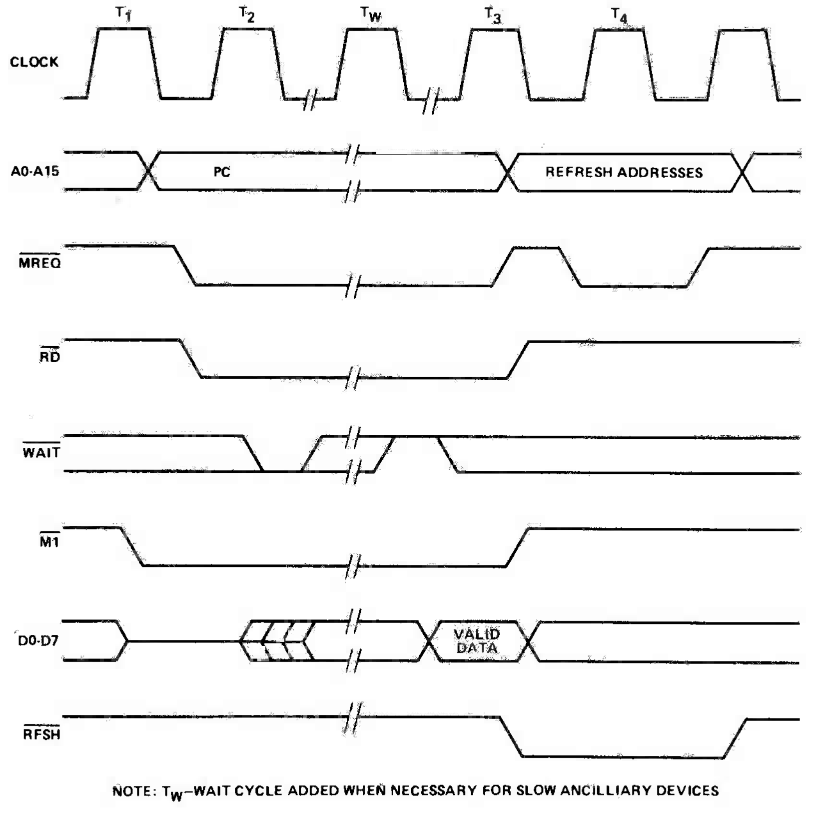


Fig. 8 Timing diagram of the Z80 CPU.

There are two distinct ways of doing this; one is to extend the existing decoding and the other is to use a PROM in a way similar to the original DRAM Board design. The latter approach would follow almost exactly the DRAM design, and those of you wishing to attempt that will find enough information in the original article.

The much simpler approach, if not as profitable in terms of added memory, is to modify the existing decoding. Normally the memory map is decoded into four 16K blocks at the primary decoding level, and by using the unused blocks within the memory map the usable RAM can be expanded. Using the Video Genie as an example, the original circuit is shown in Fig. 6a, and the modified one in Fig. 6b. In the latter the two unused outputs of the 74LS139 (Z25) are combined to give a total RAM area of 48K. Note that there is an unused 16 pin socket on the main PCB which can be used for the additional IC.

It can be seen then that the 4864/4116 replacement technique is relatively simple and produces a very neat and reliable 32K expansion to the average system. To go further than the 32K addition requires more effort and the advantages of retaining the RAM on the original PCB become less: the purpose-built Z80 64K RAM card then comes into its own. As with the original DRAM Board design, it can be designed to be as flexible as possible, thus allowing for all the vagaries that can and do exist in the original target system. The power on jump vector, which tricks the CPU into thinking that there is EPROM at 0000 hex at restart only where there is actually RAM, is the most common difficulty to overcome. Note that this is a must for CP/M systems.

The concluding part of this article in next month's ETI will describe the new DRAM board for use with Z80 microprocessors.

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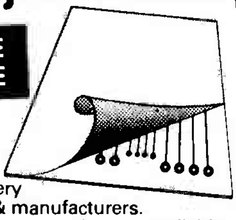

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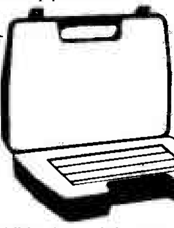

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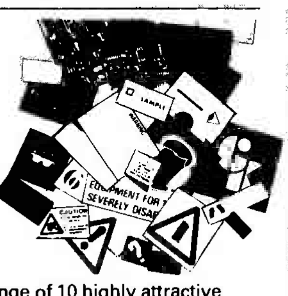

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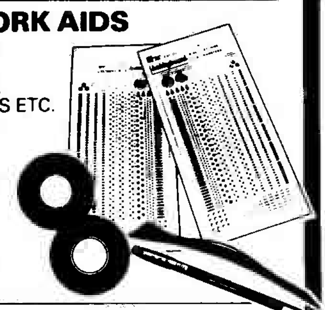

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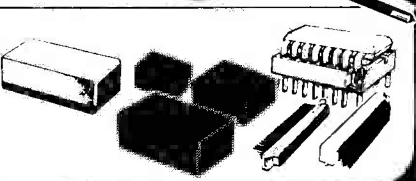

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REVIEW: EC50 SOL

There could be a whole new generation of soldering irons just around the corner. Dave Bradshaw has been trying his skills on the EC50 iron from Litesold.

It is one of my few beliefs that one of the largest impacts that electronics will have on the world is to make hitherto 'stupid' devices 'intelligent'. By this, I mean that vacuum cleaners, as an example, may have the ability to modify the power going to the motor to prevent the usual off-load 'racing' that often occurs, and, possibly, to reduce the noise (if you have ever used an industrial cleaner, you'll understand the need for this latter point).

So it is not a little ironic (if you will excuse the impending pun) that soldering irons haven't changed all that much — most of those in use in hobby circles are pretty primitive specimens.

Actually, manufacturers have a somewhat impressive term for the sort of iron that just about everyone has — they call them **thermally balanced;** this means that the iron's temperature will settle at the point where the heat input is equalled by the convection and radiation losses from the bit and barrel and conduction losses into the handle.

When the iron is applied to a workpiece, the temperature of the tip will inevitably drop. The iron will then have to recover after removal off the job. The heat that goes to the job comes from both the heat stored in the iron before contact (the heat is stored in the thermal capacity of the materials in the bit and element) and from the heat being generated in the iron.

It is here that there is a conflict of design requirements. A fairly massive iron would be able to solder larger jobs than one with a lower capacity, because it would have a larger reservoir of stored heat to give to the job. However, it will take a lot longer to heat up a more massive iron (as well as to cool it down) and it will, after a fairly largish heat outflow, take longer to recover; also it will probably be less convenient to use because it will be 'bit-heavy.

To get round this you can increase the power of the element. If you've ever had to solder with a more powerful iron than you would normally use, you'll probably have found, as I have, that in some ways it's a lot more convenient than using a small iron. The element is so hot that anything you apply the tip to is heated up in no time at all, and you can work a lot faster than normal. However, the crunch is that a larger power almost invariably means a longer barrel, or a much hotter tip, or both. A longer barrel means that soldering any number of joints is very tiring, because it's that much more difficult to position the bit accurately. A hotter tip means that you run the risk of destroying delicate components or of stripping off PCB foils.

All this said, it's really quite surprising that simple, thermally balanced soldering irons work as well as they do! However, if you're going to be a serious constructor, it's almost inevitable that you will have to buy two or possibly even three irons of different sizes to make it possible to deal with all the soldering requirements you are likely to meet.

Soldering Electronic

Well, the obvious thing to do is to have some form of electronic control over the heat supplied to the soldering iron element. This is relatively simple in principle — a temperature sensor in the element is linked to some electronics that turns the element on whenever the temperature drops below a selected value. The problem is that the way that this is usually built is to have a separate control unit, with a special iron that can be used with only that particular unit. This is done because it is easiest to control a low voltage — so the control units have largish transformers in them to supply the low-voltage soldering iron element as well as the control electronics (it goes without saying that the element of a controlled soldering iron is usually rather more powerful than that of the equivalent thermally balanced unit, otherwise the controlled iron would actually be worse than the balanced unit).

This has two main disadvantages: firstly, it makes the soldering iron/control unit expensive — you'd be hard put to buy a controlled iron with control unit for under £50; secondly, it makes the iron a lot less convenient to cart around.

Even with a separate control unit, you don't always get a particularly flexible unit — with many of them, to alter the bit temperature you have to change the bit itself. This means that you have to let the iron cool off first!

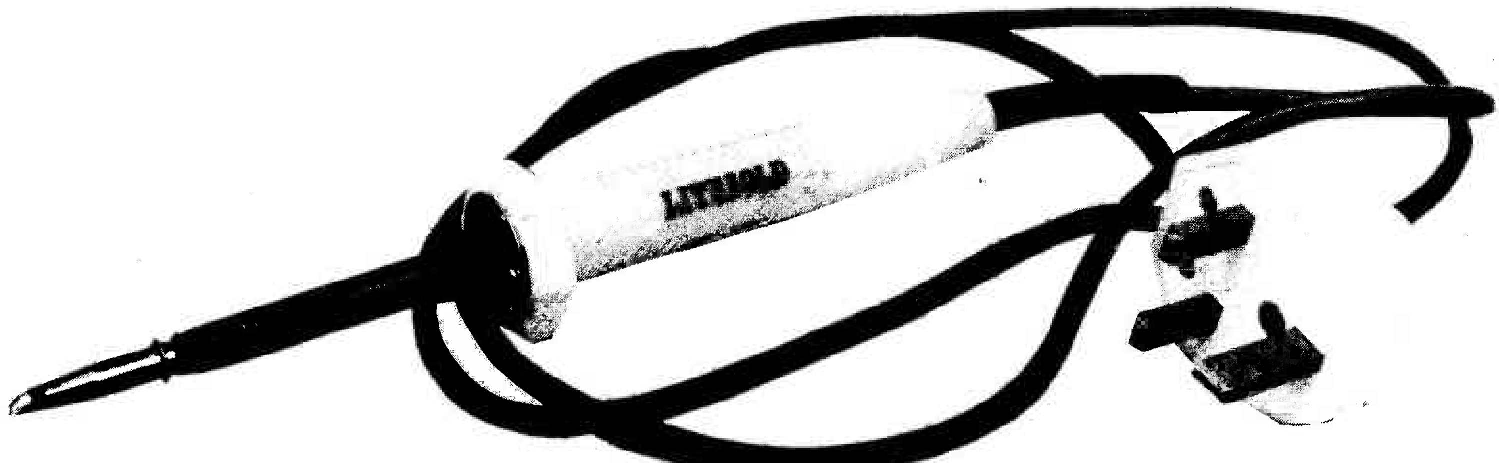
Some irons have been made that have a controlled temperature and don't need a separate unit; however, until recently, so far as we know these were not electronic — they used either the Curie point or some sort of thermal expansion effect to open and close mains contacts, with the resulting questionable applicability to delicate (particularly CMOS) electronics.

Enter The EC50!

It is on to this scene that Litesold have launched the EC50. This is an electronically controlled soldering iron but with all the electronics mounted in the handle. Don't worry, there isn't a mains transformer in there too, the element operates at mains voltage and is switched on and off by a triac at zero crossing.

To supply the electronics, Litesold have come up with a rather neat trick — and before other manufacturers copy it, I must point out that it is the subject of

DERING IRON



The soldering iron is shown at about 65% actual size here.

a patent. Like all really good ideas, it seems so obvious that you wonder why no one thought of it before.

The trick is this: to get the correct supply voltage for the electronics, some sort of mains dropper is required. A dropper resistor is used, but rather than being in the handle, where its eight watts of disipation would make the iron uncomfortable to hold, it is wound onto the element itself, as a separate winding, so it contributes towards the heating of the element.

The temperature of the element is monitored by a thermistor mounted right up at the top end of the element, so it actually sits inside the bit. According to Litesold, this thermistor is the single-most expensive bought-in component in the iron! The temperature of the iron can be set using a control on the side of the handle.

Inside is a rather friendly neon (I'm afraid that I'm an old reactionary in that I prefer neons to LEDs as indicators!) which indicates both when the mains is applied to the iron and when the element is on. One gripe I would make about soldering irons in general is that there is no indication of when mains is being applied — how many of you (like me) have picked up a soldering iron by the wrong end, thinking that you'd switched it off some time before? Wouldn't it be a good idea if more irons had indicators in their handles?

In Use

Well, no matter how elegant the ideas that went into the iron, the crunch issue is how well it performs. This I, and a few other members of the ETI team, were only too pleased to put to the test.

First of all, I tried some PCB assembly work using the standard bit. The PCB I assembled did have 0.1" spaced DIL ICs on it; however, there was no tracking inbetween the pins. Using the standard bit, soldering was a bit tight, although possible to get a reasonable job (I'm not the world's most fussy solderer anyway!). Later, Phil Walker assembled one of our 64K DRAM boards using the iron but with a special fine-work bit, and his conclusion that this was actually easier than using his usual iron, which is a soldering station with a pointed bit.

The heat supplying capabilities of the iron were not exactly taxed by this trial, so off I went, scurrying down into my cellar to see what I could find. After beating off monstrous spiders, creepy-crawlies, etc, I eventually uncovered two items of valve gear — one was an oscilloscope that I built many moons ago, and the second was an old "Williamson' valve amplifier that had been donated to me by the father of a friend (it's amazing how junk cupboards give up their wares to you when you mention that you're interested in electronics!).

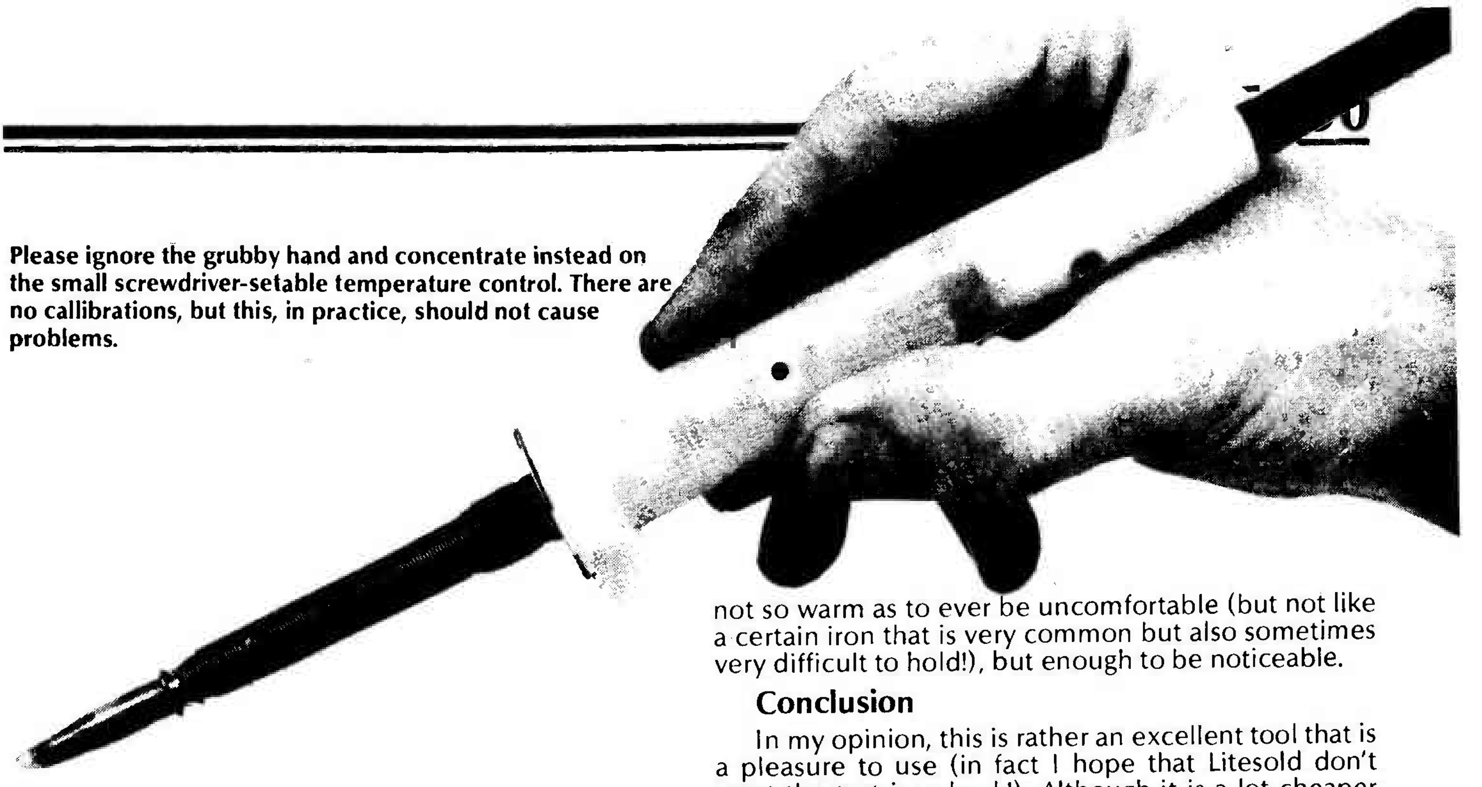
The oscilloscope had been assembled using a 25W iron, coincidentally also made by Litesold but a rather older vintage, so it was not that surprising that I could find nothing in it to tax the iron. However, the amplifier was a different matter.

It was built using a hefty piece of copper wire as a busbar earth line; besides this it used paper smoothing capacitors as there used to be a time when people thought that unpolarised capacitors 'sounded' better than electrolytic ones (I've heard that somewhere before. . .). These capacitors have massive metal terminals, and it looked as though they had been soldered to the busbar using a blowtorch (perhaps I exagerate a little, but only a very little!). Here was a test!

However, the iron coped admirably with these joints, making it possible to dismantle them and make them up again — though this was the only time that I saw the second section of the indicator neon on for any noticeable period.

Finally, I used the iron to solder some rather awful cheap PCB board that I was foolish enough in my youth to build a whole audio amplifier with. The board is made fom paxolin, and the copper has a very bad tendancy to lift off when any heat is applied to it, making periodical repairs to the amplifier a nightmare.

