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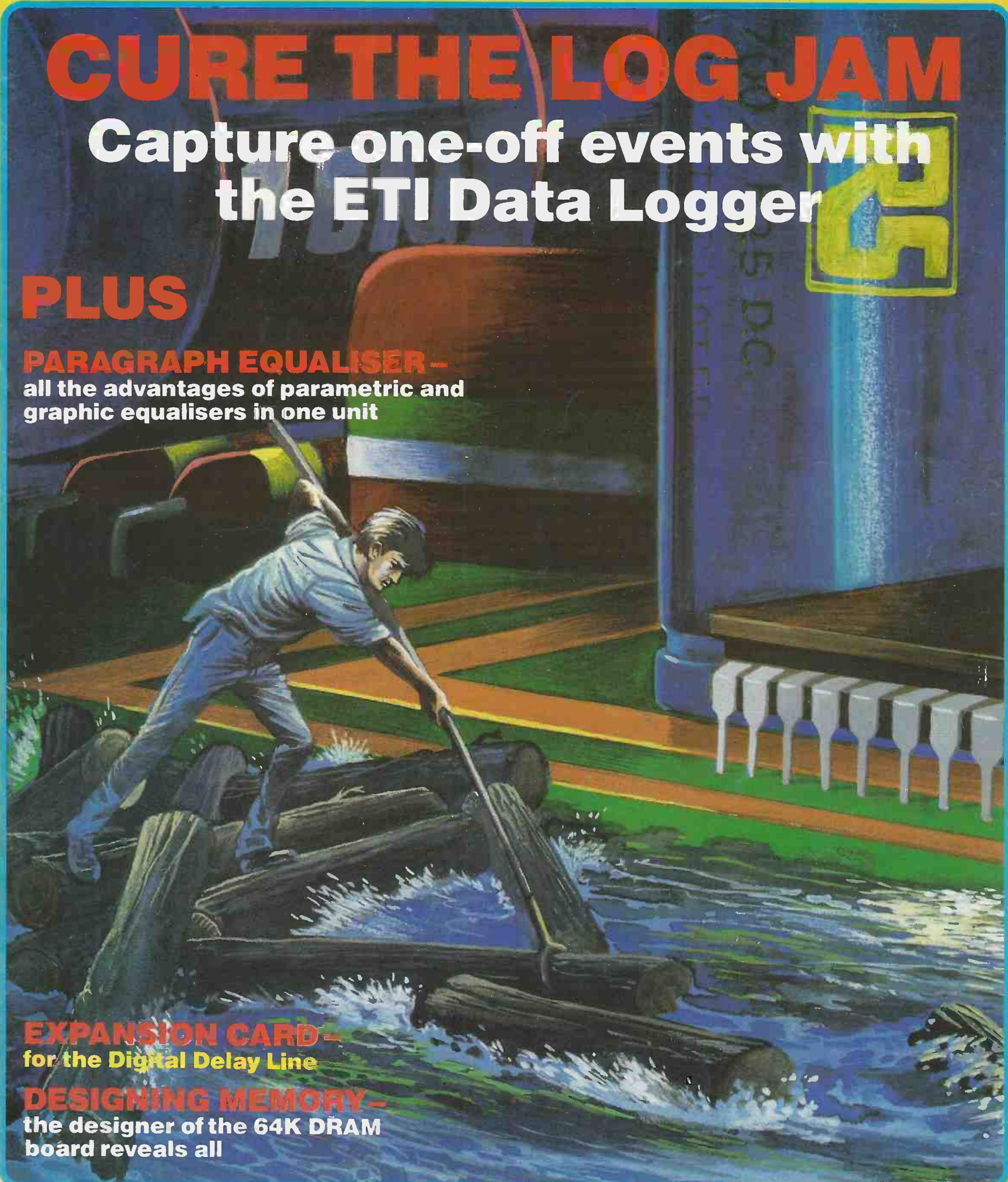
electronics today INTERNATIONAL

FEBRUARY 1985 99p



CURE THE LOG JAM

Capture one-off events with the ETI Data Logger

PLUS

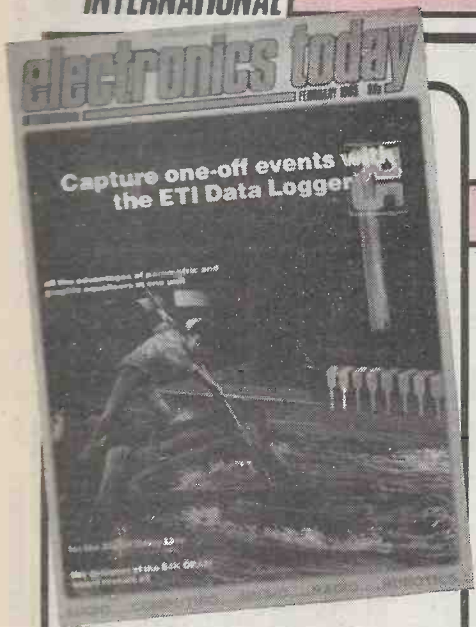
PARAGRAPH EQUALISER –
all the advantages of parametric and graphic equalisers in one unit

EXPANSION CARD –
for the Digital Delay Line

DESIGNING MEMORY –
the designer of the 64K DRAM board reveals all

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

electronics today INTERNATIONAL FEBRUARY 1985 VOL 14 NO 2



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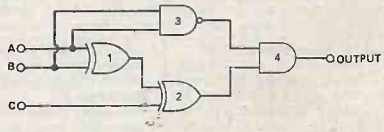
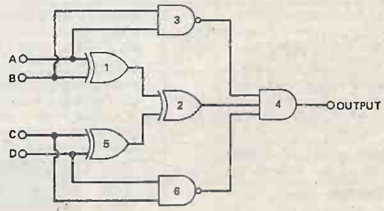
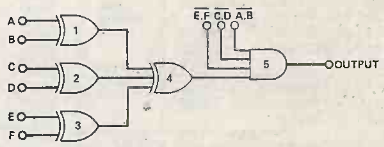
FEATURES







PROJECTS

My God! It's not the picture that's seized up — its Des Lynam! *(With apologies to sporting media megastar)*

INFORMATION

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SWITCHES
TOGGLE: 2A, 250V
SPST **35p** DPDP **48p**

SUB-MIN TOGGLE

SPST on/off	58p
SPDT c/over	64p
SPDT centre off	85p
SPDT biased both ways	105p
DPDT 6 tags	80p
DPDT centre off	88p
DPDT biased both ways	145p
DPDT 3 positions on/on/on	185p
4-pole 2 way	220p

SLIDE 250V:

DPDT 1A	14p
DPDT 1A c/off	15p
DPDT ½A	13p

PUSHBUTTON 6A
with 10mm Button

SPDT latching	150p
DPDT latching	200p
SPDT moment	150p
DPDT moment	200p

Mini Non Locking

Push to Make	15p
Push to Break	25p

DIGITAST Switch
Assorted Colours
75p each

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 adjusiable 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 SWITCHES

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 switches

Decade Switch Module	275p
B.C.D. Switch Module	298p
Mounting Cheeks (per pair)	75p

TURNED PIN Low Profile DIL SOCKET

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

JUMPER LEADS (Ribbon Cable Assembly)
IDC Female Header Socket Jumper Leads 36"

	20 pin	26 pin	34 pin	40 pin
Single ended	160p	200p	280p	300p
Double ended	290p	370p	480p	525p

GAS/SMOKE DETECTORS
†GS812 or TGS813
£6 each

VEROBOARD 0.1in

2½ x 3¼	95p
2½ x 5	110p
3¾ x 3¾	110p
3¾ x 5	125p
3¾ x 17	420p
4¾ x 17	590p
Pkt of 100 pins	55p
Spot face cutter	150p
Pin insertion tool	185p

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

PROTO DECs

Veroblock	480p
S-Dec	395p
Eurobreadboard	590p
Bimboard 1	575p
Superstrip SS2	1350p

VERO WIRING PEN

+ spool	380p
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 **475 pr**

COPPER CLAD BOARDS

Fibre glass	Single-sided	Double sided
6" x 6"	100p	125p
6" x 12"	175p	225p

DIL 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

2x6 way	—	111p
2x12 way	—	160p
2x15 way	—	165p
2x18 way	210p	175p
2x22 way	215p	250p
2x23 way	175p	—
2x25 way	285p	275p
2x28 way	190p	—
2x30 way	310p	—
2x36 way	360p	—
2x40 way	380p	—

SIL SOCKET 0.1" Pitch 20 way **65p**

ANTEX SOLOERING IRONS

C15W	525p;	CS17W	545p
C18W	550p;	XS25W	570p
Spare Bits	85p;	Elements	230p
Iron Stand	175p;	Heat Shunt	30p

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	·	220p	285p
DIN41612 2 x 32 A + C	295p	·	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	88p	178p
28 pin	290p	295p
40 pin	250p	255p

RIBBON CABLE
price per foot

	Grey	Color
10 way	15p	28p
16 way	25p	40p
20 way	30p	50p
24 way	40p	65p
28 way	55p	80p
34 way	60p	85p
40 way	70p	90p
50 way	100p	135p
64 way	120p	160p

ZIF TEXTOOL DIL SOCKETS

24 pin	575p
28 pin	695p
40 pin	845p

'D' CONNECTORS

	9 way	15 way	25 way	37 way
Male				
Solder lugs	80p	105p	160p	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

AMPHENOL CONNECTORS

	IDC	Solder
24 way IEEE	475p	470p
36 way Centronix	525p	475p
24 way Female	490p	450p

PANEL METERS
FSD
60 x 46 x 35mm
0-50µA
0-100µA
0-500µA
0-1mA
0-5mA
0-10mA
0-50mA
0-100mA
0-500mA
0-1A
0-2A
0-25V
0-50V AC
0-300V AC
"S"
"VU" **490p each**

CRYSTALS

32.768KHz	100
100KHz	545
200KHz	370
455KH	370
1MHz	275
1.008M	275
1.28MHz	450
1.6MHz	395
1.8MHz	545
1.8432M	250
2.0MHz	225
2.4576M	200
3.12MHz	240
3.278M	150
3.5794M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.19430M	200
4.433619M	100
4.608MHZ	200
4.80MHz	200
5.0MHz	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	225
7.0MHz	150
7.168MHz	250
7.7328MHz	250
7.68MHz	200
8.0MHz	150
8.089333MHz	395
8.86723M	220
9.00MHz	200
10.0MHz	175
10.24MHz	200
10.5MHz	250
10.7MHz	150
12.0MHz	175
12.528M	300
14.31814M	170
15.0MHz	240
16.0MHz	220
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	240
48.0MHz	240
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**
RL8-111 205R Coil, 12V DC (10V7 to 19V5) **195p**
RL8-114 740R Coil, 24V DC (22V to 37V) **200p**

ASTEC UHF MODULATORS

Standard 6MHz	375p
Wideband 8MHz	550p

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

PIEZO TRANSDUCERS PB2720 **70p**

LOUDSPEAKERS
Miniature, 0.3W- 8Ω

2", 2¼", 2½", 3"	80p
2½" 40Ω 64Ω or 80Ω	80p
6" x 4" 8Ω	200p
7" x 5" 8Ω	225p
8" x 5" 8Ω	250p

MONITORS
- ZENITH — 12" Green, Hi-Resolution Popular **£68**
- MICROVITEC 1431, 14" Colour RGB input. Connecting cable incl. **£165**
- MICROVITEC 1451, 14" Medium resolution **£265**
- KAGA 12", Med-res. RGB Colour. Has flicker-free characters. Ideal for BBC, Apple, VIC, etc **£195** (car £7)
- KAGA 12". As above but Hi-Resolution **£259** (car £7)
- Connecting Lead for KAGA **£5**

Carriage £7 Securicor

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 **235p**
6VA: 2x6V-0.5A; 2x9V-0.3A, 2x12V-0.25A; 2x15V-0.2A **280p**
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 **385p** (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 **985p** (75p)

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

VOLTAGE REGULATORS
1A TO220 Plastic Casing

	+ ve		− ve	
5V	7805	50p	7905	50p
12V	7812	50p	7908	60p
15V	7815	45p	7912	50p
18V	7818	45p	7915	50p
24V	7824	50p	7918	50p
			7924	50p

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	585p
LM317KP	450p	79HG − 2.25V to −24V; 5A	685p
LM323K	450p	78S40	225p
LM337	175p		
LM723 Var	30p		
78S40	225p		

SOLDERCON PINS
Ideal for making SIL or DIL Sockets

100 pins	45p
500 pins	195p

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

BROTHER HR15 PRINTER
A high quality Daisy Wheel printer at the price of a Dot Matrix printer.

Price £339 (car. £7)

CMOS

4000	20	4072	25	4536	275
4001	25	4073	26	4538	80
4002	25	4075	25	4539	90
4006	75	4076	68	4541	95
4007	25	4077	25	4543	70
4008	60	4078	25	4544	150
4009	45	4081	25	4548	40
4010	60	4082	25	4549	400
4011	25	4085	80	4553	245
4012	25	4086	60	4554	180
4013	60	4089	125	4555	35
4014	60	4093	37	4556	55
4015	60	4094	70	4557	250
4016	40	4095	95	4558	120
4017	60	4096	100	4559	395
4018	60	4097	275	4560	180
4019	58	4098	80	4561	104
4020	90	4099	110	4562	350
4042	43	4160	95	4566	165
4021	58	4161	96	4568	250
4022	67	4162	96	4569	175
4023	30	4163	96	4572	45
4024	50	4174	96	4580	255
4025	22	4175	105	4581	125
4026	90	4194	105	4582	90
4027	43	4408	850	4583	100
4028	45	4409	850	4584	60
4029	75	4410	725	4585	70
4030	35	4411	750	4597	330
4031	130	4412	805	4599	155
4032	70	4415	590	40085	90
4033	130	4419	280	40097	45
4034	148	4422	770	40098	42
4035	70	4435	850	40100	215
4036	275	4440	900	40101	130
4037	115	4450	360	40102	140
4038	75	4451	350	40103	412
4039	280	4490	450	40104	120
4040	60	4500	395	40105	220
4041	57	4501	38	40106	60
4042	50	4502	60	40107	55
4043	42	4503	99	40108	325
4044	50	4504	95	40109	100
4045	110	4505	385	40110	235
4046	60	4506	100	40114	240
4047	60	4507	45	40161	194
4048	55	4508	130	40163	75
4049	38	4510	55	40174	75
4050	35	4511	55	40175	75
4051	70	4512	55	40181	220
4052	60	4513	150	40182	80
4053	60	4514	115	40192	75
4054	85	4515	115	40193	95
4055	85	4516	55	40194	70
4056	85	4517	275	40195	75
4057	1000	4518	48	40244	196
4059	435	4519	32	40245	196
4060	68	4520	53	40257	196
4061	500	4521	115	40373	220
4062	986	4522	125	40374	220
4063	85	4526	40	45106	588
4066	45	4527	65	**OPTO**	
4067	245	4528	68	OCP71	120
4068	25	4529	150	ORP12	85
4069	25	4530	90	ORP61	86
4070	25	4531	130	BPX25	250
4071	25	4532	65	BPW21	320
		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	100p
Green/Yellow	115p
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	275

ISOLATORS

IL74	145
ILQ74	145
ILQ74	275
TIL111/2/4	70
ILCT6 Darlington	135
TIL117	125
4N33 Photo Darlington	136

7 Segment Displays

TIL312 .3" CA	120
TIL313 .3" CC	120
TIL321 .5" CA	140
TIL322 .5" CC	140
TIL729/730	140
DL704 .3" CC	125
DL707 .3" CA	125
FND357 Red	120
FND500	120
.3" Green CA	150
.6" Green CA	215
.3" ± 1 Red CA	150
3" ± 1 Green CA	150
LCD 3½ Digits	496
LCD 4 Digits	530
LCD 6 Digits	625
Reflective Switch	225
SLOTTED Optical Switch similar to RS Comp.'s	295

COMPUTER CORNER
- QL RGB MONITOR, Medium resolution £239
- EPSON RX80 Printer £229
- EPSON RX80 F/T Printer £245
- EPSON FX80 Printer £316
- EPSON FX100 Printer £435
- KAGA/TAXAN KP810 Printer £235
- KAGA/TAXAN KP910 Printer £339
- SEIKOSHA GP100A Printer £339
- BROTHER HR15 Daisywheel £339

Cable for above printers to interface with BBC Micro £7

- TEX EPROM ERASER — Erases up to 25 Eproms. Has a built-in safety switch £30
- SPARE 'UV' Lamp Bulb £8
- C12 Computer CASSETTES in Library cases 36p
- 8½" & 9½" Fan Fold paper (1000 sheets) .... £7 (Carr. 150p)

(Securicor Carriage charge on printers is £7)

CALL IN AT OUR SHOP FOR A DEMONSTRATION ON ANY OF THE ABOVE ITEMS. BE SATISFIED BEFORE YOU BUY OR WRITE IN FOR OUR DESCRIPTIVE MICRO PERIPHERALS LEAFLET.

DISC DRIVES
(CUMANA)
DRIVES CASED with PSU & CABLES

- **CS100** — Single Cased with PSU, 40 Track, 5¼" S/S 100K £129
- **CD200** — Twin Cased with PSU, 40 Track, 5¼" S/S 200K £265
- **CS200** — Single Cased with PSU, 80 Track, 5¼" S/S 200K £175
- **CD400** — Twin Cased with PSU, 80 track, 5¼" S/S 400K £349
- **MITSUBISHI 5¼" SLIM LINE DISC DRIVES**
  Double Sided, Double Density, Track Density 96 TPI, Track to track access time 3msec.
- **MITSUBISHI Single Slimline,** 5¼" Cased with PSU. DSDD. 1 Megabyte (400 K with BBC) £199
- **MITSUBISHI Twin Slimline,** 5¼" Cased with PSU. DSODD. 2 Megabyte. (800 K with BBC) £425

5¼" DISKETTES (Lifetime Warranty)

- **10 3M Diskettes Single side Double density** £13
- **10 3M Diskettes Double side Double density** £23

N.B Carriage on Drives £7 securicor

SPECTRUM 32K UPGRADE
Upgrade your 16K Spectrum to full 48K with our RAM Upgrade Kit. Very simple to fit. Fitting instructions supplied.

£22

SPECTRUM CENTRONICS/RS232 PRINTER INTERFACE
★ It was the first! It is still the best!
★ Centronics and BI-DIRECTIONAL RS-232 with full hand-shaking.
★ Obeys SPECTRUM LLIST and LPRINT.
★ Split-Speed Operation for RS-232.
(Use it to communicate with the BBC MICRO or OTHER PERIPHERALS)
★ Interface 1, Interface * & Microdrive compatible.
★ Configuration program creates customised M/C driver to suit your printer.
★ HI-RES screen dumps in 2 sizes on EPSON, SEIKOSHA, STAR, SHINWA, MANNESMAN TALLY, NEC, RITEMAN, KAGA, etc. This is a STANDARD FEATURE! Not an extra.
★ Compatible with TASWORD TWO and most professional programs.

Complete Unit incl. Software tape + manual **£29.95**
Special Interface Cable **£8**

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SERVICE SHEET

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

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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 telephone number).

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OOPS!

Corrections to projects are listed below and normally appear for several months. Large corrections are published just once, after which a note will be inserted to say that a correction exists and that copies can be obtained by sending in an SAE.

ZX81 EPROM Programmer (May 1984)

On the overlay diagram on page 27, the resistance shown between IC9 and IC5 should be R2 not R1, the resitance shown between IC6 and IC7 should be R8 not R5. In the parts list, C1 should be listed as 220uF not 22uF; the circuit diagram gives the value correctly. R3 is marked "see text" but no reference is then made to it: it should be chosen to suit the LED used. LED1 is shown reversed on the circuit diagram on page 28 but the connections shown on the overlay diagram are correct. The first statement in program 1 on page 30 should read "SET PERSONALITY SWITCHES THEN PRESS CONT".

Spectrum Joystick Interface (June 1984)

The PCB and the circuit diagram do not agree; the circuit diagram is correct, and all PCBs sent out by the PCB service should have been amended. IC3 is 74LS241, as correctly stated in the parts list but incorrectly given in the footnote to the circuit diagram.

CMOS Tester (August 1984)

C3 and C2 are reversed on the overlay: C3 is the electrolytic and C2 the polyester. R33 is 100K, not 1M as given in the parts list, and RV1 is a 1M horizontal skeleton preset. R1-16 are two, eight-resistor SIL packages, the component labelled C14 on the overlay is SK1, and the connections to D2 shown in Fig. 3 are reversed. On the circuit diagram, the eight lines connecting SW9-16 to the inverters are shown in reverse sequence. Some of the inverters have been given the wrong designations; the correct sequence, reading down from the top, is:- IC1f, IC2a, IC2b, IC1e, IC1d, IC1c, IC1b, IC1a, IC2c, IC2d, IC2e, IC3d, IC3a, IC3b, IC3c, IC2f. Finally, the pin numbers are missing from ICs 3e and f; the input of IC3e is pin 11 and its output pin 12, and the input of IC3f is pin 14 and its output is pin 15. The PCB is correct in all respects.

Sharp Joystick Interface (August 1984)

Some of the inverter pins are incorrectly labelled on the circuit diagram. Pins 11 and 10 are shown reversed on IC1b, pins 9 and 8 are shown reversed on IC1c, and the output of IC4d is pin 10, not pin 20. Note that a number of the inverters have been incorrectly shown as non-inverting buffers.

AM/FM Radio (November 1984)

In Fig. 2, the oscillator and IF sections should be shown connected to ground; the PCB is correct. In Fig. 4, C31 should be 10n to give the 75us deemphasis shown in Fig. 3, but 4n7 has been found to give a brighter midrange. R38 in Fig. 5 should, of course, be 820k rather than 280k and it and the bottom end of C38, C44 etc should be shown connected to ground. In the construction section on page 25, four pieces of 8mm plywood are mentioned but in fact only three are needed — the fourth side is the front panel. See also the note in December News Digest regarding availability of the inductors.

Digital Control Port (November 1984)

The second sentence in the "Testing" section on page 30 should include the words 'without any ICs in place'. In the second paragraph of that section, the check for +5V should be made on pin 3 of IC101, not IC1. At the bottom of the first column on page 31, the last sentence should finish with B3 = 0.

Video Vandal (November 1984)

In Fig. 8 on page 54, R16 and R17 should be shown connected to the base of Q4, and C12 and SW2 should be in the D output line rather than the OV line. It may also be beneficial to add a diode across R3 with its anode connected to the slider of RV1. In Fig. 10, R52 and LED2 are shown connected across the +12V supply but it is better to place them across the −12V supply so as to even-up the dissipation in the ICs.

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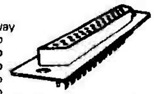
	9 way	15 way	25 way	37 way
Plugs solder lugs	55p	66p	90p	150p
Right angle	90p	135p	200p	350p
Sockets solder lugs	80p	100p	135p	260p
Right angle	120p	180p	290p	420p
Covers	100p	90p	100p	110p



CONNECTORS

DIN	Plug	Skt	Jack	Plug	Skt
2 pin	9p	9p	2.5mm	10p	10p
3 pin	12p	10p	3.5mm	9p	9p
5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	12p	13p	4mm	18p	17p

UHF (CB) Connectors:
PL259 Plug 40p. Reducer 14p.
SO239 square chassis skt 38p.
SO239S round chassis skt 40p.
IEC 3 pin 250V/6A.
Plug chassis mounting . . 38p
Socket free hanging . . 60p
Socket with 2m lead . . 120p

SCRs

▶C106D 35
400V 8A 70
400V 12A 95

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2.3 and 4.7mm bits to suit . 85
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Spare nozzle for above . 70
10 metres 22 swg solder . 100
0.5kg 22 swg solder . . 750

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3VA PCB Mounting
2x6V@0.25A;2x9V@0.15A
2x12V@0.12A;2x15V@0.1A 180p

6VA PCB Mounting
2x6V@0.5A;2x9V@0.4A
2x12V@0.3A;2x15V@0.25A 270p

Standard. Chassis Mounting
6VA: 2x6V@0.5A; 2x9V@0.4A
2x12V@0.3A;2x15V@0.25A 240p

12VA: 2x6V@1A; 2x9V@0.6A
2x15V@0.4A;2x20V@0.3A 350p

VERO

Verobloc . 395
Veroboard Size 0.1 in matrix
2.5 x 1 26
2.5 x 3.75 95
3.75 x 5 120
3.75 x 17 350
4.75 x 17 455
VQ board 190
Veropins per 100
Single sided 55
Double sided 65
Spot face cutter . . . 145
Pin insertion tool . . . 185
Wiring pen 375
Spare spool 75p Combs . 6

SWITCHES

Submin toggle:
SPST 55p. SPDT 60p. DPDT 65p.
Miniature toggle:
SPDT 80p. SPDT centre off 90p.
DPDT 90p. DPDT centre off 100p.
Standard toggle:
SPST 35p. DPDT48p
Miniature DPDT slide 14p.
Push to make 15p.
Push to break 22p.
Rotary type adjustable stop.
1P12W, 2P6W, 3P4W all 55p each.
DIL switches:
4SPST 80p 6 SPST 80p. 8 SPST 100.
Min. DPDT slide 14p. Push-make 15.

MICRO

		27128-250	1225	6800	200	6522	330
		6116P3	480	6802	280	6532	520
		6264P15	2980	6809	600	6551	540
2716	310	4116P4	70	6810	140	8085A	320
2532	380	4164-15	480	6821	140	8156	380
2732 one time programmable	360	41256-15	2850	6840	360	8251	350
		Z80A CPU	290	6850	165	8253	370
		Z80A P10	320	6852	240	8255	320
2732	430	Z80A CTC	320	6875	500	8259	400
2764-250	495	Z80A S10	880	6880	100	MC1488	70
2764 BBC	495	Z80A DMA	880	6502	370	MC1489	70

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	Low profile	Wire wrap
8 pin	7p	28p
14 pin	8p	45p
16 pin	10p	55p
18 pin	12p	60p
20 pin	13p	[illegible]
22 pin	15p	75p
24 pin	17p	82p
28 pin	15p	95p
40 pin	25p	135p

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24 pin 430p 28 pin 480p
40 pin 595p

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Preset kit. Contains 5 of each value from 100 ohms to 1M (total 65 presets 425
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25 6BA ½" bolts 25 4BA ¼" bolts 50 6BA washers
50 6BA nuts 25 6BA ½" bolts

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20 metre pack single core connecting cable ten different colours. 75p
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Standard screened . . 16p/m
Twin screened . . 24p/m
2.5A 3 core mains . . 23p/m
10 way rainbow ribbon 26p/ft
20 way rainbow ribbon 47p/ft
10 way grey ribbon . 14P/ft
20 way grey ribbon . 28p/ft

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78L15	30	79L15	45
7805	40	7905	45
7812	40	7912	45
7815	45	7915	45
LM317K	270	LM723	40
LM317T	90	78H05	550
LM323K	420		

DIODES

		▶1N4001	3
BY127	12	1N4002	5
OA47	10	1N4006	7
OA90	8	1N4007	7
OA91	7	1N5401	12
OA200	8	1N5404	16
OA202	8	1N5406	17
1N914	4	400mW zen	6
▶1N4148	3	1.3W zeners	13

OPTO

3mm red	8	5mm red	8
3mm green	11	5mm green	11
3mm yellow	11	5mm yellow	11

Clips to suit 3p each.

Rectangular:		TIL32	40
red	12	TIL111	60
green	17	TIL78	40
yellow	17	ORP12	85
ILD74	95	ILQ74	185
TIL38	35	TIL100	75
2N5777	45	Tri-color Led	35

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Com cathode. Com anode.
DL704 0.3" 95 DL707 0.3" 95
FND500 0.5" 100 FND507 0.5" 100
10 bar DIL LED display, red 180
5mm superbright LED 250mcd red 30

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PP3 battery clips . 6
Red or black crocodile clips . 6
Black pointer control knob . 15
Pr Ultrasonic transducers . 390
▶6V Electronic buzzer . 65
▶12V Electronic buzzer . 70
▶PB2720 Piezo transducer . 75
▶64mm 64 ohm speaker . 70
▶64mm 8 ohm speaker . 70
20mm panel fuseholder . 25
Red or black probe clip . 35
4mm terminals . 33
12 way 'chocolate' block . 21
ultra-min. 6 or 12v rel. SPDT 130
ditto, but DPDT . 195

EURO CONNECTORS

Gold flashed contacts:	Rt. angle plug	Wirewrap socket
64 way A+B	195	230
64 way A+C	220	270
96 way A+B+C	320	330

TRIACS

400V 8A 65
400V 16A 95
400V 4A 50 BR100 25

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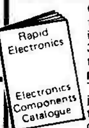

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COMPUTER CONNECTORS

ZX81 2 x 23 way edge connector wire wrap for ZX81 . . . 150
SPECTRUM 2 x 28 way edge connector wire wrap. . . 200
AMPHENOL PLUGS
24 way IEEE IDC. . . . 450
36 way Centronix IDC . . . 490

RIBBON CABLE

Grey Ribbon cable. Price per foot

10 way	14	34 way	58
16 way	25	40 way	68
20 way	28	50 way	90
26 way	38	60 way	100

CAPACITORS

Polyester, radial leads. 250v. C280 type: 0.01, 0.015, 0.022, 0.033 - 6p; 0.047, 0.068, 0.1 - 7p; 0.15, 0.22 - 9p; 0.33, 0.47 - 13p; 0.68 - 20p; 1u - 23p.
Electrolytic, radial or axial leads: 0.47/63V, 1/63V, 2.2/63V, 4.7/63V, 10/25V - 7p; 22/25V, 47/25V - 8p; 100/25V - 9p, 220/25V - 14p; 470/25V - 22p; 1000/25V - 30p; 2200/25V - 50p.
Tag end power supply electrolytics: 2200/40V - 110p; 4700/40V - 160p 2200/63V - 140p; 4700/63V - 230p
Polyester, miniature Siemens PCB: 1n, 2n2, 3n3, 4n7, 6n8, 10n, 15n, 7p; 22n, 33n, 47n, 68n, 8p; 100n, 9p; 150n, 11p; 220n, 13p; 330n, 20p; 470n 26p; 680n, 29p; 1u 33p.