At first, I used the iron at its temperature setting as delivered (this is the setting that it was used on for the other jobs in this report). With this setting, the foil lifted fairly quickly after application of the iron. However, turning the iron's temperate down to minimum made it possible to solder without the foil lifting — although the fluxes in the solder will



Please ignore the grubby hand and concentrate instead on the small screwdriver-setable temperature control. There are no callibrations, but this, in practice, should not cause problems.

obviously have a lower scouring effect at this lower temperature, making it necessary to tin all component leads beforehand.

Ian Pitt reports that he tried using the iron for a number of unusual jobs, including soldering together the joint of a small pair of scissors and soldering metal contact straps onto RR size NiCads, all of which the iron did successfully.

The only grumble that we all had about the iron was that the handle got slightly warm in one place — not so warm as to ever be uncomfortable (but not like a certain iron that is very common but also sometimes very difficult to hold!), but enough to be noticeable.

Conclusion

In my opinion, this is rather an excellent tool that is a pleasure to use (in fact I hope that Litesold don't want the test iron back!). Although it is a lot cheaper than a soldering station, it is still around four times the price of a conventional soldering iron, so you would have to do quite a lot of soldering to justify the cost. That said, for use away from the bench, it is obviously much more convenient to be able to carry just one iron rather than several.

The EC50 costs £26.19 direct from Litesold, and this price includes P&P and VAT. Litesold's full name is actually Light Soldering Developments Limited, and they may be found at 97/99 Gloucester Road, Croydon, Surrey CR0 2DN, telephone 01-689 0574/5/6.

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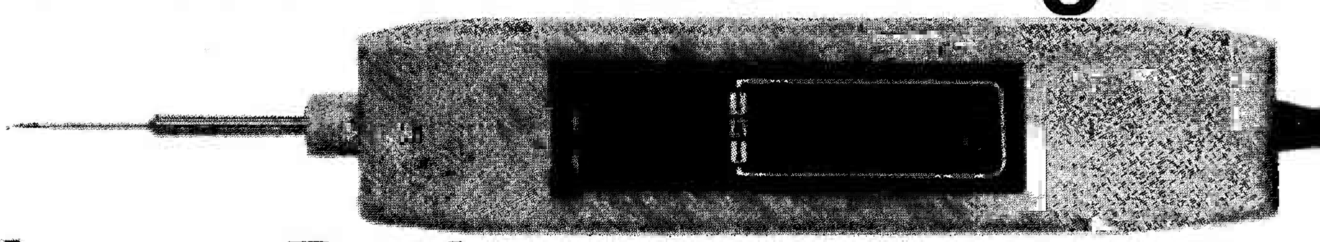

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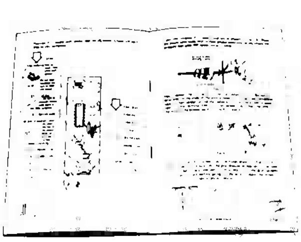

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BENCH POWER SUPPLY

The floor is littered with exhausted HP2s, your home-made solar power plant has started its winter hibernation, and the gerbil hasn't spoken to you since you attached that dynamo to its exercise wheel. ETI to the rescue with a superb bench power supply unit from Grenson.

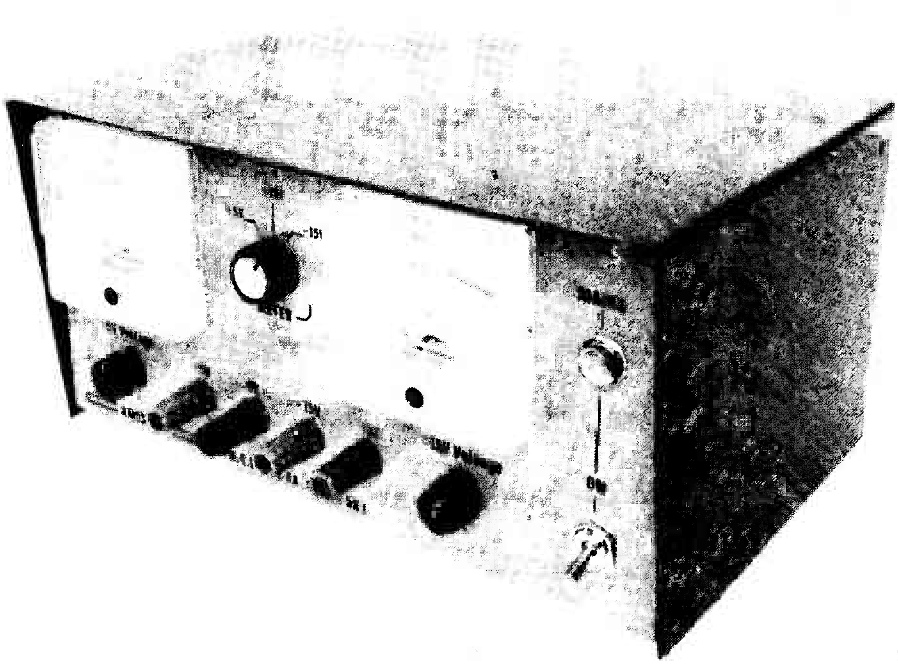
Bench power supplies rarely come high on the electronics enthusiasts' list of essential test equipment. There must be many who, having acquired a multimeter, 'scope, and possibly a signal generator, are then content to go on powering their high-tech lash-ups from a string of dry batteries. Yet for the really serious experimenter a power supply is virtually an essential, the only practical means of obtaining multiple and dual rail supplies which are reasonably stable and can be varied in voltage. Even people who only use their equipment and skills to construct projects from magazine articles (ours of course!) or to repair ailing electrical equipment are bound to wish they had one sooner or later. How many pieces of battery-operated equipment have you tried to repair in which the battery compartment becomes unusable as soon as the case halves are separated?

Fear not, gentle ETI readers, salvation is at hand. The ETI bench power supply does just about everything you could reasonably ask of such a unit, costs much less to build than equivalent commercial designs, and is even available as a full kit of parts. It has outputs of +5V, +15V and −15V all of which can be varied, and two meters measuring voltage and current which can be jointly switched to monitor any of the outputs. The +5V supply gives 2.5A and is variable over the range 3-8V. The +15V and −15V supplies give 0.5A each and are variable over the range ±8 to ±16V; a single control varies both supplies, the negative output accurately tracking the positive one to ensure that the two are balanced at all times. All supplies are protected against overload and against external voltages injected into their outputs.

Construction

The PCB should be assembled first, inserting solder pins then small components such as resistors and semicoductors before the capacitors. Ensure C5 and C11 have M4 fibre washers fitted over their legs before soldering them onto the board. This will prevent solder flowing through PCB holes. Check the polarity of all the components, particularly diodes and capacitors as these will be destroyed if fitted incorrectly. All wirewound resistors and diodes need to be mounted at least ⅛" clear of the board to prevent heating of the SRBP material. This is particularly important with D1, D2, D3 and D4.

If you are not building the power supply from the kit, you



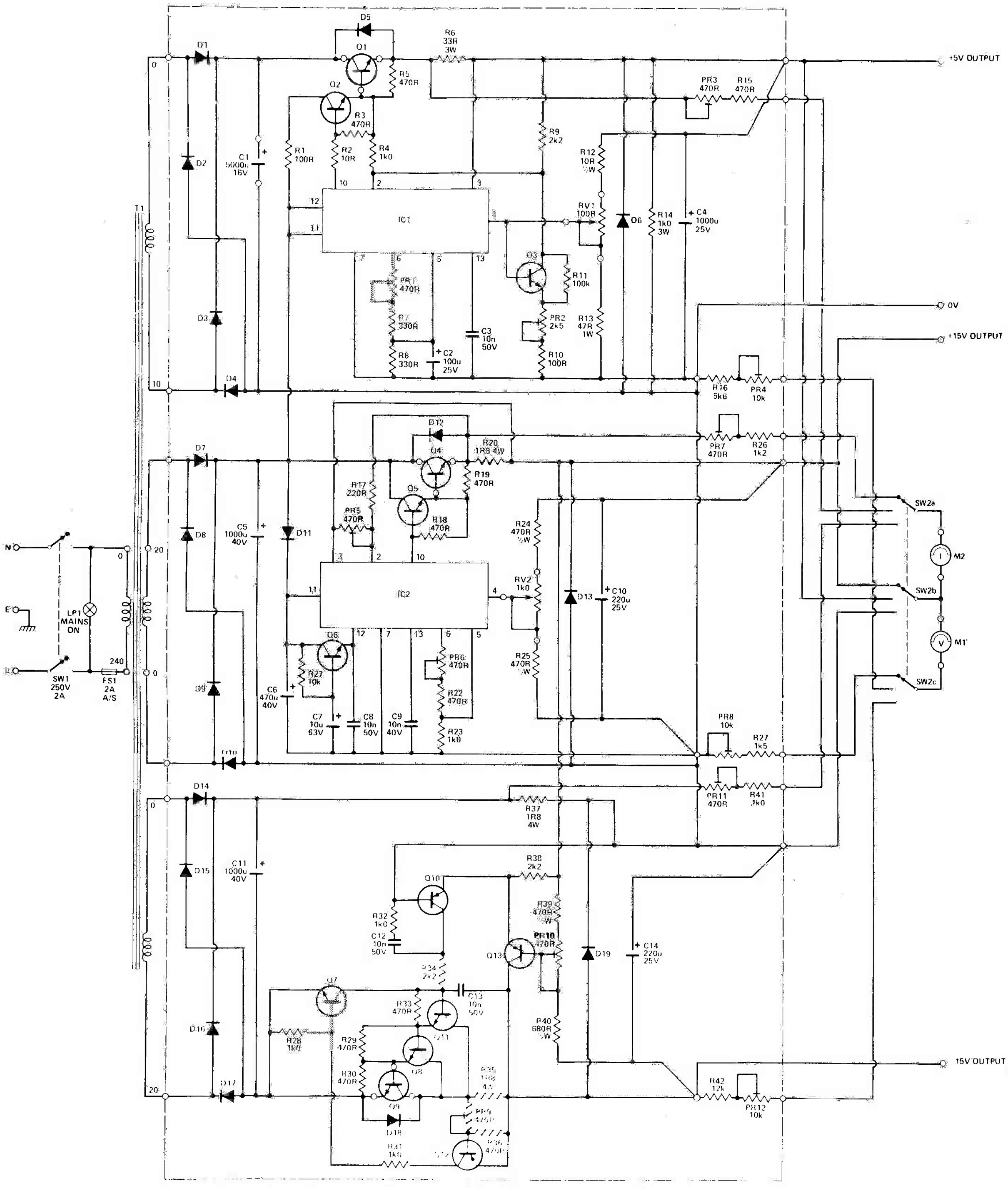


Fig. 1 Circuit diagram of the bench power supply unit.

Reservoir capacitor voltages

the voltage on	C1	should be approximately	+13.5
" " "	C5	" " "	+29
" " "	C11	" " "	−29

Power transistor voltages

		collector	base	emitter
TR1	(+5V supply)	+13.5	+5.6	+5.0
TR4	(+15V supply)	+29.0	+15.6	+15.0
TR9	(−15V supply)	−15.0	−28.2	−28.7

IC voltages

	pin	4	5	6	7	10	11	12
IC1	(+5V supply)	+2.3	+2.3	+7.2	OV	+6.2	+28.3	+28.4
IC2	(+15V supply)	+3.8	+3.8	+7.2	OV	+16.2	+28.0	+26.5

Table 1 Voltage check list to aid trouble-shooting. The measurements were made with the unit running from 240V mains, the outputs set at +5, +15 and −5V, no output loads, and with respect to OV.

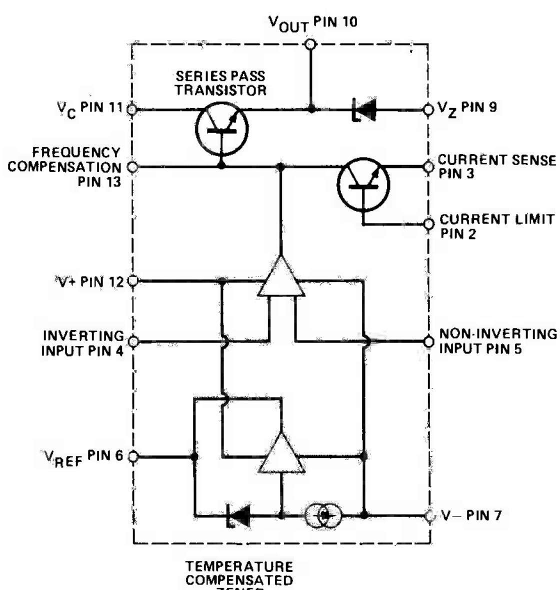


Fig. 2 (left) Equivalent internal circuit of the MC1723.

BUYLINES

A complete kit of parts for this project will be available from Grenson Electronics Ltd, High March, Long March Industrial Estate, Daventry, Northants NN11 4HQ, tel 03272 5521. The kit will cost £48.50 plus £3.35 post and packing plus VAT, making a total of £59.62. Alternatively, the unit is available built and tested for £82 plus post, packing, and VAT, making a total of £98.15. Note that the PCB for this project will NOT be available through our PCB service.

HOW IT WORKS

10V is produced from the secondary of T1 and is full wave rectified via D1, 2, 3, 4. The resulting voltage is then smoothed by C1 and fed to Q1 collector, Q1 being biased on by Q2 which is in turn controlled via pin 10 by IC1. The output from pin 10 is determined by pins 4 and 5, both being inputs to the control amplifier on the IC. Pin 6 is a fixed reference of 7V and is trimmed by PR1 and fed to pin 5, while pin 4 senses the output voltage via the divider chain R12, RV1 and R13. Therefore RV1, which is situated on the front panel, controls the output voltage over the range 3V to 8V. The capacitor C4 is used as an output filter.

The voltage produced across wire-wound resistor R6 at high loads, ie greater than 2.5 amps, is used to operate the over current protection circuit. This circuit consists of R9, Q3, R11, PR2, R10 and pins 2,3, on the IC. The over current trip level is set using PR2 and is kept constant over the voltage range by the action of Q3. The over current mode on the +5V line has a foldback characteristic, which results in a short circuit current of approximately 1 amp.

The +5V line is protected from +ve or −ve voltages injected back into its output by D5 and D6. Full current and voltage metering is provided and is calibrated using PR3 to set the current meter and PR4 the voltage meter.

The +15V output is produced in the same way as the +5V output using the 723 linear regulator. The only difference in circuit terms is Q6 which ensures a smoother supply to run IC2 and the absence of Q3, which is due to the difference in over current protection. Whilst the +5V has a foldback mode the +15 and −15 both go into a constant current mode. The overload limit on the +15V is adjusted with PR5.

The output voltage is adjusted in the same way using RV2, and as on the +5V line the output is fully protected against misuse and the injection of other voltages by D12 and D13.

The −15V is produced in a different way to that of the +5V and +15V. It does not use an IC but has the control circuit constructed with discrete components. Q13 and Q10 are in a long tailed pair configuration and function as a virtual earth amplifier to control the base of Q11. Any error in the −15V output is corrected by reducing or increasing the drive on Q9 via Q8. Fine adjustments to align the −15V are made using PR10. Hence, when RV2 on the front panel is adjusted the −15V should track the +15V across it's entire range of 8-16V. Overcurrent on the −15 is the same as on the +15; constant current is adjusted by PR9. The circuit Q7, R28, R31, Q12, R36, PR9 is used in place of the IC as in +5, +15 for overcurrent protection on the −15V. The −15V supply is protected against misuse and injected voltages by D18 and D19.

Full current and voltage metering is provided for the ±15V lines and is adjustable using PR12 and PR11 for −15 and PR7 and PR8 for +15V. The 3 pole, 3 way rotary switch SW2 provides switching between outputs for the meters so that they can indicate voltage and current simultaneously for each line.

PARTS LIST

Resistors (all ¼W, 5%, unless otherwise stated)

R1 10	100R
R2	10R
R3, 5, 15, 18, 19, 22, 29, 30, 33, 36	47R
R4, 23, 28, 31, 32, 41	1k0
R6	R33 3W wirewound
R7, 8	330R
R9, 34, 38	2k2
R11	100k
R12	10R, ½W
R13	47R, 1W
R14	1k0 3W wirewound
R16	5k6
R17	220R
R20,35,37	1R8 4W wirewound
R21	10k
R24,25,39	470R, ½W
R26	1k2
R27	1k5
R40	680R, ½W
R42	12k

RV1	100R
RV2	1k0
PR1, 3, 5, 6, 7, 9, 10, 11	470R horizontal skeleton preset
PR2	2k5 horizontal skeleton preset
PR4, 8, 12	10k vertical skeleton preset

Capacitors

C1	5000u 16V electrolytic
C2	100u 25V electrolytic
C3, 8, 9, 12, 13	10n 50V ceramic
C4	1000u 25V radial electrolytic
C5, 11	1000u 40V radial electrolytic
C6	470u 40V radial electrolytic
C7	10u 63V radial electrolytic
C10,14	220u 25V radial electrolytic

Semiconductors

IC1, 2	MC1723
Q1, 4, 9	2N3232
Q2, 5, 8, 11	2N3053
Q3, 6, 7	BC107
Q10, 13	MM4002
Q12	BCY70
D1, 2, 3, 4, 5, 6, 12, 13, 18, 19	BY255
D7, 8, 9, 10, 14, 15, 16, 17	BYX36
D11	1N4148

Miscellaneous

M1, 2	1mA FSD meter
SW1	mains toggle, 2A 250V
SW2	3 pole, 3 way rotary switch

PCB; IC sockets; M4 fibre washers; Heatsinks; insulated terminals; mains fuseholder and fuse; knobs; mains neon; Case; mains cable and strain-relief bush; solder tags; insulating kits for the power transistors; nuts, bolts, washers, etc.