Tantalum bead:
0.1, 0.22, 0.33, 0.47, 1.0 @ 35V - 12p. 2.2, 4.7, 10 @ 25V - 20p; 15/16V - 30p; 22/16V - 27p; 33/16V - 45p; 47/6V - 27p; 47/16V - 70p; 68/6V - 40p; 100/10V - 90p.
Cer. disc. 22p-0.01u 50V, 3p each.
Mullard miniature ceramic plate: 1.8pF to 100pF 6p each.
Polystyrene, 5% tol: 10p-1000p, 6p; 1500-4700, 8p; 6800 0.012u, 10p.
Trimmers. Mullard 808 series: 2-10 pF, 22p; 2-22pF, 30p; 5.5-65pF, 35p

BRIDGE RECTIFIERS

		2A 200V	40
		2A 400V	45
		6A 100V	80
		6A 400V	95
1A 50V	20	VM18 DIL 0.9A	
1A 400V	35	200V .	50

IDC CONNECTORS

	PCB Plug St.	PCB Plug Rt. ang.	Socket	Edge Conn.
10 way	70	70	70	–
16 way	75	80	80	–
20 way	90	90	95	130
26 way	105	110	115	155
34 way	115	130	130	180
40 way	140	140	145	210
50 way	165	165	170	240
60 way	195	195	200	–

RESISTORS

Carbon film	1+	25+
¼W 5% 4.7ohm - 10M	2p	1p
½W 5% 4.7ohm - 4M7	3p	2p
Metal film		
¼W 1% 10ohm - 1M	4p	3p

25+ price applies to 25+ per value not mixed.

CRYSTALS

		4.194MHz	150
		4.43MHz	100
100KHz	235	5.008MHz	240
1MHz	275	6.0MHz	140
1.8432M	200	6.144MHz	150
2.0MHz	225	7.0MHz	150
2.4576M	200	8.0MHz	140
3.276M	150	10.0MHz	170
3.579M	95	12.0MHz	170
4.0MHz	140	16.0MHz	200

BOXES

		Aluminium	
		3 x 2 x 1"	65
Plastic with lid		4 x 2¾ x 1½"	95
& screws		4 x 2¼ x 2"	95
71x46x22mm	50	6 x 4 x 2"	120
95x71x35mm	86	7 x 5 x 2½"	165
140x90x55mm	140	8 x 6 x 3"	205

LINEAR

		ICL7611	98	LM358	50	LM3915	265	NE567	130	TDA1024	115
		ICL7621	190	LM377	210	LM13600	110	NE570	370	TL061	40
555CMOS	80	ICL7622	200	LM380	80	MC1310	150	NE571	370	TL062	65
556CMOS	150	ICL8038	295	LM381	150	MC1496	70	NE5532	160	TL064	105
709	35	ICL8211A	220	LM382	130	MC3302	75	NE5534	105	TL071	38
741	16	ICM7224	785	LM384	140	MC3340	130	RC4136	65	TL072	60
748	35	ICM7555	80	LM386	90	MF10CN	330	RC4558	40	TL074	110
AY31270	720	ICM7556	150	LM387	120	ML922	390	SL486	195	TL081	30
AY38910	390	LF347	150	LM393	60	ML924	290	SL490	220	TL082	50
AY38912	430	LF351	40	LM710	48	ML925	290	SN76018	150	TL084	105
CA3046	65	LF353	75	LM711	60	ML926	210	SN76477	380	TL170	50
CA3080E	65	LF356	90	LM725	70	ML927	210	SP8629	250	UA2240	140
CA3089	200	LM10C	325	LM733	70	ML928	210	SP0256AL2	425	ULN2003	80
CA3090AQ	375	LM301A	30	LM741	16	ML929	210	Speech data	50	ULN2004	80
CA3130E	85	LM311	45	LM747	60	NE529	225	TBA800	70	XR2206	365
CA3140E	38	LM318	135	LM748	35	NE531	135	TBA810	90	ZN414	80
CA3160	95	LM324	45	LM1458	35	NE544	170	TBA820M	65	ZN423	135
CA3136	100	LM3342	85	LM2917N8	195	NE555	20	TBA950	220	ZN424P	130
CA3189	260	LM3352	125	LM3900	45	NE556	45	TCA940	165	ZN425E	350
CA3240E	100	LM339	40	LM3909	85	NE565	115	TDA1008	320	ZN426E	300
ICL7106	680	LM348	60	LM3914	265	NE566	140	TDA1022	490	ZN427E	600
										ZN428E	450
										ZN459	285
										ZN1034E	200

TRANSISTORS

				BC548	5	BFR40	23	2N1613	30	2N3906	10		
				BC549	10	BFR80	23	2N2218A	45	2N4037	45		
				BC557	10	BFR81	23	2N2219A	28	2N4058	10		
AC125	35	BC158	11	BC558	10	BFX29	30	2N2221A	25	2N4060	10	TIP35C	125
AC126	30	BC158	10	BCY70	16	BFX84	30	2N2222A	20	2N4061	10	TIP36A	115
AC127	30	BC159	10	BCY71	16	BFX85	30	2N2368	25	2N4062	10	TIP36C	130
AC128	30	BC160	40	BCY72	16	BFX86	30	2N2369	18	40360	40	TIP41A	45
AC176	25	BC168C	10	BD115	55	BFX87	30	2N2484	27	40361	50	TIP42A	45
AC187	25	BC169C	10	BD131	40	BFX88	30	2n2646	60	40362	50	TIP120	60
AC188	25	BC170	8	BD132	40	BFY50	27	2N2904	28	40408	50	TIP121	60
AD142	120	BC171	10	BD133	50	BFY51	27	2N2904A	28	2N5457	30	TIP122	60
AD161	42	BC172	8	BD135	35	BFY52	27	2N2905	28	2N5458	30	TIP141	110
AD162	42	BC177	16	BD136	35	BFY53	30	2N2905A	28	2N5459	30	TIP142	120
AF124	60	BC178	16	BD137	35	BFY55	30	2N2906	28	2n5485	35	TIP147	120
AF126	50	BC179	18	BD138	35	BFY56	30	2N2906A	28	2N5777	45	TIP2955	70
AF139	40	BC182	10	BD139	35	BRY39	50	2N2907	24	2N697	20	TIP3055	60
AF186	70	BC182L	10	BD140	35	BSX20	22	2N2907A	24	2N698	40	TIS43	40
AF239	55	BC183	10	BD204	110	BSX29	35	2N2926	10	2N706A	20	TIS43	40
BC107	10	BC183L	10	BD206	110	BSY95A	30	2N3053	28	2N708	25	TIS44	45
BC107B	12	BC184	10	BD222	85	BU205	160	2N3054	55	2N918	35	TIS45	45
BC108	10	BC184L	10	BF180	35	BU206	200	2N3055	50	TIP29	35	TI590	30
BC108B	12	BC212	10	BF182	35	BU208	170	2N3442	120	TIP29A	35	TI591	30
BC108C	12	BC212L	10	BF184	35	MJ2955	99	2N3702	9	TIP29B	35	VN10KM	65
BC109	10	BC213	10	BF185	25	MJE340	50	2N3703	10	TIP29C	35	VN46AF	94
BC109C	12	BC213L	10	BF194	12	MJE520	50	2N3704	9	TIP30	35	VN66AF	110
BC114	22	BC214	10	BF195	12	MJE521	90	2N3705	10	TIP30A	35	VN88AF	120
BC115	22	BC214L	10	BF196	12	MJE3055	70	2N3706	10	TIP30B	35	ZTX107	11
BC117	22	BC237	7	BF197	12	MPF102	40	2N3707	10	TIP30C	40	ZTX108	11
BC119	35	BC238	7	BF198	15	MPF104	40	2N3708	10	TIP31A	35	ZTX109	11
BC137	40	BC308	10	BF199	18	MPSA05	23	2N3709	10	TIP31B	35	ZTX300	14
BC139	38	BC327	8	BF200	35	MPSA06	25	2N3772	170	TIP31C	40	ZTX301	16
BC140	29	BC328	8	BF244B	35	MPSA12	29	2N3773	195	TIP32A	35	ZTX302	16
BC141	30	BC337	8	BF246	35	MPSA55	30	2N3819	32	TIP32B	38	ZTX304	20
BC142	28	BC338	12	BF256B	45	MPSA56	30	2N3820	50	TIP32C	40	ZTX341	20
BC143	30	BC477	22	BF257	32	MPSU05	55	2N3823	65	TIP33A	65	ZTX500	13
BC147	10	BC478	22	BF258	30	MPSU06	55	2N3866	90	TIP33C	75	ZTX501	18
BC148	10	BC479	22	BF259	30	MPSU55	55	2N3903	10	TIP34A	70	ZTX502	18
BC149	10	BC517	30	BF337	35	MPSU56	55	2N3904	10	TIP34C	80	ZTX503	18
BC157	11	BC547	5	BFR40	35	2N118L	22	2N3905	10	TIP35A	105	ZTX504	25

TTL

		7412	25	7440	25	7476	40	74107	40	74157	80	74180	85
		7413	36	7442	74	7480	50	74109	60	74160	90	74181	230
		7414	60	7444	105	7483	65	74121	50	74161	90	74182	85
7400	25	7416	43	7446	130	7485	110	74122	50	74162	90	74190	120
7401	25	7417	43	7447	98	7486	38	74123	92	74163	90	74191	120
7402	25	7420	25	7448	98	7489	170	74125	50	74164	115	74192	120
7403	25	7421	30	7450	25	7490	55	74126	50	74165	90	74193	110
7404	25	7422	30	7451	25	7491	80	74132	60	74167	200	74194	80
7405	25	7427	30	7453	25	7492	55	74141	80	74170	170	74195	63
7406	45	7428	30	7454	25	7493	55	74145	85	74173	100	74196	120
7407	45	7430	25	7460	25	7494	90	74147	130	74174	100	74197	85
7408	25	7432	35	7472	35	7495	70	74148	105	74175	80	74198	195
7409	25	7433	35	7473	40	7496	80	74150	130	74176	80	74199	195
7410	25	7437	43	7474	36	7497	170	74153	70	74177	80		
7411	25	7438	45	7475	55	74100	125	74154	135	74179	90		

CMOS

		4016	26	4034	145	4054	70	4081	18	4502	50	4529	80
		4017	43	4036	270	4055	70	4082	20	4503	45	4532	65
		4018	55	4039	270	4059	400	4085	60	4507	45	4534	390
4000	18	4019	35	4040	46	4060	70	4086	60	4508	115	4538	70
4001	18	4020	48	4041	55	4063	80	4089	120	4510	48	4543	65
4002	18	4021	55	4042	45	4066	24	4093	26	4511	50	4549	390
4006	65	4022	60	4043	45	4067	230	4094	70	4512	50	4553	215
4007	18	4023	18	4044	50	4068	18	4095	70	4514	115	4555	50
4008	50	4024	35	4046	60	4069	18	4097	260	4515	115	4556	50
4009	40	4025	18	4047	52	4070	22	4098	70	4516	48	4559	390
4010	40	4026	120	4048	50	4071	18	40106	38	4518	48	4560	110
4011	18	4027	28	4049	26	4072	18	40109	100	4520	48	4584	38
4012	18	4028	40	4050	26	4073	18	40163	75	4521	110	4585	65
4013	26	4029	45	4051	48	4075	24	40173	100	4526	70	4724	140
4014	50	4030	18	4052	48	4076	60	40175	75	4527	60		
4015	42	4031	125	4053	60	4077	24	40193	90	4528	45		

LS TTL

		LS20	22	LS75	38	LS123	70	LS161	60	LS221	78	LS365	42
		LS21	22	LS76	28	LS125	37	LS162	60	LS240	105	LS366	42
		LS22	22	LS78	28	LS126	37	LS163	60	LS241	80	LS367	42
LS00	22	LS26	22	LS83	68	LS132	53	LS164	70	LS242	80	LS368	42
LS01	22	LS27	22	LS85	82	LS136	35	LS165	95	LS243	80	LS373	80
LS02	22	LS30	22	LS86	35	LS138	48	LS166	88	LS244	80	LS374	80
LS03	22	LS32	22	LS90	40	LS139	48	LS170	120	LS245	88	LS375	55
LS04	22	LS37	22	LS92	50	LS145	92	LS173	80	LS247	77	LS377	100
LS05	22	LS38	22	LS93	45	LS147	130	LS174	60	LS251	55	LS378	88
LS08	22	LS40	22	LS95	58	LS148	115	LS175	60	LS257	55	LS390	82
LS09	22	LS42	60	LS96	120	LS151	55	LS190	75	LS258	55	LS393	82
LS10	22	LS47	78	LS107	42	LS153	80	LS191	55	LS259	90	LS399	115
LS11	22	LS48	78	LS109	42	LS154	220	LS192	75	LS266	28	LS541	115
LS12	22	LS51	22	LS112	42	LS155	55	LS193	75	LS273	80	LS670	170
LS13	35	LS55	22	LS113	32	LS157	48	LS195	60	LS279	55		
LS14	45	LS73	28	LS114	32	LS158	48	LS196	75	LS283	70		
LS15	22	LS74	28	LS122	56	LS160	60	LS197	75	LS353	85		

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DIGEST

Alliance For Science

Three trade unions concerned with science and technology have got together to form the Alliance for Science, a campaign aimed at promoting expansion in the UK's research and development programmes. The Alliance was launched at a press conference in London on December the 3rd and brings together the Association of Scientific, Technical and Managerial Staffs (ASTMS), the Association of University Teachers (AUT) and the Institution of Professional Civil Servants (IPCS).

The Alliance has published a pamphlet in which they set out their aims. They want to highlight the decline in research and development spending in this country compared with that of our competitors. They claim that R & D spending in this country has been growing at a rate of 2.8% a year compared with 3.3% in France, 4.7% in Germany and 6.4% in Japan. They also want to bring to public attention the damage they believe is being done by spending cuts in the research councils, government research departments and higher education, the crucial role they believe R & D plays in the regeneration of the economy, and the disastrous effects the economic climate has on investment in innovation. They plan to campaign to reverse the cuts of recent years in public sector R & D, to ensure that long-term high risk capital is available for private sector R & D and to improve the links between public sector research bodies and industry and the spin-off of defence R & D into civil research. Other aims of the alliance include the securing of better national R & D statistics and fuller disclosure of company data, increased trade union involvement in R & D decision making and the development of a co-ordinated national science strategy.

The Alliance For Science will be campaigning over the coming months to achieve these aims and plans to make available campaign literature on a number of topics. Those interested should contact either Hilary Tivey at ASTMS, 79 Camden Road, London NW1 9EF, tel 01-267 4422; Paul Cottrell at AUT, United House, 1 Pembridge Road, London W11 3HJ, tel 01-221 4370; or Joe Duckworth at IPCS, 75-79 York Road, London SE1 7AQ, tel 01-928 9951.

● American publishers Blacksburg are planning to produce a book of useful scientific and engineering routines written as programmes for small computers. They are sure that many engineers will have developed such programs for their own use and are particularly interested in BASIC routines for popular micros. Copyright for programs used will remain with the authors, and those interested should contact The Blacksburg Press Group, P.O. Box 242, Blacksburg, Virginia 24060, USA. Their telephone number is 703-951 9030, but do remember that they are in the Eastern time zone!

● Dynamic Logic were a little unhappy about our article on London's new auto-loos (Digest, October '84, p.15). They assure us that it is almost impossible for anyone to be stuck inside a faulty auto-loo for more than a few minutes as there are two handles which can be used to open the door and it will open automatically after fifteen minutes anyway. I'm sure we're all relieved to hear that.

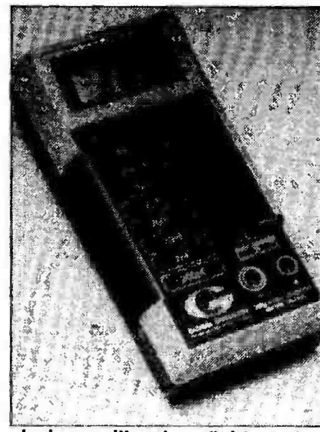
● *Velleman have introduced a tape/slide synchroniser which allows the pulses required for automatic operation of a slide projector to be recorded onto a cassette machine. The kit costs £7.95 plus VAT plus £1.00 post and packing and is available from Electronic & Computer Workshop Ltd, 171 Broomfield Road, Chelmsford, Essex CM1 1RY, tel 0245-262149.*

● Maplin have brought out the latest issue of their annual catalogue, as bulky as ever and once again with prices on the page. It costs £1.35 and is available at branches of W.H. Smiths or can be obtained direct from Maplin Electronic Supplies Ltd, P.O. Box 3, Rayleigh, Essex SS6 8LR, tel 0702-554155.

Hand-Held Capacitance Meter

GSC have introduced a digital capacitance meter designed for hand-held battery operation. Its features include a 3½ digit resolution, accuracy to 0.2% of reading, capacitance measurements of 1pF to 2000 μF and switch selection of capacitance range.

The Model 3000 has a 0.5 inch high numeric liquid-crystal display with annunciators to indicate low battery and excessive compensation of stray capacitance. Designed to operate with a 9V battery, it also has a front-panel zero adjust control to permit nulling of stray and incidental capacitance and a tilt stand for easy positioning. Suggested applications include quality control, inspection, production,



design, calibration, field service, and systems installation.

The Model 3000 comes complete with a pair of test leads, fuses, battery, and an instruction manual and costs £89.50 plus £2.50 post and packing plus VAT.

Global Specialties Corporation, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ, tel 0799-21682.

It's Quicker By Snail

Quicker, that is, if you're trying to learn a fast-action computer game. For the snail is the symbol of Slomo, a peripheral which actually slows a micro down, even bringing it to a complete halt if desired, to provide infinitely variable skill levels for games, 'freeze-frame' for displays and slow running for development.

Slomo is available in versions to suit the Spectrum, BBC, Electron and Commodore 64 microcomputers and simply plugs into the user port. For all except the BBC a user port extender is provided; Slomo attaches to the tube output on the BBC and an adaptor is used for second processor connections. A push button selects instant freeze-frame which remains for as long as the button is held down. A second button selects timer mode and operates in conjunction with the speed control to provide continuous adjustment from normal operation to complete stand-still. An LED indicates when the timer mode has been selected.

Slomo works by setting a Bus Request signal on the system bus. The processor acknowledges this and then does nothing further until the signal is removed. The manufacturers claim that it is compatible with any add-on that does not require the Bus Request signal and that it is totally harmless to the host micro. British and World patent applications are pending in respect of the device.

Slomo is expected to find a wide range of applications. In addition to allowing people to cheat at games it can be used as a software development aid, enabling graphics to be viewed pixel by pixel and sound to be heard note by note. Educational programmes could be controlled using Slomo to suit particular age groups and displays could be frozen for discussion or special emphasis without program modification. Other advantages include the ability to halt a program during interruptions and the possibility of photographing screen displays using the freeze frame.

Slomo is available by mail order and costs £14.95 inclusive of VAT and postage. Customers should remember to state which microcomputer they intend to use it with. Cambridge Computing Research Ltd, 61 Ditton Walk, Cambridge CB5 8QD, tel (trade enquiries only) 0223-214451.

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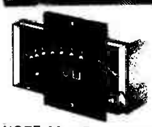
Now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models available to suit the needs of the professional and hobby market. i.e., Industry, Leisure, Instrumental and Hi-Fi. etc. When comparing prices, NOTE all models include Toroidal power supply, Integral heat sink, Glass fibre P.C.B., and Drive circuits to power compatible Vu meter. Open and short circuit proof. **Supplied ready built and tested.**

OMP100 Mk II Bi-Polar Output power 110 watts R.M.S. into 4 ohms, Frequency Response 15Hz - 30KHz —3dB, T.H.D. 0.01%, S.N.R. —118dB, Sens. for Max. output 500mV at 10K, Size 360 × 115 × 72mm. PRICE £32.99 + £2.50 P&P.

OMP/MF100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 80, Slew Rate 45V/uS, T.H.D. Typical 0.002%, Input Sensitivity 500mV, S.N.R. —125dB. Size 300 × 123 × 60mm. PRICE £39.99 + £2.50 P&P.

OMP/MF200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 250, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. —130dB, Size 300 × 150 × 100mm. PRICE £62.99 + £3.50 P&P.

OMP/MF300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 350, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. —130dB, Size 330 × 147 × 102mm. PRICE £79.99 + £4.50 P&P.



Vu METER Compatible with our four amplifiers detailed above. A very accurate visual display employing 11 L.E.D. diodes (7 green, 4 red) plus an additional on/off indicator. Sophisticated logic control circuits for very fast rise and decay times. Tough moulded plastic case, with tinted acrylic front. Size 84 × 27 × 45mm. PRICE £8.50 + 50p P&P.

NOTE: Mos-Fets are supplied as standard (100KHz bandwidth & Input Sensitivity 500mV). If required, P.A. version (50KHz bandwidth & Input Sensitivity 775mV). Order — Standard or P.A.

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Three models (Ratings RMS into 4 ohms)
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8" 50 WATT R.M.S. Hi-Fi/Disco.
20 oz. magnet. 1½" ally voice coil. Ground ally fixing escutcheon. Res. Freq 40Hz. Freq. Resp. to 6KHz. Sens. 92dB. PRICE £9.90 Available with black grille £10.90. P&P £1.50 ea.
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1½" voice coil. Res. Freq. 35Hz. Freq. Resp. to 4KHz. Sens. 94dB. PRICE £38.00 + £3.00 P&P ea.

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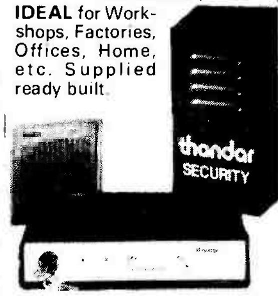

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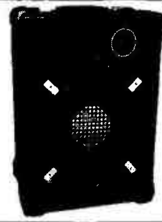

STEREO CASSETTE DECK

STEREO CASSETTE DECK
Ideal for installing into Disco and Hi-Fi cabinet/Consoles. Surface mounting (Horizontal). Supplied as one unit with all electronics including mains power supply.
★ Metal top panel Black finish
★ Piano type keys including pause
★ Normal/Chrome tape switch
★ Twin Vu Meters
★ 3 Digit counter
★ Slider Record Level control
Size 171 × 317 mm Depth 110 mm
PRICE £35.99 + £3.00 P&P

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★ Control loads up to 1Kw
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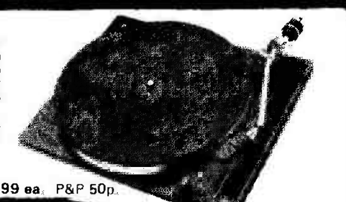

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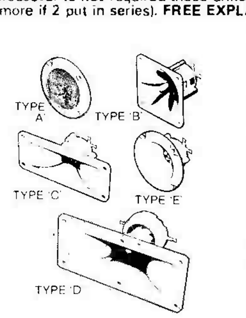

TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. **Price £4.90 each + 40p P&P.**
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TYPE 'D' (KSN1025A) 2" × 6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. **Price £8.99 each + 40p P&P.**
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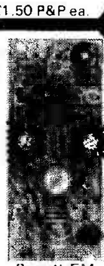

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STEREO DISCO MIXER with 7 band graphic equaliser and 10 segment L.E.D. Vu Meters. Many outstanding features.
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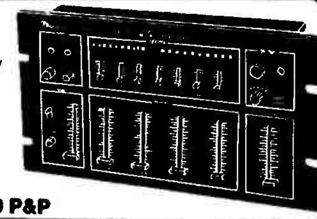

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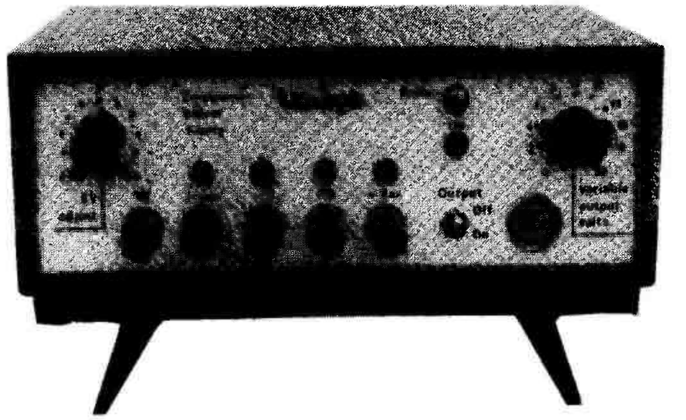
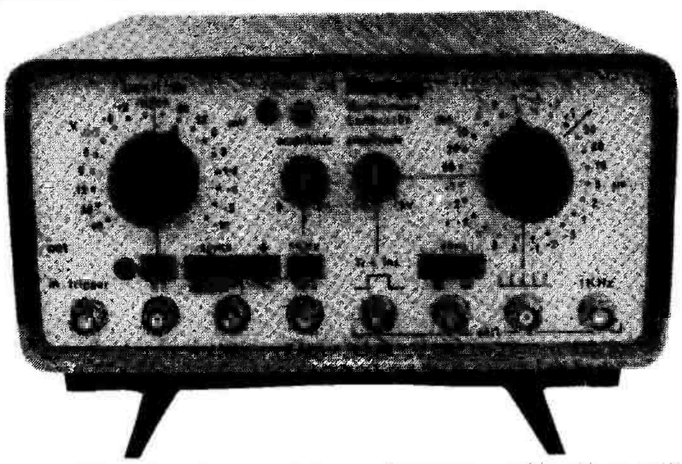
Otter Resurfaces

In our April '84 issue News Digest we featured two oscilloscope accessories manufactured by a British company called Otter Electronics. Since then, the company have got into a bit of hot water because another company had registered the same name, so they have now become Waugh Instruments and appear to be on dry land at last.

The re-born company have introduced two new products and have re-launched the two original products in their new livery. One of the new products is another oscilloscope accessory, a calibrator. Waugh claim that it provides all the facilities necessary for checking and re-calibrating oscilloscopes with bandwidths of up to 150MHz. It has a calibrated amplitude square wave generator for checking input attenuators, a wide range of crystal-controlled timing signals with periods from 10ns to 5s, and a 50Hz and 1kHz sine wave generator for checking trigger circuits and for locking sweep circuits whilst checking amplifiers and supply rails for hum. A square wave rise time of less than 1ns allows vertical amplifier rise times to be checked and a fully interlaced composite video generator with both positive and negative going outputs allows the checking of sync separators used for television measurements. The calibrator costs £484.00 plus VAT which includes the cost of carriage within the UK.





The other new product is a designer's power supply which offers $\pm 5V$ rails variable from $\pm 4.5V$ to $\pm 5.5V$ and a second pair of supply rails which can be adjusted from 0 to $\pm 20V$. The $\pm 5V$ rails offer up to 500mA with both rails loaded and 700mA with one rail only loaded and the $\pm 20V$ rails offer up to 200mA with both rails loaded and 250mA with only one rail loaded. Each pair of rails has a single voltage control which affects both rails equally. All of the outputs are protected against overload and shorting to other rails and a LED above each terminal indicates the overload condition. An output switch is provided which connects all of the rails to 0V through suitable bleed resistors when it is put in the off position. A 5-pin DIN output socket is provided to enable quick connection to test circuits and other frequently used items and the manufacturers claim that the complete unit is small enough to fit under the tilt-stand of most oscilloscopes, thus saving valuable bench space. The designer's power supply costs £144.00 plus VAT which again includes delivery within the UK.

The μ amplifer which we described in our April issue now costs £144.00 plus VAT and the isolation amplifier which we also featured costs £157.00 plus VAT. Both prices include delivery within the UK.

Waugh Instruments Ltd, Otter House, Weston Underwood, Olney, Buckinghamshire MK46 5JS, tel 0234-712445.

The Light That No-One's Seen

Arlen Electronics believe that one of their products is not receiving the attention it deserves. The device is a semiconductor starter for fluorescent lights which is claimed to offer double the tube life obtained with conventional starters, but in spite of this advantage the company have only had moderate success with it so far.

The Pulsestarter has been developed over a period of four years by Arlen and the UK subsidiary of Texas Instruments. Unlike conventional starter switches which apply high voltage pulses and literally kick the tube into fluorescence, the Pulsestarter preheats the tube cathodes and then applies a controlled pulse when the tube is ready. This is much closer to the way in which fluorescent tubes are intended to be used and is similar to the system employed in industrial starterless units. The result is greatly reduced cathode wear since the conventional system strips emissive material from the cathodes every time the tube is started up. The Pulsestarter is also said to automatically compensate for adverse conditions and will allow a longer period of preheating in cold weather. When the tube reaches the end of its life, the device disconnects the circuits until the tube has been replaced, preventing the repeated attempts at starting which are such an annoying feature of conventional starters and removing the associated risk of control equipment damage and even fire.

In spite of all these advantages, the Pulsestarter has not taken the lighting industry by storm and Arlen believe that vested interests are doing their best to prevent it being more widely used. Tube manufacturers are obviously not going to be keen on a device which makes their products last longer and thus reduces sales of replacements, and companies with maintenance contracts are also likely to be a little put out at the prospect of fewer repairs.

For details contact Arlen's distributors, C.J. Skilton Ltd, Great Gibcracks Chase, Butts Green, Sandon, Chelmsford CM2 7TR, tel 0245-400535.

List Watch

Casio have come up with a handy little unit which allows users to keep the names and telephone numbers they need to refer to literally at arms length. The Data Bank 500 behaves like any other digital watch but can store up to fifty sets of six letters and twelve numbers and display any of them on demand. Information is fed in and later recalled using a couple of buttons, and Casio suggest that in addition to telephone numbers the watch can be used to store bank account codes, birthdays and anniversaries, postal codes, travel schedules and a whole range of other information. It should be available through Casio's normal retail distributors and the recommended selling price is £41.95.

Casio Electronics Company Ltd, Unit 6, 1000 North Circular Road, London NW2, tel 01-450 9131.

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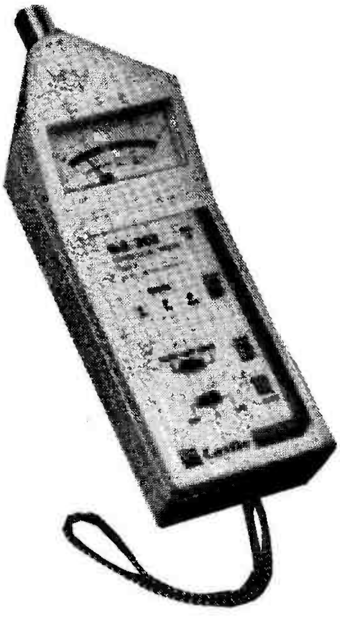


Noise Exposure Meter

The GA202 Noise Exposure Meter from Castle Associates is designed to simplify sound exposure measurements in industrial and other environments and includes a scale reading directly in dBA/time. It conforms to the requirements of BS5969, has a measuring range of 40–140 dB and its features include push-button range selection with LED indication and a hold facility for determining maximum RMS or peak values.

In most countries there are legal limits to the noise level industrial employees may be subjected to. The maximum allowable exposure is expressed as 100% dose, and for each 3dBA increase in the sound level the working time must be halved. The GA202's dBA/time scale allows both the sound level and the maximum permitted exposure time at that level to be read directly, thus simplifying measurements.

The meter has three ranges with shift register selection and LEDs to indicate which range is in use. Switchable slow, fast and peak response times are provided and a maximum hold button allows peak or maximum RMS values to be captured and read. The meter is linearly scaled and both 'A' and linear weightings are provided.

The instrument is housed in a diecast case which is said to be ergonomically designed and very tough, and the battery compartment is made of moulded plastic to reduce the risk of damage from leakage. The battery compartment cover forms the back of the case and is also made of plastic so that the unit can be used on desktops, etc, without scratching the surface. A wrist-strap and tripod mounting thread are supplied as standard and a complete kit of accessories is available which comprises a companion GA602 calibrator, a windshield and a leather shoulder case which holds the meter and the accessories along with an A5 clipboard.

The GA202 and its accessories are the first products in a complete new range promised by Castle Associates. The meter costs £195.00 plus VAT and the kit of accessories costs £162.00 plus VAT and comes with a free noise survey pad.

Castle Associates, Salter Road, Cayton Low Road Industrial Estate, Scarborough, North Yorkshire YO11 3UZ, tel 0723-584250.

Exhibitions, Conferences, Etc

As this is the first issue of the new year, it seems appropriate to include a round-up of forthcoming exhibitions, conferences, and other electronics get-togethers.

The 1985 Which Computer? Show will take place at the National Exhibition Centre, Birmingham from the 15th to the 18th of January. The organisers believe it will be the largest ever display of computer hardware, software and peripherals and the 350-plus organisations taking part will be exhibiting many thousands of products including over one hundred new items. The show is aimed at everyone from those buying a first computer through to companies seeking to computerise their operations, and the free visitors information pack includes what is claimed to be a 'jargon-free' check list prepared by the National Computing Centre to help purchasers identify their needs. The show also includes beginners workshops and seminars, and further details and a copy of the free information pack can be obtained from Hugh Keeble, Show Manager, Which Computer? Show, Chatsworth House, 59-61 London Road, Twickenham TW1 3SZ, tel 01-891 5051.

A little more specialist in appeal is Lightshow'85 which will be staged at London's Olympia Exhibition Centre from the 20th to the 24th of January. The show is organised by the Decorative Lighting Association and is trade only. For details contact the DLA at Bryn House, Bishop's Castle, Shropshire SY9 5LE, tel 0588-4658.

Even more specialist, perhaps, is the Fourth Battery Seminar And Exhibition which will be held at the Royal Crest Hotel, London, on the 29th January. The seminar is organised by ERA Technology and will concentrate on maintenance-free batteries for standby power applications. For details contact Miss T.L. Ecclestone, Seminar Organiser, ERA Technology Ltd, Cleeve Road, Leatherhead, Surrey KT22 7SA, tel 0372-374151.

Something completely different will be going on at the Carleton Community Centre, Pontefract, on the 10th of March from 11.00am to 4.30pm. The Pontefract & District Amateur Radio Society are holding a components fair, and although the event is tied closely to the Mobile Radio Rally it will concentrate on home construction and do-it-yourself. A number of traders are expected to attend and only components, surplus equipment and instruments, etc, will be on sale; there will be no new equipment. For details contact N. Whittingham, G4ISU, 7 Ridgedale Mount, Pontefract WF8 1SB, tel 0977-792784.

The Electronic Production Efficiency Exposition '85 will be held at the National Exhibition Centre, Birmingham, from the 30th of April to the 2nd of May. The event is a combined exhibition and conference which is concerned with the factory of the future. Beyond that, we know nothing about it, so if you want to know more you'll have to contact the organisers, Network Events Ltd, Printers Mews, Market Hill, Buckingham MK18 1JX, tel 0280-815226.

Power '85 is a new exhibition organised by the Power Supply Manufacturers Association and will take place at the Metropole Hotel, Brighton, from the 21st to the 23rd of May. There will be about 140 stands at the exhibition and the products on display will cover both power supplies and alternative sources such as batteries and solar cells. The PMSA are currently evaluating papers for presentation and welcome further submissions from engineers who feel they have constructive comments to make about power supply technology and the application of power supplies in commercial and industrial equipment. Contact M.A. Poftawka, The Power Supply Manufacturers Association, 7-8 Saville Row, London W1X 1AF, tel 01-437 4127.

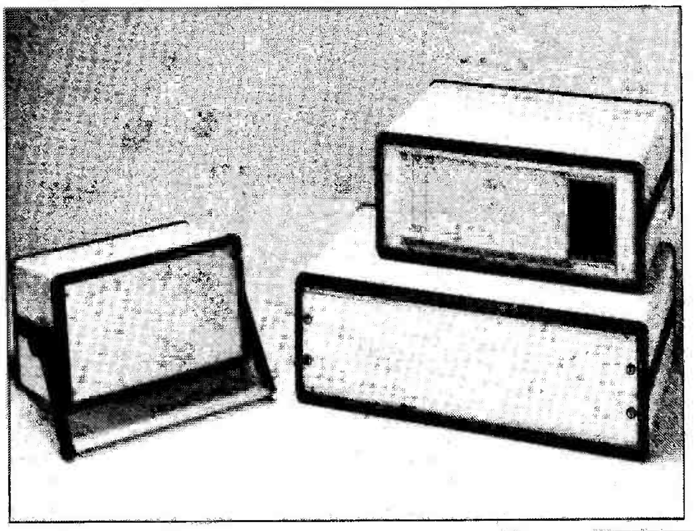
Gone are the days when telephones all looked the same and were only available from the GPO. Responding to this change, Network Events are organising Phone'85, an exhibition devoted solely to the users of telephone equipment and covering the range from single telephones to large, multi-user systems for international corporations. The event will take place at the Kensington Exhibition Centre, London, and will open to the trade only on June the 4th and to the general public on June 5th and 6th. For details, contact Network Events at the address given above for the Electronic Production Efficiency Exposition.

The same people are also organising another event in the same place and at the same time. Competa '85 is described as a conference and exhibition for all users of computers and peripherals and that's all we know, so for further details get in touch with Network Events.

The Leeds Electronics Show will be held at The University of Leeds from the 3rd to the 5th of July. The show is in its 22nd year and hopes to have 223 stands on display. Details are available from Evan Steadman Services Ltd, The Hub, Emson Close, Saffron Walden, Essex CB10 1HL, tel 0799-266699.

Interconnection Europe'85 is a conference and exhibition concerned with interconnection technology, products and applications and will take place from the 10th to the 12th of September at the Cumberland Hotel, Marble Arch, London. It is claimed to be the only European event dedicated to interconnection technology and the new venue has been chosen to allow for an anticipated expansion of 80% compared with last year's show. Over 100 stands will be on display and a number of papers will be delivered by manufacturers, distributors and end-users. For details contact Ms Teresa Arrowsmith, Conference Secretary, Benn Electronics Publications Ltd, P.O. Box 28, Luton, Bedfordshire LU2 0ED, tel 0582-417438.

Finally, the International Test And Measurement Exhibition and conference (ITAME) will be held at Olympia 2, London from the 27th to the 29th of November. The event covers all areas of electronic test and measurement and is organised by Network Events, whose address appears above.



Versatile Cases

New from West Hyde Developments is a range of instrument cases which are said to have been designed for maximum versatility. Made from ABS and aluminium, the cases can be used with plug-in cards, in 19" racks or with a plain front panel and the accessories available include prop-up handles and chassis plates.

The Botron cases come in ten sizes which range from 264 to 414mm wide, 249 to 508mm deep and are either 178 or 202mm high. The front and back bezels are moulded from brown ABS and are connected together by aluminium rails in each corner. The top and bottom panels are moulded in cream polystyrene and have a textured finish. Standard 19" front panels may be fitted using a special adaptor kit and a purpose-designed card frame based on the Critchley Europak system is also available. The prop-up handles and chassis plates are part of a range of accessories for the cases and all items are available ex-stock.

The Botron cases range in price from £34.21 to £48.08 plus VAT. West Hyde Developments Ltd, 9-10 Park Street Industrial Estate, Aylesbury, Buckinghamshire HP20 1ET, tel 0296-20441.

Miniature Vacuum Cleaner

The minivac is a portable, battery operated vacuum cleaner which is designed for cleaning the interiors of sensitive electronic, photographic and other equipment. Unlike the compressed air blowers which are often used for this purpose and which simply blow minute particles into the air or into other parts of the equipment, the Minivac collects the particles in a small cloth bag for later disposal.

The Minivac operates from a 9V battery or from the mains using an adaptor. It has two lens-quality fine brush vacuum heads and is claimed to be very powerful inspite of its small weight and size. The cloth collection bag has a velcro flap to allow quick and easy disposal of accumulated debris and a separate attachment is available to turn the device into a blower.

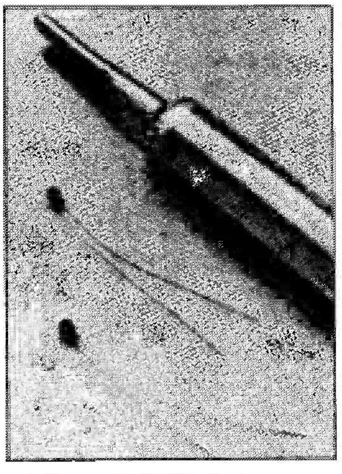
The Minivac is expected to be used in industry and the home for cleaning photographic equipment, typewriters, computers, audio and video cassette recorders, precision models and much more. It costs £19.60 plus VAT and is available from O & S Photographic, South Block, The Maltings, Sawbridgeworth, Hertfordshire, tel 0279-722208.

Accurate NTC Thermistor

Siemens have introduced a negative temperature coefficient thermistor which operates over the temperature range of −40° to +100°C and has an accuracy of better than 0.1°C over the body temperature range of 30° to 50°C.

The M841 thermistor has silver plated 20mm long leads and is available in 3k or 5k versions. Other versions with resistances of up to 100k will shortly be available. The accuracy of the device corresponds to a resistance tolerance of ±0.4%, and suggested applications include high resolution electronic thermometers, heating/air conditioning controllers for use in cars and warning sensors to alert drivers to critical outside temperatures.

Siemens have also announced an extended temperature range version, the M861. This offers an accuracy of ±0.1°C over the entire temperature range from



−40° to +120°C. It is epoxy coated and has 25mm long, 0.25mm thick nickel leads with Teflon insulation. The rated resistance is 30k but both lower and higher values will be available later.

Siemens Ltd, Siemens House, Windmill Road, Sunbury-on Thames, Middlesex TW16 7HS, tel 09327-85691.

● The new Cricklewood catalogue covers eight sides of A4 and lists semi-conductors, resistors, capacitors, switches, connectors, hardware, tools and even valves. They will accept credit card orders over the telephone as well as supplying goods to mail order and their North London shop is open all week. Copies of the catalogue are available from Cricklewood Electronics Ltd, 40 Cricklewood Broadway, London NW2 3ET, tel 01-450 0995.

● The British Amateur Electronics Club have just sent us a copy of their October Newsletter — and it's now early December. Still, they do apologise for this lateness and it does contain articles on logic gates, display driver circuitry and phase control. If you want to know more contact Mr. C. Bogod, "Dickens", 26 Forest Road, Penarth, South Glamorgan, tel 0222-707813.

● *Cambridge Systems Technology have produced an IEEE488 interface for the Sinclair QL microcomputer. The Q-488 fits the expansion slot on the QL and allows it to communicate at up to 70k bytes/second with up to sixteen IEEE488-compatible test instruments, printers, plotters, disc drives, etc. Contact Cambridge Systems Technology, 30 Regent Street, Cambridge CB2 1OB, tel 0223-323302.*

● Chartwell-Bratt are publishing a series of computer textbooks which each deal with a particular topic and will sell for around £4.00. The books have been written by and in conjunction with university lecturers in computer studies from around the country, and are intended to improve the situation for students who frequently have to buy expensive books which only contain a few passages of interest to them. The first seven titles should already be available and further titles will be issued at a rate of about three a month. Chartwell-Bratt Ltd, Old Orchard, Bickley Road, Bickley, Bromley, Kent BR1 2NE, tel 01-467 1956.

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4585	60p
4724	150p
14411	750p
14412	750p
14416	300p
14419	260p
14490	420p
14495	450p
14500	650p
14599	200p
22100	350p

LINEAR ICs

AD7581	£15
ADC0808	1190p
AM7910DC	£25p
AN103	200p
AY-1-5050	100p
AY-3-1270	750p
AY-3-1350	350p
AY-3-8910	400p
AY-3-8912	500p
CA3019A	100p
CA3028A	110p
CA3046	70p
CA3059	325p
CA3080	350p
CA3080E	70p
CA3086	60p
CA3089E	210p
CA3090AQ	375p
CA3130E	90p
CA3130T	100p
CA3140E	45p
CA3140T	100p
CA3160E	90p
CA3161E	180p
CA3162E	180p
CA3189E	270p
CA3240E	150p
CA3280G	270p
D7002	£10
DAC1408-8	225p
DAC0800	225p
DAC0808	225p
DG308	300p
HA1366	190p
ICL7106	675p
ICL7611	95p
ICL7650	400p
ICL7660	250p
ICL8038	300p
ICM7216B	£22
ICM7217	750p
ICM7555	100p
ICM7556	140p
LC7120	300p
LC7130	300p
LC7137	350p
LF347	180p
LF351	60p
LF353	90p
LF355	90p
LF356N	110p
LF357	100p
LF13331	350p
LM10C	450p
LM301A	30p
LM307	45p
LM308CN	75p
LM310	225p
LM311	60p
LM318	150p
LM319	180p
LM324	45p
LM334Z	115p
LM335Z	130p
LM336	180p
LM339	40p
LM348	60p
LM358P	50p
LM377	210p
LM380N-8	150p
LM380	120p
LM381AN	170p
LM382	200p
LM383	325
LM384	220
LM386N-1	100p
LM387	270p
LM389	180p
LM391	180p
LM392N	110p
LM393	85p
LM394CH	375p
LM709	35p
LM710	48p
LM711	100p
LM723	60p
LM725CN	300p
LM733	65p
LM741	18p
LM747	70p
LM748	30p
LM1011	480p
LM1014	150p
LM1801	300p
LM1830	250p
LM1871	300p
LM1872	300p
LM1886	600p
LM1889	450p
LM2917	300p
LM3302	75p
LM3900	60p
LM3909	100p
LM3911	180p
LM3914	350p
LM3915	340p
LM3916	340p
LM13600	100p
M51513L	230p
M51516L	450p
MB3712	200p
MB3730	400p
MC1310P	150p
MC1413	75p
MC1445	250p
MC1458	45p
MC1495L	250p
MC1496	70p
MC3340P	200p
MC3401	50p
MC3403	65p
MF10CN	340p
MK50240	900p
MK50398	790p
ML920	500p
ML922	400p
MM6221A	300p
NE531	120p
NE544	190p
NE555	22p
NE556	60p
NE564	400p
NE565	120
NE566	150p
NE567	125p
NE570	400p
NE571	300p
NE592	90p
NE5532P	150p
NE5533P	160p
NE5534P	120p
NE5534AP	150p
OP-07EP	500p
PLL02A	500p
RC4136	55p
RC4151	200p
RC4558	55p
S566B	300p
SAA1900	£16
SFF96364	850p
SL490	300p
SN76013N	300p
SN76023N	300p
SN76033N	300p
SN76115N	215p
SN76489	400p
SN76495	400p
SP0256AL2	700p
SP8515	750p
TA7120	120p
TA7130	150p
TA7204	150p
TA7205	90p
TA7222	150p
TA7310	150p
TBA641BX1	400p
TBA231	120p
TBA800	80p
TBA810	90p
TBA820	80p
TBA820M	75p
TBA920	200p
TBA950	225p
TC9109	500p
TCA210	350p
TCA220	350p
TCA270	350p
TCA940	175p
TDA1004A	500p
TDA1010	225p
TDA1022	450p
TDA1024	110p
TDA1170S	300p
TDA2002	325p
TDA2003	290p
TDA2004	240p
TDA2006	320p
TDA2020	320p
TDA2030	180p
TDA2541	400p
TDA2593	500p
TDA2653	700p
TDA3560	990p
TDA3810	750p
TDA7000	350p
TEA102	700p
TL061CP	40p
TL062	60p
TL064	90p
TL071	40p
TL072	70p
TL074	110p
TL081	35p
TL082	55p
TL083	75p
TL084	100p
TL094	200p
TL170	50p
TL430C	120p
UAA1003-3	935p
UA759	320p
UA2240	120p
UAA170	170p
UCN4801A	350p
ULN2001A	90p
ULN2002A	90p
ULN2003A	90p
ULN2004A	90p
ULN2068	290p
ULN2802	190p
ULN2803	180p
ULN2804	190p
UPC575	275p
UPC592H	200p
UPC1156H	300p
UPC1185H	350p
XR210	400p
XR2206	350p
XR2207	375p
XR2211	575p
XR2216	675p
XR2240	120p
ZN409	190p
ZN414	80p
ZN419P	175p
ZN423E	130p
ZN424E	130p
ZN425E8	350p
ZN426E	300p
ZN427E	600p
ZN428E	450p
ZN429E8	225p
ZN450E	750p
ZN459CP	300p
ZN1034E	200p
ZN1040E	660p
ZN134J	£23
ZNA234E	950p

REAL TIME CLOCK

MC6818P	450p
MM58174AN	850p
MSM5832RS	350p

TELETEXT DECODER

SAA5020	600p
SAA5030	700p
SAA5041	£16
SAA5050	900p

VOLTAGE REGULATORS

FIXED PLASTIC

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

OTHER REGULATORS

Fixed Regulators		
LM309K	1A 5V	140p
LM323K	3A 5V	350p
78H05KC	5A 5V	540p
78H12	5A 12V	640p
78P05	10A 5V	900p
Variable Regulators		
LM305AH		250p
LM317T	TO-220	150p
LM317K	TO3	240p
LM337T		225p
LM350T	10A+VAR	400p
LM396K	10A+VAR	£15
LM723N		50p
78HGKC	5A+VAR	575
78GUIC	1A+VAR	225p
79HGKC	5A−VAR	675p
79GUIC	1A−VAR	250p
Switching Regulators		
ICL7660		250p
SG3524		300p
TL494		300p
TL497		300p
78S40		250p

OPTO-ELECTRONICS

2DL704 Red	140p	MAN4640	200p
DL707 Red	140p	MAN6610	200p
FND357	100p	NSB5881	570p
FND500/TIL730	100p	TIL311	650p
FND507/TIL729	100p	TIL729	100p
MAN74DL704	100p	TIL730	100p
MAN71/DL707	100p	MAN8910	250p
MAN3640	175p	MAN8940	250p

OPTO-ISOLATORS

ILQ74	130p	TIL111	70p
MCT26	100p	TIL112	70p
MCS2400	180p	TIL113	70p
MOC3020	150p	TIL116	70p
ILQ74	220p	6N137	360p
		6N139	175p

LEDS

TIL209 Red	12p	TIL222 Green	18p
TIL211 Green	18p	TIL226 Orange	22p
TIL212 Yellow	20p	MV57164 Red Array (10)	225p
CXQ95 (bi-colour)	100p	MV54164 Green Array (10)	225p
TIL220 Red	15p	Rect Leds R,G,Y	30p

COUNTERS

74C925	650p
74C926	650p
74C928	650p
72168	£22
ZN1040	670p

DISPLAYS

DL704	140p
DL707Red	140p

COMPUTER COMPONENTS

CPU

1802CE	650p
2650A	£12
6502	350p
6502A	550p
65C02A	£15
6502B	800p
6800	250p
6802	300p
6809	650p
6809E	£12
68B09	£12
68B09E	£16
68000-LB	£36
8035	360p
8039	420p
8080A	420p
8085A	650p
8086	£22
8088	£17.50
8748	POA
TMS1601	£12
TMS9980	£12
TMS9995	£12
WD55	£14.50
Z80	280p
Z80A	325p
Z80B	800p
TMS9903	£25
TMS9911	£18
TMS9914	£14
Z80PIO	260p
Z80APIO	325p
Z80CTC	325p
Z80ACTC	325p
Z80DART	650p
Z80ADART	800p
TMS4500	£14
TMS9901	500p
TMS9902	500p
Z80DMA	900p
Z80ADMA	£10
Z80ASIO-0/1/2/9	900p

SUPPORT DEVICES

2651	£12
3242	800p
3245	450p
6520	300p
6522	350p
6522A	550p
6532	520p
6551	550p
6821	150p
68B21	220p
6829	£12.50
6840	375p
68B40	600p
6850	160p
68B50	250p
6852	250p
6854	650p
68B54	800p
6875	500p
8154	650p
8155	400p
8156	400p
8205	225p
8212	220p
8216	160p
8224	300p
8226	300p
8228	420p
8243	290p
8250	950p
8251A	350p
8253C-5	370p
8255AC-5	400p
8256	£16
8257C-5	400
8259C-5	400
8271	POA
8275	£29
8279	£11
8284	750p
8288D	£11
8755A	£24

MEMORIES

2016-150	400p
2101	400p
2102	250p
2107B	500p
2111A-35	400p
2114-2L	350p
2114-3L	250p
2114-4L	200p
2147	320p
4027-3	300p
4116-15	200p
4116-20	150p
4118-3	500p
4164-15	500p
41256-20	£25
4164-20	420p
4416-20	450p
4532-20	250p
4816AP-3	200p
5101/55D1	370p
5514/5114	250p
5516	650p
6116P-3	450p
6116LP-3	500p
6264-15	£24
6514-45	250p
6810	160p
74S189	225
74S201	350p
74S289	225p
93415	600p
93L422	950p
93425	600p

ROMS/PROMS

28L22	475p
24S10	250p
18S030	200p
18SA030	200p
74S188	180p
74S287	225p
74S288	180p
74S387	225p
74S473	475p
74S474	400p
74S570	650p
74S571	300p
74S573	500p
82S23	150p
82S123	150p
82S129	175p

EPROMs

2516+5v	350p
2516-35	550p
2532	450p
2532-30	550p
2564	650p
2708	300p
2716+5v	350p
2716-35	550p
2732	450p
2732A-2	700p
2732A-35	600p
2764-25	650p
27C64-25	£14
27128-25	£18
27128-30	£16
TMS2716	500p

CRT CONTROLLER

CRT5027	£18
CRT5037	£12
CRT6545	£9
EF9364	£8
EF9365	£30
EF9366	£30
EF9367	£36
MC6845	650p
MC6845SP	750p
MC6847	650p
SFF96364	£8
TMS9918	£30
TMS9927	£14
TMS9928	£20
TMS9929	£16

INTERFACE ICs

AD558CJ	775p
AD561J	£20
AD7581	£15
ADC0808	1190p
AM25S10	350p
AM25LS2521	350p
AM25LS2538	350p
AM26LS31	120p
AM26LS32	120p
D7002	£12
DAC80-CB1-V	£28
DM8131	600p
DP8304	350p
DS3691	500p
DS8830	140p
DS8831	150p
DS8832	150p
DS8833	225p
DS8835	280p
DS8836	150p
DS8838	225p
LF13201	450p
MC1488	60p
MC1489	60p
MC3446	250p
MC3459	450p
MC3470	475p
MC3480	850p
MC3486	250p
MC3487	250p
MC4024	325p
MC4044	325p
MC14411	900p
MC14412	750p
ML922	400p
ULN2001	90p
ULN2003A	90p
ULN2004A	90p
ULN2068	290p
ULN2802	190p
ULN2803	180p
ULN2804	190p
75107	90p
75108	90p
75109	120p
75110	90p
75112	160p
75113	120p
75114	140p
75115	140p
75121	140p
75122	140p
75150P	120p
75154	120p
75159	220p
75160	500p
75161	350p
75162	400p
75172	300p
75182	90p
75188	60p
75189	60p
7535	150p
75451	70p
75452	70p
75453	70p
75454	70p
75480	150p
75491	65p
75492	65p
8T26	120p
8T28	120p
8T95	120p
8T96	120p
8T97	120p
8T98	120p
81LS95	140p
81LS96	220p
81LS97	140p
81LS98	220p
88LS120	500p
9602	300p
9636A	160p
9637AP	160p
9638	160p
ZN425E8	350p
ZN426E8	350p
ZN427E	600p
ZN428E8	450p
ZN429E	210p
ZN447E	900p
ZN459CP	300p

DISC CONTROLLER ICs

6843	£8
8272	£28
FD1771	£20
FD1791	£22
FD1793	£20
FD1795	£28
FD1797	£22
WD2793	£36
WD2797	£32
WD1691	£15
WD2143	£8

CHARACTER GENERATORS

RO3-32513	
U.C.	750p
L.C.	700p
DM86S64	£12
MC66760	750p
SN74S262AN	£10

KEYBOARD ENCODERS

AY52376	1150p
AY 5 3600	750p
74C922	650p
74C923	650p

BAUD RATE GENERATORS

MC14411	750p
COMB116	650p
4702B	750p

UARTs

AY-3-1015P	300p
AY-5-1013P	300p
COM8017	300p
IM6402	360p
TR1602	300p

UHF MODULATORS

6MHz UHF	375p
8MHz UHF	450p
Sound & Vision 12MHz	£12

CRYSTALS

32.768 KHz	100p
100 KHz	400p
1.00MHz	270p
Freq in MHz	
1.8432	225p
2.00	2255
2.45760(L)	200p
2.45760(S)	250p
2.5	250p
2.662	250p
3.276	150p
3.5795	020p
4.00	150p
4.194	200p
4.43	100p
4.608	250p
4.9152	250p
5.000	150p
5.068	250p
6.00	140p
6.144	140p
7.00	150p
7.168	175p
8.00	150p
8.867	175p
10.00	175p
10.50	250p
10.70	150p
11.00	300p
12.00	150p
14.00	175p
14.318	160p
14.756	250p
15.00	200p
16.00	200p

LOW PROFILE SOCKETS BY TEXAS

8 PIN	9p
14 pin	10p
16 pin	11p
18 pin	16p
20 pin	18p
22 pin	22p
24 pin	24p
28 pin	26p
40 pin	30p

WIRE WRAP SOCKETS BY TEXAS

8 pin	30p
14 pin	42p
16 pin	45p
18 pin	50p
20 pin	66p
22 pin	75p
24 pin	75p
28 pin	100p
40 pin	130p

TRANSISTORS

AD161/2	45p
BC107/8	18p
BC109C	20p
BC169C	18p
BC172	18p
BC177/8	30p
BC179	30p
BC182/3	15p
BC184	16p
BC187	30p
BC212/3	16p
BC214	18p
BC237	16p
BC327	16p
BC337	16p
BC338	16p
BC461	40p
BC477/8	36p
BC516/7	50p
BC547B	20p
BC548C	16p
BC549C	16p
BC557B	18p
BC559C	24p
BCY70	30p
BCY71	36p
BD131	75p
BD132	80p
BD135/6	40p
BD139	40p
BD140	40p
BD189	60p
BD232	60p
BD233	75p
BD235	85p
BD241	60p
BD242	60p
BD379	60p
BD380	60p
BD677	40p
BF244B	40p
BF256B	50p
BF257/8	40p
BF337	36p
BFR39	32p
BFR40/1	32p
BFR79	32p
BFR80/1	32p
BFR96	180p
BFX29	45p
BFX30	45p
BFX84/5	30p
BFX86/7	30p
BFX88	30p
BFX89	180p
BFY50	30p
BFY51/2	30p
BFY56	33p
BFY90	90p
BRY39	45p
BSX19/20	30p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
BUX80	600p
BUY69C	350p
E310	50p
MJ413	250p
MJ802	400p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJ4502	400p
MJE340	60p
MJE2955	150p
MJE3055	120p
MPF102	40p
MPF103/4	40p
MPF105	40p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	30p
MPSA70	50p
MPSA93	40p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
TIP29A	35p
TIP29C	40p
TIP30A	35p
TIP30C	40p
TIP31A	40p
TIP31C	45p
TIP32A	45p
TIP32C	40p
TIP33A	70p
TIP33C	80p
TIP34A	90p
TIP34C	120p
TIP35A	120p
TIP35C	140p
TIP36A	140p
TIP36C	150p
TIP41A	50p
TIP41C	55p
TIP42A	60p
TIP42C	65p
TIP54	160p
TIP55	180p
TIP120	75p
TIP121	75p
TIP122	80p
TIP125	75p
TIP126	80p
TIP142	120p
TIP147	120p
TIP2955	90p
TIP3055	70p
TIS93	30p
VN10KM	50p
VN66AF	90p
VN88AF	£1
ZTX108	16p
ZTX300	18p
ZTX452	45p
ZTX500	20p
ZTX502	20p
ZTX504	22p
ZTX552	55p
ZTX652	60p
ZTX752	70p
2N697	35p
2N698	45p
2N706A	36p
2N708	36p
2N918	45p
2N930	30p
2N1131/2	50p
2N1613	36p
2N1711	36p
2N2102	70p
2N2160	350p
2N2219A	30p
2N2222A	30p
2N2369A	30p
2N2484	30p
2N2646	50p
2N2904/5	30p
2N2906A	30p
2N2907A	30p
2N2926	12p
2N3053	36p
2N3054	60p
2N3055	55p
2N3442	140p
2N3553	240p
2N3584	250p
2N3643/4	48p
2N3702/3	16p
2N3704/5	16p
2N3706/7	16p
2N3708	16p
2N3773	200p
2N3819	40p
2N3823	30p
2N3866	90p
2N3902	700p
2N3904	18p
2N3906	18p
2N4036	65p
2N4037	65p
2N4123/4	27p
2N4125/6	27p
2N4401/3	25p
2N4427	90p
2N4871	50p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5245	40p
2N5401	60p
2N5459	30p
2N5460	60p
2N5485	36p
2N5875	250p
2N5883	375p
2N6027	30p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1306	100p
2SC1307	150p
2SC1957	90p
2SC1969	150p
2SC2028	80p
2SC2029	200p
2SC2078	160p
2SC2335	200p
2SC2612	200p
3N128	200p
3N140	200p
3N141	200p
3N201	200p
3N204	200p
40290	250p
40361/2	75p
40595	120p
40673	90p
40871/2	100p

DIODES

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

BRIDGE RECTIFIERS

1A 50V	19p
1A 100V	20p
1A 400V	25p
1A 600V	30p
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DESIGNING MEMORY

Just what is involved in obtaining a working design? Phil Walker uses the example of the 64K DRAM card and the DRAM fix (ETI Dec '84 and Jan '85 respectively) as an example to show how it's done.