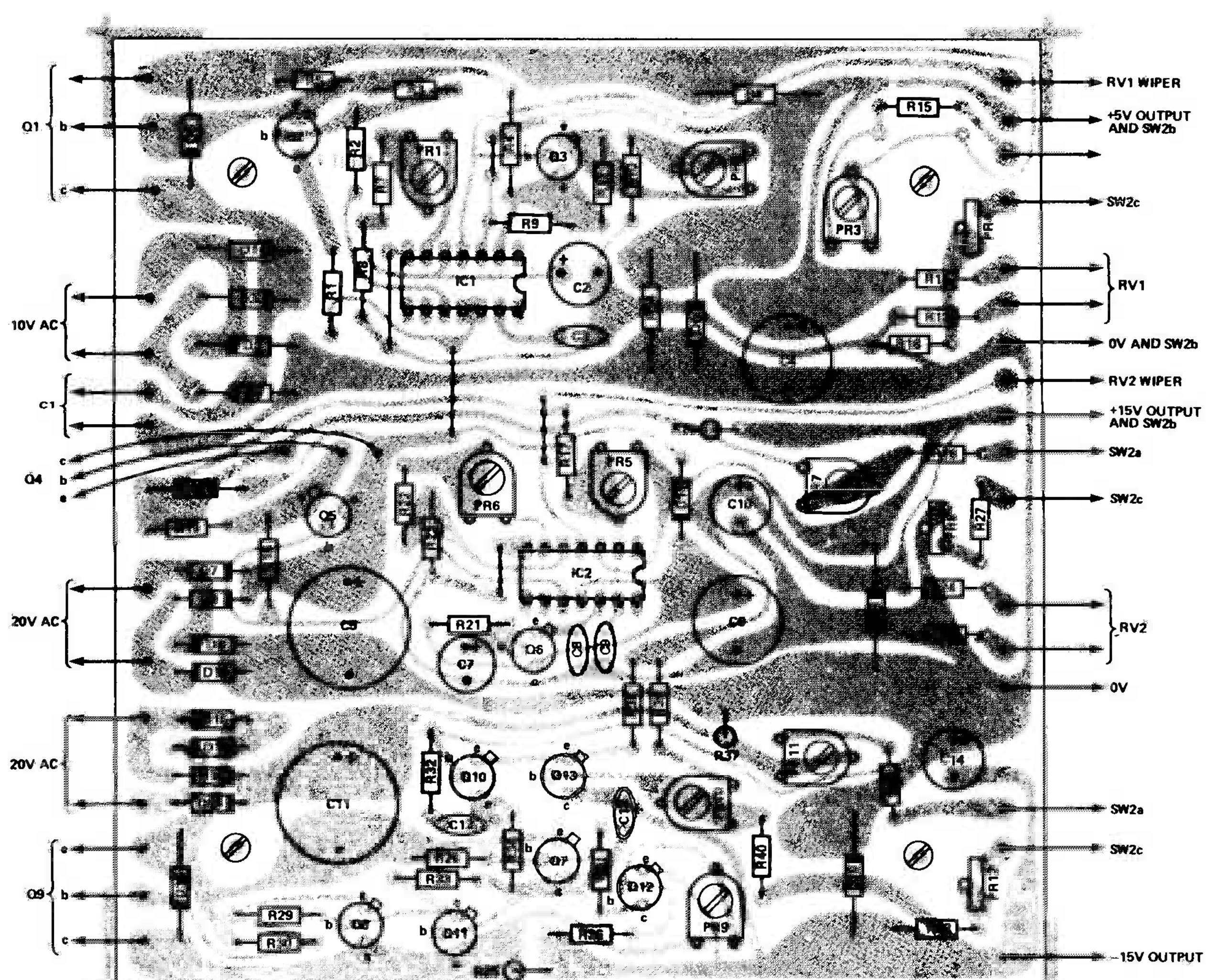


Fig. 3 Overlay diagram of the PCB.

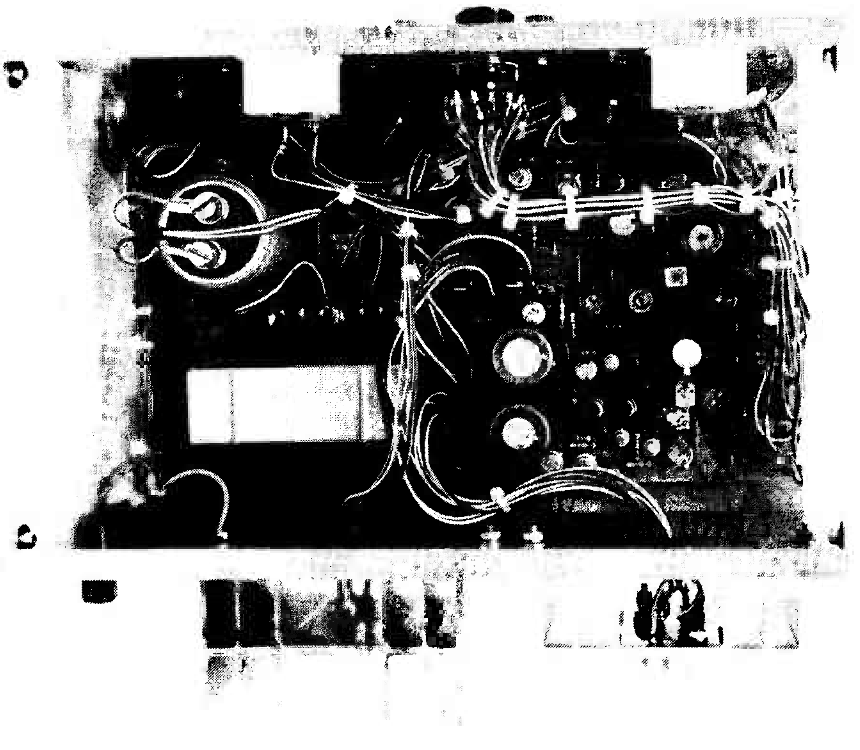
will have to find and drill your own case. The case supplied with the kit and used in our prototype measures about 265 x 130 x 180 mm, and almost any case of about the same size or a little larger should be suitable. However, you should bear in mind the weight of the transformer and choose a fairly sturdy case, preferably steel rather than aluminium. Drill out your case to suit the components, if possible following the layout used in the prototype and shown in the photographs, but don't worry if this proves difficult because the layout is not critical.

Mount all the front panel components except the two meters which are fragile and best left until last. The rotary switch, SW2, is best wired before fitting into place, but don't terminate the ends of the wires to PCB pins yet. Take care when tightening RV1 and RV2 as overtightening will cause damage to the potentiometers.

Wire RV1, RV2 and all of the output sockets to form a loop which passes horizontally behind the front panel slightly above the components concerned. Make up the two heatsink assemblies ensuring that each power transistor (Q1, Q4, Q9) is properly insulated using mica washers and bushes. A smear of silicone grease under each transistor and mica washer helps heat transfer from the transistor case to the heat sink. Take the three leads from each power transistor through their respective grommets, the collector connection being via a solder tag on the transistor mounting screw.

Mount the transformer and use a large capacitor clip to mount C1 vertically near the front panel. Fit the mains fuse holder and cable clamp to the rear panel, then wire the fuse, switch, neon and the transformer primary, taking care to ensure that a good earth is established by cleaning paint off under the heatsink mounting screw and using a solder tag. Wire the transformer secondary and C1, using the solder tags. The PCB can now be fitted into place, and all wires terminated to the relevant solder pins. Start with the transformer secondary and power transistors followed by the output sockets and voltage pots and finally the rotary switch.

It is best to leave the meters off until the unit has been tested so as to avoid the risk of damage. When all has been checked and found to be working, wire the meters to the appropriate connections on the rotary switch SW2.



Setting up

When the time for switch on comes there are two options; a) use a variac and wind the input up slowly or b) just switch straight on!

If a variac is available, initially supply the unit with a few volts only. Having ensured that the unit is not taking large amounts of mains current, check that the polarity of the DC unstabilised voltages across the terminals of C1, C5 and C11 are correct. If all is well, increase the mains supply slowly whilst measuring the outputs to ensure that they are rising a few volts behind their respective unstabilised supplies and are correctly polarized. With RV1 and RV2 set at midway, the outputs should start to stabilize at their nominal values. If the outputs are correct, increase the mains supply to 240V and proceed with the setting up.

If you intend to switch the unit straight on, double check the connections throughout the unit, paying particular attention to the mains fuse, transformer, smoothing capacitors C1, C5 and C11 and the power transistors Q1, Q4 and Q9. Make sure all the diodes and IC's are the right way round! Set pots RV1 and RV2 to mid range. If all is well, 2.5V-4V should appear at the 5V output, with 8V-11V on the ±15V terminals.

With the unit switched on and working, rotate RV1 on the front panel and check that the +5V output varies from approximately 3V to 8V. Adjust PR1 on the PCB to set the upper and lower limits accurately.

Compare the voltages on the +15 and −15 volt outputs and adjust PR10 on the PCB until the −15V output agrees with the +15V output. Rotate RV2 on the front panel and check that both outputs swing in tandem from approximately ±8V to ±16V, then adjust PR6 on the PCB to set the upper and lower limits accurately.

The next stage is to set the overload protection circuits on each output to the appropriate trip values, and this is most easily accomplished using variable resistors as the loads. However, don't worry if you can't get hold of any variable resistors with a high enough power rating because, with a little care, it is perfectly possible to set the levels using only a few odd fixed wirewound resistors.

Assuming the use of a 10 ohm 20 watt variable load resistor and a current meter in series between the +5V output terminal and the 0V terminal, set PR2 fully anti-clockwise and the resistor to minimum load, ie 10 ohms, and switch on. With RV1 set to give maximum output, adjust the load resistor to give 2.75 A current reading on the external meter. Slowly turn PR2 clockwise until the current just starts to fall. If the load is now increased the output voltage and current should collapse. Leaving PR2 set, return the load resistor to 10 ohms and repeat the test first with RV1 set fully in one direction and then the other, checking that the current limit remains the same from 3 to 8V output. The short circuit current should be equal to or less than one amp.

If you only have fixed value wirewound resistors to hand, choose one or more to give a value which will draw 2.75 A at between 3 and 8V. Thus a 1.2 ohm 10 watt, a 2.7 ohm 25 watt, or anything in between would be suitable. Connect this resistor or resistors in series with the meter across the +5V output and adjust the voltage until the meter reads 2.75 A. Slowly turn PR2 clockwise until the current just starts to fall, then reduce the value of the load resistance either by shorting it or, preferably, by placing another similar value of resistance in parallel with it. The output voltage and current should now both collapse. If you have sufficient wirewound resistances to hand, make up another load resistance of a different value so that you can repeat the test at a different output voltage.

The procedure for setting the +15V current limit is the same as for the +5V except for the values and the constant current characteristic of the 15V lines. The ideal load would be a 50 ohm, 50 watt variable resistor in conjunction with a 1 amp FSD meter connected between the +15V terminal and the 0V terminal. With PR5 turned fully anticlockwise, the output current is set to 0.55 A and PR5 slowly adjusted clockwise until the voltage just starts to fall. The output current should remain the same at any overload level. Check the current limit is the same across the +15V output range, and note that the −15V line should collapse with the +15V line even though it is not loaded.

The −15V output is set up in exactly the same way as the +15V output, except, of course, that the meter and load resistance are connected between the −15V and 0V terminals. With PR9 turned fully clockwise adjust the load resistor to give 0.55 A, then slowly turn PR9 anti-clockwise until the voltage just begins to fall. Again, the output current should remain the same at any overload level, and you should check that limiting takes place at the same point across the −15V voltage range.

As with the +5V output, the ±15V outputs can be set up without variable loads by choosing suitably rated resistors whose value is such that they will draw 0.55 A at between 8 and 16 volts. A 15 ohm 5 watt, 27 ohm 15 watt, or anything in between could be used. The procedure is then the same as that given above except that the current is set to 0.55 A using the output voltage control, RV2, and you will have to check that the current remains the same for all overload levels by placing resistors in parallel with the load to reduce it in value.

If all is well so far, you are now ready to install the meters. M1 is the voltmeter and M2 is the current meter, and they should be connected to SW2 in accordance with the circuit diagram and taking great care to observe polarity. Set both meters mechanically to zero using their centre screws, then switch on the supply and set the +5V output to 5V exactly using an accurate external meter. Set SW2 in the +5V position and then adjust PR4 until M1 reads correctly. Connect an ammeter and variable load resistor in series across the +5V output and adjust the resistor to give exactly 2A reading on the meter (if you don't have a variable resistor with a high enough rating, choose one or more wirewound resistors to give 2A or a similar current which is clearly marked on both meter scales). Adjust PR3 until M2 agrees with the reading on the external ammeter.

Turn SW2 to the +15V position and use an accurate voltmeter to set the +15V output to exactly 15V using RV2. Adjust PR8 until M1 agrees with the external voltmeter. Connect an accurate ammeter in series with either a variable load resistor or a network of fixed wirewound resistors across the +15V output so that a current of 0.5 A is drawn, then adjust PR7 until M2 reads 0.5 A. Repeat the procedure for the −15V supply with SW2 set to −15V and using PR12 to adjust the voltage reading on M1 and PR11 to adjust the current reading on M2.

Trouble Shooting

The bench power supply is quite straightforward in its construction, and provided you have followed the guidelines given you should have no problems getting it to work first time. If, however, you are unfortunate enough to encounter difficulties, the following notes should help you to sort it out.

If, on switch on, the fuse blows immediately, check very carefully the mains wiring up to the primary of the transformer; it is very unlikely that a fault on the secondary of the transformer will cause the mains fuse to blow. If the fuse remains intact but the unit gives no output at all, check the wiring around C1, C5, and C11 and the orientation of the rectifying diodes. The correct voltages to be found on these three capacitors are given in Table 1. Check also the wiring of the three power transistors and make sure that the voltages on them agree with those given in Table 1. Next, check the +15V circuitry in detail since a fault here will prevent any voltage appearing at the +5 and −15V outputs even if these are working correctly. This is because the +15V line supplies the drive for the +5V line, and the −15V line is designed always to mirror exactly the voltage appearing on the +15V output. The +15V circuitry is also the first place to look if the unit works correctly on the +5V output but not on the +15 and −15V outputs. The voltages which should appear on IC1 in the +5V circuitry and IC2 in the +15V circuitry are shown in Table 1.

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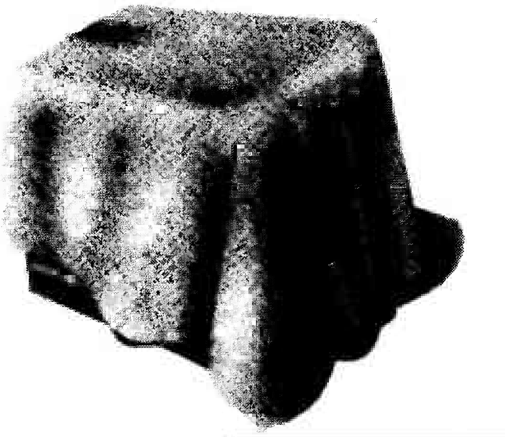

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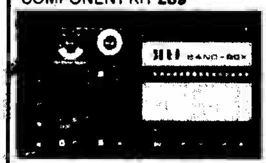

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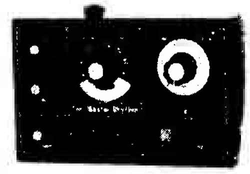

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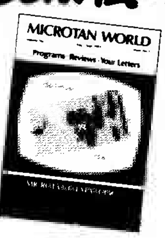

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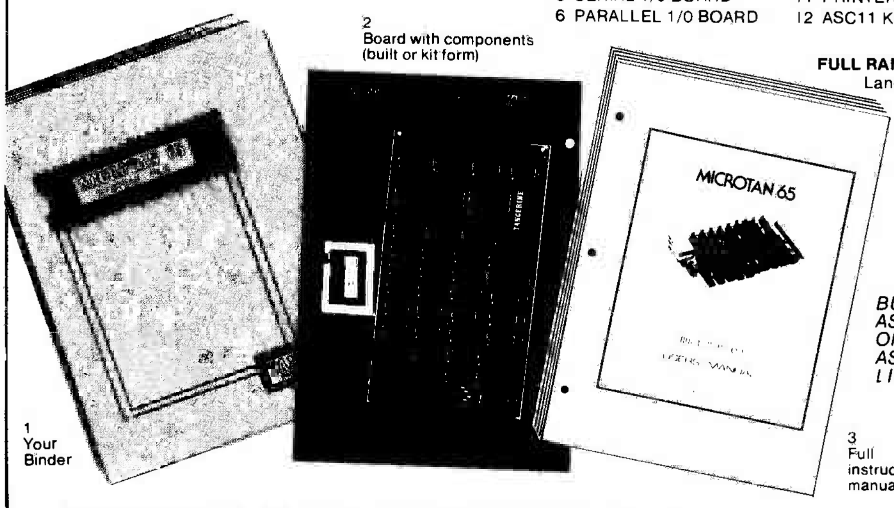

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MODULAR PREAMPLIFIER PART THREE

In this final part, we give constructional details of this expandable audio project. Designed by Barry Porter.

As with the smaller preamplifier described in December, assembly is based on the use of a mother board with the individual modules plugged into mating connectors. The pins for these are on a 0.1" pitch, so it is quite acceptable to use a length of veroboard to carry the interconnection busses between modules.

Details of the disc amplifier, muting relay control and power supply were given in part 1, and will not be repeated here. If it is required that insertion of the headphone jack plug should cause the output relay to cut off the unbalanced output, the 6V8 zener diode in the delay circuit should be connected to earth via the common contact switch on the jack socket as shown in Fig. 10. So that the headphone amplifiers are not powered when they are not in use, their supply voltages should be obtained from the switched rails of the delay relay.