The design of electronic projects can, like most human undertakings, be long or short term, easy or difficult, with all shades of grey in between. In both the hobby world and professional life, it is unusual to go straight from original concept to final hardware with no deviations or modifications along the way. So in the long winter evenings as you sit by the fire working out the details of your next piece of electronic wizardry, don't be in too much of a hurry to commit pen to cheque-book or solder to iron.

The first step is to design what you want: write it down in as much detail as possible. Now try to come up with as many different ways of getting there as possible. Choose two or three of these to consider in detail, and examine their good and bad points.

At this stage you will need information on the various devices and components you may want to use. The catalogues of the larger distributors can be very helpful, but obviously, they do not have the detail that you will find in manufacturers' data books. (One point though, those readers who have access to RS Components will probably already have found that they do produce some very useful data sheets for the semiconductors they distribute.)

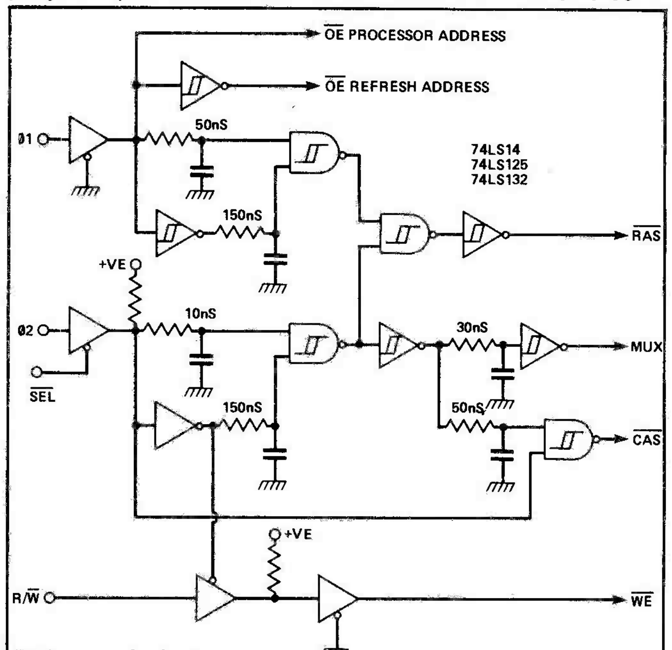
When you have all the information, choose a design approach that satisfies your requirements easily, in other words, an approach which does not require you to operate close to the limits of the devices. In particular, be careful that power dissipation, gain and bandwidth at the lower end of the specified (on the device data) range will not lead to trouble in analogue circuits; on digital circuits, look out for propagation delays and over-critical timing, at either the fast or slow limits (or a combination of both).

After this, you should be in a position to draw circuit diagrams and even outline physical dimensions to your project if they are important. Make sure that, at least on paper, your design will do what you want every time and has no hidden modes of operation, especially at power-on and power-off. Examine what you have and check that it is what you want. Look back to your original requirements and see if it fulfils them (it probably won't).

Now is the time to build something. If it is a large project, then it is wise to build the essential part or parts of the circuitry and test them on some sort of breadboard system. Make sure that these bits do what your theory predicts. If not, **find out why!** If you don't do this you will have really wasted your time. You will learn more from understanding why thing's don't work (first time) than from a series of first-time successes. Naturally it is very frustrating to have your brain-child fail miserably at the first hurdle, but with perseverence your success rate will improve or the complexity of project will increase. With any luck both will occur.

Having chased all the gremlins out of the wirework so far it is time to take the plunge and make the whole thing. Two things are likely to trip you up now, apart from the sillies such as wrong wiring or PCB error. The first is that your original idea had a flaw which has been overlooked or was not apparent until the whole thing came together. The second is that some external equipment or system does not interact with it as planned. In either case some careful thought will be needed to find the appropriate action. This part is often the most frustrating and expensive and leads to red faces, lost tempers and much burning of midnight oil in industry.

A good designer is one who by experience, imagination or both can avoid most of the likely problems in a project by the most suitable choice of method and com-



#1 (paper design)

For:
Timing derived from processor clocks.
All timing periods controllable.
Only three active packages.

Against:
Timing affected by temperature.
Timing for $\overline{RAS}$ determined by differences between networks.
Too many passive components.
Long time delay φ_1 and φ_2 to RAS.
Address buffer controls too near RAS timing.
Uses φ_1 and φ_2 signals.

ponents. Often he or she will use well-tried circuit elements and configurations as building blocks for the new design. New concepts or components will be tested both in theory and practice before being relied upon. In this way it is made likely that problems arising at the prototype stage will be trivial for the most part (wiring error, etc.) or relatively easy to isolate. The unfortunate thing is that most designers operate under a "wanted yesterday" regime and cannot take all the time needed for such deliberation. This is true possibly to an extreme degree amongst hobbyists.

The alternative to designing projects yourself is, of course, to let someone else do it. In this case you must either pay someone to design what you want (or think you want) or get it from a book or magazine (ETI of course!). In this latter case you are restricted to what is published but must still make the effort to understand fully the circuitry you are making. If you do not understand what you have made, you are going to be in big trouble if anything goes wrong. You may get a little help by writing in but publishers usually have neither the time nor money to employ clairvoyant faultfinders.

To illustrate the design process I have included a section on the recent GNOS-EX memory expansion card. Not that this is necessarily a shining example of perfection but it serves to illustrate some of the foregoing comments.

GNOS-EX Development

This started in earnest about six months ago. For some time we had been aware that all was not well with our original 64K DRAM card for the Microtan system, especially in the control logic area. Since this was mostly invested in the 74LS608 memory control device there was not a great deal we could do about it.

In the meanwhile, we had published a DRAM card for Z80-based systems using the TM4500 memory controller. It would have been relatively simple to adapt this to 6502 use, but we did not think this the most useful or illuminating approach. Alternatively, we decided to design the project using the simplest standard TTL devices possible for the control section, along with the lesser known 4416 DRAMs. The 4416 is a 16K x 4 variant on the 64K x 1 devices used in the earlier designs. Although it's slightly more expensive than the latter, it offers the considerable advantage that the user need not populate the memory fully to obtain a workable system, as memory devices need be used in just pairs so 16, 32 or 48 Kbyte options are available, besides the full 64K.

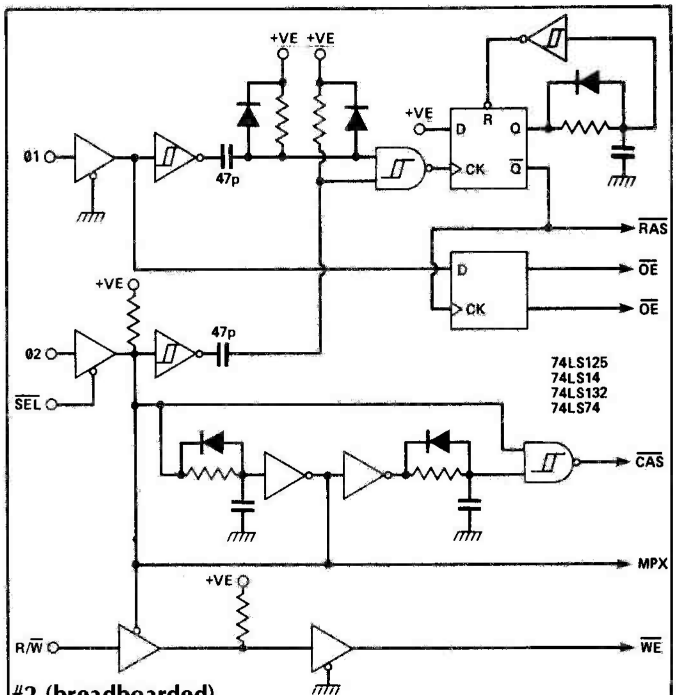
The requirements for this project can be summarised as:

1. To provide up to 64K of dynamic memory;
2. To operate from the signals from a 6502 microprocessor;
3. To use standard TTL devices, preferably SSI and MSI types.

Other factors were considered but were deemed subsidiary to these for this purpose.

Design Approaches

#1 The first ideas on the possible control logic design tended to follow the original circuitry. Both φ_1 and φ_2 were used to obtain the requisite timing signals. In the 6502 data sheet these two signals are supposed to be non-overlapping, ie one falls to zero before the other rises. Looking at these on an oscilloscope showed that if this was the case, and it certainly did not appear so, it was of little practical use as a little stray capacitance or variation in gate propagation delay would nullify any benefits it gave.



#2 (breadboarded)

For:	**Timing for $\overline{RAS}$ provided by edges of φ_1 and φ_2.**
	Common control of $\overline{RAS}$ in processor and refresh periods.
	Address buffers switched at end of $\overline{RAS}$ cycle, not near φ_1 or φ_2.
Against:	**Timing dependent on temperature – made worse by Schmitt thresholds being near 0V rail.**
	No provision for start-up reset sequence.
	Quite a lot of passive timing components.

Did not work due to differentiator capacitors being too small to trigger NAND Schmitt. Increasing capacitors did not help as they could not discharge sufficiently in the time available to be ready for the next cycle.

The first paper design used the φ_1 and φ_2 signals to generate the $\overline{RAS}$, $\overline{CAS}$ and MUX signals with the aid of R-C delay networks and Schmitt input gates and inverters. This in fact used only three IC packages – one less than the final design. However it was felt that the number of passive components was excessive and that the timing they would give would be rather critical and temperature dependent.

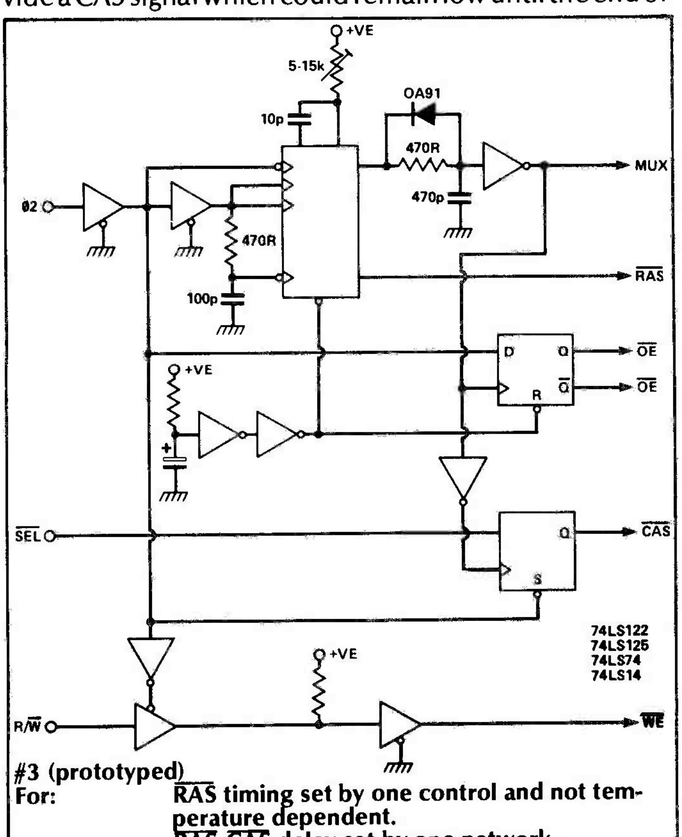
#2 The next serious attempt used a D-type latch connected as a monostable to generate the RAS pulse triggered by two differentiator networks from the φ_1 and φ_2 inputs. The other half of the latch package was used to control the processor and refresh address buffer outputs. This was clocked on the rising edge of the $\overline{RAS}$ signal and sampled the state of the φ_1 input to determine whether the next operation would be a refresh or processor operation. This was felt to have great merit as it ensured that the address presented to the memories was stable well before and after the active RAS falling edge. The idea persisted into the final design.

The MUX and $\overline{CAS}$ signals were still generated by R-C delays. In spite of this the circuit was felt to have some merit and was breadboarded. Unfortunately the differentiator networks did not function as planned and the monostable was not triggered reliably. The fault was found to be that the capacitors were too small to overcome the capacitance at the inputs to the gate, and increasing them did not help since then they were too large to recharge before the next cycle.

#3 A deliberate attempt was made in this design to eliminate as many of the R-C delays as possible. This led to the use of the 74LS122 monostable, as it is claimed to operate quite reliably at these time periods. Also with the multiplicity of trigger inputs, it was found possible to make the '122 trigger on both the rising and falling edges of the same input signal. This made it possible to dispense with the φ_1 signal and refer all timing to the φ_2 input. This also suited the designer quite nicely, as the φ_1 signal is not available on the system expansion bus connector.

With the critical timing taken care of by the monostable, the only other timing delays needed were between $\overline{RAS}$ and $\overline{CAS}$ and non-critical delay to make the monostable trigger on both edges. The former was very simply accomplished by an R-C network and, although vital, this was found to be stable enough for this project.

The data sheet on the 4416 states that the column addresses must be stable by the time the $\overline{CAS}$ signal goes low. In this design there is one extra device propagation delay in the $\overline{CAS}$ signal path more than in the address multiplexer path. In practice, this was found to give about 20ns separation in the right direction. In going from the D-type latch monostable circuit to the 74LS122 and retaining the buffer control part there was a spare D-type latch available. This was quickly put to use to sample the select signal at an appropriate time and provide a $\overline{CAS}$ signal which could remain low until the end of a processor access cycle. This configuration not only removed a lot of constraints on the select decoding logic but also keeps data available at the memory devices until the 6502 has captured it. It also makes sure that there are no short or erroneous $\overline{CAS}$ outputs which would lead to mis-operation of the memory chips.



#3 (prototyped)

For: $\overline{RAS}$ **timing set by one control and not temperature dependent.**
$\overline{RAS}$-$\overline{CAS}$ delay set by one network.
Only two main timing networks.
Address buffers switched half-way through cycle.
Once $\overline{CAS}$ triggered stays low to end of cycle – makes data remain on outputs.

Against: **Stopped working when processor warmed up**

Refer to data sheets for 6502 and 4416 to get probable reason that 6502 guarantees data out valid for 200ns after φ_2 goes high. 4416 requires data valid whenever the later of $\overline{WE}$ or $\overline{CAS}$ goes low for a write cycle.

The essential control logic as designed together with the various address multiplexers, refresh counter and 16K of memory were constructed on a small PCB. This was connected via a simple interface to the designer's Ohio Superboard. This is a rather old 6502 system, which has been much modified, and now runs at a clock speed of 1.25MHz. After sorting out all the usual bugs and making the necessary adjustments, the project seemed to work well . . . for 10 minutes. No reason for the latch-up was apparent, so freezer spray was applied to various parts to see if there was a thermal problem. Lo and behold, it was the 6502 processor! However, since this had been working satisfactorily for some years, and still did so when not connected to the new memory, it was felt that the fault must be a little more obscure.

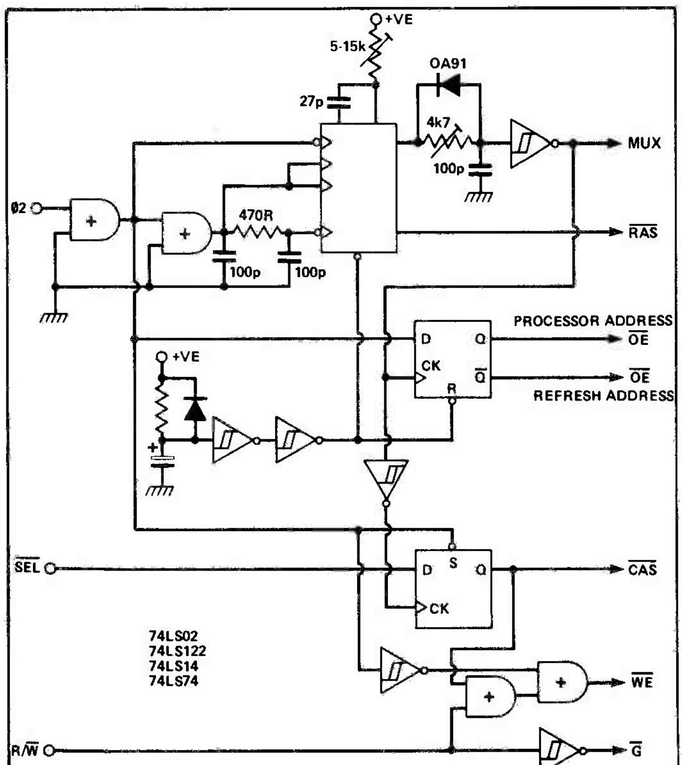
The next thing was to dig out all the data on the 6502 and the 4416. A combined timing diagram was drawn to illustrate the interaction between the two devices and the effect of the control logic. It had been noticed that although the data read from a location was not the same as that written to it each read operation was consistent with the last. This pointed to the possibility that there was a problem in the write operation. In fact the specification of the 6502 states that data in a write cycle is only guaranteed stable 200ns after the φ_2 rising edge. The 4416, however, requires that the data be stable whenever the later of $\overline{CAS}$ or $\overline{WE}$ goes low. In the design at this time it was the $\overline{CAS}$ which was critical. It was easy to adjust the delay to get round this problem, but this immediately raised another in the read cycle.

Here, the 6502 requires that data from the memories be stable 100ns before the φ_2 falling edge. The 4416 is guaranteed to supply this data 120ns after the $\overline{CAS}$ signal goes low. Being really pessimistic this would require a minimim φ_2 high time of 420ns, which looks a little adrift from the observed 360ns. To get around this, at least partly, the $\overline{WE}$ signal was gated with the $\overline{CAS}$ and φ_2 signals such that it occurred after the $\overline{CAS}$ signal. This meant that there was a little more leeway in the timing and the $\overline{CAS}$ signal could occur earlier. This was even better in the final design where there was an extra delay through the 'LS139 decoder.

#4 Having got the prototype working satisfactorily, the time arrived to lay out a PCB for the final design. This took about four days for the double-sided artwork and a further three days to have it photographically reduced and a board etched, drilled and populated. A new interface to the Superboard was constructed and the design tested. This brought to light one or two things like the $\overline{RAS}$ and $\overline{WE}$ being swapped on the memories and the desirability of more test points on essential signal paths. These items were corrected on the PCB artwork to yield the final PCB pattern.

Once the $\overline{RAS}$ and $\overline{WE}$ problem had been solved the project worked as required although it was not possible to check operation with the slower 4416-20 devices as only 4416-15 were available from the suppliers.

One extra feature had been added to the design between the #3 and #4 versions and that was the $\overline{G}$ signal derived by an inverter from the R/$\overline{W}$ line. This is necessary because during an active processor access cycle, all the memory devices will perform a read operation except for a pair selected to have data written if the processor wants a write cycle. The $\overline{G}$ signal is routed by



#4 (final)

For: All advantages of previous design.
Uses quad NOR package instead of buffers – one less resistor.
$\overline{WE}$ signal slightly after $\overline{CAS}$ instead of before it.
$\overline{G}$ signal available to disable memory data output in WRITE mode.
Works on a 1.25 MHz 6502 system.
All edge triggered from φ_2 – samples $\overline{SEL}$ signal, CAS cannot be aborted once started.

Against: Requires adjustment to be made for best operation.
Relies on short time delays around inputs of monostables.
Memories must not be accessed for eight cycles after power-up.
As it stands, is not usable for 4164 devices with data in and data out pins commoned.

the 'LS139 to the pair of memories to be accessed only during a read operation. At all other times the $\overline{G}$ pins of the memories will be high thus preventing their data bus drivers fighting for control of the bus. This does not affect the internal operation of the memories.

As a bonus and a service to readers who had built the 1983 DRAM design the control logic was re-configured to fit a small PCB such that it could be used to replace the control logic of the earlier design. Some small changes were necessary because of the select logic polarity difference and the use of 4164 memory devices. This was built onto the original project and tested under the same conditions and worked perfectly, as far as could be ascertained.

This concludes the description of how this project was designed. Although it cannot cover all the thought processes, prejudices, scribblings on odd bits of paper and strange flights of fancy which make up the design process, it serves as an illustration of how one starts with one set of ideas and progresses to the final solution discarding most or all of the original concepts on the way. This is probably quite common in designing electronic or other hardware (and software?) and is probably more useful than doggedly trying to get the first idea to work.

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ZN428J-8	9.70
ZN429E-8	1.60
ZN432CJ-10	20.79
ZN432E-10	13.00
ZN433CJ-10	25.00
ZN434	0.98
ZN435	4.38
ZN436E	1.26
ZN440	55.00
ZN441	46.80
ZN447	7.80
ZN448E	6.66
ZN448J	12.48
ZN449	2.72
ZNA134J	22.50
ZNA234E	9.40

VOLTAGE REF.

ZN404	0.50
ZN423	0.98
ZN458	0.92
ZN458A	0.92
ZN458B	1.12
ZNREF 025	1.90
ZNREF 040	1.90
ZNREF 050	1.90
ZNREF 062	1.90
ZNREF 100	3.05

BUFFERS

81LS96	0.80
81LS97	0.80
81LS98	0.80
8T26A	0.80
8T28	0.80
8T28A	0.80
8T95	0.80
8T97A	0.80
8T98	0.80

OPTOISOLATORS

4N25	0.75
4N26	0.75
4N33	0.90

UHF MODULATORS

UM1111	2.95
UM-1233	3.45

VOLTAGE REG.

7805	0.75
7812	0.75
7815	0.75
78H05SC	7.50
78H12ASC	8.95
78HGASC	9.95
78L05	0.30
78L12	0.30
78L15	0.30
78S40DM	7.50
78S40PC	3.00
7905	0.95
7912	0.95
7915	0.95
LM309K	0.95
LM317K	2.45
LN323K	4.95
LM338K	4.50

FAIRCHILD FAST

74F00PC	0.60
74F04PC	0.60
74F08PC	0.65
74F109PC	0.65
74F11PC	0.52
74F138PC	0.52
74F138PC	1.26
74F139PC	1.26
74F151	1.26
74F153	1.26
74F157	1.30
74F158	1.17
74F161	2.34
74F164	1.68
74F175	1.82
74F181	3.90
74F189	5.10
74F190	3.20
74F191	3.20
74F194	1.68
74F20PC	0.52
74F240	3.16
74F241	2.42
74F243	2.80
74F244	2.96
74F245	6.08
74F251	1.26
74F253	1.26
74F257	1.26
74F258	1.34
74F280	1.74
74F283	1.74
74F32PC	0.52
74F352	1.26
74F353	1.26
74F373	3.16
74F374	3.16
74F379	1.83
74F381	6.62
74F382	4.22
74F398	3.16
74F399	2.70
74F521	2.76
74F533	3.16
74F534	3.16
74F537	6.02
74F538	4.38
74F539	4.38
74F64PC	0.52
74F74PC	0.58
74F86PC	0.77

HIGH SPEED CMOS

74HC00N	0.42
74HC02N	0.42
74HC03N	0.64
74HC04N	0.44
74HC08N	0.42
74HC107N	0.78
74HC109N	0.50
74HC10N	0.64
74HC112N	0.86
74HC113N	0.86
74HC132N	1.28
74HC137N	1.81
74HC138N	1.20
74HC139N	0.78
74HC151N	1.16
74HC153N	0.90
74HC157N	1.02
74HC158N	1.02
74HC160N	0.90
74HC161N	0.90
74HC162N	1.51
74HC163N	1.51
74HC164N	0.95
74HC165N	2.24
74HC173N	1.35
74HC174N	0.80
74HC175N	0.78
74HC194N	1.28
74HC195N	1.28
74HC20N	0.40
74HC237N	1.80
74HC240N	1.38
74HC241N	1.34
74HC242N	2.24
74HC243N	2.24
74HC244N	1.32
74HC251N	1.03
74HC253N	1.03
74HC257N	1.03
74HC266N	0.92
74HC273N	2.24
74HC27N	0.80
74HC280N	3.26
74HC32	0.40
74HC373N	2.40
74HC374N	2.40
74HC393N	1.78
74HC4002	0.64
74HC4017	1.16
74HC4020	1.46
74HC4024	1.20
74HC4040	1.46
74HC4060	1.46
74HC4075	0.64
74HC42N	0.90
74HC4511	2.51
74HC4514	3.76
74HC4538	2.36
74HC4543	3.04
74HC51N	0.64
74HC533N	2.40
74HC534N	2.40
74HC589N	1.72
74HC58N	0.64
74HC595N	1.84
74HC597N	1.72
74HC73N	0.84
74HC74N	0.84
74HC75N	0.92
74HC76N	0.64
74HC85N	2.02
74HC86N	0.80
74HCU04N	0.80