BUYLINES

We have arranged for the supply of the harder-to-get parts for the various modules; in the following packs, the parts are as specified by the designer.
Disc amplifier (R2,3,6,9,10,11,12,13, 14,15,16,C3,7,8,9,11,12,13) £6.10;
Tone control (RV1-5 stereo pots, C1, 3,4,9,11,12) £6.55;
Unbalanced output stage (R4,6,11,13, balance control pot, C1,2,3,6,7,8,9,10, 13,14) £6.55;
Balanced output stage (C3,4,5,6) £3.68
Headphone amplifier (C1,2) £1.38
All these prices include VAT but not postage, which is 80p per pack on top. The packs are available from XCEL Audio Parts Ltd, 2nd Floor, 33 London Road, Bromley, Kent BR11 1JG, telephone 01-464 4967. Note that the PCBs are available from our PCB service, and that there has been additional advice on obtaining parts for the modules in earlier installments of this article, but it was too long to repeat here!

Other constructional comments in part 1 may be applied to this larger unit, which may be built into one of the standard rack-sized cabinets obtainable from a number of suppliers.

Once the preamplifier is working (again, see part 1) the output belance pre-sets must be adjusted to give equal voltages from the two outputs. The easiest way to do this is to temporarily connect two equal value, close tolerance resistors in series with the output and adjust the respective pre-set for zero volts at their junction when a 1 kHz signal is applied. (Fig. 11).

In use, the performance of this pre-amplifier is virtually identical to the more basic unit described in part 1. With the tone controls switched into circuit the noise increase is only about 1 dB with negligible additional distortion. The limited amount of control has caused no problems — in practice, if more than 10dB of lift or cut is required, it's not hi-fi you've got but a potential advertising copy for exchange and mart!

The situation that displays the advantages of the tone control most is when small bass-light loudspeakers are being used. Applying a limited amount of bass lift, with the frequency control set to about 50 Hz, will usually make it possible to increase the speakers' bass extension without encountering overload problems — something that is impossible to do when the turn-over frequency is fixed.

Although not detailed here, the individual 'building blocks' method of construction lends itself to a number of possibilities — for example, it is quite easy to modify the tape connections to allow for two recorders with cross dubbing, even providing balanced record outputs if required. A further enhancement could be to include record level controls on the front panel, with suitable VU or LED monitors displaying the signal level being sent to the recorder. Indeed, with a little thought, that Concorde flight-deck look might not be too far away . . . .

Some Changes

There have been some relatively minor changes between the circuit diagrams published last month and the PCB layouts printed here. They are:

on the tone control module:
C2 was left off the circuit diagram in error; this is a compensation capacitor for IC1 (as C5 is for IC2) and is included on the overlay;
C13 and C14 have been added in the leads to the wipers of RV2 and RV4; these are to prevent any offset voltages being passed around and amplified;
IC4 and IC5 have been combined into a single dual op-amp rather than two single op-amps;
on the balanced output stage:
IC1a and b have been interchanged;
on the headphone amplifier:
the input filtering to IC1 has been changed and the values of R1 and R2 are different; however, the PCB allows the original circuit to be used if desired;
on all modules:
supply line decoupling capacitors have been added; these were not shown on the circuit diagram last month (except for the headphone amplifier, where unpolarised capacitors have been added in parallel with the existing electrolytics).

Note also that the tone control stage is split over three boards for stereo operation. Unfortunately, it wouldn't quite fit onto two, so it was decided to split off the filter sections so that at some future date, constructors could alter

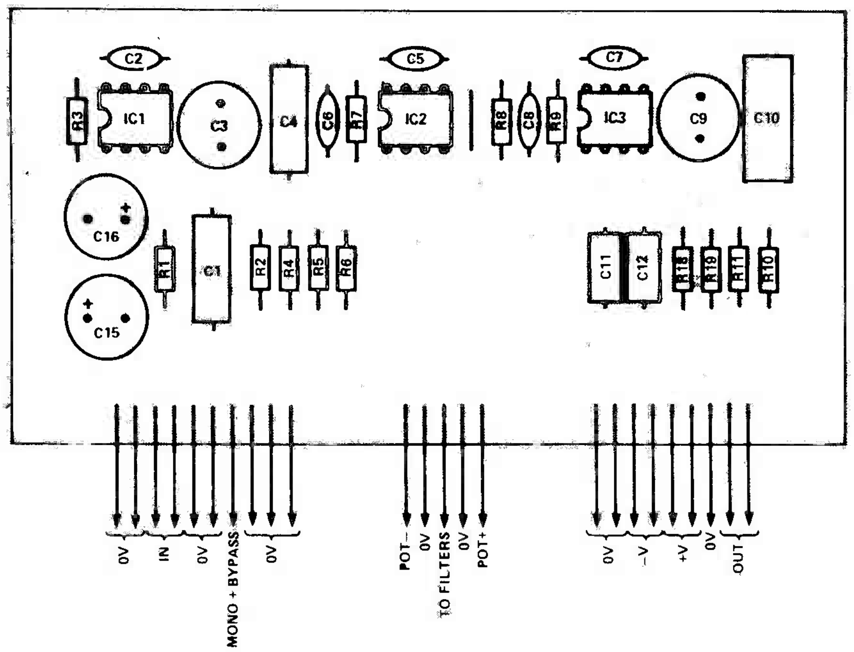
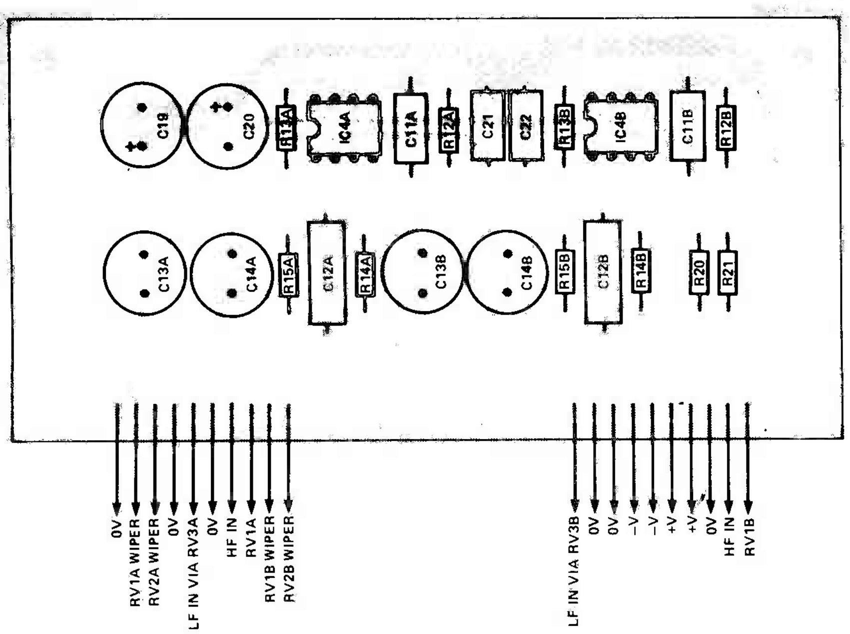


Fig. 1 PCB overlays for the tone control: the main board above is for a single channel, so two of these are required, whilst the filter board (below) is a stereo board, so only one of these is required. Note carefully which parts you need two of for stereo.



PARTS LIST — TONE MODULE

RESISTORS	
R1*	100k
R2*	330k
R3*	10R
R4*	47k
R5*,10*	1k8
R6*,11*	8k2
R7*,8*,9*,16*	10k
R12*	3k6
R13*	3k9
R14*	2k2
R15*	4k7
R17*	1k2
R18-21	33R
RV1**,2**,4**	10k lin
RV3**	50k anti-log
RV5**	10k log
CAPACITORS	
C1*	330n 250V Mullard polyester
C2*,5*,7*	22p 2½% polystyrene
C3*,9*,13*,14*	22µ16V PCB non-polarised electrolytic
C4*,10*	100n 250V Mullard polycarbonate
C6*,C8*,C11*	10p 2½% polystyrene
C12*	150n Mullard polycarbonate
C15*,16*,19,20	220µ 25V PCB electrolytic
C17*,18*,21,22	100n polyester
SEMICONDUCTORS	
IC1*,2*,3*	NE5534
IC4*	NE5532

MISCELLANEOUS
PCBs: 2 off tone, 1 off filter; edge connectors: 6 off 10 way, 2 off six way

* R1 to 17, C1 to 18 and IC1 to 4 are required in both channels so two of each are required for stereo.
** RV1 to 5 could be stereo potentiometers or two single potentiometers each for stereo, as required.

these, for example, to include a 'mid' control.

Swings And Roundabouts

It is possible to modify the component values of the **disc amplifier** and of the **unbalanced output** stage so that it is not necessary to use E96 series resistors. This will actually give a less accurate response technically (degrading the error on the RIAA characteristic to 0.3dB), but for most people this will not be that noticeable (if it is noticed at all!)

For the disc amplifier, the modified component values are as follows:

R2	4k7
R3	6k8
R6	12k
R10	7k5
R11	560R or 1k0*
R12	39R or 82R*
R13	6k8 or 8k2*
R14	3k3 or 1k5*
R15	82k
R16	15k//330k (T3 = 3179.5µs)
C7	10n
C11	33n

* For R11, 12, 13, 14 the first figure given is for moving coil cartridges and the second is for moving magnet.

The value of R9 that should be used will depend on the required sensitivity of the input stage; for **moving coil** cartridges, the appropriate values are as follows:

R9 Value	Sensitivity
10k	0.11 mV
5k6	0.2 mV
3k3	0.33 mV
2k2	0.49 mV

For moving magnet, the following values are appropriate:

R9 Value	Sensitivity
820R	2.17 mV
560R	3.03 mV
270R	5.41 mV
150R	8.0 mV

Additionally, IC1 (LM394) can be replaced with a parallel pair of

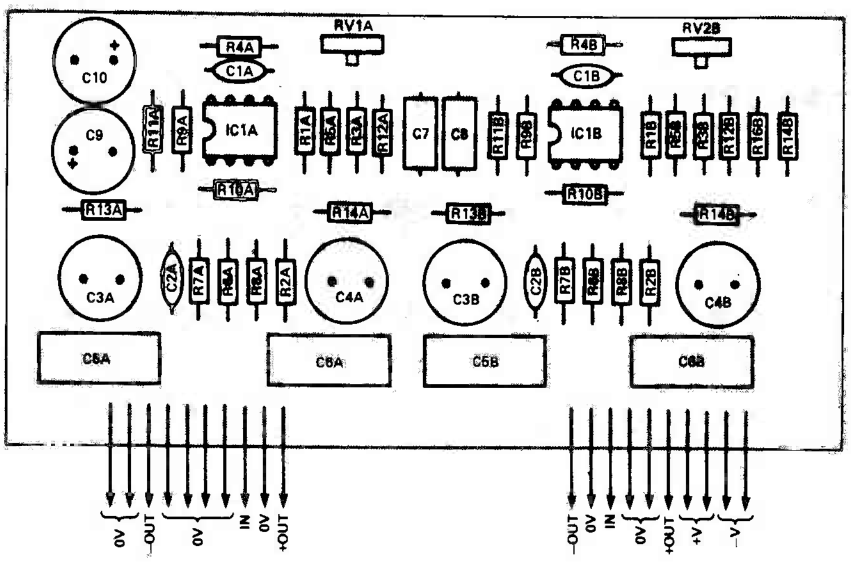


Fig. 2 Overlay of the PCB for the balanced output driver — this is a stereo board, so only one is required, but note the components that you have to obtain two of.

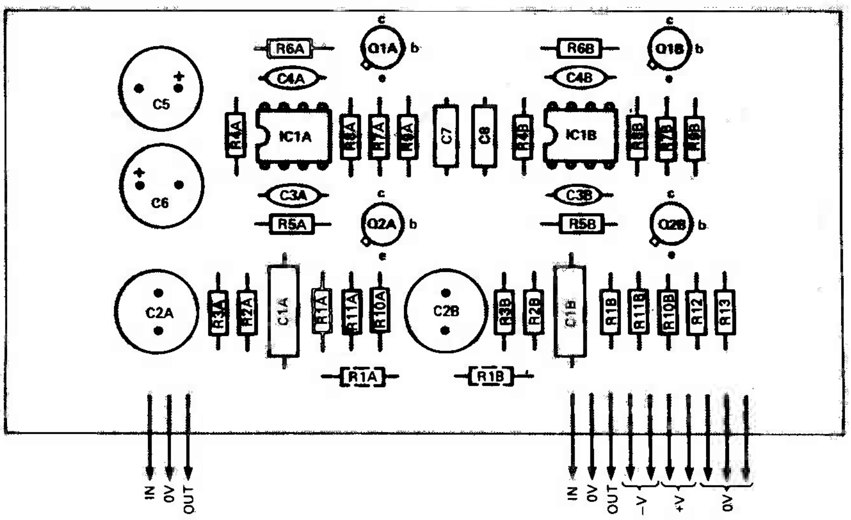


Fig. 3 Overlay diagram for the headphone amplifier; again, this is a stereo board, and again, you will have to sort out which components you need two of.

2SD786 transistors, which are available from XCEL Audio Parts Ltd, and they are somewhat cheaper than the LM394.

For the unbalanced output stage, the modified component values will depend on whether it is to be used as a tape output buffer or as an output stage to feed the power amplifier. For use as a tape output buffer, the values shown in Table 1 apply.

Record Output Level	Gain	R6	R4	C2
499.5 mV	7.95 dB	1k5	1k0	100µ
976.9 mV	13.77 dB	3k9	1k0	100µ
1.2 V (0 VU)	15.65 dB	5k6	1k1	100µ

Table 1 Revised component values for the tape output buffer.

PARTS LIST — BALANCED OUTPUT MODULE

RESISTORS	
R1*,2*,3*,4*,5*,6*, 7*,8*	3k3 1%
R9*,10*	33R 1%
R11*,12*	1k0
R13*,14*	47k
R15,16	33R
RV1*	10k min vertical preset
CAPACITORS	
C1*,2*	22p polystyrene
C3*,C4*	100µ16V PCB non-polarised electrolytic
C5*,6*	100n Mullard polycarbonate
C7,8	100n 250V Siemens polyester
C9,10	220µ 250V PCB electrolytic
SEMICONDUCTORS	
IC1*	NE5532
MISCELLANEOUS	
PCB; edge connectors: 2 off 10 way	

* R1-14, RV1, C1-6 and IC1 are required in both channels, so two of each of these components are needed for stereo.

PARTS LIST — HEADPHONE AMPLIFIER

RESISTORS	
R1*	47k
R2*	330k
R3*	1k0
R4*	150k
R5*	1k5
R6*,7*	10R
R8*	470R
R9*,10*	4R7
R11*	47R
R12,13	33R
CAPACITORS	
C1*	100n 250V polyester
C2*	22µ 16V PCB non-polarised electrolytic
C3*	10p polystyrene
C4*	22p polystyrene
C5,6	100µ 25V PCB electrolytic
C7,8	100n polyester
SEMICONDUCTORS	
IC1*	NE5534
Q1*	BC411 or similar NPN
Q2*	BC461 or similar PNP

* R1-11, C1-4, IC1 and Q1,2 are required in both channels so two of each are required for stereo.

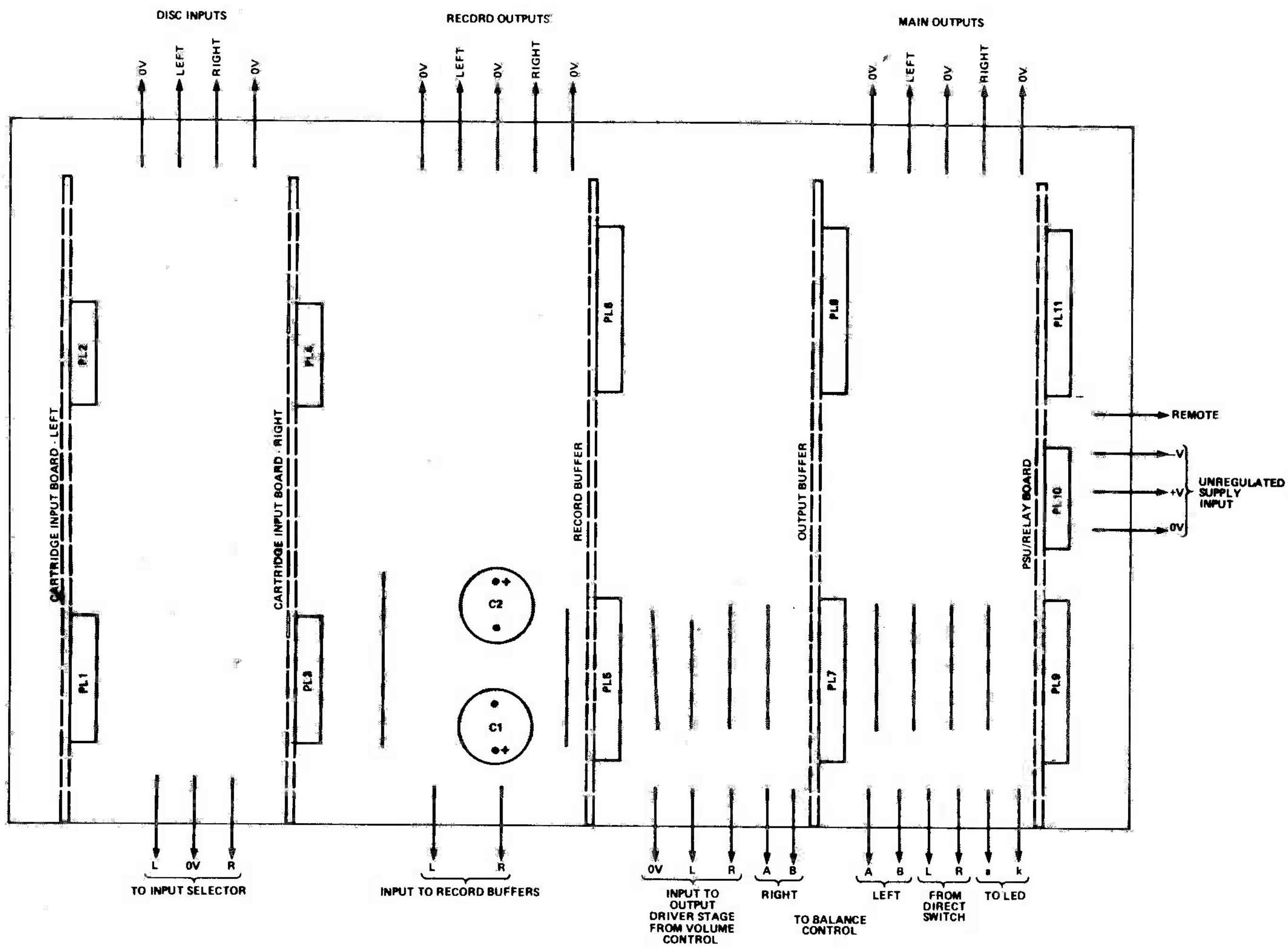


Fig. 4 Here is the overlay diagram for the mother board of the preamp as featured in the first part of the description in December '83; this board will be available through the PCB service. However, we have not reproduced a lay-out for the mother board of the extended system because the whole idea is for it to be adaptable to your needs — so everyone can make up their own, customised preamp using the same basic blocks.