TTL

74LS00	0.17
74LS01	0.17
74LS02	0.17
74LS03	0.17
74LS04	0.25
74LS05	0.25
74LS08	0.17
74LS09	0.25
74LS10	0.17
74LS109	0.27
74LS11	0.17
74LS112	0.54
74LS113	0.27
74LS114	0.44
74LS12	0.25
74LS122	0.42
74LS123	0.53
74LS124	2.30
74LS125	0.49
74LS126	0.29
74LS13	0.17
74LS132	0.73
74LS136	0.46
74LS138	0.77
74LS139	0.77
74LS14	0.28
74LS145	1.23
74LS148	1.50
74LS15	0.25
74LS151	0.36
74LS153	0.36
74LS155	0.24
74LS156	0.77
74LS157	0.24
74LS158	0.62
74LS160	0.80
74LS161	0.34
74LS162	0.80
74LS163	0.80
74LS164	1.10
74LS165	0.61
74LS166	1.95
74LS173	0.63
74LS174	1.30
74LS175	0.96
74LS181	2.09
74LS190	0.98
74LS191	0.75
74LS192	0.36
74LS193	1.10
74LS194	0.28
74LS195	0.78
74LS196	1.10
74LS197	1.10
74LS20	0.17
74LS21	0.17
74LS22	0.17
74LS221	0.62
74LS240	1.40
74LS241	0.48
74LS242	1.36
74LS243	1.36
74LS244	1.40
74LS245	1.95
74LS248	0.39
74LS249	1.16
74LS251	0.78
74LS253	0.25
74LS257	0.78
74LS258	0.27
74LS259	0.42
74LS26	0.30
74LS261	2.60
74LS266	0.19
74LS27	0.17
74LS273	1.35
74LS279	0.77
74LS28	0.17
74LS283	1.00
74LS290	0.29
74LS293	0.29
74LS30	0.17
74LS32	0.25
74LS33	0.17
74LS365	0.33
74LS366	0.33
74LS367	0.34
74LS368	0.36
74LS37	0.17
74LS373	1.50
74LS374	0.52
74LS375	0.26
74LS377	0.46
74LS378	1.22
74LS379	1.50
74LS38	0.25
74LS386	0.50
74LS390	1.10
74LS393	0.52
74LS40	0.25
74LS42	0.25
74LS47	0.30
74LS48	0.35
74LS49	0.34
74LS51	0.17
74LS54	0.17
74LS55	0.17
74LS670	2.30
74LS73	0.30
74LS74	0.35
74LS75	0.28
74LS76	0.17
74LS78	0.19
74LS83	0.28
74LS85	0.39
74LS86	0.42
74LS90	0.21
74LS91	1.30
74LS92	0.22
74LS93	0.21
74LS95	0.77

CMOS 4000 Series

4000	0.16
4001	0.15
4002	0.16
4006	0.55
4007	0.16
4008	0.50
4009	0.25
4010	0.25
4011	0.19
4012	0.16
4013	0.29
4014	0.40
4015	0.50
4016	0.29
4017	0.40
4018	0.40
4019	0.30
4020	0.41
4021	0.56
4022	0.42
4023	0.23
4024	0.40
4025	0.16
4026	0.74
4027	0.52
4028	0.34
4031	0.93
4033	2.40
4034	1.00
4035	0.54
4040	0.41
4041	0.36
4042	0.40
4043	0.41
4044	0.43
4045	2.00
4046	0.55
4047	0.50
4048	0.40
4049	0.50
4050	0.29
4051	0.40
4052	0.48
4053	0.50
4054	1.30
4055	0.72
4060	0.50
4063	0.60
4066	0.50
4068	0.16
4069	0.23
4070	0.23
4071	0.23
4072	0.23
4073	0.23
4075	0.46
4076	0.48
4077	0.23
4078	0.2
4081	0.2
4082	0.2
4085	0.6
4086	0.4
4093	0.2
4099	0.5
4502	0.5
4507	0.4
4508	0.9
4510	0.4
4511	0.5
4512	0.4
4514	1.0
4515	1.8
4516	0.4
4518	0.4
4519	0.2
4520	0.6
4521	1.3
4522	0.8
4526	0.5
4527	0.5
4528	0.4
4532	0.6
4541	0.8
4543	0.6
4553	2.0
4555	0.3
4556	0.44
4585	0.48

CRYSTALS

A111B	1MHz	4.50
A112A	1.008MHz	2.70
A113A	1.8432MHz	3.50
A116A	2.4576MHz	2.00
A120B	4MHz	1.25
A132A	6MHz	1.30
A140A	8MHz	1.25
A169A	3.6864MHz	2.00
A173A	9.8304MHz	2.75
A182A	19.6608MHz	2.50

DIL SKTS TIN

		1+	100+
07070802	8 PIN	0.07	0.05
07071402	14 PIN	0.09	0.07
07071602	16 PIN	0.09	0.07
07071802	18 PIN	0.15	0.10
07072002	20 PIN	0.19	0.14
07072202	22 PIN	0.21	0.15
07072402	24 PIN	0.24	0.16
07072802	28 PIN	0.26	0.17
07074002	40 PIN	0.29	0.18

DIL SKTS GOLD

06060802	8 PIN	0.16
06061402	14 PIN	0.20
06061602	16 PIN	0.21
06061802	18 PIN	0.22
06062002	20 PIN	0.28
06062202	22 PIN	0.32
06062402	24 PIN	0.42
06062802	28 PIN	0.46
06064002	40 PIN	0.66

DIL SKTS W/WRAP TURNED PIN

9090802	8 PIN	0.36
9091402	14 PIN	0.75
9091602	16 PIN	0.86
9091802	18 PIN	0.96
9092002	20 PIN	1.08
9092202	22 PIN	1.18
9092402	24 PIN	1.28
9092802	28 PIN	1.50
9094002	40 PIN	1.70

ZIF SOCKETS

08082402	24 PIN	5.70
08082802	28 PIN	6.90
08084002	40 PIN	8.25

DIGITAL DELAY LINE

Greedy for more, eh? Well here's the expansion card, together with some notes and hints on how to use the unit. Design and development by Ray Lowe.

The memory expansion circuit is shown in Fig. 1. Comparing this with the 'motherboard' memory section (Fig. 3, p19, ETI Dec. '84) shows that the two are identical lumps of circuitry. So, to understand how it works — as if you didn't know — you'll have to find a back issue. Selection between the two memory sections is made by inhibiting them alternately via the inverter preceeding the 'EXP' control line.

Installation of the extra memory is straightforward, but requires careful soldering to the logic PCB (motherboard). The best — and easiest — way to accomplish this is shown in Fig. 2. Remember to follow construction tips given in the earlier articles.

The expansion PCB layout diagram shows connections labelled with the pin no. to which they should be connected. These numbers refer to the pins of ICs in the usual fashion, ie looking downwards on the component side of the PCB and starting with no. 1 at top left hand corner, adjacent to the notch, and numbering anticlockwise.

Possible Adaptions

Drum machine: if you know a little about digital electronics, you can try adding a simple circuit which will page between memory or expansion card(s), via the INHibit pins,to give a drum machine-like programmability.

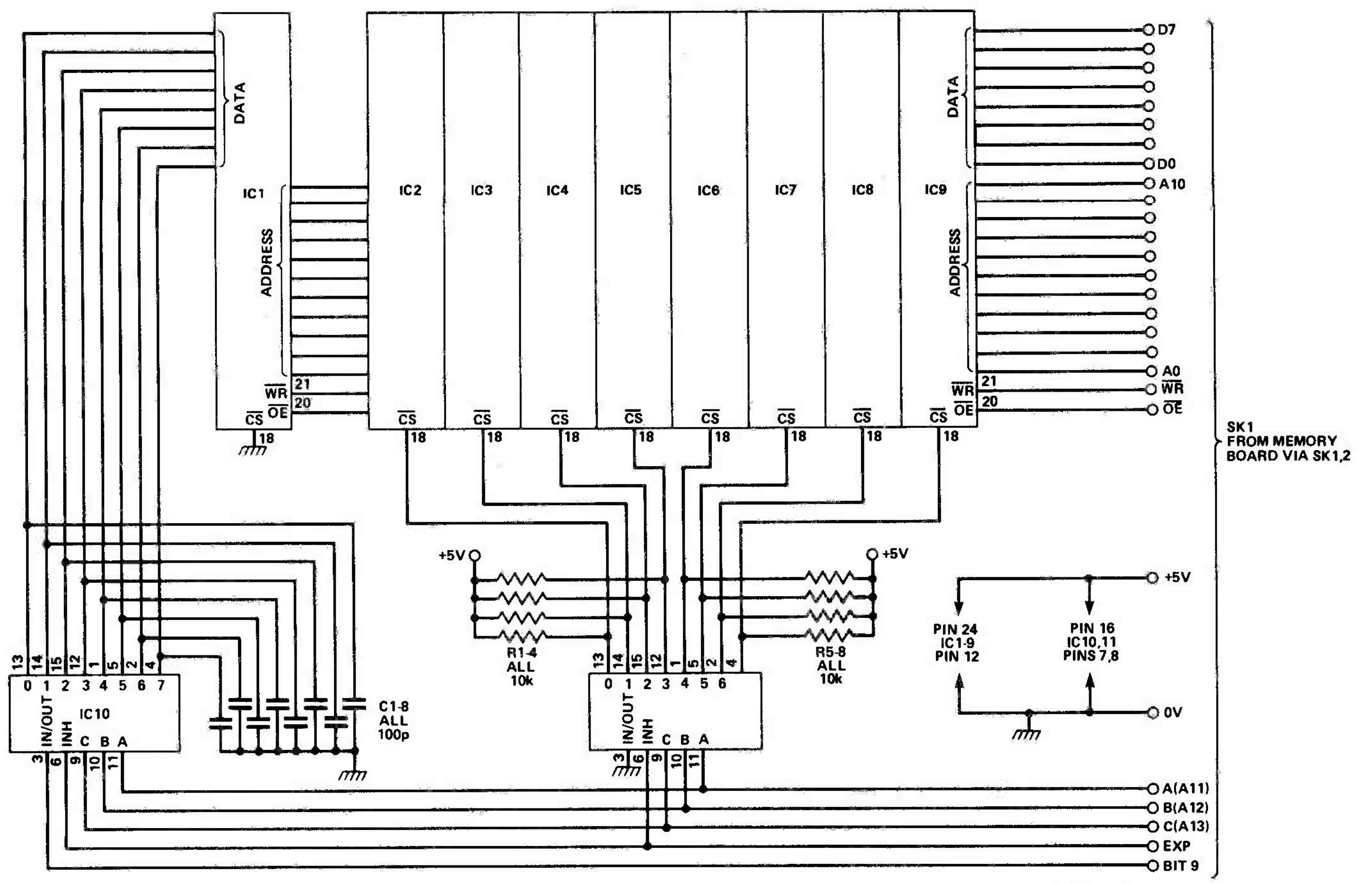


Fig. 1 Circuit diagram of the expansion card. On IC1-9, the data is on pins 9 to 1 and 13 to 17, and the address on pins 1 to 8 and 19, 22, 23; it does not matter one jot in which order these pins are used in this circuit, and, as you'll see on the PCB, the order is changed between some ICs merely to help the track lay-out.

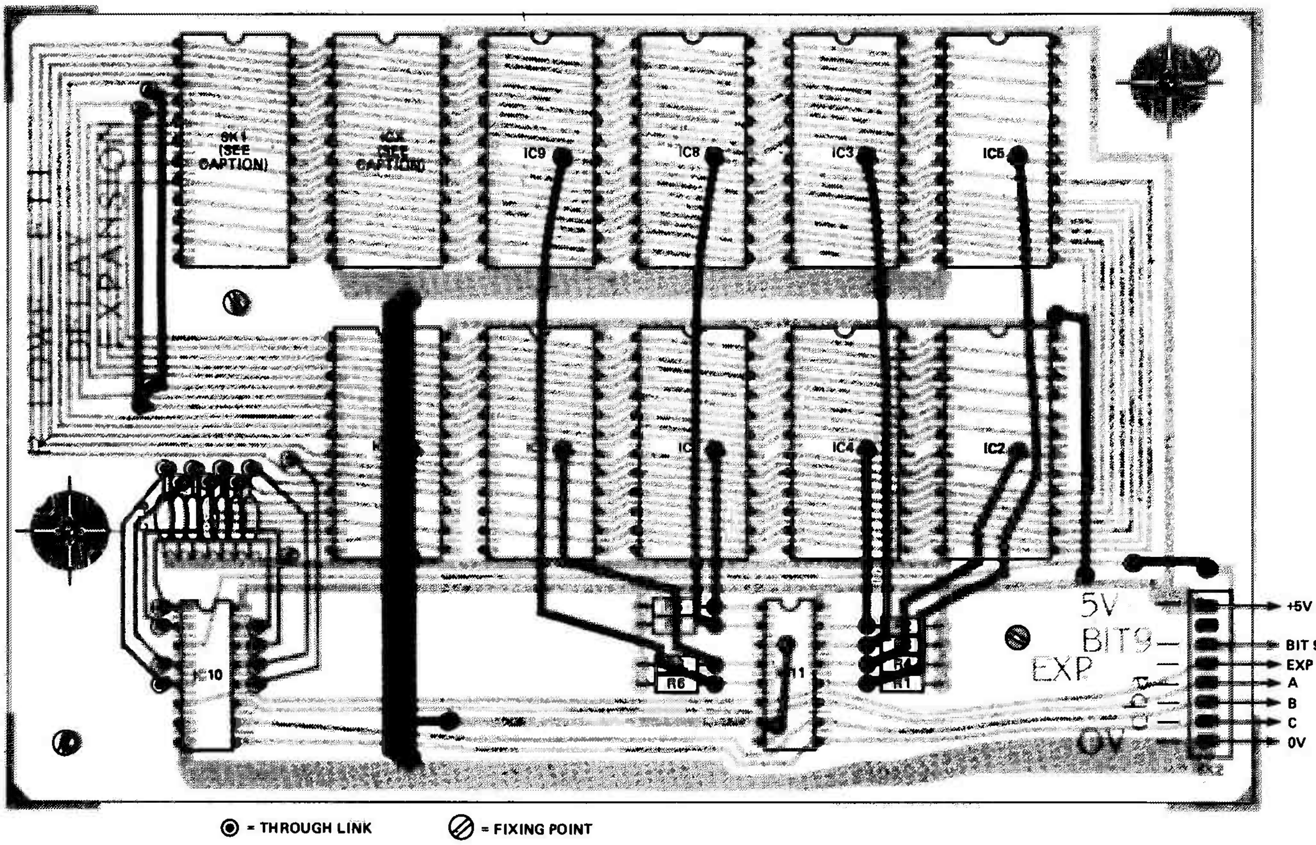


Fig. 2 Overlay diagram of the expansion card, which is connected to the main memory card using a short length of ribbon cable with header sockets at both ends. On the main memory card, one of the memory ICs will have to be removed to allow the header plug to be inserted, and this IC should be transferred to the position marked ICX on the expansion card. Be sure to get the orientation of the header sockets right! Note also that some additional links to the expansion card come in via SK2, and these are all labelled on the expansion card and on the main memory card overlay.

This can be used in the percussion mode, with a trigger input from a sequencer or drum contacts, for example. The amount of memory required to store percussive sounds would be quite small so that only two or three chips need be present per expansion card.

External delay modulation: you can apply, via a 100k resistor, an externally-generated control voltage to the inverting input of IC14a — from a foot pedal, for example, to allow external delay (pitch) modulation when playing live.

Audio storage scope facility: not very musical, I admit, but the unit will do this job with no modification (although you do need to have a 'scope already to connect to it!). Probably only 4K of memory would be needed for this use.

Finally, pseudo-stereo could be achieved simply, by taking the 'straight' and delayed channels to separate inputs on the stereo amplifier.

Using The Unit

There now follow some notes on using the unit, with or without the expansion card. One general point which should be noted is that the setting of the input gain control should be done carefully to obtain best results. The gains of other units before and after the unit should be adjusted to compensate. The objective is to use the maximum signal level you can, to avoid quantisation noise, etc, whilst maintaining just enough headroom to prevent transients, etc, grossly overloading the A-to-D.

If the unit is used in conjunction with other effects, then the best position for it will have to be determined by experiment. Obviously you'll obtain different effects from different orders of the effects units. However, if a compression type of effect, such as sustain, is used, then placing the delay line after this effect will take advantage of the reduced dynamic range. Similarly, a noise gate will probably give better results if used before the delay line.

A footswitch can be connected, via the front panel socket, to switch the delay channel in or out, by shorting the 'EXT' pin to analogue ground. Similary, externally generated trigger pulses in the range 5 to 20 volts can be

PARTS LIST

RESISTORS (all ¼W 5%)

R1–8	**10k**

CAPACITORS

C1–8	**100p ceramic**

SEMICONDUCTORS

IC1–9	**6116, any speed**
IC10,11	**4051**

MISCELLANEOUS

IC Sockets: 11 off 24-way (one of these is SK1), 2 off 16 way; 1 off 8-way connector and socket (SK2), 0.1" pitch; 2 off 24-pin header sockets; ribbon cable; PCB: wire, solder, etc.

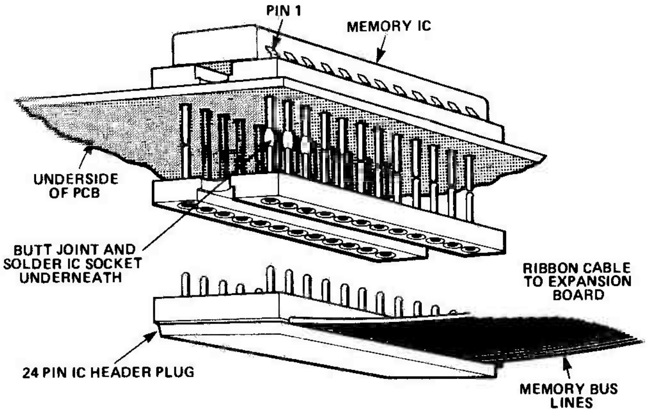


Fig. 3 An alternative method of connecting the expansion card to the main memory, and which avoids having to move one of the memory ICs. However, you must be careful to get the orientation of the header socket right.

applied to the logic board via the trigger input. The delay channel is reset by the leading edge of the pulse and remains reset until the trailing edge. So far, these inputs have proved to be idiot-proof, but don't try to prove us wrong . . .

Using 'Freeze' And 'Percussion'

To store a sound, press freeze in at any time, or have the freeze switch out and the percussion switch in. Set the input signal level, then, by either momentarily releasing the percussion switch or by applying a trigger pulse, start the record cycle and the signal is now recorded. Note that a trigger source can sometimes be derived from a signal source, eg drum contact. With percussion already in, push in freeze to write protect the sound. Applying trigger pulses, etc, will regenerate the sound upon request (percussive mode) or the sound can be continually cycled with the percussion switch out.

The stored sound can be manipulated by means of the delay time buttons, the bandwidth control, and the low frequency oscillator. The repeat control affects the decay rate once freeze has been released.

BUYLINES

Nothing here should cause any problems. The PCB is, as ever, available through our PCB service.

Effects

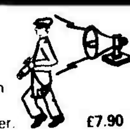
Chorus and flanging type effects are obtained by using short delays and mixing the original and delayed channels equally. The time delay constitutes a phase difference and results in comb filtering. By modulating the delay time, the filter frequency is modulated and a sweeping type effect is generated. Multi-repeats also enhance some effects. Pitch change is accomplished by using longer delays and varying the delay time. Vibrato and double tracking can be achieved in this way. Varying the delay time can make the sound appear to come from a Coca-Cola tin to a huge cavern, depending upon setting.

These are just a few effects that can be produced — the only limitation is that of imagination!

" IM SHUNTING THE SLOW SAWTOOTH INTO THE SIDING WHILE THE EXPRESS SINEBURST IS CLOCKED THROUGH ON THE MAIN LINE "

ETI

ELECTRONIC SIREN KIT



Produces an extremely loud piercing swept frequency tone from a 9-15V supply. Enable input for easy connection to alarm circuits. Includes 5in. Horn Speaker. **£7.90**

Mini Siren
As above, but with a small speaker (instead of horn speaker) for internal use. Complete with box **£4.30**

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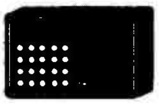
MICROPROCESSOR TIMER KIT



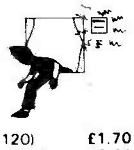
Designed to control 4 outputs independently switching on and off at preset times over a 7-day cycle. LED display of time and day, easily programmed via 20-way keyboard. Ideal for central heating control (including different switching times for weekends). Battery back-up circuit. Includes box. 18 time settings.

CT6000K **£39.00**

XK114. Relay Kit for CT6000 includes PCB, connectors and one relay. Will accept up to 4 relays. 3A/240V c/o contacts **£3.90**

701 115 Additional Relays **£1.65**

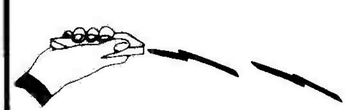
SECURITY PRODUCTS



Protect your home and property and save by building your own burglar alarm system.

Stair Mat 23 × 7 in (950 120) **£1.70**
Floor Mat 29 × 16 in (950 125) **£2.60**
Tamper-proof connecting block (950 110) **£0.30**
Door/Window Contacts. Flush mounting, 4 wire, Magnet/switch Per Pair. (950 140) **£1.05**
Window Tape 0.5" wide. 50m. (950 145) **£2.50**
Window Tape Terminations Per pair. (950 150) **£0.36**
Key-operated Switch. 1.5A/250V SPST Heavy chrome metal (350 128) **£4.50**
Passive Infra-Red Detector Detects intruder's body heat. Range 10 metres. 12V DC, n/o & n/c contact. (950 135) **£40.00**
Alarm Control Unit. 4 input circuits, 2-instant and 2-delayed. Adjustable entry, exit and alarm times. Built and tested. Full instructions supplied. Size: 180 × 130 × 30mm. Supply: 12V DC. (950 160) **£26.00**
Ultrasonic Burglar Alarm. Self-contained mains or battery powered unit complete with horn and AC adaptor. Imputs for pressure mats and other sensors together with exit/entry delays enable this unit to be used as a complete system. **£45.00** + p&p £2.20
8W Horn Speaker. 5.5 ins. 8 ohm. Ideal for sirens, etc. 2.5m lead and 3.5mm jack plug (403 148) **£6.15**

INFRA-RED REMOTE CONTROL KITS



These kits are designed to enable infra-red remote control to be incorporated into virtually any application from switching car locks or alarms to controlling Hi-Fi or TV. The application will determine the interface circuitry between the receiver and the controlled device. General instructions and applications are supplied. The kits are coded and provide a high degree of security and noise immunity.

MK 18 Transmitter Kit – for use with MK11/MK12 receivers. Requires PP3 battery. Size: 8 × 2 × 13cms. Range approx. 60 ft. **£6.80**

Keyboards for MK18
MK9 4-way for use with MK12 **£1.90**
MK10 16-way for use with MK12 **£5.40**
MK13 11-way for use with MK11 **£4.35**

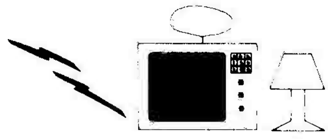
MK11 Receiver Kit – mains powered. Provides 10 latched plus 3 analogue outputs ideal for controlling audio amplifiers, TV or lighting where control of light brightness is required. **£13.50**

MK14 AC Power Controller Kit for (phase) controlling AC loads from MK11 analogue outputs, eg lamp dimming. **£5.20**

MK19 Stereo Amplifier Controller Kit – for remote control of bass, treble and volume (or balance) by MKII. Includes a one of 10 decoder remote channel or input selection. May be connected between the pre-amp and power amp of almost any audio system. **£10.70**

MK12 Receiver Kit – mains powered with 16 latched or momentary outputs. Latched version is for applications requiring one output on at a time, eg TV channel selection. Momentary type gives an output only during transmission. Lines may be latched as required. Size: 9 × 4 × 2cms **£13.50**

MK15 Dual Latched Solid State Relay for switching mains loads such as lamps, TVs, etc. from the outputs of the MK12 (momentary). 15 items may be switched independently using 8 MK15s. Triacs (not supplied) switch at mains zero to reduce interference. **£4.50**



ELECTRONIC LOCK KIT

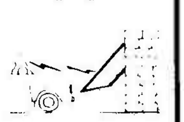
With hundreds of uses indoors, garages, car anti-theft devices, electronic equipment, etc. Only the correct easily changed four-digit code will open it! Requires a 5-15V DC supply. Output 750mA. Fits into standard electrical wall box.
Complete kit (except front panel)
XK101 **£11.50**
Electric Lock Mechanism for use with existing door locks and the above kit. (Requires relay.) 12V AC/DC coil. (701 150) **£14.95**

HOME LIGHTING KITS

These kits are designed to replace a standard wall switch to control up to 300w of lighting.

TDR300K	Remote Controlled Light Dimmer	**£14.95**
MK6	Transmitter for above	**£4.50**
TD300K	Touch Dimmer	**£7.75**
TS300K	Touch Switch	**£7.75**
TDE/K	2 way extension for above kits	**£2.50**
LD300K	Rotary controlled Light Dimmer	**£3.95**

IR GARAGE DOOR CONTROLLER KIT



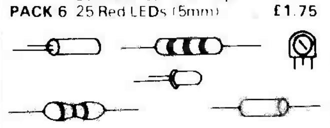
For controlling motorised garage doors and switching garage and drive lights on/off up to a range of 40 ft.

Lots of applications like controlling lights and TVs, etc. in the home. Ideal for aged or disabled persons, this coded kit comprises of a mains powered infra red receiver with a normally open relay output plus two latched transistor outputs, battery powered transmitter and opto isolated solid state mains switch.

XK103 **£25.00**
XK105 Extra transmitters **£10.50**

COMPONENT PACKS

PACK 1 650 Resistors 47R-10M 10 per value **£4.00**
PACK 2 40 × 16V Electrolytics 10-1000µF 5 per value **£3.25**
PACK 3 60 × Polyester Capacitors 0.01-1µF 250V 5 values **£5.55**
PACK 4 45 Presets 100R-1M **£3.00**
PACK 5 30 × Low Profile IC Sockets 8, 14 & 16 pin **£2.40**
PACK 6 25 Red LEDs (5mm) **£1.75**



BT STYLE PHONE CONNECTORS

Line Jack Units
Master Unit (first line unit) has bell capacitor and surge arrester. Flush or surface mounting. Screw connectors.

Master (flush)	(960 110)	**£3.00**
Master (surface)	(960 112)	**£3.00**
Master (mini surface)	(960 113)	**£3.50**
Secondary (flush)	(960 114)	**£2.65**
Secondary (surface)	(960 116)	**£2.65**
Secondary (mini surf)	(960 117)	**£3.00**
Dual outlet adaptor	(960 118)	**£4.20**
4 way line cord with plug to spade terminals	(960 120)	**£2.00**
4 way line cord	(960 130)	**£0.20 per m**

DISCO LIGHTING KITS

DL1000K This value-for-money 4-way chaser features bi-directional sequence and dimming. 1kW per channel. **£15.95**
DLZ1000K A lower cost uni-directional version of the above. Zero switching to reduce interference. **£8.95**
Optional opto input allowing audio 'beat'/light response **(DLA/1)** **70p**
DL3000K 3-channel sound to light kit features zero voltage switching, automatic level control and built-in microphone. 1kW per channel. **£12.95**

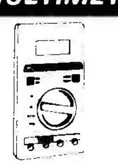
PANTEC KITS

PN2	FM Micro Transmitter	**£7.50**
PN3	Stabilised Power Supply	**£13.70**
PN5	2 × 10w Stereo Amplifier	**£14.50**
PN6	2 × 40w Stereo Amplifier	**£24.95**
PN7	Pushbutton Stereo Preamp	**£12.80**
PN8	Tone & Volume Control	**£13.60**
PN11	3w FM Transmitter	**£11.95**
PN13	Single Channel FM Transmitter	**£9.80**
PN14	Receiver for above	**£15.50**

LCD DIGITAL MULTIMETERS

LOW COST! 10M ohm. 3½ digit 0.4 in display. Auto zero and polarity, low batt. indication, overload protection. Includes test leads, battery, spare fuse, manual, carrying case.
AC Volts: 0 - 200 - 500.
DC Volts: 0-2-20-200-1000.
DC Current: 0-20m-200mA.
Resistance: 0-2k-20k-200k-2M.
Size: 138 × 86 × 36mm.
(405 202) **£25.95**

Professional – 10M, 0.5 in, 3½ digit. Overrange and low battery indication. Overload protection. Includes leads, spare fuse, battery, manual and case. Transistor Checker. Size: 175 × 93 × 42mm.
AC Volts: 0-200-750.
DC Volts: 0-200m-2-20-200-1000.
DC Current: 0-20u-2m-20m-200mA. 0-10A.
Ohms: 0-200-2k-20k-200k-2M. 0-20M.
(405 204) **£33.50**



Auto Ranging. 3½ digit 10mm display. Continuity buzzer, low battery, overload and range indication. 10A internal shunt for AC/DC current measurement. Carrying case supplied.
AC Volts: 0-2-20-200-600.
DC Volts: 0-0.2-2-20-200-1000.
AC Current: 0-200mA. 0-10A.
DC Current: 0-200mA/0-10A.
Resistance: 0-200-2k-20k-200k. 0-2M.
Size: 160 × 85 × 29mm.
(405 206) **£44.85**

High Sensitivity Temperature Probe. For use with a multimeter to measure temperatures from –50°C to +250°C. Accuracy: 1.5°C@25°C, 2°C@100°C. Response time (in water), 5 seconds. Includes case, calibrated scale and instructions. (405 220) **£8.50**

DVM/ULTRA SENSITIVE THERMOMETER KIT

Based on the ICL 7126 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 0.1°C. The kit has a sensitivity of 200mV for a full-scale leading automatic polarity and overload indication. Typical battery life of 2 years (PP3). **£15.50**

TK ELECTRONICS

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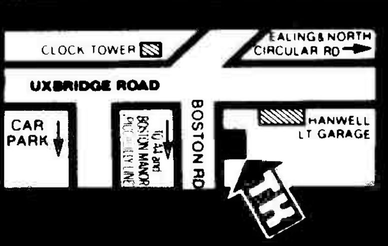
ORDERS 01-567 8910
ENQUIRIES 01-579 9794
01-579 2842 TECHNICAL AFTER 3pm



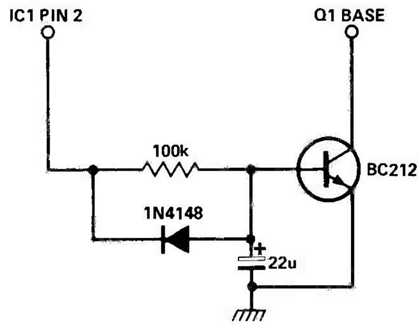
TECH TIPS

Auto-Repeat for the Cortex

V.F. Gray
Purley

For less than 30 pence, a useful auto-repeat function can be added to the Cortex computer keyboard. There are so few components in the circuit that they can easily be soldered directly onto the back of the keyboard PCB.