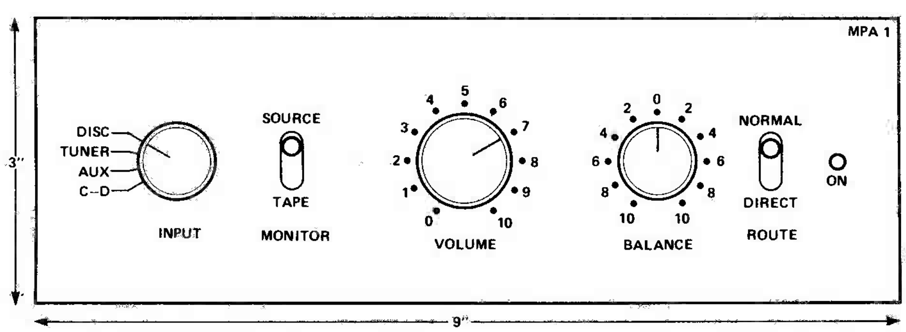


Fig. 5 A suggested front-panel lay-out for the small preamplifier.

Control Callibration	Imbalance
2	1.94dB
4	3.93dB
6	6.02dB
8	8.29dB
10	10.88dB

Table 2 Characteristics of the balance control.

For use as an output stage, R4 can be 180R and R6 can be 220R. The revised balance control characteristics are shown in Table 2.

After all that, all that remains for us to do is to wish you happy listening!

ETI

PARTS LIST — MOTHER BOARD

CAPACITORS

C1,2	220µ 25V electrolytic

MISCELLANEOUS

PL1,3	8-way edge plug
PL2,4,10	6-way edge plug
PL5-9,11	10-way edge plug

ADDITIONAL PARTS REQUIRED TO MAKE FULL PREAMPLIFIER (EXC. UNREG SUPPLY)

Input selector switch: 4-way (or to suit) 2-pole
Tape/source switch: 2-pole 2 way
Volume control: 10k log stereo (but see 'Construction', ETI Dec '83, page 60)
Balance control: 1k0 lin stereo
Direct switch; 2-pole 2-way
Output resistor: to suit (100R suggested)
Indicator LED: to suit
Connectors for disc, aux, tape, tuner (as required) and output (also PSU); knobs, case, etc as required

AUDIO DESIGN

When it comes to the reel issues of audio recording, John Linsley Hood has got it taped.

Although the tape recorder, in its cassette form, is now so common a part of our lives that we can take it almost for granted, in reality, recording on magnetic tape is beset with so many problems, and hedged round with so many restrictions and limitations, that it is surprising that it even works at all, let alone that it gives the superb results which, when all is done well, it can!

Having said that, it is difficult to find any descriptions of this technique which explain these problems and limitations in a way which is at all easy to follow — so before I proceed to look at the types of circuitry which are needed for tape recording, I propose to try to explain, as simply and lucidly as I can, just what it is that we need to do.

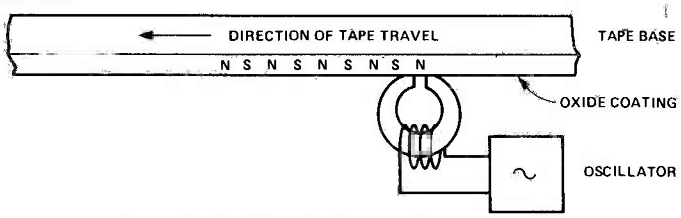


Fig. 1 The basic principle of tape recording.

The Process

If we pull a piece of unmagnetised iron oxide coated tape past a recording head, as in Fig. 1, and we apply an alternating current to the electrical winding on this head, we will leave a series of magnetised regions, as indicated by N-S-N-S-N-S . . . . , produced by the magnetic field at the trailing edge of the record head gap. These will have a 'wavelength' along the tape given by $\lambda =$ tape speed (ins/sec)/frequency (Hz). If we try to replay this, with a head having a gap length X, we will have zero output when $X = \lambda$, since both ends of the gap will be sitting on parts of the tape which are identically magnetised (i.e., both N or both S). This is **Problem No. 1:** the gap length of the replay head imposes an absolute limit on the upper frequency response.

It is a characteristic of magnetic induction that the voltage induced in a coil of wire is linearly proportional to the speed with which the magnetic flux through that coil is changed. In mathematical terms this is expressed $V = L.dB/dt$ where L is the inductance, B is the flux density and t is time. (d/dt is the mathematical notation for a rate of change with time).

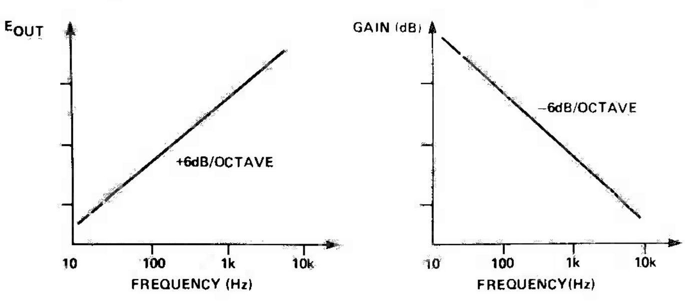


Fig. 2 (left) The theoretical AC output from a tape replay head.
Fig. 3 (right) An idealised replay amplifier characteristic.

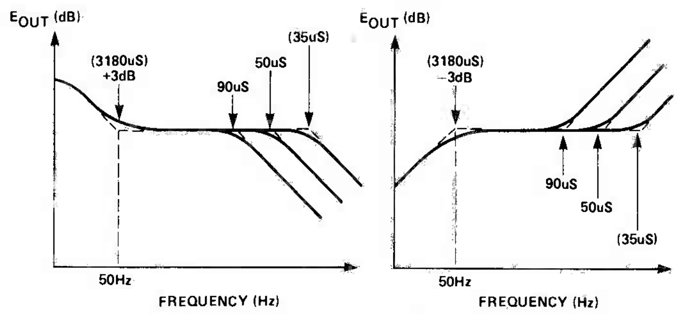


Fig. 4 (left) NAB recommended record characteristic (effective).
Fig. 5 (right) NAB recommended replay response (effective).

The result of this is that if we were to record at a constant remanent flux level on the tape, which we will assume will be given by a constant level of (RMS) current through the record head, we will end up with a replay characteristic as shown in Fig. 2, in which the output increases linearly with frequency. This will necessitate a replay characteristic such as Fig. 3 if we are to get a level final frequency response; this, in itself, would not present any great circuitry difficulty.

In the same way in which an internationally agreed standard is employed in the manufacture and replay equalisation used for 33 RPM and 45 RPM gramophone records (the RIAA standard) there is an internationally accepted standard for record and replay equalisation for tape and cassette recording (the NAB standard). This requires *effective* record and replay characteristics of the type shown, with the appropriate time-constants for the turn-over points on the frequency scale, in Figs. 4 and 5. When the replay equalisation curve is superimposed

15ins/sec 38cms/sec	50/3180 NAB/BSI	35 DIN/CCIR
7.5ins/sec 19cms/sec	50/3180 NAB/BSI	70 DIN/CCIR
3.75ins/sec 9.5cms/sec	90/3180 BSI	140 CCIR
	70 or 120/3180 BSI and DIN/CCIR (Cassette only)	

Table 1 Equalisation time constants of various standards; NAB (or NARTB) — National Association of Radio and Television Broadcasters (USA); BSI — British Standards Institute; DIN — Deutscher Industrie Normenausschus (W. Germany); and CCIR — Comite Consultatif International des Radiocommunications (International Standards Organisation).

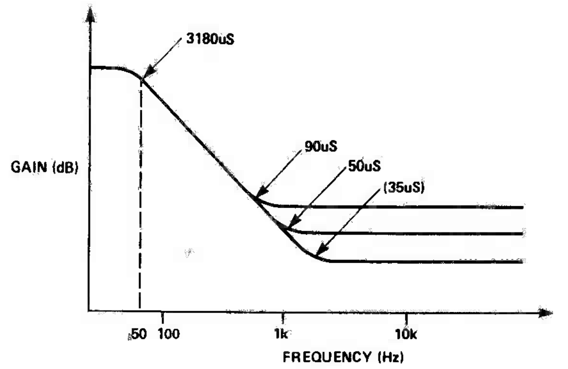


Fig. 6 A practical replay equalisation characteristic for reel-to-reel tape-recorders which conforms to NAB recommendations (cassette replay to BSI/DIN specifications would use 70/120 us).

on the curve of Fig. 3, we get the practical replay equalisation characteristic of Fig. 6, which is what we will hope to find if we do some measurements on the replay side of a commercial tape or cassette recorder.

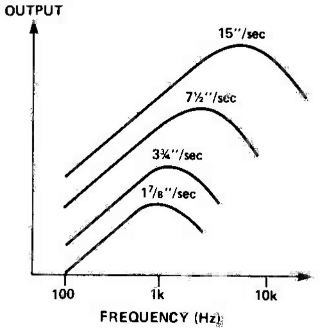
To avoid the need for a replay gain characteristic which continues to rise as frequency decreases, the NAB curve provides for an LF turn-over point of 50 Hz, expressed as a 3180 μs time constant, and an HF turn-over point that depends on tape speed as listed in Table 1. Turn over frequency, f, is given by $f=1/2\lambda\pi CR$; the value of CR is the time constant, and this is normally expressed in microseconds (μs) so that Cs in nanofarads and Rs in kilohms can be used directly for calculations, avoiding the need to throw in factors of 10^9, etc.

Problems

The above has assumed an ideal world; however there are a number of problems, as follows (this is not a complete list!).

1. Maximum replay frequency: As already mentioned, the size of the replay gap imposes an absolute limit on the upper frequency response.

2. Effect of replay head gap spacing: Since it is the trailing edge of the record head gap which leaves the remanent magnetic domains on the tape, to a first approximation, the width of the recording head gap is not very important. However, this is not true of the replay head (as we've already seen). Below the maximum replay frequency, the HF response is very dependent on gap width, as I have shown in Fig. 7. Unfortunately, the output from the head also falls as the head gap-width is reduced, partly because there is less magnetic material in the gap, and partly because of the magnetic shunt effect due to the proximity of the two sides of the head gap.



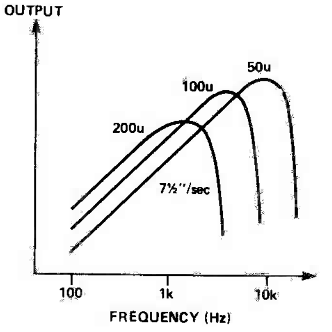


Fig. 7 (left) Output level versus frequency response for different tape speeds.

Fig. 8 (right) Output level versus frequency response for different head gaps.

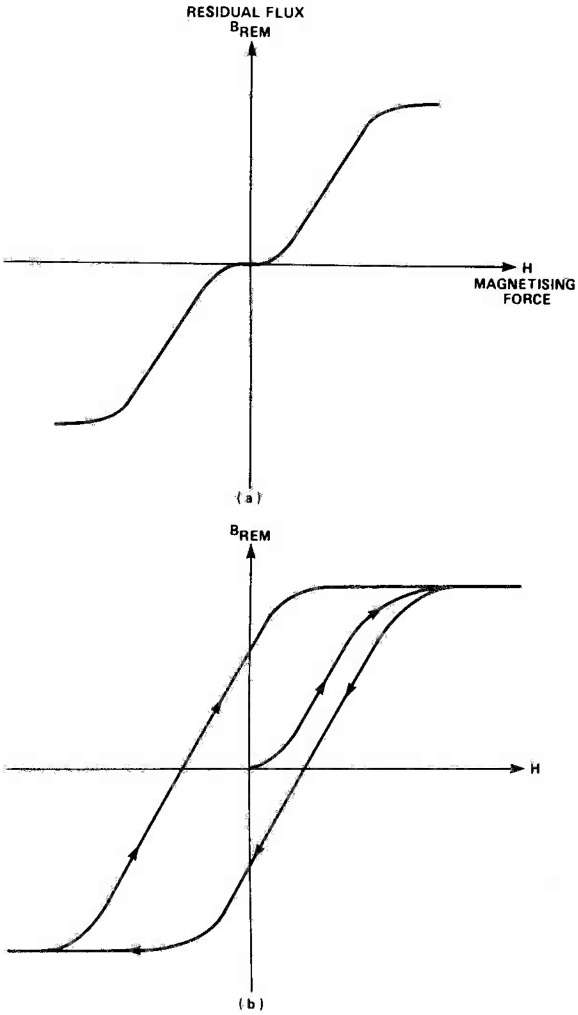


Fig. 9 Tape magnetisation characteristics: (a) for small magnetisations; (b) for large magnetisation.

3. Effect of tape speed: The differing equalisation characteristics quoted above tacitly recognise that the performance of the recorder, other things being equal, will be very strongly influenced by the speed at which the tape passes under the replay head. Not only will the output signal fall as the speed is reduced, the HF performance will also be impaired, as I have shown in Fig. 8.

4. Tape magnetic non-linearity: All of the above problems pale into insignificance in comparison with the high degree of non-linearity of the magnetic tape itself. The characteristics of this are shown in Fig. 9. If a small signal current is applied to the windings of the recording head (which is an electro-magnet with a small parallel gap held in contact with the tape, set as accurately as possible perpendicular to the direction of motion of the tape), the remaining flux on the tape (B_r) will be related to the applied magnetising force (H, which is proportional to the current flow through the winding on the head) in the way shown in Fig. 9a.

Clearly, this would not lend itself to hi-fi reproduction. At small signal levels the recording would be very inefficient, with hardly any remaining magnetism on the tape at all. At higher levels there would be the equivalent

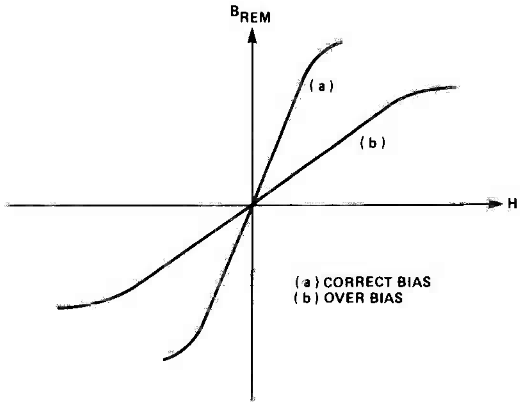


Fig. 10 The effect of HF bias on tape magnetisation linearity.

of a large amount of 'crossover' distortion, and at greater recording levels still, there would be a lot of 3rd and other high-order harmonics generated as the tape magnetisation was pushed into the regions where the curve flattened again. Also, to add to the problems, if the tape is magnetised fully, there is a 'hysteresis' loop in its magnetic characteristic, as shown in 9b.

Fortunately, after a lot of early experimentation with this medium, a trick was found which would solve this snag. This scheme was known as 'HF bias', or, in normal tape parlance simply as 'bias'. I will explain.

5. Need for bias: If a suitable high frequency AC signal is simultaneously applied to the recording head with the signal which it is desired to record, and if this HF signal, which will typically be somewhere in the range 30 kHz-250 kHz, is a good bit larger than the recording signal (typically 20 to 100 times) so that it sweeps the BH characteristics of the tape backwards and forwards across the non-linear region of the BH characteristic, one can, surprisingly, end up with a quite linear magnetisation of the tape, as shown in Fig. 10a. However, as you will by now expect, there is another snag, and this is that the final recording characteristics of the tape depend on the size of the applied bias waveform. If we apply more, we get the curve shown in Fig. 10b., which is one of reduced recording sensitivity. Also, too much bias tends to 'erase' the higher audio frequencies which we are trying to record. Moreover, the 'correct' level of bias depends a lot on the actual tape being used at the time, and, without previous experience, we cannot know what that will be!

6. Problems with bias: The dependence of recording characteristics on bias level is shown in the graph of Fig.

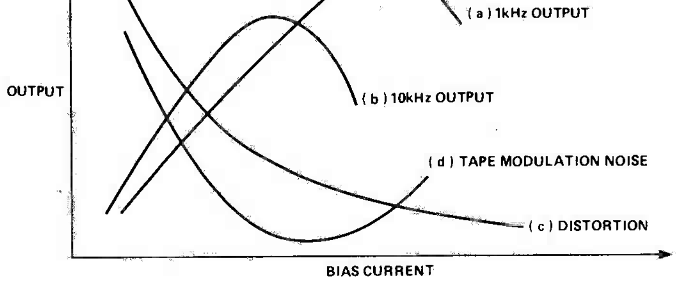


Fig. 11 How recording characteristics vary with bias current; note that only curves a) and b) are to the same scale.