When the keyboard encoder strobe signal goes high (key pressed) the 22u capacitor starts to charge via the 100k resistor. Eventually, if the key is still pressed, the BC182 will conduct sufficiently to simulate pressing the



Repeat key. When the key is released, the strobe goes low and the capacitor discharges via the 1N4148 diode and the BC182 stops conducting.

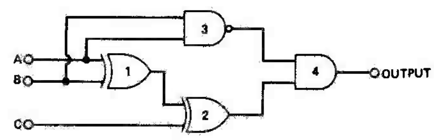
With the component values shown, any character key which is held down for more than about half a second will start to automatically repeat.

Expanding Ex-OR Gates

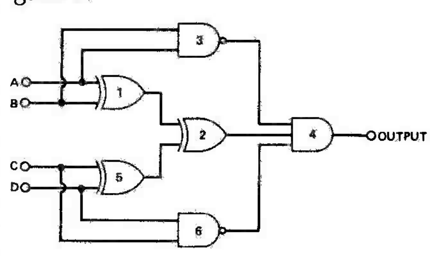
L. Robertson
Aberdeen

Exclusive-OR gates are only obtainable in 2-input packages, and simply cascading two gates does not give the correct truth table. Any application, therefore, which requires an Ex-OR gate with three or more inputs is going to involve some tricky logic combinations.

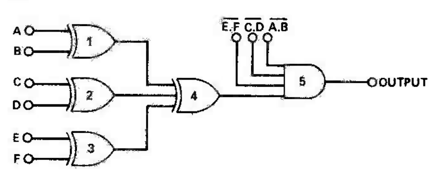
In the first circuit, inputs A and B are fed into gate 1 and the output of the gate is combined with input C at gate 2. This arrangement satisfies every part of the truth table except A = B = C = 1, where the output from gate 2 will be 1 instead of 0. To overcome this problem, inputs A and B are also fed to gate 3 so that, when both are high, the consequent high output from that gate will disable gate 4 and so produce a final output of 0.

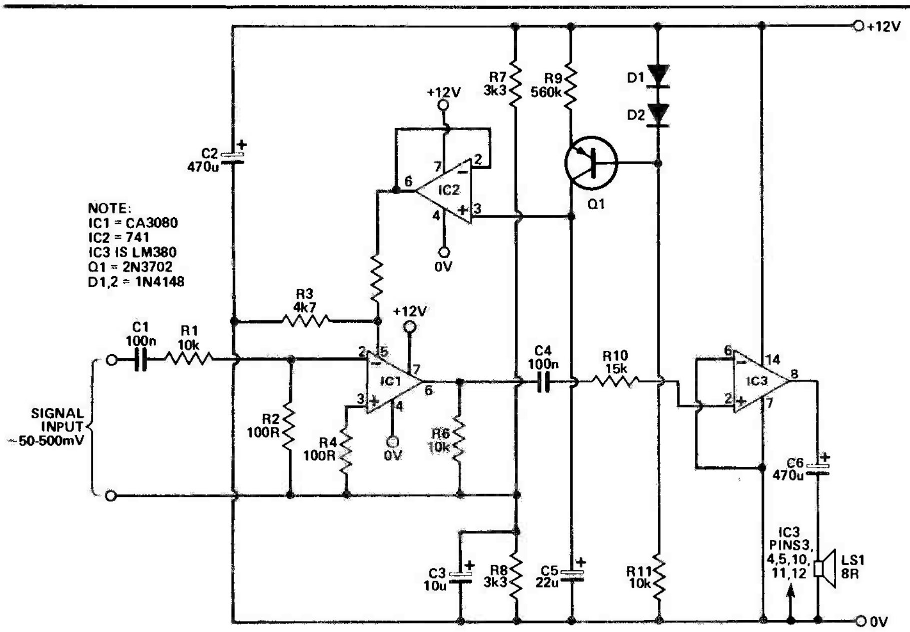


If a four-input arrangement is required, the expansion can be achieved by treating inputs C and D in the same way as inputs A and B in the first circuit. Thus, in the second circuit, gate 5 performs a similar function to gate 1 and gate 6 behaves in the same way as gate 3.



The final permutation is a six-input gate, shown in simplified form in the third circuit diagram. The three-input Ex-OR gate shown as gate 4 is made up as shown in the first diagram above and the pairs of inputs AB, CD, EF are combined in three NAND gates and fed to three of the inputs of the final AND gate.





Crescendo Alarm

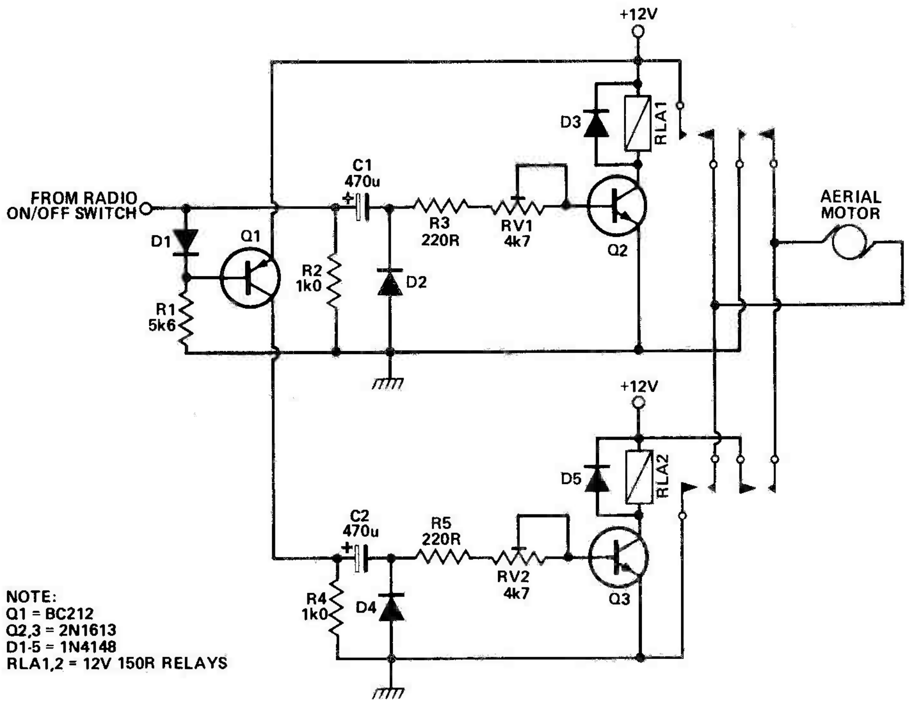
A.N. Collinson
Doncaster

This circuit is designed for the benefit of those who find the start of the day a little too alarming. It can be coupled to an alarm clock or almost any other timing mechanism and produces an output which builds up from nothing to full volume. The sleeper is thus aroused by the very minimum volume necessary.

The input can be an oscillator or almost any other audio source (eg., music from a radio-alarm). R1 and R2 provide attentuation and the signal is then fed to IC1, a transconductance amplifier whose gain is controlled by the current entering pin 5. Q1, D1, D2 and R11 provide a constant current of around 1uA which is used to charge capacitor C5. The constant current ensures that the voltage across C5 rises linearly, full charge being reached after about 3 or 4 minutes. This voltage is passed to IC1 via IC2 and R5, R3 being included to compensate for IC2's offset. The output of IC1 is coupled via R10 and C4 to the audio amplifier IC3 and then to the loudspeaker.

Automatic Car Aerial

T. Williams
Shoreham-by-Sea



This circuit, which is for use with negative earth cars, will automatically extend a motorised aerial when the radio is switched on and retract it when the radio is switched off.

The circuit requires two +12V connections, one from the car's electrical system via a suitable fuse and the other from the radio on/off switch. The ground connection can be made to the car body and the only other connections are those to the aerial motor.

Q1 is normally turned on. When the input from the radio on/off switch is applied, Q1 is turned off and current flows through C1, R3, RV1 and into the base of Q2. Q2 then turns on, energising relay RLA1 and thus extending the aerial. The period of time for which power is applied to the aerial motor can be adjusted by RV1.

When the radio is switched off, Q1 is turned on again and current flows through C2, R5, RV2 and into the base of Q3. Q3 then turns on, energising RLA2 and retracting the aerial. RV2 adjusts the period for which power is applied. **ETI**

DAMMIT REF! DON'T ANY OF YOU KNOW ANYTHING? RED IS TWO, BLACK IS NOUGHT, YELLOW IS FOUR--!

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CABLE
PER METRE
Wire Wrapped 6p
Red/White/Black
Solid 1/.6
11 Colours 4p
Hook-up 7/.2
11 Colours 3p
Heavy Duty 32/.2
4 Colours 15p
TINNED COPPER
per 4oz reel
SWG 16 80p
SWG 18 85p
SWG 20 95p
SWG 22 95p
SWG 24 95p
EN COPPER
per 2oz Reel
SWG 14 70p
SWG 16 80p
SWG 18 90p
SWG 20 90p
SWG 22 90p
SWG 24 105p
SWG 26 105p
SWG 28 105p
SWG 30 110p
SWG 32 110p
SWG 34 115p
SWG 36 125p
SWG 38 125p
SWG 40 150p
FIGURE 8
Per metre
7/.25 13p
Coloured Ribbon
Per Foot
10 Way 20p
20 Way 40p
34 Way 80p
MAINS
Per Metre
2 Core
Oval 3A 20p
Round 6A 45p
3 Core
Round 3A 35p
Round 6A 50p
Round 13A 80p
POWER
1mm T&E 40p
1.5mm T&E 45p
2.5mm T&E 60p
6mm T&E 150p
TV Coax 40p
SCREENED
Single Round 17p
Twin Round 20p
Figure 8 Min 20p
Figure 8 Std 30p
4 Core 70p
SPIRAL WRAP
1/8" 15p
1/4" 20p
1/2" 45p
WIDE RANGE OF CABLE MARKERS, SLEEVING, TIES, FIXINGS IN STOCK - PHONE FOR DETAILS.

CAPACITORS
PLATE CERAMIC
1.8pF-22nF 8p
DISC
10pF 10p
47pF 15p
100pF 15p
470pF 15p
1000pF 11p
2200pF 11p
.01uF 8p
.022uF 5p
.047uF 8p
.1uF 8p
.47uF 15p
POLYSTYRENE
22pF 13p
47pF 8p
68pF 8p
100pF 8p
150pF 8p
220pF 8p
330pF 8p
470pF 8p
560pF 8p
680pF 8p
1000pF 8p
1500pF 8p
2200pF 8p
3300pF 8p
4700pF 8p
5600pF 10p
6800pF 10p
.01uF 14p
.022uF 19p
.047uF 25p
.1uF 49p
POLYESTER
.01uF 8p
.015uF 8p
.022uF 8p
.033uF 9p
.047uF 9p
.068uF 9p
.1uF 9p
.15uF 15p
.22uF 11p
.33uF 16p
.47uF 16p
.68uF 28p
1uF 28p
2.2uF 49p
ELECTROLYTIC
uF/V
1/63 8p
2.2/50 9p
4.7/63 9p
10/16 8p
10/25 8p
10/35 10p
10/63 13p
22/10 8p
22/16 10p
22/25 10p
22/35 11p
22/63 15p
47/10 10p
47/16 11p
47/25 13p
47/35 15p
47/63 24p
100/10 11p
100/16 13p
100/25 15p
100/35 19p
100/63 25p
220/16 15p
220/25 20p
220/35 23p
220/63 33p
470/16 23p
470/25 27p
470/35 31p
470/63 48p
1000/10 24p
1000/16 29p
1000/25 41p
1000/35 45p
1000/63 75p
2200/10 39p
2200/16 46p
2200/25 58p
2200/35 74p
3300/25 74p
3300/35 92p
4700/10 59p
4700/16 74p
4700/25 103p
NON-POLARISED
1uF 25p
2.2uF 25p
3.3uF 25p
4.7uF 25p
6.8uF 50p
10uF 25p
22uF 35p
33uF 40p
47uF 40p
100uF 70p
THOUSANDS OF OTHER CAPACITORS IN STOCK I.E. SILVERED MICA, 1% POLYSTYRENE, POLYCARBONATE, MYLAR, TANTALUM TRIMMER, VARIABLE etc. etc.

CRYSTALS
100k 460p
1M 600p
2M 220p
3.2768M POA
4M 180p
4.19304M 320p
4.433619M 320p
6.144M 130p
10M 200p
18.432M 270p
26.54M 200p
26.59M 200p
26.64M 200p
26.69M 200p
26.74M 200p
26.8M 200p
26.995M 200p
27.045M 200p
27.095M 200p
27.145M 200p
27.195M 200p
27.245M 200p
27.255M 200p

CONNECTORS
Cros Clips 10p
Terminal Post 40p
1mm Plug 20p
1mm Socket 15p
2mm Plug 20p
2mm Socket 15p
3mm Plug 20p
3mm Socket 15p
4mm Plug 15p
4mm Socket 15p
Phono Plug 11p
Phono Link Skt 20p
Jack Plug 2.5mm 15p
Jack Plug 3.5mm 15p
Jack Skt 2.5mm 15p
Jack Skt 3.5mm 15p
Jack Skt Line 2.5mm 25p
Jack Skt Line 3.5mm 25p
Jack Plug ¼" Mono 25p
Jack Plug ¼" Stereo 30p
Jack Skt ¼" Mono 25p
Jack Skt ¼" Stereo 35p
Jack Skt Line Mono 25p
Jack Skt Line Stereo 30p
Coax Plug 15p
Coax Skt Surf 30p
Coax Skt Flush 25p
Coax Line Skt 45p
Coax Coupler 45p
Car Aerial Plug 15p
FM Aerial Plug 20p
NC Plug 100p
BNC Round Skt 100p
BNC Square Skt 100p
BNC Free Skt 110p
BNC Str. Adapt 140p
BNC T Adapt 300p
VHF Plug PL259 50p
VHF Plug PL259 50p
Small Reducer 20p
Large Reducer 20p
PL259 Rt.Ang 90p
VHF Round Skt 50p
VHF Square Skt 50p
Elbow Adapt POA
Straight Adapt 60p
UHF T Adapt 160p
Female T Adapt 180p
XLR Line Plug 180p
XLR Chassis Skt 330p
XLR Line Skt 230p
XLR Chassis Plug 160p
DIN Plugs 2 pin 10p
3 pin 15p
4 pin 35p
5 pin A 15p
5 pin 240° 20p
5 pin 360° 30p
6 pin 40p
7 pin 20p
8 pin 60p
DIN Skts 2 pin 10p
3 pin 20p
4 pin 15p
5 pin A 15p
5 pin B 20p
6 pin 20p
7 pin 20p
DIN Line Skt 2 pin 15p
5 pin 30p
D-Type Plug 9W 80p
15W 150p
25W 150p
DType RtAng Skt 9W POA
15W POA
25W POA
Plug 9W POA
15W POA
25W POA
Covers 9 120p
15 120p
25 130p
Latches 9 30p
15 50p
25 60p
Power Plug 2.1mm 15p
2.5mm 15p
IEC Line Skt 95p
IEC Chassis Plug 90p
IEC Chassis Skt 90p
IEC Line Plug 70p
Bulgin P429 50p
P646 165p
P430 125p
P649 135p
P650 110p
P635 100p
P636 130p
P551 300p
P552 100p
SA2403 160p
SA2404 95p
SA2190 50p
SA1862 50p
SA2111 200p
SA2019A 150p
SA2020 140p
SA2367 180p
SA2368 95p
MANY OTHER CONNECTORS, ADAPTORS & LEADS IN STOCK.

OPTO
LED Std Red 10p
Green 18p
Yellow 15p
LED Min Red 10p
Green 18p
Yellow 18p
LED WP Std 3p
Min 3p
LARGE RANGE OF PANEL LAMPHOLDERS, DE LUXE LED's, etc. etc.

FUSEWARE
20mm Panel Holder 45p
1¼" Panel Holder 59p
20mm Chassis Holder 14p
1½" Chassis Holder 17p
Lin Holder 14p
Fuse Clips 3p
20mm FUSES
100mA, 150mA, 250mA, 500mA, 1A, 1.5A, 2A, 3A, 5A 9p
20mm Antisurge Fuses
500mA, 1A, 2A 12p
1½" FUSES
100mA, 150mA, 250mA, 500mA, 1A, 2A, 3A, 5A, 10A, 13A, 15A 9p
1" Fuses 2,3,5,13A 15p

RESISTORS
⅓W 5% E24 2p
.4W 1% E24 7p
1W 5% E12 10p
3W 5% E12 10p
3W WW R22-1R 30p
3W WW 2R2+ 20p
7W WW 30p
10W WW 35p
25W WW 170p
WW Pots 3W
High Quality 275p
10R, 25R, 50R, 100R, 250R, 500R, 1K, 5K, 10K, 50K

SEMICONDUCTORS
SO EXTENSIVE IS THE RANGE OF LISTED SEMICONDUCTORS PLEASE SEND LARGE S.A.E. FOR DETAILS.
TRANSISTOR MOUNTS
TO3 10p
TO66 10p
DIL SOCKETS
8 pin 9p
14 pin 11p
16 pin 12p
18 pin 16p
20 pin 17p
22 pin 20p
24 pin 21p
28 pin 24p
40 pin 35p
RANGE OF HEAT SINKS AVAILABLE PHONE FOR QUOTATION

SPEAKERS
Miniature Buzzer
6V or 12V 90p
Ultrasonic 600p
Transducers Pair
Elliptical 5"x3" 198p
6"x4" 262p
7"x4" 314p
7"x5" 338p
8"x5" 5W 386p
8"x5" 8W 521p
9"x6" 431p
Miniature 1" 90p
1½" 90p
1¾" 90p
2" 90p
2¼" 90p
2½" 8R 90p
2½" 64R 100p
Round 5" 4W 174p
5" 25W 409p
5" 60W 1587p
5¼" 10W 476p
5½" 15W 771p
6" 5W 297p
6" 5W 297p
6" 60W 1632p
6½" 7W 423p
8" 6W 359p
8" 10W 423p
8" 20W 963p
8" 60W 1346p
10" 10W 700p
10" 20W 1113p
10' 30W POA
12" 60W 2862p
12" 100W 4073p
12" 150W 4336p
15" 150W 7185p
15" 200W 8735p
18" 200W £108

MOTOROLA PIEZO TWEETERS
2" 231p
3½" 897p
2"x6" Horn 938p
2"x5" 795p
2½" 457p
3¾" 624p
4"x10" 1435p
CROSSOVERS
2 Way 15W 188p
2 Way 100W 690p
3 Way 25W 193p
3 Way 40W 338p
3 Way 60W 502p
4 Way 80W 628p

SWITCHES
Toggle Std SPST 47p
DPDT 62p
Min SPST 68p
SPDT 70p
SPDT c/off 83p
DPDT 85p
DPDT c/off 117p
4PDT 209p
4PDT c/off 244p
Push to make 20p
Push to break 20p
Key 5W SPST 259p
Rotary 1P12W 62p
2P6W 62p
3P4W 62p
4P3W 62p
Slide Min DPDT 22p
Std DPDT 22p
DIP 4W 105p
6W 128p
8W 1156p
10W 184p
Microswitch 83p

TRANSFORMERS
6-0-6 @ 100mA 167p
6-0-6 @ 250mA 185p
9-0-9 @ 100mA 167p
9-0-9 @ 250mA 185p
12-0-12 @ 50mA 155p
12-0-12 @ 100mA 171p
12-0-12 @ 250mA 188p
0-12/0-12 @ 500mA 369p
9-0-9 @ 1A 283p
12-0-12 @ 1A 538p
0-12-15-20-24-30 @ 1A 666p
6-0-6 @ 2A 440p
9-0-9 @ 2A 476p
12-0-12 @ 2A 538p
0-12/0-12 @ 2A 538p
0-12-15-20-24-30 @ 2A 900p
90-0-20 @ 2A 745p
30-0-30 @ 2A 933p
12-0-12 @ 3A 721p
0-15 @ 3A 647p
6-0-6 @ 4A 538p
9-0-9 @ 4A 687p
12-0-12 @ 4A 845p
0-15 @ 6A 949p
6-0-6 @ 8A 980p
12-0-12 @ 8A 1615p
TOROIDS:
30VA 6V 950p
9V 950p
12V 950p
15V 950p
18V 950p
50VA 6V 1150p
9V 1150p
12V 1150p
15V 1150p
80VA 18V 1200p
22V 1200p
30V 1200p
120VA 30V 1300p
160VA 35V 1500p
300VA 35V 2000p
500VA 35V 2650p
ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT VOLTAGES SHOWN.

ORDERING INFORMATION:

P/P 50p on orders less than £20 in value otherwise post free. All components full spec & guaranteed. Discounts available on orders over £50 - phone for details. For unlisted components phone for price.

PARAGRAPH EQUALISER

Barry Porter describes a project guaranteed to raise the blood pressure of members of the anti tone-control brigade — a ten band equaliser with parametric control of frequency and Q.

Graphic equalisers are to be found in almost every audio environment, particularly in the sound reinforcement and public address arenas. Recording studios use them in a vain attempt to make their monitors sound like loudspeakers, and they may be seen lurking amongst the megawatt amplification systems that many pop groups use as an alternative to talent, where they enable the last drop of output level to be extracted before acoustic feedback gets the upper hand and sends twenty tons of hardware and half a dozen superstars into lunar orbit.

Most graphic equalisers consist of a number of small, slider potentiometers arranged so that the positions of their control knobs give an indication of the frequency response setting of the unit. Another type of equaliser, often found as part of the input channels of large studio mixing consoles, is the Parametric. This is an equaliser in which the three main parameters, amplitude, frequency and Q, are continuously variable.

The Paragraph is a combination of both equaliser types. Although it resembles a graphic equaliser, each slider is accompanied by two rotary controls that allow the frequency and Q of the particular band to be adjusted. As a consequence, an almost infinite number of frequency response variations can be obtained, making the unit far more versatile than other types of equaliser. The circuitry of the ParaGraph is quite elaborate, yet its performance is well up to professional studio standards which means that it is vastly superior to a fair percentage of the esoteric megabuck hi-fi equipment that gets drooled over in certain circles.

A block diagram of the ParaGraph is shown in Fig. 1, and it will be seen that the input and output stages are electronically balanced to simplify connection to professional equipment. As the unit may be used in the tape loop of a hi-fi pre-amplifier, provision is made for a tape output and return, the output capable of being selected to pre or post the equalisation stage so that either a flat or an equalised signal can be recorded. The input level control is arranged so that in its central position the unit is operating at unity gain, with 10dB of gain or attenuation available at the limits of the control.

Principle Of Operation

The usual method of obtaining band pass and stop characteristics is shown in Fig. 2, where an LC filter is used to shunt the input or feedback signal of a differential amplifier. This arrangement works extremely well but does not allow the centre frequency or Q to be easily adjusted, an essential requirement if you want total freedom over the response variations that can be achieved.

In the ParaGraph, active circuitry is used as the response shaping element in the form of State Variable filters. One of these is shown in Fig. 3, and consists of two matched integrators and a summing stage. The output of IC2 has a bandpass characteristic with unity gain at the resonant frequency (f_o), which is decided by the input resistors and integration capacitors of IC2 and IC3 by

$$f_o = \frac{1}{2\ R_fC}$$

The bandpass Q may be independently adjusted by the input and feedback resistors RQ1 and RQ2, the value being

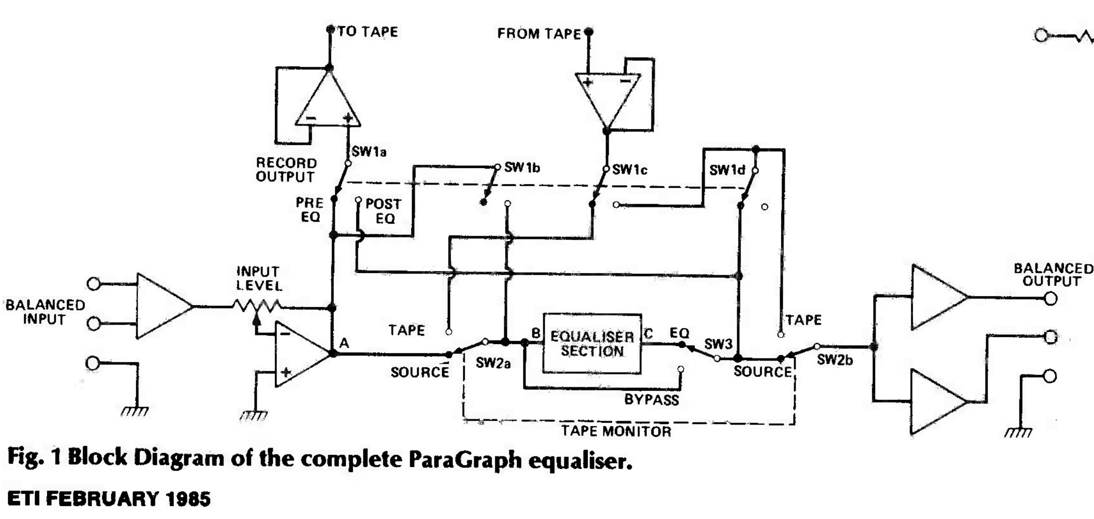


Fig. 1 Block Diagram of the complete ParaGraph equaliser.

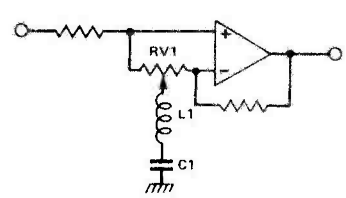


Fig. 2 An example of the type of filter element used in many graphic equalisers.

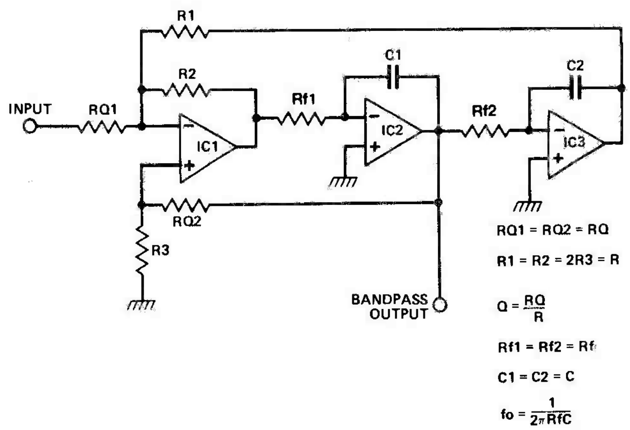


Fig. 3 A state variable filter of the type used in the ParaGraph.

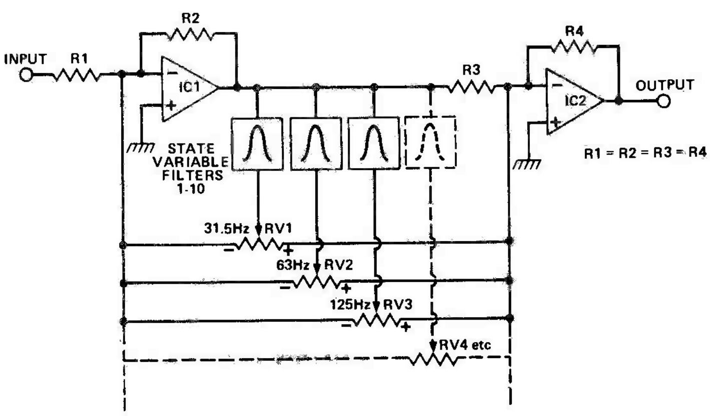


Fig. 4 The amplitude control system used in the ParaGraph.

$$Q = \frac{RQ}{R}$$

The range of each Q control is from 0.5 to 5.5, which in practice has been found to be ideal.

The method of obtaining lift and cut is shown in Fig. 4. The main signal path is through the two inverting stages, IC1 and IC2. The output of IC1 drives the state variable filters, and it can be seen that in the cut position of any of the control potentiometers, the associated filter is placed in the negative feedback loop of IC1. In the lift position R3, the input resistor of IC2, is bypassed by the output of the bandpass filter. This control system is extremely symmetrical so that the lift and cut response curves are virtually identical, and as the outputs of the filters are added to the main signal path at summing points there is no interaction between individual controls when several filter stages are used.

The ParaGraph contains ten stages with octave spacing between them, the nominal operating frequencies being 31.5Hz, 63Hz, 125Hz, 250Hz, 500Hz, 1kHz, 2kHz, 4kHz, 8kHz and 16kHz. The frequency adjustment range of each band was rather difficult to decide. It would have been nice to have given each band a range of two octaves, making for example, the 1kHz control sweep from 500Hz to 2kHz. Although this is possible, it results in a situation where the 1kHz position of the control is not central, which could cause operational problems. The potentiometer law necessary to give a completely linear frequency sweep is so obscure (a kind of reverse semi-logarithmic) that a compromise was arrived at. This uses linear controls, and the circuit values are arranged so that the central position gives the required frequency and the range is from approximately three-quarters of an octave below that frequency to one octave above.

The Circuit

The ParaGraph input stage circuitry is shown in Fig. 5. The RF rejection filter formed by R1, R2, and C1 and C2 has its −3dB point at 88.4kHz, and the network around IC1a gives a balanced input with unity gain. Under normal circumstances, the input may be DC coupled as it will usually be driven by a balancing transformer or an AC coupled output stage, but if there is any danger of DC voltages reaching the input a 10u capacitor should be placed in series with both R1 and R2. If the unit is to be used exclusively with unbalanced equipment, the input stage may be modified by omitting R1, R3 and C1 and changing R4 to 1k0, R5 to 100K and R6 to 10R.

Following the balanced input is a gain adjustment stage, IC1b, which allows the overall gain of the system to be changed from unity by plus or minus 10dB. This should be sufficient to cope with most requirements, but the swing can be increased to 20dB by reducing the value of R7 and R8 to 1k1. It will be noted that the track and wiper of RV1 are not isolated from the DC conditions of IC1, and noise may be generated every time the control is adjusted. In practice this is unlikely to cause problems because, once the system gain has been set, it will normally remain untouched while the ParaGraph is in use.

The output of IC1b is AC coupled by C3 and C4 so that clicks are not

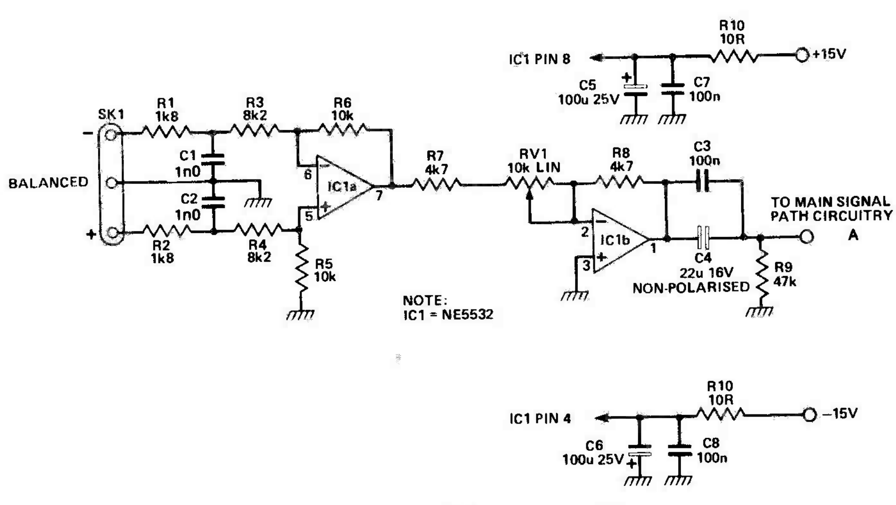


Fig. 5 Circuit diagram of the ParaGraph input stage.

generated by the switches that follow. If you are wondering why the two capacitors are connected in parallel, you are obviously out of touch with current thinking and manufacturing practice. It has been shown that the use of normal electrolytic capacitors in the signal path of high quality audio equipment can cause significant degradation of the signal, sufficient to be quite audible in most cases. The use of special non-polarized electrolytics cures most of the problems but they can cause the high frequency end of the audio spectrum to sound slightly rough. This effect is cured by the addition of a small value bypass capacitor which employs polycarbonate or polypropylene in its construction.

As there may be the odd soul who is brave enough to insert the ParaGraph into his or her hi-fi system (sing three choruses of "The emotion went up the chimney when my response got equalised" to the tune of Beethovens' 9th) provision has been made for the connection of a tape recorder and the monitoring of its output.

With SW1 in the Pre EQ position as shown in Fig. 1, the tape output will be unequalised whereas the main signal and the tape return (when selected by SW2) will pass through the equalisation stage. When SW1 is switched to Post EQ, the tape output originates after the equaliser (except when the Bypass switch, SW3, is operated) so that any response corrections may be applied to the recorded signal. In this situation, the main signal will also be equalised but the tape return will not, so a valid comparison between the recorder input and output can be made by operating SW2.

Both tape input and output signals are buffered from the main signal path so that the operation and performance of the ParaGraph cannot be affected by external equipment. These buffer stages are shown in Figure 6.

The main signal path summing stages are shown in Fig. 7 and hardly need an explanation, other than to note that as the overall signal phase is non-inverting, the section may be bypassed by a simple, single pole switch as shown in Fig. 1.

The ten state variable filters are identical except for the values of the integration capacitors. The filter circuit is shown in Fig. 8, and Table 1 lists the capacitor values and frequency control calibration points.

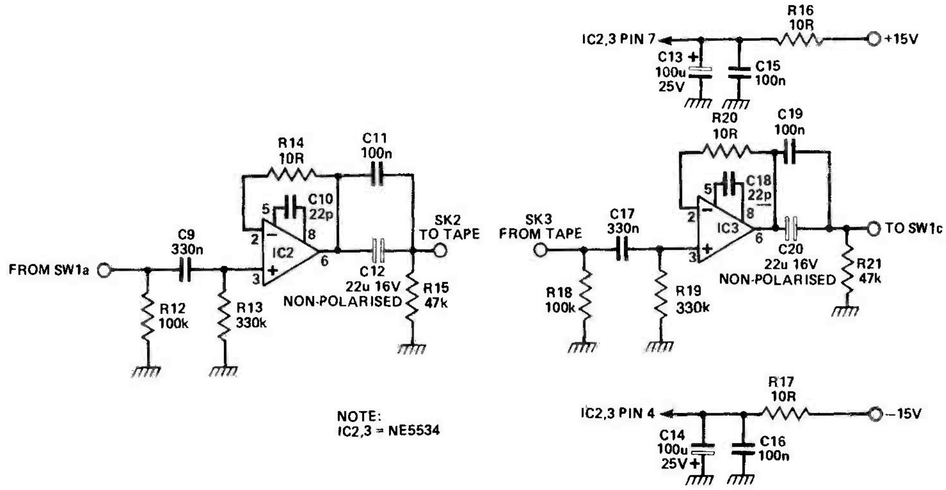


Fig. 6 Circuit diagram of the tape buffers.

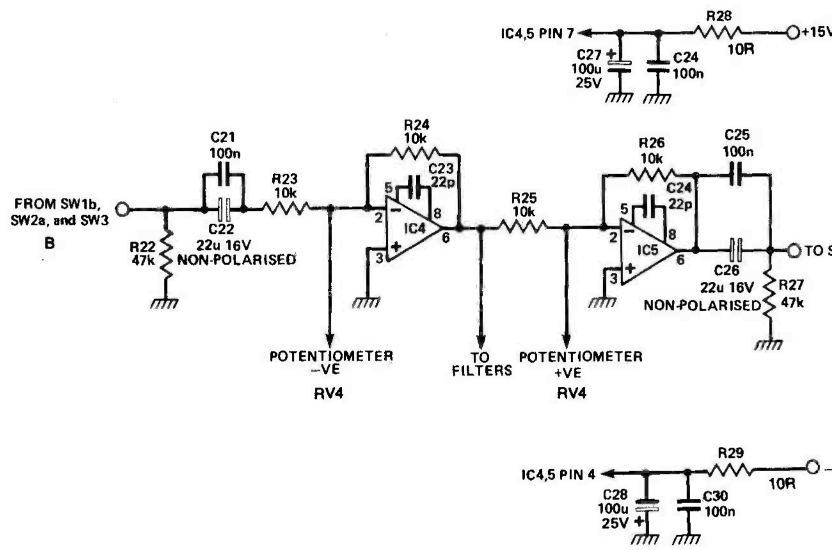


Fig. 7 Circuit diagram of the main signal path.

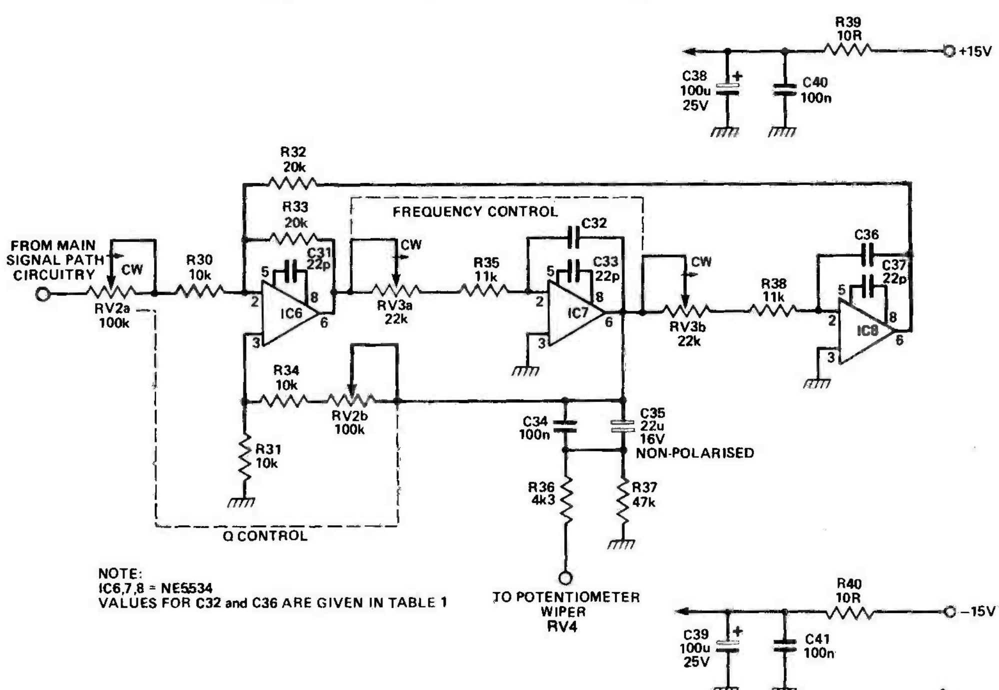


Fig. 8 Circuit diagram of the state variable filters.

CAPACITOR VALUES	RESULTANT FREQUENCY (Hz) AT: A	B	C	D	E
220n//10n//390p	20	25	31.5	42	63
100n//15n//220p	42	50	63	84	125
47n//10n//330p//220p	84	100	125	170	250
22n//6n8	170	200	250	335	500
10n//2n2//2n2	335	400	500	670	1k
3n6//3n6	670	800	1k	1k3	2k
3n6	1k3	1k6	2k	2k7	4k
1n8	2k7	3k2	4k	5k4	8k
680p//220p	5k4	6k4	8k	10k7	16k
220p//220p//10p	10k7	12k8	16k	21k4	32k

Table 1. Values for C32 and C36, the frequency-determining capacitors on the filter board. Close-tolerance polystyrene or polycarbonate types should be used throughout.

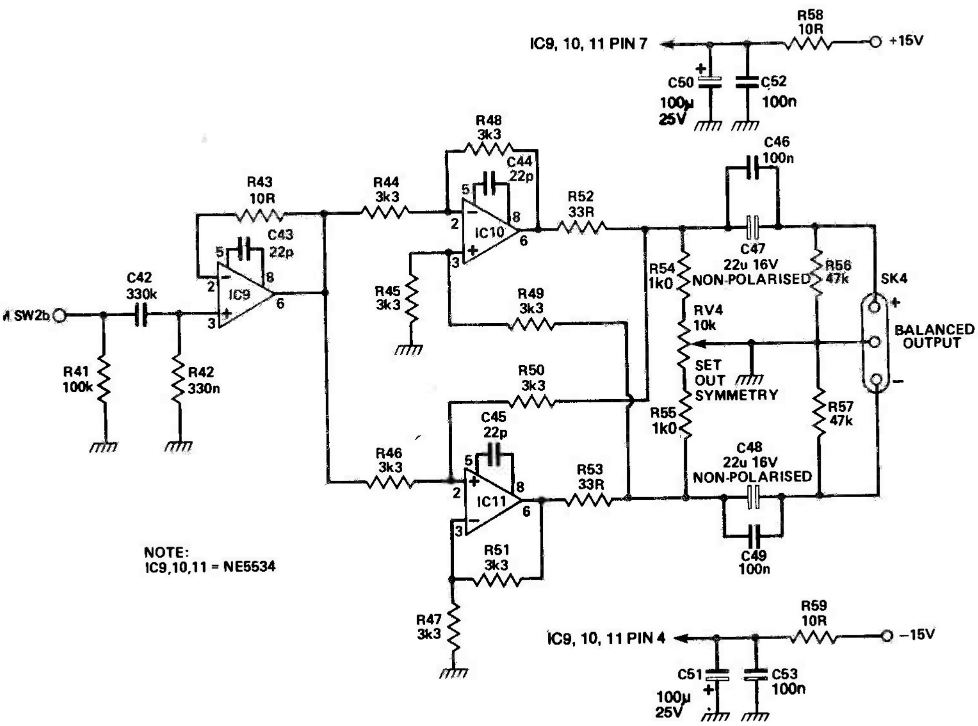
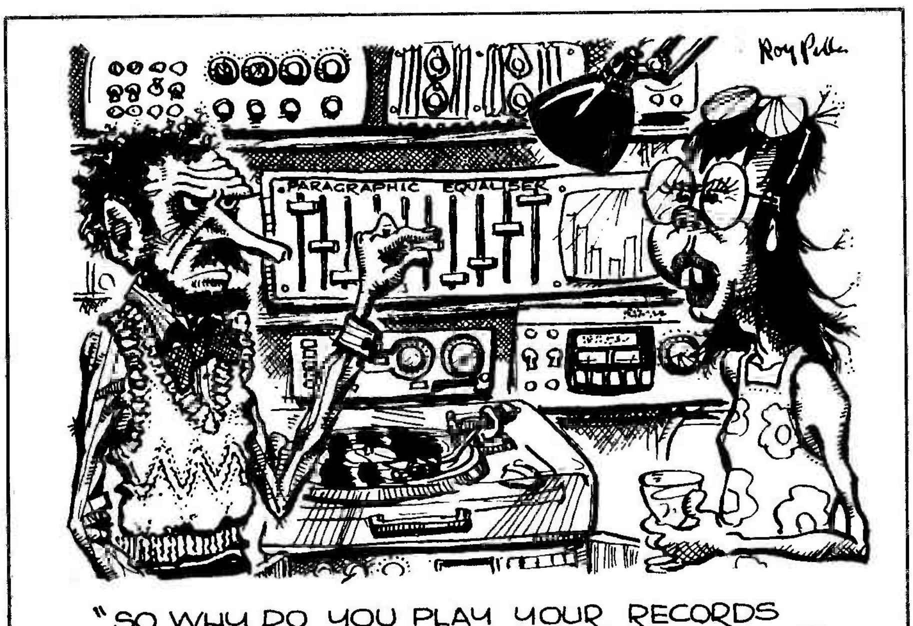


Fig. 9 Circuit diagram of the balanced output stage.



"SO WHY DO YOU PLAY YOUR RECORDS INTO A PARALYTIC BREATHALYSER THEN?

Both the frequency and Q adjustments may be re-calculated to give different ranges to those suggested. It is not recommended that Q values above 10 are used, but the number of bands may be increased or decreased to suit individual requirements. However, the suggested configuration would seem to offer the best compromise between over simplification and operational and constructional over-complexity.

The amount of available lift and cut is controlled by R36 (Fig. 8), the value shown giving a maximum of 10.4dB. A different value may be substituted, the resulting amplitude extremes being given by

$$A(dB) = 20_{\log}\left[\frac{1}{R7}\,(10+R7)\right]$$

The ParaGraph uses the balanced output stage shown in Figure 9. Rather than repeat the operating principles of this circuit and of balanced connections in general, interested readers who are still awake are referred to the brief description that was given on Page 57 of the January '84 issue of ETI.

ETI

To be completed.

BUYLINES

Radial non-polarised electrolytics are not readily available to the amateur but axial 50v types are sold by Maplin, Circuit and Electrovalue and should fit into the space if stood on end. The polystyrene or polycarbonate capacitors used for C32 and C36 should ideally be 1% tolerance types, but if you use 5% types instead you should omit some of the smallest capacitors from the parallel combinations listed in Table 1: there is little point in using either the 330p or the 220p in parallel with 5% tolerance 47n and 10n capacitors, for example, because the tolerance on the larger capacitors considerably exceeds the value of the smaller ones. Maplin stock a range of 1% tolerance polystyrene capacitors which covers some of the values needed, and it is perfectly permissible to use 5% small value capacitors in parallel with 1% tolerance large values. Watford, Rapid, Cricklewood and Technomatic are among those who stock both the NE5532 and the NE5534 and 4-pole double-throw switches suitable for use in the SW1 position are available from most of the above companies and a large number of other advertisers. 1% tolerance metal film resistors are also widely available and Newrad or West Hyde Developments ought to be able to help you with 19" rack-mounting cases. The PC mounting potentiometers are sold by Cirkit and the PCBs are available from our PCB service.

DISTORTION METER

Having discussed the basic principles and the design criteria in last month's article, John Linsley Hood goes on to describe the circuitry of this versatile test instrument.

The basic layout of the THD meter is shown in Fig. 6 and the final circuit is shown in Fig. 7. RV1 acts as a gain control in the input circuit of IC1a, a buffer stage which ensures that the Wien network is always driven from a low AC impedance. From the output of this the signal is divided into three paths, the upper RC parallel network, the inverter stage, and a feed to the mode switch, SW2, which allows the network to be effectively bypassed so that the full scale meter setting can be determined.

In the other positions of SW2, the two halves of the network are connected to produce the notch characteristic required. It will be understood that for a perfect balance to be obtained, the input from the inverter to the lower limb needs to be exactly twice as large as the input to the upper limb. To arrange this, a 2k2 10-turn pot, RV4, is connected in series with the op-amp feedback resistor so that its gain can be adjusted. This is the Trim control on the instrument front panel.

Ideally, the tuning of this instrument would be done by two twin gang pots (shown as Ra and Rb in Fig. 6). However, I want to keep the circuit noise level as low as possible, and this depends in part on the circuit resistance values, as does the proneness of the circuit to pick up hum. I don't want to make Ra (RV2 in Fig. 7) much higher than 10k, and sadly, in this country, dual gang pots with a resistance lower than 4k7 ohms are very difficult to come by. The one source of 1k dual gangs I know of has a rather stiff and rubbery feel, which makes them unsuitable for the fine tuning position.

I have, therefore, with regret — since this makes the instrument a little more awkward to use — opted for a single fine-tune pot, the 100 ohm RV3. This reluctant compromise means that the final notching out of the signal input requires interacting adjustments of both RV3 and RV4. If a decent quality low resistance dual-gang pot can be obtained by the constructor, the other half should be inserted in series with R6, whose value can then be reduced to 470R.

As mentioned before, it is necessary to sharpen up the notch of the system a bit to prevent unwanted attenuation of the lower harmonics. This is done by negative feedback to IC1 from IC2 through R9, R2 and R8.

There are two signal filtration stages. IC3a is a high-pass hum filter with a turn-over frequency of 250Hz and an attenuation of 20dB/octave to give thorough 50/100Hz removal: A low-pass filter built around IC3b has a similar slope and a turn-over frequency of 4700Hz. These two options are selected by SW3 and SW4. The low-pass HF-noise filter allows an instrumental identification of the type of harmonics associated with crossover distortion, which would be at 7, 9, 11, and 13kHz on a 1kHz signal.

So, if the minimum signal is noted on a test at 1kHz and the low-pass filter is then switched in and the new minimum noted, the amount of high-order harmonics present can be determined by an RMS subtraction of these two values. To distinguish between high-order harmonics and general noise, the extent to which the difference between the filtered and unfiltered signal levels changes when the signal input is removed can be noted.

The final stage of the distortion meter part of the circuit is the buffer amplifier, which precedes the meter attenuator, and from which an oscilloscope monitor signal can be obtained if needed.

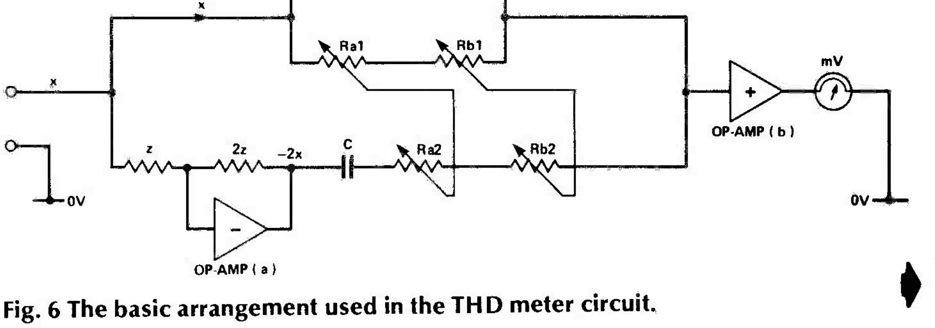


Fig. 6 The basic arrangement used in the THD meter circuit.

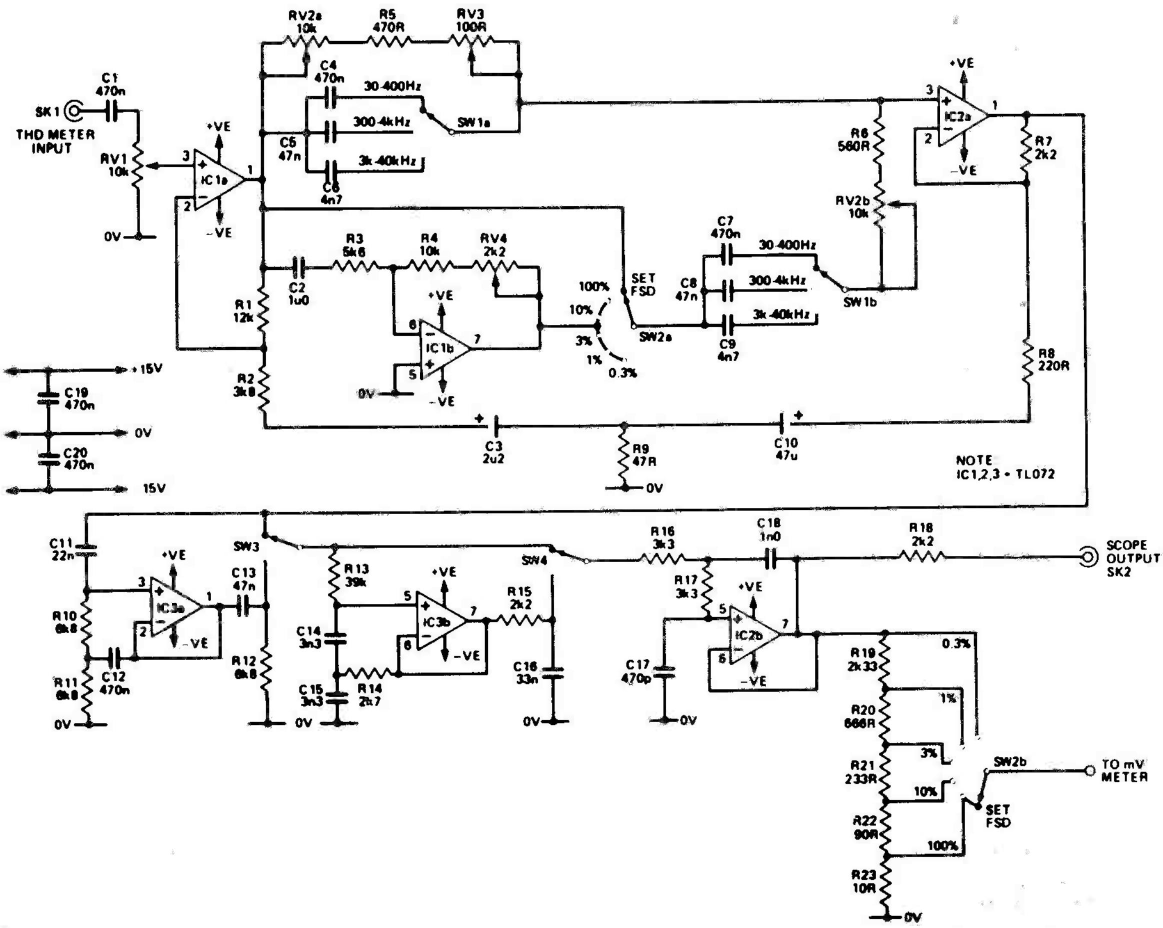


Fig. 7 The final circuit diagram of the THD meter.

An option which is also available is to build a further HF filter into the input circuit of the unity-gain buffer amplifier, IC2b. This should have a -12dB/octave slope and a turn-over frequency of 50kHz, which serves as a useful bandwidth limit. If this is not required, SW4 output can be taken to the non-inverting input of IC2b and C17, C18, R16 and R17 deleted.

The Millivoltmeter Circuit

Since any distortion meter requires an AC millivoltmeter to display the result, and a millivoltmeter on its own makes quite a useful bench instrument, I have decided to make the input to the measuring circuit available separately by way of an independent switched attenuator (see Fig. 8).

The circuit itself is straightforward enough, with a 100μA meter in a diode bridge in the feedback network of an op-amp. Since the millivoltmeter is intended to be usable as a general purpose instrument, I have used a two stage circuit built around a dual FET-input op-amp (TL072 or LF353), in which the first half acts just as a gain stage. This permits both a high input impedance, and a 20Hz-100kHz (-3dB) bandwidth.

Although the input attenuator suggested has a total chain resistance of 100k, this choice was

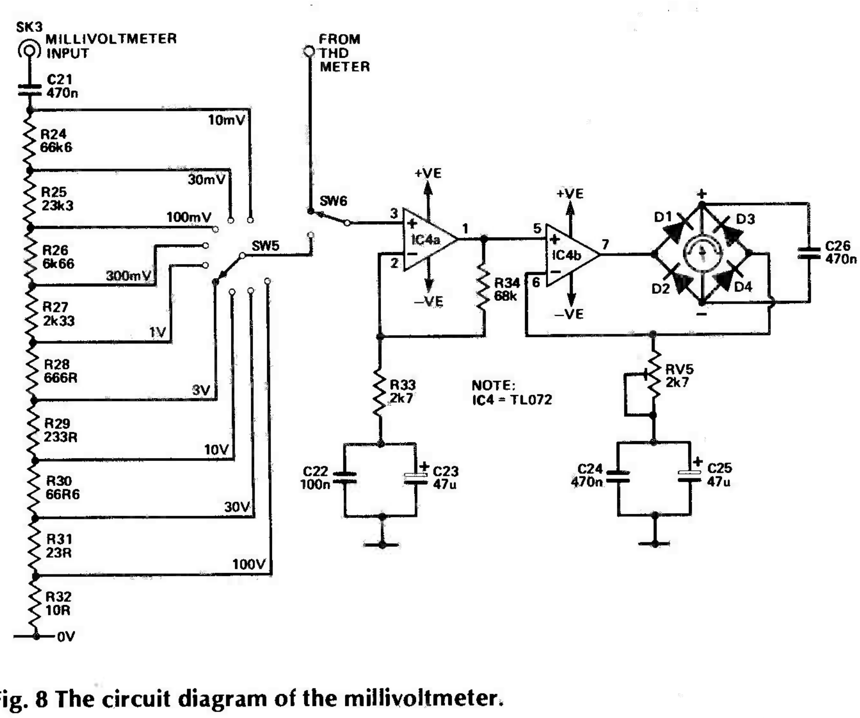


Fig. 8 The circuit diagram of the millivoltmeter.

mainly in the interests of preventing the input from being too sensitive to inadvertent signal pick-up from other parts of the circuit within the same box. If the constructor is happy to screen this part of the circuit well, there is no reason why the quoted attenuator chain resistors should not be scaled up to give an input impedance of 1M ohm or even higher, although this might affect the frequency response flatness.

Calculating the actual resistor values in the chain is a bit awkward if one does not know the method. For simple minded people like me, a lot of confusion is removed if one thinks about the current flow down the chain. So, if we choose a 100k total, 100V RMS will give a current flow of 1mA (RMS). This will develop 10mV across 10 ohms, hence the value of R32. The next full-scale reading required is 30V. This will cause a current flow of 30/100k = 300μA. 10mV drop will then require 10mV/300μA = 33.333 ohms, which gives the value of R31+ R32, from which R31 = 23.3R, and so on.

These can be made up, depending on the accuracy required (which, in turn, will depend on the quality and tolerances of the resistors available, and upon the quality of the meter movement) by placing standard value resistors in parallel. A 6k66 ohm resistor can be approximated by putting a 330k and a 6k8 in parallel (=6.662k), a 23.33k resistor by putting a 33k, a 100k and a 390k in parallel (=23.33k) or by a 22k and a 1k in series (23.0k), and so on.

The proper operation of this type of measurement circuit requires that the return path from the inverting input of the op-amp to the 0V line has a low AC impedance at the highest operating frequencies likely to be used, so it is prudent to bypass the tantalum bead capacitors in the feedback path with small, non-polarised types. The + and − supply lines for the instrument are also bypassed to the 0V lines on the main PCB by 0.47μF non-polarised capacitors.

When the meter is used just as a millivoltmeter the input attenuator presents a more or less constant input impedance regardless of the Range switch position, although, as mentioned earlier, it can be increased if desired.

The Spot-Frequency Oscillator

It is a great convenience to have a good quality sine-wave signal source actually on the instrument, and from my experience of making measurements of this kind I find that one does not carry out these tests over a continuous spread of frequencies but rather at certain spot points.