11. In this curve (a) shows the relationship between recorded level and bias current at 1 kHz, and (b) the same thing for an input recording signal at 10 kHz. Clearly, the bias setting has a large effect on the flatness of frequency response of the tape recorder. Curve (c) shows the effect on the distortion of the recoded signal of the bias level. Good HF response is not readily compatible with low THD. The effect of bias level on tape 'modulation' noise is shown in Fig. 11, curve (d). Here, happily, low noise levels fit in fairly well with other needs.

The actual frequency of the bias signal is not very important, though there is some evidence that the recorded noise level on the tape, and the distortion at the upper end of the audio spectrum, may both be lessened by the choice of the higher bias oscillator frequency. The snag here is that it is the current through the head which is important, and because the windings have inductance, a higher bias frequency will require a higher applied bias voltage. Also, the head will work progressively less efficiently at higher frequencies, which contributes to this effect.

7. Design of bias oscillator: The tape cannot distinguish the source of the signal which is applied to it. It will therefore record small noise voltages present on the bias voltage waveform just as easily as it will record the noise components present on the incoming signal. So, if the bias voltage waveform is 20 times the size of the signal being recorded, its signal-to-noise ratio will need to be a lot more than 20 times better if it is not to degrade the S/N ratio of the incoming signal. You will note that I have referred to bias *voltage*, not to bias current. This is because the noise signal will be wide band, and will not be restricted by the inductance of the head to the same extent as the HF bias waveform. Therefore, the higher the bias frequency, the better the S/N ratio which is demanded of the bias oscillator.

The actual waveform of the bias oscillator is not so important, provided that it is symmetrical. If it is unsymmetrical, it will have the effect of the B-H curve, which will reduce the available undistorted output. Also, an unsymmetrical waveform contains an implicit DC component, which will magnetise the head, greatly reducing its effectiveness, and possibly causing partial erasure of the tape.

In the early 1970s, when I was very interested in cassette recording, I did some experiments with both square wave and sawtooth bias waveforms. Both worked, and the square appeared to be quite effective. However, for reasons of practical convenience, it is desirable that the erase oscillator should operate at the same frequency as the bias oscillator, and it is easier to get large voltages at a good S/N ratio from an LC sinewave oscillator. Square wave (RC) generators tend to have a fairly poor S/N ratio, due to jitter on the 'flip' times.

8. Effect of head inductance: Our aim, in recording, is to record all the frequencies in the audio band equally. However, the recording head has inductance, which will restrict the flow of current at higher frequencies. It is necessary, therefore, to find some way around this problem. Of the possible solutions, the simplest is to put a resistor, say 47k, in series with the output from the recording amplifier, to swamp the effect of the changing impedance of the record head with frequency. This also helps keep the bias HF voltage out of the recording amplifier. Bias voltage intrusions would probably do no harm provided that they did not push the record amplifier into a non-linear or overload condition.

Other useful solutions, which make lesser demands on the size of the signal output from the recording amplifier, are to design this amplifier so that it has a high output impedance, or to use a current NFB loop to make the amplifier look like a constant current source. All DC components must be rigorously excluded from the head windings to avoid head magnetisation. If a DC blocking capacitor is used, it should be of good quality, and switch-on current surges through this must be prevented.

9. Head alignment: The way in which the width of the replay head affects the HF response of the recorder has been shown above (Fig. 7). This presumes that the head is accurately aligned so that its gap is at right-angles to the direction of travel of the tape. If the gap is skewed, its effective length will be greater, and the HF output will be less. The same applies if the record and replay heads do not have the same alignment. This may be less important if one records ones own tapes, but on pre-recorded tapes this is vital. Happily, alignment tapes are fairly easy to buy. On these, though a double-beam oscilloscope makes matters simpler, one can do quite a good job by just adjusting head azimuth for maximum HF output, usually by working upwards through the frequency test bands provided.

10. Noise and noise reduction: Because of the granular nature of the oxide coating deposited on the tape, all tape recordings will suffer from some degree of background noise. In addition to this, any parts of the record process which tend to clump, or otherwise disturb, the uniformly random distribution of the manetic domains will make this background noise worse. Erase oscillator systems are not perfect in this respect, as can be shown by listening to the background noise on a bulk erased tape, as bought, and after it has been 'erased' by ones own recorder following the recorder of a zero signal.

The output from the tape recorder will depend on the tape speed and (although not discussed so far, this is a fairly logical extension of the arguments above) on the tape width at the head; so, the lower the tape speed and the narrower the tape head width, the worse the signal to noise ratio will be. This becomes a particular problem with cassette recorders, where the tape creeps past the head at 1.875"/sec, and the track width is only 30 thou. or so anyway. The signal output from a cassette recorder replay head will be minute, and will demand a lot of skill in the design of the replay amplifier.

The poor basic S/N ratio of the reproduced signal from a cassette replay head (though this is now improved by better heads and better tapes) has brought into prominence the various noise reduction schemes, of which the most common is the Dolby B system, used by most cassette recorder manufacturers under license from the Dolby Laboratories. In this a degree of HF pre-emphasis is applied to the record signal, in which both the amount of HF pre-emphasis and the turn-over point above which this pre-emphasis is applied, is automatically adjusted in response to the measured level of the incoming signal. The reverse compensation is applied on replay to restore a flat frequency response.

There is a snag, of course. This is that, unless some means is provided for monitoring the tape output which is only posible on relatively expensive three-head cassette machines, some assumptions must be made by the cassette recorder manufacturer, in setting up the Dolby B replay operating levels, about the actual signal level which his recorder will give on replay for a given

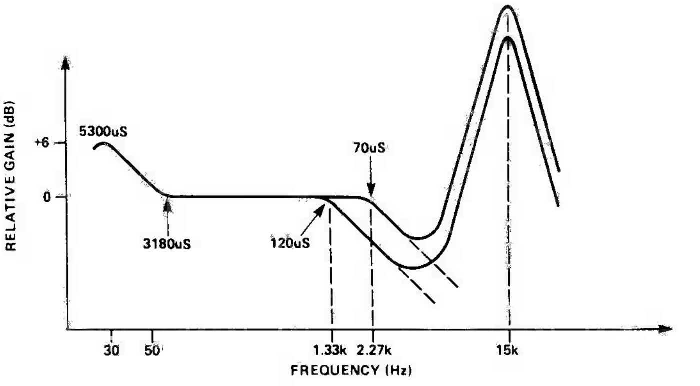


Fig. 12 Record pre-emphasis and de-emphasis for cassettes, showing additional compensation for head losses.

input recording level. This will depend on the actual tape chosen by the user, and on the appropriateness of the bias setting. Nevertheless, in spite of these objections, the Dolby B system does work surprisingly well, even on simple machines, and can give a 6-10dB improvement in overall S/N ratio.

Nowadays, predictably, Dolby B processing circuitry is available on a single IC chip, the LM1011, which, complete with application circuitry, can be bought by the experimentally minded for a few pounds. The use of these for any commercial gain would however, require a license from the Dolby laboratories.

In many commercial machines, the relay amplifier is muted while the tape is not moving to avoid drawing the attention of the listener to the background hiss of the replay amplifier. This is a refinement I wish I had thought of in the middle 1970s when I published my own cassette recorder design. One lives and learns!

11. Head losses: We have assumed, so far, that the recording and replay heads — which are often the same unit in cassette recorders — behave in a perfect manner. They don't. Mainly because of the finite gap width, their HF performance is poor. This means that some form of HF pre-emphasis has to be applied, during recording, to assist in achieving a satisfactory HF output. This recording pre-emphasis, of 15-25dB magnitude, will be applied, as shown in Fig. 12, at the point where it is expected that the replay HF response will start to fall. This is not a good thing, since it will tend to cause HF overload, and increased distortion and intermodulation effects, but is feasible because signal amplitudes at HF are generally low.

Practical Circuit Design

We have seen from the above what some of the problems are in tape recording. Since these are exaggerated in cassette recorders, because of the narrow low-speed tape tracks, a look at the design of the electronics in a cassette recorder — excluding the Dolby processing — will show the types of circuit layout which will be needed in all these systems.

Replay Amplifier

The over-riding consideration here is of low noise in the amplifier, since the input signal will only be about 0.5 mV, and a 60dB S/N ratio will demand an effective input noise of 0.5 uV, from the amplifier and input circuitry. Figure 13 of Part 2 (ETI October 1983) we saw that this

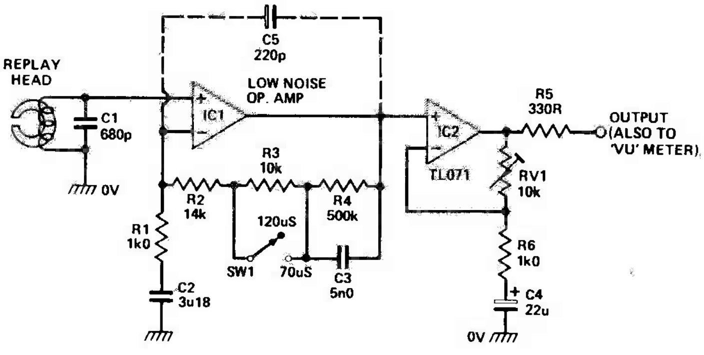


Fig. 13 A typical cassette replay amplifier giving the frequency response shown in Fig. 6.

will depend on the input circuit resistance, the bandwidth, and the input devices. Fortunately, the effective bandwidth of the replay amplifier, because of its downward slope with frequency, is only 1 to 2 kHz. Nevertheless, this necessitates an effective input resistance of only some few thousands of ohms. We must be careful, therefore, that we do not needlessly include input resistive components, to add to the 300-600 ohms of the head winding resistance. The required equivalent input noise resistance required by the desired S/N ratio does put most of the audio ICs out of consideration; however, there are a few, such as the Signetics/Mullard NE5533/5534, the Precision Monolithics/Raytheon OP27, and the Hitachi 12017, which would be satisfactory electrically. Of these, the latter has a non-standard base connection, which would make it awkward to substitute, whereas the ICs with the standard 741 type connections could be upgraded as better devices appeared.

In commercial units, for reasons of economy it is customary to use the same amplifier for both record and replay, with appropriate component changes accomplished by multiple switching. however, from the point of view of the amateur constructor, and certainly for the ease of explanation, it makes life easier to show the record and relay circuits as separate entities. I have shown a suitable circuit design, based on a low-noise op-amp, in Fig 13.

In this circuit, the output of the replay head (through suitable switching if it is combined with the record head) is taken directly to the input of IC1. The gain-frequency characteristics of this stage are determined by the RC network in its negative feedback loop. Referring back to Fig. 6, we see that the LF gain is rolled off at 50 Hz (a 3180μS time constant), at a gain of 500. From this we can infer that the total resistance in the feedback path, from output to −ve in, must be 500K, if R1 is 1k0. Also, the time constant of R1C2 must be 3180sS. If R1 is 1k0 then C2 must be 3180 nF or 3.18μF. This shows how simple the use of 'time constants' makes the task of working out circuit component values.

Now, we require the gain to decrease linearly from 50Hz to 1.33 kHz (in the case of the 120μS equalisation) or 2.27 kHz (for 70 uS). This we can accomplish by means of C3 and R2 and R3, switched by S1. If C3 is 5n0F — this must have an impedance greater than 500 k at 50 Hz, but we can't afford to go too high (Z_{C50} for 5n0 is 636k) — then the 120μS time-constant will be given for a value of R2+R3 of 120/5 = 24k. Also, the 70μS time constant will require R2 on its own, to be 70/5 = 14k. So R2 = 14K and R3 = 10K.

IC2 is a simple output buffer stage, to give an adjustable gain of 1 to 11, depending on the setting of RV1. R5 gives some output isolation, and the value of C4 is chosen so that the LF response is adequate. Since 3.18μF gives a −3dB point at 50Hz, 22μF will give a −3dB point at 7Hz, which is low enough.

A small circuit refinement is the inclusion of C1 across the cassette head to tune the head, with its internal inductance, to some 15 to 18 kHz. The actual value will depend on the head inductance, and can be calculated from the formula $f_0 = 1/2\sqrt{LC}$. A value of 680-820pF will be in the right order. This limits the wideband noise output from the head, and reduces the chance of noise being worsened by cross-modulation within the input IC amplifier.

C5 across the first amplifier stage performs a similar bandwidth limiting function. This may not be acceptable for the NE5533 or 5534, so regard it as an option.

Record Amplifier

This has to meet five design requirements. The output must be large enough to drive the cassette record head through the 47 k swamp series resistance. A normal IC op-amp will do this quite well, with very low distortion, when operated from ±12 or 15V supplies. It has to provide a means for adjusting the record signal level. It has to provide a modicum of bass lift, say +3dB at 50Hz and +6dB at 30Hz, to compensate for the specified roll-off in the replay curve. It has to provide the specified de-emphasis at 70μS or 120 μS as required, and finally, it has to generate a peak, of +15dB or so, at 15kHz, to offset the head losses.

A circuit which will meet these requirements, and give a high quality performance, is shown in Fig. 14. In this IC3 is a simple unity gain buffer amplifier, which has a low output impedance but yet allows a high impedance input to the record level control. R9, R10, C6 and S2 generate the 70 and 120μS de-emphasis characteristics.

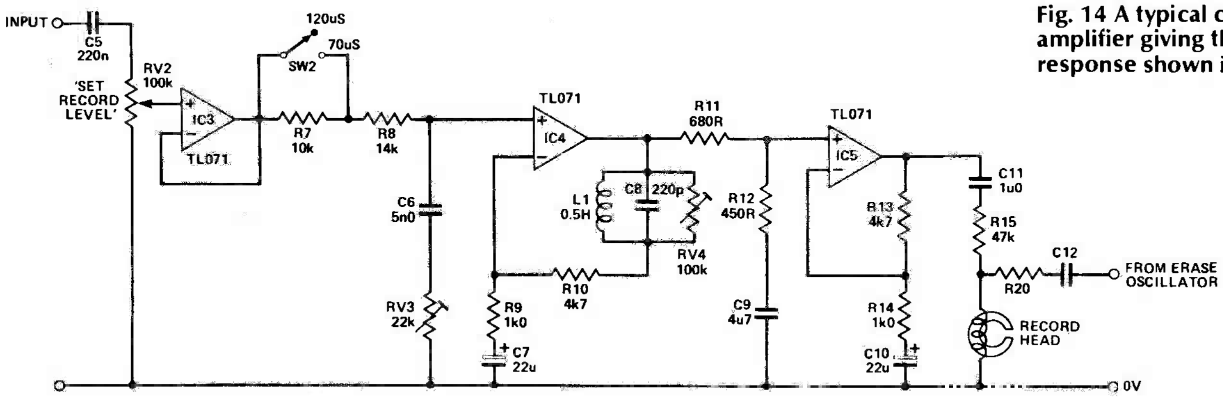


Fig. 14 A typical cassette record amplifier giving the frequency response shown in Fig. 12.

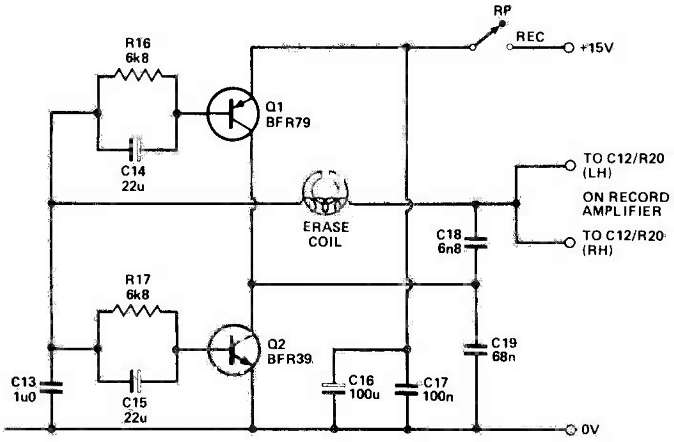


Fig. 15 A cassette recorder bias and erase oscillator.

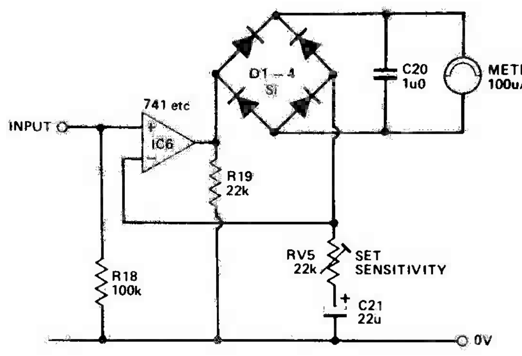


Fig. 16 A simple recording level meter circuit.

Since we have calculated suitable values for these for the replay amp., we can use these again. R11 is a trimmer resistor which we can use to assist in getting an optimally flat overall frequency response, by lessening the extent of this de-emphasis. IC4 is a gain stage with a low-frequency gain of 5.7. However, the LCR network formed by L1, C8 and RV4 is tuned to resonate at 15 kHz; this makes the gain increase at this frequency to an extent which is governed by the Q of the circuit, which can be adjusted by RV4 (for the tuned circuit, $f_0 = 1/2\pi\sqrt{LC}$).

R11, R12 and C9 generate the boost at 50 Hz (3180 µs, the time constant of C9R11) and the levelling off at 30 Hz (5300 µs, the time constant of C9(R11+R12)). IC5 is another straight gain stage, with a gain of 5.7, and this drives the record head through C11 and R19.

Overall, the gain of this amplifier is 30 at 1 kHz, which allows a 5 V RMS output from IC5 for a 170 mV input. Bias is applied to the head directly from the bias oscillator circuit.

Bias and Erase Oscillator

In reel-to-reel recorders, and in the rather more up-market cassette decks, a separate transformer would be used, both as the coil in the LC erase oscillator, and as a transformer coupling from a secondary winding to drive the erase coils and HF bias circuitry. However, in cassette recorders, provided it is not proposed to use 'metal' tape (for which very high erase voltages across the erase head are needed to achieve the required 60dB erasure of previously recorded signals) it is quite satisfactory to use the erase head itself as the coil in the oscillator circuit, and up to 25V RMS can be generated by the oscillator circuit shown in Fig. 15. A small proporton of this is then bled off through an RC network to bias the record head.

The actual RMS bias voltage across the head for optimum recording characteristics must be determined by experience for the record head and tape being used, but it will probably lie somewhere between 5.5 and 10 V RMS, as measured by a wide-bandwidth AC milli-voltmeter. Understandably, from Figs. 10 and 11, there is no such thing as a 'correct' bias voltage setting. All that one can do is to try to choose a voltage at which all of the conflicting tape characteristics are partially satisfied, in your own judgment. As simple a soluton as any is to design the record and replay amps so that they give a reasonably good frequency response, and then trim the 'bias' voltage so that the overall frequency response is as level as possible. Obviously, if one has good instruments and a lot of time to experiment, a better compromise value could be found.

In Conclusion

These then are the basics of tape recording, and the circuits shown above, when used with a suitable cassette mechanism, an adequate power supply (derived for example from a pair of + and − output 12 or 15 V IC stabilisers and a decent quality pair of supply line bypass capacitors) and some form of recording level indicator which could well be a simple one-IC AC millivoltmeter of the form shown Fig. 16., could be used to make a quite high performance DIY cassette recorder. However, being realistic, I do not really believe that anyone in the UK at the moment would want to build himself a cassette recorder — unless, of course, he had most of the parts already to hand — when he could buy one, ready built, and with all the trimmings, for about two thirds of the wholesale price of the components.

Nevertheless, it is useful to know what kind of circuitry is employed in tape recorders, and what the problems and limitations are, so that one might rebuild or modify existing unsatisfactory equipment, or simply so that one can know where the strengths and weaknesses of the method lie. Also, because every tape or cassette recorder represents the end product of a very large number of design compromises, which affect distortion, modulation noise, overload characteristics, flatness of response and background noise level, as well as the straightforward HF bandwidth, cassette and reel to reel tape recorders differ in sound quality, one from another, very much more than, say, audio amplifiers or tuners do. Evaluation of the effect of these many compromises is truly an appropriate field for the 'subjective' listener.

I have tried, in this series, to take a brief look at the types of circuitry which are used in audio equipment, to try to show how the designer might do his circuit calculations, and to attempt, where possible, to remove the mystery from this subject. During this, I have been aware that one of the major areas of calculation, that involving capacitors and resistors, has been skirted round rather hurriedly, and the reader has been left with just a few useful landmarks, rather than a map. This is because more detailed calculations require the use of algebra employing 'complex numbers'. However, speaking as one who is really a very poor mathematician, I honestly do not think that there is anything in this which should frighten anyone (especially if they have a pocket calculator to do the sums for them) — indeed, some of the calculations are really quite fun to do. I am therefore very pleased that the Editor has indulged my wish to try to show that this is really quite simple, in the next part of this series.

ETI

MACHINE CODE PROGRAMMING

Every month we plunge deeper into the arcane mysteries of machine code — taking our readers with us, we hope. This month, Bob Bennett goes beyond the index registers

Last month I gave examples of instruction of the form **Ld (pq),A** etc, and showed how two bytes are pushed back onto the stack. I also left you with the question of what happens if you push HL and pop DE. The answswer is that both HL and DE now hold the data that was in HL originally.

One last thing, for the moment, regarding the stack: when you have finished with your machine code program and wish to return to BASIC, for example, then you must make sure that everything that you pushed onto the stack has been popped off. This is because when you GOSUB, and call to USR (machine code) program is a GOSUB, then the return address is pushed onto the stack. When the time to return comes along then the address is popped off the stack, but if you have left some pushes un-popped, so to speak, then some very funny things can happen.

Whether you use pq to represent an address, or mn a number, doesn't matter a jot, as long as you, the programmer, know what is happening. However, what is significant is the presence or absence of brackets in the instruciton, as I mentioned last month. Fig. 11 shows part of a program with a Z80 instruction to load HL with 30,000d or 7530h. Note how the low byte, the one in L, goes straight after the instruction. Some of you will be familiar with the BASIC instruction, PRINT PEEK (address) + 256 x PEEK (address + 1); now you can match up the request with Fig. 11. The difference between the two instructions 2A — **Ld HL,(Pq)** and 21 — **Ld HL,mn** should now be apparent. The first instruction loads the contents of the address pq into L, and the contents of pq + 1 into H; the second instruction loads the byte n into L and the byte m into H. If the two bytes mn represent an address, then HL is said to be pointing to that address.

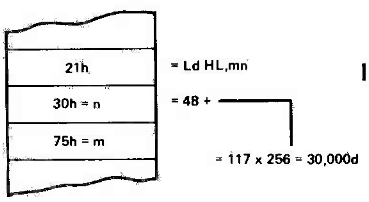


Fig. 11 Z80 instruction to load HL with 30 000 decimal.

Taking The Indirect Route

The Z80 instruction 77 — **Ld(HL),A** is an example of indirect addressing, which if you work it out, means load the contents of the A register into the address which is pointed to by the HL pair. This is the machine code equivalent of the BASIC instruction POKE (address), with whatever. Earlier I explained that the display file is a series of addresses, with each address holding a byte of information relating to the screen display. I also gave the address 16384d - 400Ch as being the address of screen position 0,0 for no particular computer. Fig. 12 shows how to poke the code for the letter A onto the screen at position 0,0 using one method, and Fig. 13 shows a different method. However, an explanation is required for the method used in Fig. 13.

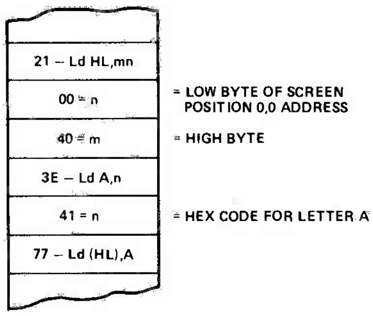


Fig 12 One way of printing a screen position 0,0.

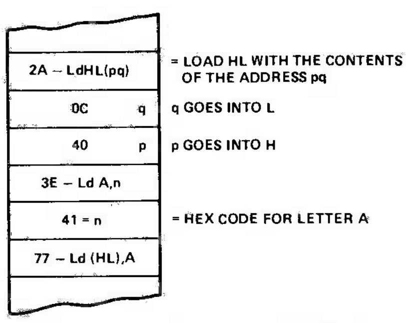


Fig. 13 Another way of printing a screen position 0,0.

Suppose that you didn't know the address of the position 0,0 on the screen, but the system variable called D File held the address. If the address of D File was 19634d - 400Ch this would mean that 400Ch would hold the low byte of the address of position 0,0 and 400Dh would hold the high byte.

One last example in this section is the Z80 instruction 7E — **Ld A,(HL)**, which is the machine code equivalent of the BASIC instruction PEEK (address). Of course, registers other than A and HL can be used, but you should by now be able to identify the other instructions. Just in case you are wondering about the term indirect addressing, the instruction 77 — **Ld (HL),A** pokes the contents of register A into the address *via* the HL pair. What I haven't mentioned yet is the use of such instructions in a program, so here is a short explanation using the two instructions given above.

Suppose instead of poking the letter A onto the screen, we had poked the code for 1 (this could be the start of a score, or the first try at something or other). Later on in the program we will want to test for the limit, say 9, and if we have reached it then finish, otherwise increase (increment) the score and carry on. The instruction 7E — **LD A,(HL)**, where HL points at the screen position of the number, will load A with the number on the screen. Comparing register A with the limit, 9, we can either finish if A equals 9, or increment A, poke it back onto the screen, and carry on with the program. I'll be covering the compare instructions later on, but it does involve the use of the flags. Things should be starting to fall into place now, but it does require a little thought.

Fingering The Index

Because the index registers X and Y allow great flexibility in machine code programming, this section will cover a lot of ground. As you get to know how the index registers work the easiest way to visualise them is as pointers to a table, the X registers moving horizontally, and the Y registers moving vertically. This doesn't happen literally of course, but the table concept can easily be programmed. Because I wrote about indirect addressing in the last section, I'll give a couple of examples from the 6502 set using indirect and indexed addressing together. Pre-indexed indirect addressing is the grand title of the first example, and Fig. 14 will make what's happening clearer.

The instruction A1 — **Ld A,(I,X)** requires a second byte after the op-code (A1). This second byte is added to the contents of the X register to get the address of the first of two sequential bytes in zero page of the memory. These two bytes form the address of the byte to be loaded into the accumulator (or A register). In the example I've assumed that the X register holds 70h and that the second byte of the instruction is 0Ah. These two are then added together to get 7Ah (any carry bits will be lost) which is used as a pointer to locations 007Ah and 007Bh in the memory. The contents of these two locations are treated as a 16-bit address (low byte in the lower address) and in our example this is 4000h. This is the address which holds the byte to be loaded into the accumulator, in this case FFh, to finish the instruction. Note that the X register still contains 70h at the end of the instruction. A most useful mnemonic would be A ← (byte 2 + (X)) which illustrates quite clearly what is happening. Although I mentioned zero page addressing above, you could have reasoned out what was going on without it, because the X register will only hold one byte.

The second example from the 6502 set is B1 — **Ld A(I),Y** which is a post-indexed indirect instruction, with the mnemonic A ← ((Y) + (byte2)). Before you look at Fig. 15, and before you read my explanation, see if you can work out what it does; think of the use of brackets.

The second byte, in this case BE, is address 00BE, and 00BE and 00BF hold the two bytes of an address, in this case 4000h. The byte in the Y register, which is FFh, is now added to 4000h to make 40FFh, and in address 40FFh is the data that is loaded into the A register. What could be simpler?

Please note that only certain index registers can do particular jobs in the 6502 set. I leave it as an exercise for you to work out how the two prefixes pre- and post- are justified.

The Z80 CPU has a host of instructions involving index registers IX and IY. The instructions for the IX and IY pairs are the same as those for the HL pair with the prefix DD for IX and FD for IY instructions. As an example I'll take the Z80 opcode 77 — **Ld (HL),A** which I used in the previous section; the instruction DD 77 — **LD (IX + d),A** is the indexed equivalent. This is quite straightforward; it means: poke the contents of A into the address formed by adding d to IX. That letter "d" means that there are three bytes in the instruction and "d", for displacement, is the third byte. This byte is treated as an 8-bit signed 2's complement number and thus has a value between −128d and +127d. (80h = −128d, 00h = 0d and 7Fh = +127d.) If IX held 4000h and we wanted to load

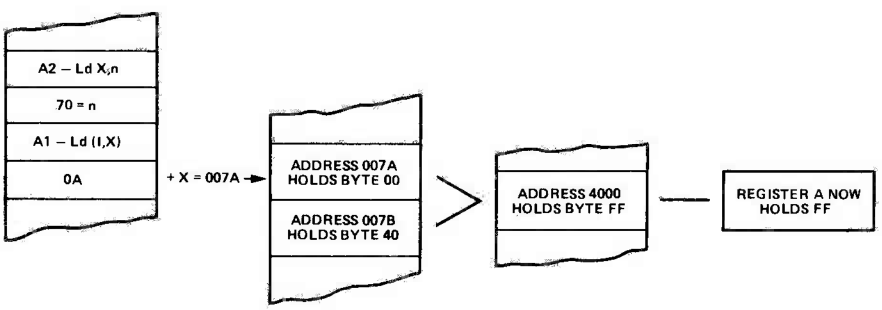


Fig. 14 Pre-indexing addressing from the 6502 set.

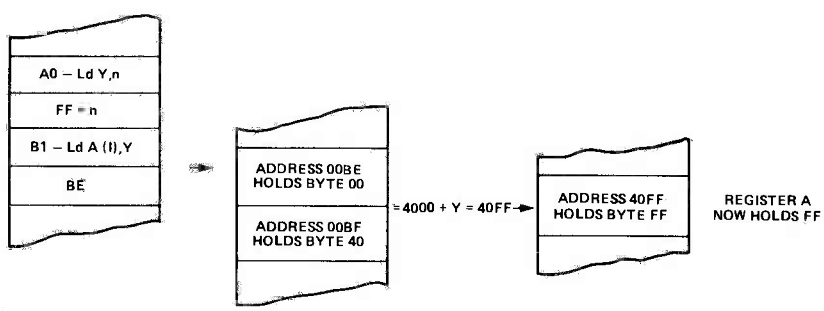


Fig. 15 Post-indexing indirect addressing from the 6502 set.

the A register into address 4079h, then the full instruction would be:- DD 77 79.

By now you should be able to recognise just about every addressing mode that you may come across. Before I carry on, though, I would like to just clear up something I just touched upon at the beginning of this month's article, when I was discussing pushing and popping.

Apart from the fact that we can't use line numbers in machine code, we do have the equivalent to GOSUB instructions where we GOSUB to an address (location). The 6502 instruction set has only the one instruction to GOSUB and that is 20 — **JSR** where JSR means jump to subroutine. Now don't confuse this jump with the relative jumps and the like, that I wrote about earlier. Just as in BASIC, this jump to a subroutine expects a RETURN which with the 6502 is 60 — **RTS** or return to subroutine (I always think of it as return to sender!).

The Z80 set has quite a few GOSUB instructions, although they are labelled CALL, with the simplest being CDpq — **Call pq.** All of the flag conditions can be used for Calls in the Z80 set; for example, CCpq — **CALL Zpq,** which means, when the result of the last instruction is zero, GOSUB pq. Again flag conditions can be used for a return, such as DB — **RET C,** when carry flag is set. The straightforward return in the Z80 set is C9. A word of warning, though: keep tracks on your calls to subroutines, and make sure that the returns match up. If in doubt, re-read this month's opening section.

A Logical Conclusion

A seemingly innocuous one-byte instruction is increment, or add one to. This can apply to single registers, pairs, index registers and even inc,(HL). The 6502 has single byte instructions for incrementing its X and Y registers only. Increment is one of three add instructions which involve the use of absolute binary arithmetic. All that means is that we will be using binary, but with no fractions and no negative or positive numbers. This will become clearer as we go along anyway.

Taking a single register first, as you would expect, increment will just add 1 to the contents of that register. This is all very well until the contents of that register reach FF, which is the maximum number that one register can hold. So now what happens? Fig. 16 should be of some help, and if you don't understand binary addition then this explanation will put you right. Remember that a binary digit, or bit, can only be either 1 or 0, if we add two 1s together the answer must be 0 and carry one over to the left. Starting at bit 0, the one on the right in Fig. 16, work your way to the leftmost bit which is bit 7.

```
Contents of register = FF = 11111111 binary
                                   1 INC or add 1
Contents of register = 00 = 00000000
```

Fig. 16 Incremementing the contents of a full register.

You should finish up with all the bits at 0, which means that the register now holds zero. So you see, incrementing a full register, or register pair, simply means that we start at zero again, and the zero flag should be set. I say *should* be set because it's always advisable to check on the flags situation in the instructions set.

By the way, what happened to the last carry to the left, the one after we added 1 to bit 7? The answer in the case of incrementing is that it was discarded, but with the next two add operations it is important, as it affects the carry flag. The 6502 also has 2 and 3-byte instructions for incrementing (and decrementing) memory locations directly and indirectly.

In the Z80 set, you can add register to register, such as **ADD A,B,** or add pairs such as **ADD HL,DE.** Again, index registers can be involved, and even an instruction such as **ADD A,(HL)**. Usually the only register that you can add a constant to is register A, in instructions such as **ADD A,n.** Fig. 17 shows the simple addition of two registers, which is quite straightforward. Again, when the two numbers added together come to more than one register can hold then the register that is being added to will pass through zero. This time, something different happens, so let's take a look at an example.

```
Contents of register A =  50 decimal = 00110010 binary
Contents of register B = 100 decimal = 01100100 binary
Contents of register C = 150 decimal = 10010110 binary
```

Fig. 17 Adding two full registers together.

Suppose register A held D1 or 209, and register B held B0 or 176 and the instruction was **ADD A,B.** Fig. 18 shows what happens, but I'll put it into words as well. Adding 209 and 176 gives an answer of 385; subtracting 256 leaves 129, which is what finishes up in register A.

Just to prove what a glutton for punishment I am, I will now go through the binary addition in Fig. 18. Bit 0, the rightmost bit, is where we start, and 0 + 1 equals 1 so a 1 goes on the bottom line. Bits 1, 2 and 3 are 0 in both registers so 0 goes on the bottom line in each case. Bit 4 in both registers is 1 so down goes 0 and a carry to the left. Two 1s make a carry from bits 5 and 6, this 1 goes into bit 7 position on the bottom line. Those two 1s above the bottom line in bit 7 position give a carry to the left, and this last carry sets the carry flag 7.

```
Contents of register A = 209 decimal = 11010001 binary
Contents of register B = 176 decimal = 10110000
Contents of register A = 129 decimal = 10000001 binary
A carry to the left sets the carry flag
```

Fig. 18 What happens when two registers added together come to more than 255 decimal.

The third add instruction is **ADC**, which stands for add with carry, and is really straightforward. What happens is that all the above rules apply plus the fact that the current value of the carry flag is added on to the total, and the carry flag altered according to what happens during the current instruction. In other words, if there is a carry over from bit 7 then the carry flag will be set, otherwise reset. The 6502 has no register to register arithmetic, but uses memory locations — especially zero page locations — instead, but always with ADC.

The subtraction instructions follow exactly the same pattern as the addition instructions with regard to the registers, etc. The first SUBtraction is DECrement, or decrease by 1, then SUB and finally SBC or subtract with carry. As you might expect, if you decrement a register, or register pair, which holds zero, then the number will zoom round to FF or FFF. Rather than me give you an example of subtracting in binary, why not have a go yourself? Write down two decimal numbers, take the smaller from the greater, convert the two numbers to binary, underneath write down the answer from the decimal subtraction converted to binary. Now work out how you can arrive at the answer.

AND The Rest

Usually there are three logical instructions that you can use which are AND, OR and XOR. Taking AND as the first example, it usually comes in the form AND,r where r is another register such as AND,C. There should be an instruction such as AND,n where n is any number up to FF, and you may get AND(HL) and even AND(IX + d). Your CPU instruction set should show what AND instructions you can use. Whatever the instruction, everything is ANDed with register A, the accumulator.

Assuming that register A holds FF and register B holds 0F, Fig. 19 shows what happens when the instruction AND,B is met. The explanation couldn't be easier: if the bits in A *and* B are both 1 then that bit remains the same in register A.

```
Register A holds FF = 11111111
Register B holds 0F = 00001111 AND
Register A holds 0F = 00001111
```

Fig. 19 The result of the instruction AND B.

Check with your CPU instruciton set, but an AND instruction will usually alter all of the flags, with the carry flag always being set. If, during the writing of your program, you are not sure of the status of the carry flag, then AND A or AND FF will always reset it for you. Another use for ANDing is to mask off certain bits, and this is worth an explanation.

In the first part of this series I made a passing mention to a refresh register which is used to ensure that data isn't lost from RAM by the simple expedient of each address from time to time. What happens is that this register, R, starts off at zero and is incremented until it reaches 7F, it is then discharged and starts at zero again. So at any time register R will hold a number between 00 and 7F. The Z80 set has an instruction ED 5F — **Ld A,R** which, if used from time to time in a program, gives the effect of putting a random number in A. If you want to make sure that this 'random' number doesn't go above a certain number all you have to do is AND,x where x is your limit; note, however that if you chose an x that is not equal to 2^n-1, this operation will not return a truly random number (why?).

The refresh register is acutally 8 bits but only the 7 lower bits are incremented automatically. The 8th bit can be set or reset by using the **Ld R,A** — ED 4F which transfers the contents of the A register to the refresh register. The refresh register will then be incremented from that value but the MSB will stay in its current state.

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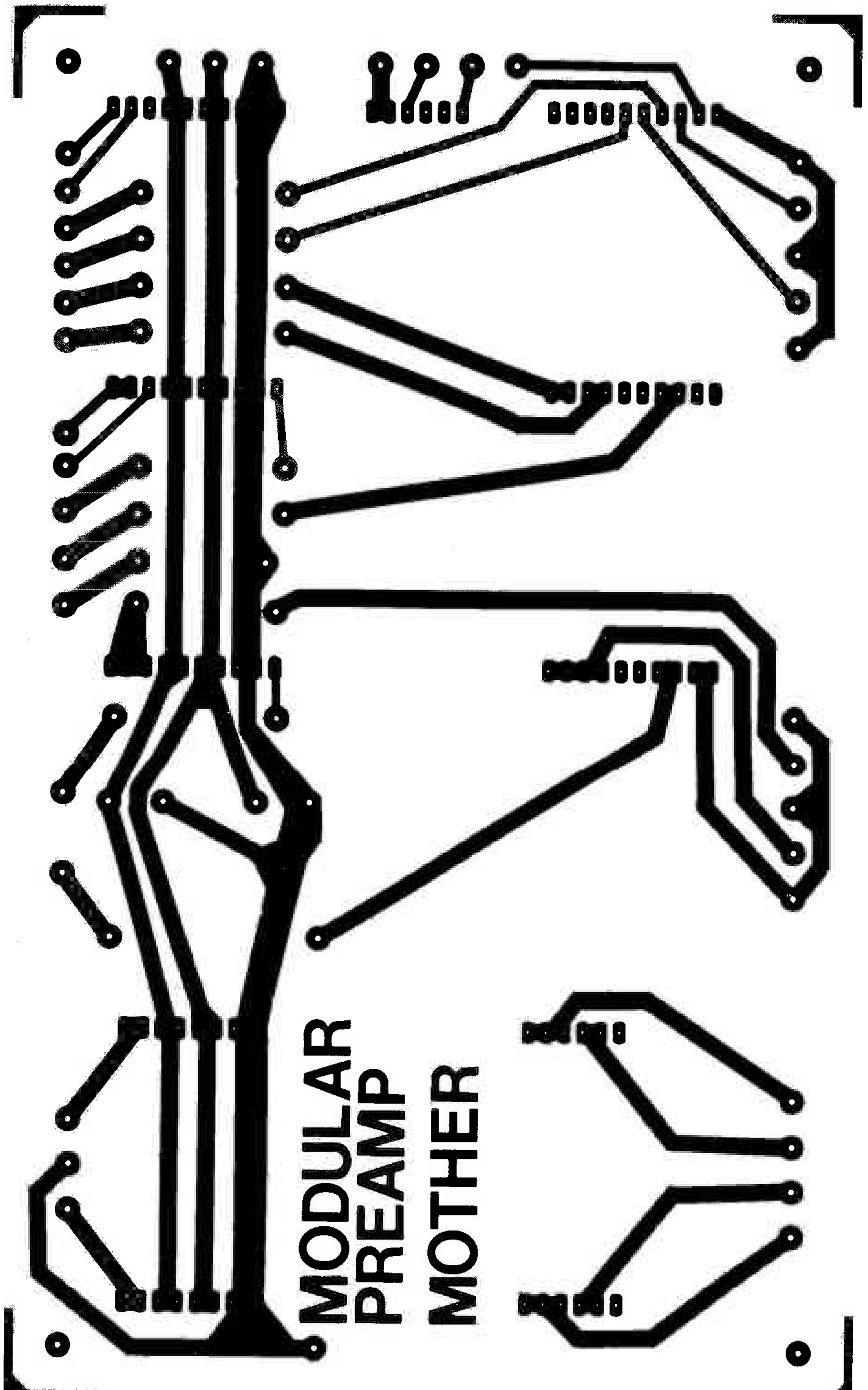

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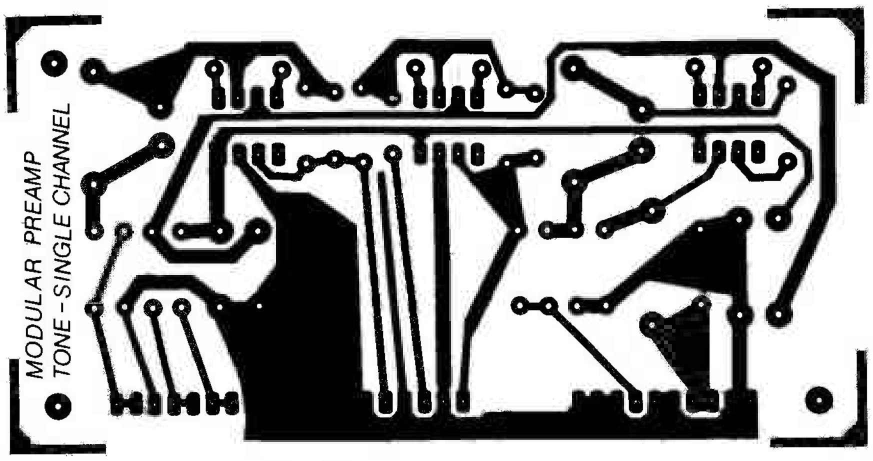

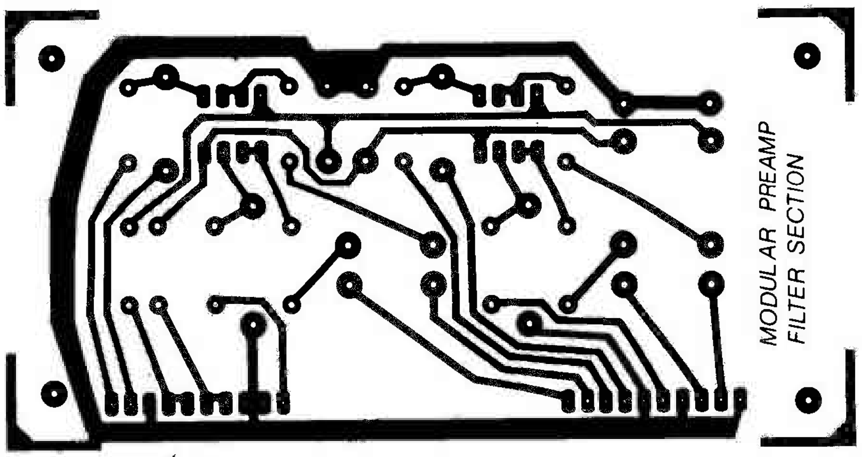

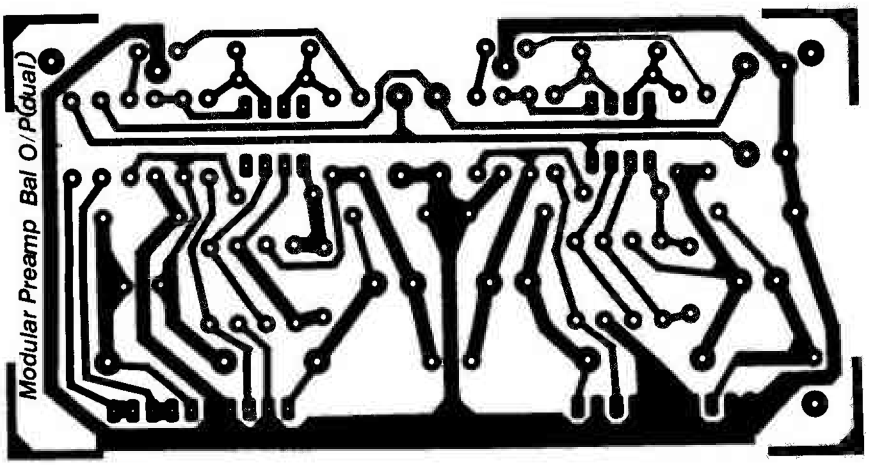

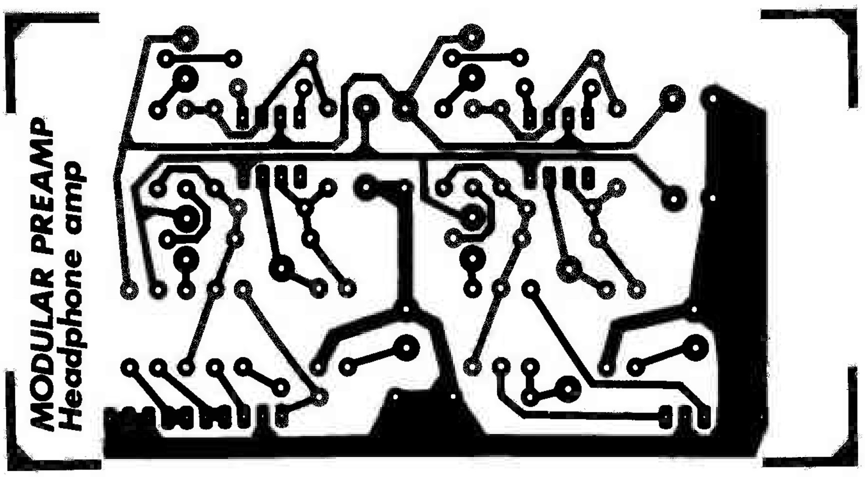

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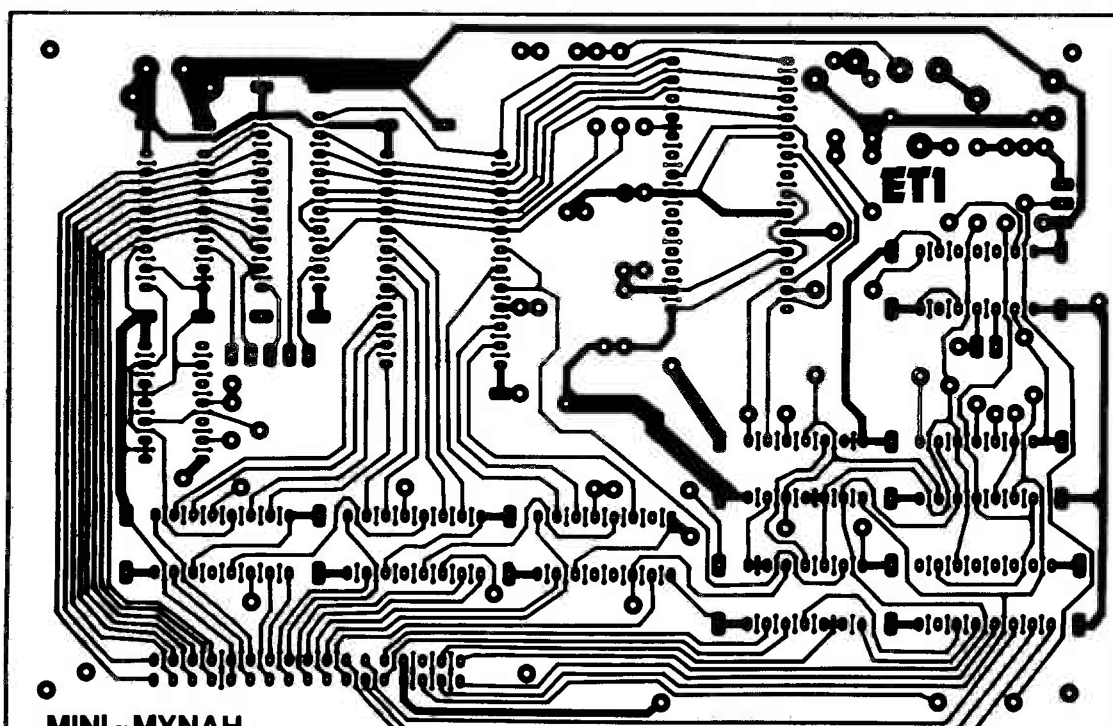

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Write For ETI

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.

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)
Corrections to this project are listed in the article "Universal EPROM Programmer Revisited" which appeared in the January '84 issue.

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)
An update article on this project will appear in the March '84 issue.

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.

Active Loudspeaker (November 1983)
Gremlins attacked the parts list on page 72 leaving a trail of 00's in their wake. The ceramic tiles should be 150 mm (6") square and you need six of them. The BAF wadding needs to be about as wide as the enclosure's internal height, i.e., about 21", and long enough to loosely fill the space when rolled up with a bit left over to cover the back of the bass unit. The thinner the wadding you use, the greater the length you will require.

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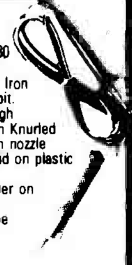

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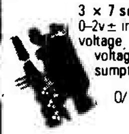

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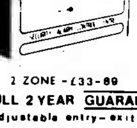

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High performance, low price kits for today's musicians

DIGITAL DELAY LINE

Digital delay circuitry is an absolute necessity for high quality studio work, but usually comes with a four-figure price tag.

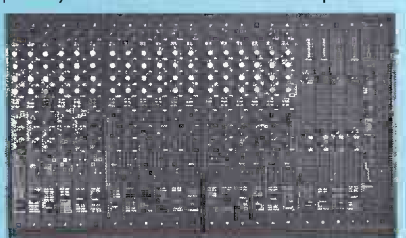
Powertran can now offer you digital quality for the price of a high analog unit. The unit gives delay times from 1.6mSecs to 1.6 secs with many powerful effects including phasing, flanging, A.D.T., chorus, echo and vibrato. The basic kit is extended in 400mSec steps up to 1.6 seconds simply by adding more parts to the PCB.

Complete kit (400mS delay) **£130**

Parts for extra 400mS delay (up to 3) **£9.50**

'DESTINY' MIXER

This versatile mixer offers a maximum of 24 inputs, 4 outputs, and an auxiliary channel. Input channels have Mic/Line, variable gain, bass/treble, and middle frequency equaliser. Output channels have PPM displays and record/studio outputs. There are send/return jacks, auxiliary, pan and fader controls, and output and group switching. There is also a headphone jack and built-in talk-back microphone.



Input channel	£19.50
Output channel	£18.50
Aux. channel	£22.50
Blank panel	£3.00
Base unit and front	£27.50
Pair of end cheeks	£12.50
Power supply and cabinet	£19.50

TRANSCENDENT 2000

ETI single board synthesizer.

This professional quality 3-octave instrument is transposable 2 octaves up or down, giving an effective 7-octave range.

There is portemento pitch bending, VCO with shape and pitch modulation, VCF with high and low pass outputs and separate dynamic sweep control, noise generator and an ADSR envelope shaper. Other features include special circuitry with precision components to ensure tuning stability.

Complete kit **£165**

MPA 200

100 watt mixer/amplifier

Here's a rugged, professionally finished mixer amp designed for adaptability, stability and easy assembly. Using new super-strength power transistors and a minimum of wiring, it offers a wide range of inputs (extra components are supplied for additional inputs), 3 tone controls, each with 15dB boost and 15dB cut, and a master volume control.

Complete kit **£49.90**

SP2-200

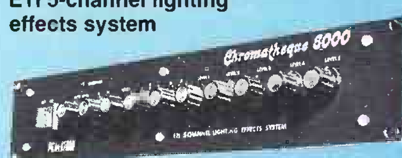
2-channel, 100-watt amplifer

The SP2-200 uses two of the power amplifier sections of the MPA 200 (above), each with its own power supply. A custom designed toroidal transformer enables both channels to simultaneously deliver over 100W rms into 8 ohms. Each channel has its own volume control, and a sensitivity of 0.775mV (OdBm) makes this amplifer suitable for virtually all pre-amps or mixers.

Complete kit **£64.90**

CHROMATHEQUE 5000

ETI 5-channel lighting effects system



Many lighting control units are now available. Some perform switching and others modulation of light output according to musical input. The Chromatheque combines both functions. It controls 5 banks of lamps up to 500W each in either analog or digital mode. And the 5 channels give more colours and more exciting linear and random sequencing than is possible with 3 or 4-channel systems. Versatile light level controls enable the lights to be partially on to suit the mood of the occasion. Wiring is minimal and construction straightforward.

Complete kit **£49.50**

All prices are exclusive of VAT. Free carriage in UK – export at cost.

Allow 21 days for delivery

POWERTRAN cybernetics ltd.

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