The reason for this is not just laziness but because, if one knows how a system behaves at, say, 1kHz and at 3kHz, it is extremely unlikely that its behaviour at 1500Hz or 2300Hz will be anything other than intermediate between the known points.

There are, it is true, certain audio amplifiers which can display very odd behaviour over certain parts of their frequency range due to the feedback loop(s) getting into a state known as conditional stability. However, such amplifiers will almost certainly have a very bad square-wave response and their general behaviour and sound will be so horrid that one shouldn't need a distortion meter to discover that they are sick!

However, to return to the oscillator. The basic circuit I have used is a two op-amp variation of the Wien bridge system shown in Fig. 9. In this, an inverting (virtual earth input) amplifier is fed with two feedback signals through the limbs of the Wien network. A positive feedback signal is obtained from the two inverting amplifiers connected in series through the RC series element, and a negative feedback signal is fed to the same point from the output of the first inverting amplifier.

The gain of the second amplifier is controlled by a thermistor in its feedback path. When the thermistor is cold, its resistance is high and ICb has a high gain. This makes the positive feedback part of the signal fed to the input of ICa larger than the NFB part, and the system oscillates. This feeds an AC signal to the thermistor which heats it up, and causes its resistance to decrease.

When the gain of ICb has dropped to a level at which the signal output is just enough to keep the thermistor warm, the output stabilises. This then automatically provides just enough positive feedback input to ICa to keep the system oscillating, and no more.

Because op-amps have a lower intrinsic distortion when used in the inverting mode (a fact which is surprising though true) and because there is no 'common mode' signal (ie, a signal fed equally to both inputs, which the op-amp must then cancel), the distortion produced by this circuit is extremely low. In fact, now that this arrangement is known, I cannot see any good reason why anyone wanting a Wien bridge oscillator should use the old conventional system, which has a considerably inferior performance, especially when one bears in mind the relatively low cost of even a high quality dual op-amp such as the TL072 or the LF353.

I have shown the measured performance of the oscillator in Table 1. Above 300Hz the THD is of the order of 0.003% or lower. The worse distortion, at 100Hz and to a slight extent at 300Hz, is third harmonic and is due to the thermistor bead actually heating up during the sine-wave cycle, reducing the gain of the system as the peak of the waveform is approached. This is the type of problem which will always occur with any amplitude-sensitive output stabilisation system. It can only be diminished by increasing the measurement time constant, which in turn makes the oscillator take a bit longer to settle down following a change in its operating frequency.

The output from ICb is about 600-700mV with an RA53, and

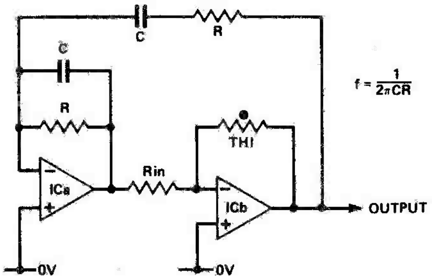


Fig. 9 The basic arrangement used in the spot frequency oscillator.

FREQUENCY (Hz)	THD (%)
100	0.02
300	0.005
1k	less than 0.003
3k	less than 0.003
10k	less than 0.003
20k	less than 0.003

Table 1 Measured performance of the spot frequency oscillator.

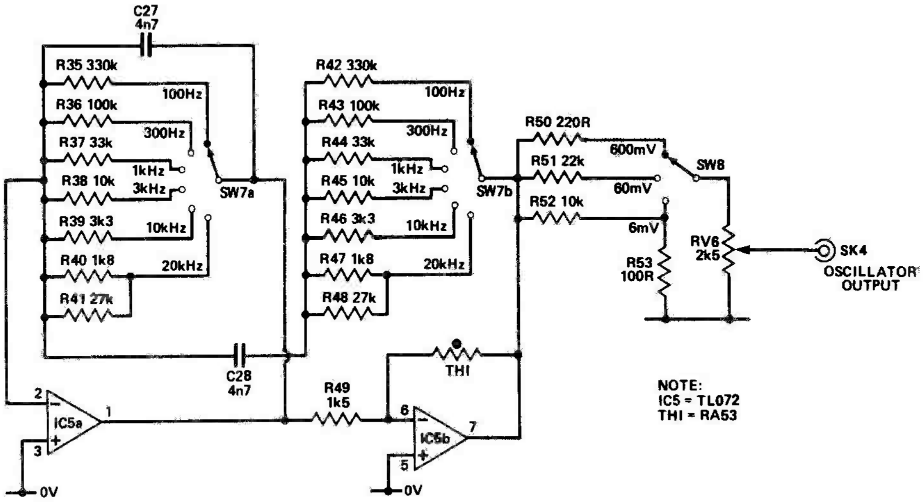


Fig. 10 The final circuit diagram of the spot frequency oscillator.

the signal level at the output of ICa, which is a feasible alternative oscillator output point, is almost exactly half this. I mention this because ICa is an active integrator with a response which decreases with frequency. Because of this, the third harmonic distortion introduced by the thermistor is reduced to about one third at ICa output which gives a very low THD oscillator indeed. However, for a THD meter whose minimum scale reading (the prototype, uses a 4 inch scale meter) is 0.005%, the circuit arrangement shown in Fig. 9 seemed adequate.

I have shown the final circuit of the oscillator in Fig. 10. I have opted to keep the value of C constant, and vary R to change the oscillator frequency. This was partly because resistors can be obtained to a higher value of accuracy than big capacitors, and partly because, with the circuit values chosen, it would allow close tolerance, low loss polystyrene capacitors to be used.

A three stage output switched attenuator is used in combination with the 2k5 output potentiometer, giving signal level ranges of 0-6mV, 0-60mV and 0-600mV. If the user wishes to increase the output somewhat, say to 1V, it can be done by putting a resistor of between 500R and 1k5 in series with the RA53. This will lessen the thermistor introduced distortion but will lengthen the setting time. On the prototype this is about 2000 cycles, which is 20 seconds at 100Hz and 0.1 second at 20kHz, but could vary a bit from one thermistor to another.

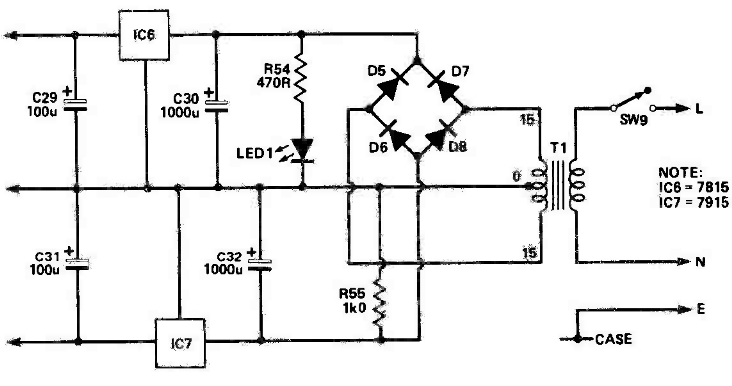


Fig. 11 The circuit diagram of the stabilised mains power supply.

Power supply

The total current consumption of the instrument is 18mA at +/−15V, which is obtained from a small stabilised power supply unit shown in Fig. 11.

As mentioned earlier, it is possible to make the instrument operate from batteries. Two options exist here. The first is to use a pair of 6V or 9V transistor radio batteries such as the PP1 or PP9 and to switch both + and − lines. The second method is to operate the unit from a single 9V battery using the adapter circuit of Fig. 12a to give a +/−4.5V line pair.

In both cases it is worthwhile substituting TL062s for IC1, IC2, IC3 and IC5, and a TL061 for IC4. This will reduce the battery current demand to some 1.5-2mA, with little performance penalty.

However, if the supply voltage option chosen is the +/−4.5V one, a problem would arise because the notch amplifier circuit would overload at the 3V RMS output required from ICs 2 and 3 for FSD on the measuring instrument. It is therefore necessary to down-grade this a bit by cutting out R19 (2k33) so that SW2b becomes as shown in Fig. 12b, giving a minimum FSD sensitivity of 1%. This will only require a 1V RMS swing from the notch amplifier (Fig. 7) which will be comfortably within its capability.

In spite of last month's promise we still couldn't find room for the rest of the article in this issue. We hope (!) to conclude it next month.

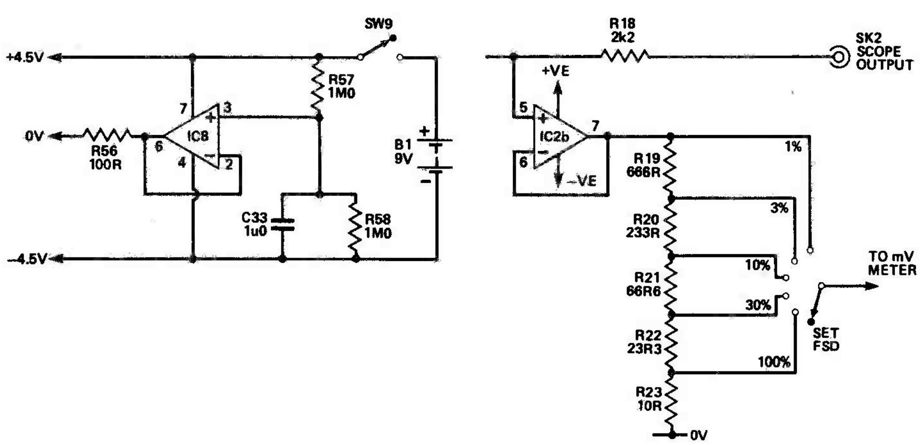


Fig. 12 a) The arrangement used to obtain a dual-rail supply from a single battery and b) the changes which must be made in the circuitry around SW2b to accommodate this arrangement.

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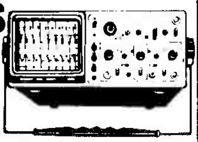

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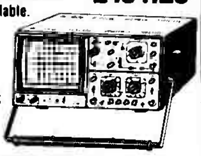

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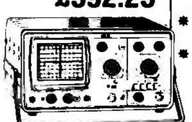

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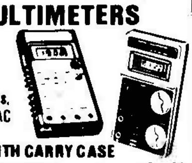
DIGITAL MULTIMETERS



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s=Slide R=Rotary
PB=Push button
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6010 28 range 10A AC/DC 20 Meg ohm (PB) **£43.50**
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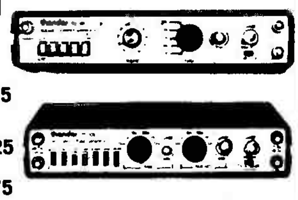

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(UK C/P 65p)

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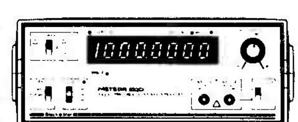
LED COUNTERS
(UK C/P 65p)



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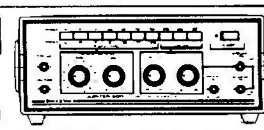

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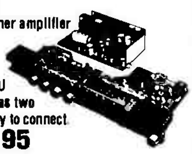

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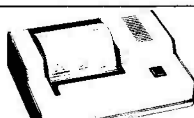

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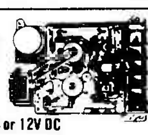

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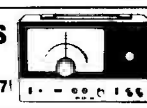

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READ/WRITE

Please send your comments to the Editor, ETI, 1 Golden Square, London W1R 3AB.

Bug In the Middle

Dear Sir,

I appreciated your listing of the three main approaches to fault finding in the article De-bugging and Fault Finding (ETI August 1984), but may I suggest an even quicker approach than working from one end or other of a piece of equipment?

It is to start in the middle, immediately eliminating one half of the circuitry, and then to go to a point roughly half-way into the half which contains the fault and so on until the problem is isolated. Taking a simple AM radio as an example, the audio detector is an obvious starting point, followed by the mixer output or the mid-point voltage of a Class B output stage, and so on. But first, and from bitter experience, always check the input and output of the power supply.

To change the subject slightly, I have decided to build John Linsley Hood's amplifier, all I have to do now is to find £250 for the kit as component supply here is not all it might be. So, to stop confusing me, can we have a moratorium on amplifier designs for the next six months?

Yours sincerely,
Chris Cosgrove
West Lothian

We take your point about the fault-finding procedure. As for the other matter, whilst we cannot say that there will be another amplifier design in ETI in the next six months, we are certainly not going to promise that there won't be one! After all, why buy ETI if you don't want a magazine that's fast-moving, innovative, up-to-the-minute, **(continued on p.109).**

Ripples On The Supply Line

Dear Sir,

As a regular reader of your excellent magazine I feel I must point out my experience of one of your advertisers. I wanted to purchase three MPSU56 transistors and checked with some of your advertisers lists. I found that Watford sold them for 60p but that they would not accept a telephoned order using a Visa card. I tried Rapid who listed the transistors at 55p each but on telephoning them I discovered that there was a minimum order charge of £5.00 and my three transistors plus some fuses did not come anywhere near that total. So, gritting my teeth, I decided to use Cricklewood Electronics, even though their price was a staggering £1.22 each plus the usual incidentals such as postage, etc.

True to their word the compoments arrived next day, but the price of the transistors had risen overnight to £1.95 each. I immediately queried this and was told there had been a price increase and that there was nothing they could do. Had I been informed before passing on my Barclaycard number that the price had risen so much I would not have placed the order. I feel I have been conned and wonder how many others have experienced this problem as small customers trying to obtain components and paying the penalty.

Yours faithfully,
R. Isbourne
Bracklesham Bay

We are sure that Mr. Isbourne is not the first person to run into this sort of problem. The situation arises partly because advertisers have to prepare their price lists well in advance in order to allow for typesetting, printing and distribution of the magazine. By the time the reader sees an ETI advertisement nearly a month will have elapsed since the advertiser submitted the original copy with its prices, and in a world where such important economic factors as exchange rates change with frightening rapidity, that is a long time. It is for this reason that most advertisers (including Cricklewood) publish a note saying that prices are subject to change.

Cricklewood tell us that anyone placing a telephone order would normally be informed of the current price of the goods but they admit that it is possible that this was forgotten in Mr. Ishbourne's case. The moral, perhaps, is that readers should always make a point of asking what price will be charged when placing telephone orders. The problem should not arise with written orders since the normal practice here is for the supplier to write back to the customer and ask for more money when a price rise occurs, leaving the customer the option of paying the extra or cancelling the order as he or she wishes.

Some Lines on Delay

Dear Sir,

May I suggest an alternative method of achieving the delay required for the Active-8 loudspeaker (ETI September to December 1984). Please excuse my long-winded arithmetic.

$c = 343$ m/sec $\qquad f_c = 4 \times 10^3$ Hz

$$\lambda = \frac{c}{f_L} = \frac{343 \times 10^3}{4 \times 10^3} = 85.75 \text{ mm}$$

$$\frac{360°}{85.75} = 4.2°/\text{mm} \times 38\text{mm} = 159.6°$$

(38mm = separation in D_2

If the voice coil leads on one loudspeaker are reversed, the phase difference becomes

$$180° - 159.6° = 20.4°$$

$$t = \frac{1}{f} = \frac{10^6}{4 \times 10^3} = 250 \text{ us}$$

$$\frac{250}{360} = 0.694\text{us}/° \times 20.4° = 14.2\text{us}$$

Therefore a delay of 14.2us could be applied to the LF loudspeaker, saving several stages of delay. Alternatively, since

$$\frac{\lambda}{z} \text{ at } f_c = \frac{85.75}{2} = 42.875 \text{ mm}$$

and $42.875 - (D) = 4.875$mm

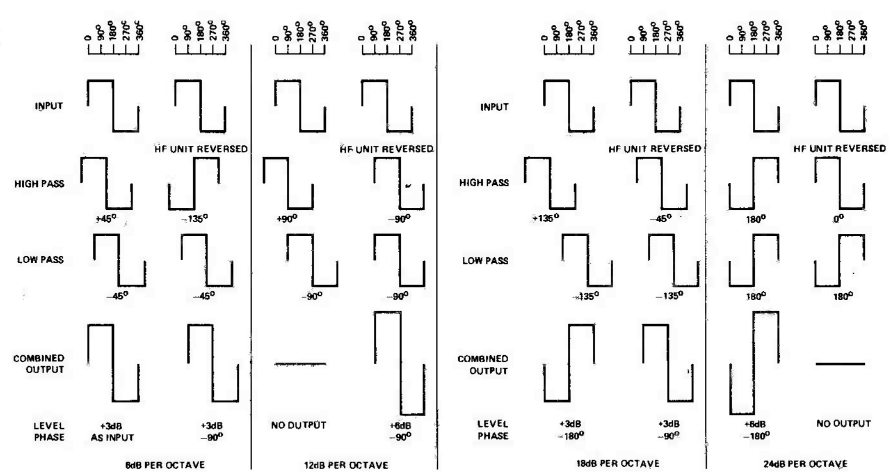
if the mechanical construction will allow, the HF loudspeaker could be brought forward by 5mm or the LF loudspeaker moved back and no delay circuit would be required at all.

Or, let

$$\lambda = 38\,(D_2) \times 2 = 76\text{mm}$$

and, as $f = \frac{c}{\lambda} = \frac{343 \times 10^3}{76} = 4.5$ kHz

By raising the crossover frequency to 4.5 kHz we can again dispense with the delay stages.
Yours sincerely,
L. R. Burns
Wokingham



The original figure, intended to show the effect of 6, 12, 18 and 24 dB per octave filters on signal levels and phase.

Barry Porter, author of the Active-8 series writes:-

The main error in Mr. Burns' reasoning is his assumption that by reversing the connections to a drive unit a time delay is introduced. Imagine that the HF unit is fed a short, positive-going pulse; with reversed connections the output from the unit will be a negative-going pulse when what is required is a delayed positive-going pulse.

The effects of various filters are shown in Fig. 4 of the first part of the series (reproduced here), and this illustrates that the connection of the HF unit is decided by the filter slope. Upon reflection, the illustration may be difficult to understand and it might have been clearer had the waveforms been drawn as sinewaves (but a certain 2½ year-old ex-mafia hit-man called Timothy prevented this by hiding my sinewave stencil in the washing machine!).

If Mr. Burns does not like the idea of using the delay stages, he may prefer to mount the HF unit on top of the cabinet using a small bracket assembly. However, as the unit has to be placed about 38mm back, the top edge of the cabinet must be chamfered or rounded and preferably covered with 3mm felt material. The position of the LF unit must then be changed to bring it as near to the HF unit as possible.

ETI

THE ETI LOGGIT DATA LOGGER

Don't get caught lying down on the job — let the ETI LOGGIT take the data while you're off having fun. Design, development and words by Phil Walker.

The ETI LOGGIT is a single PCB unit which can automatically measure and store analogue data over a period of minutes, days or weeks. A single LOGGIT card can store over 2000 separate readings to an accuracy of better than 1% (when suitably calibrated).

The device can be operated in four main modes. These are:– measure and store until memory full; measure and store until trigger signal is detected; measure and store until 1024 measurements after trigger signal; start measuring at the trigger signal and stop when full. All these modes have their uses and others may occur to the user. The most useful as far as the author is concerned is the third:– measure and store until 1024 measurements after the trigger signal. In this mode you gather and keep data for an equal time before and after the trigger event, allowing both possible causes and consequences to be observed.

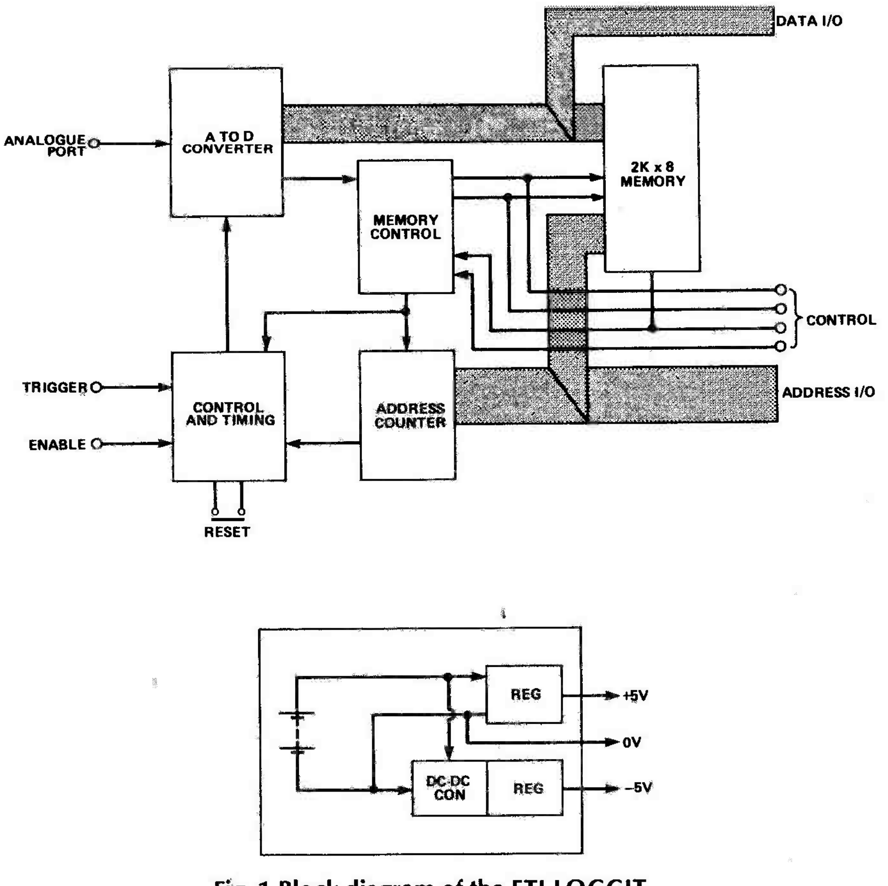


Fig. 1 Block diagram of the ETI LOGGIT.

The circuit

Two devices form the basis of this project. The first is the 8703 A to D converter made by Teledyne. This converts the incoming analogue signal to an 8 bit digital code. This is then stored in the second main device, the 6116 CMOS 2K × 8 memory. The rest of the devices are present to control the operation of the unit and provide the addresses to the RAM and the necessary power supplies for all the devices.

The control logic section of the unit starts with a programmable timer device which produces trigger pulses at a rate of from 10 every second to 1 every 25.5 seconds with the component values specified. These pulses start the ADC conversion cycle which, when it finishes, triggers another pulse which writes the data into the memory. Once this is

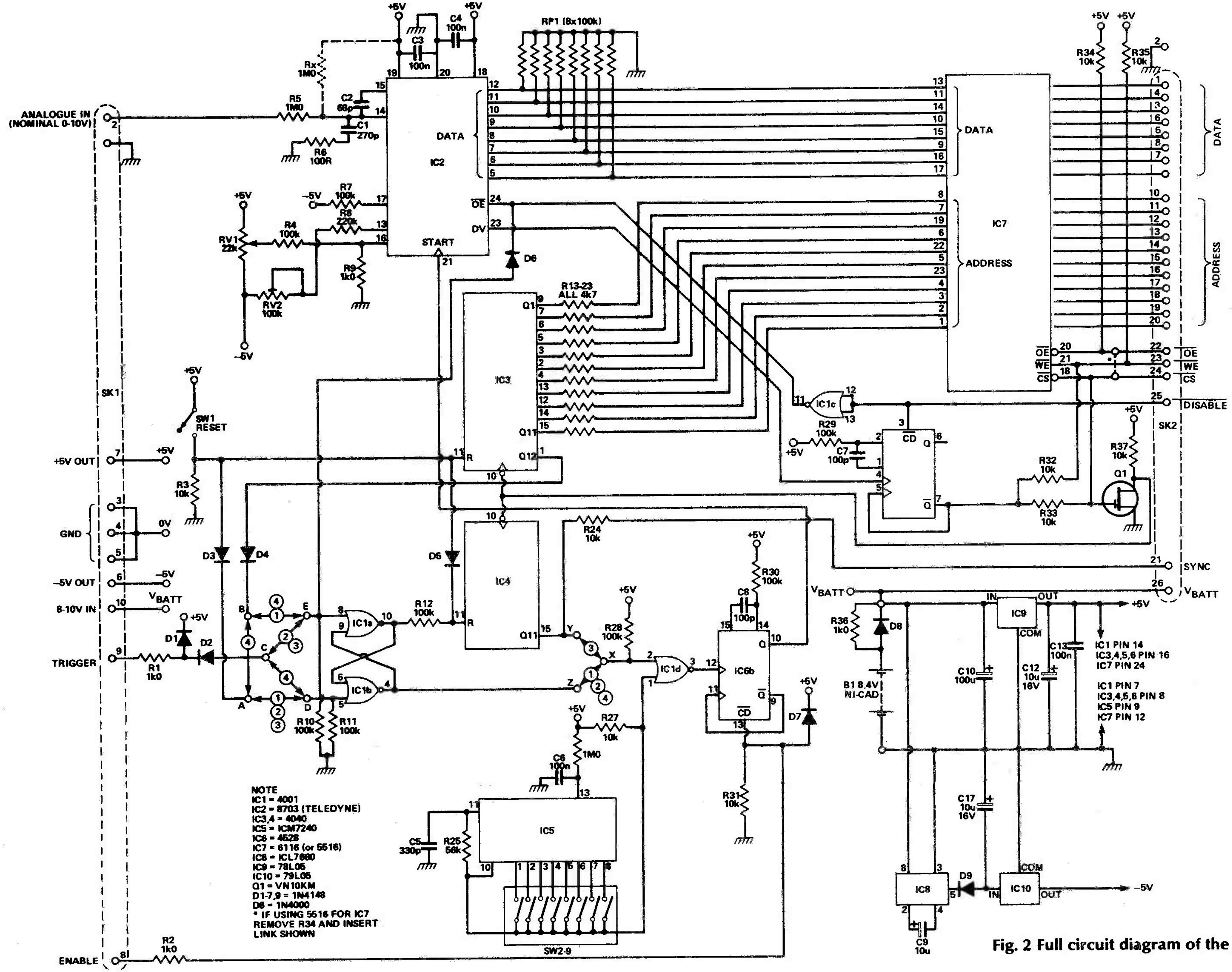


Fig. 2 Full circuit diagram of the loggit.

HOW IT WORKS

The first thing to consider is probably the most important device in the project. This is the 8730 analogue to digital converter. This works by integrating the input current and subtracting pulses of a reference current from it to maintain the integrated charge at or near zero. The number of reference current pulses necessary during a conversion period is counted and latched onto the output data bus at the end of conversion. The input to this device is effectively maintained at virtual earth potential and acts as a summing point for current.

Almost all the necessary control logic is contained within the device for A to D conversion, the only external signals needed being a start command input and busy and data valid outputs. For the convenience of computer bus connection the device is provided with an output enable pin which allows the data output to be forced into a high impedance state.

The rest of the circuit can be considered as four main blocks. The first of these is the memory. This consists of a 2k × 8 CMOS RAM type 6116 or, with a little modification, 5516. This device is used to store all the data gathered by the unit. These CMOS devices are specified because they consume very little power when not actually active. In the data logging mode of operation the memory will be active for only about 1μs at each sample time. Its quiescent current is about 100nA while its operating current is up to 50mA. Since the memory is only active for 1μs in 10ms at the fastest operation rate its average consumption will be only about 5μA worst case.

The next section we shall consider is the power supply. This is a simple split rail ±5 volt supply using low-power IC regulators. The only complication here is that the raw negative supply is generated by a DC-DC converter chip so that the whole unit can run from a single battery. The use of this device does, however, limit the input voltage to 10.5V absolute maximum.

The last two sections make up the control logic of the unit. The first and least complicated of these is the address counter. This consists of a 12-bit CMOS counter which, by means of Q1, is incremented after each data byte has been written into the memory. The outputs from this counter are coupled to the memory and output socket via 4k7 resistors. This is done so that external devices can access the memory without damaging the counter outputs simply by overdriving the existing logic state. Only 11 addresses are needed to control the memory so the twelfth output is used to indicate that the memory is full in modes 1 and 4.

The final section consists of all the bits and pieces which did not fit into the other categories. IC5 is a CMOS programmable timer which determines the sample rate of the unit. The basic timing period is set by the combination of C6/R26 but by means of SW2 to 9 any multiple from 2 to 256 of the basic period are selectable. Note that at least one switch must be closed to get any pulses at all and that the multiple obtained is one greater than the binary pattern set. SW2 is on the least significant bit.

The pulses generated by IC5 then pass to IC1d. This acts as a gate to allow them through only when required. From here they go to IC6b which generates a narrow pulse each time its input goes high. Note that the enable input from SK1 pin 8 must be high for this to happen. The pulse from IC6b then starts a conversion cycle in IC2. When IC2 has finished its A to D conversion it puts the result on the data bus and sets its DATA VALID output high. The transition from low to high triggers IC6a to produce another narrow pulse — about 1μs wide — which puts the select and write enable inputs of the memory low and writes the data into the location currently set up on the address lines.

The signal on the $\overline{CS}$ input to the memory is inverted by Q1 and R37 to drive the clock inputs to the address counter and IC4. This inversion is necessary because the counters increment on the negative-going edge of the clock signal and (as was found the hard way on the prototype!) it takes a long time for their outputs to stabilise, which causes data to be written into the wrong addresses in some cases. An FET was used in this position so that there would be minimal loading on the $\overline{CS}$ line, but it still can be overdriven by external sources.

The mode of operation of the unit is determined by connections to IC1a and b and IC4. IC1a and b form a simple set-reset latch whose state is determined by the signals selected on link points A,B,C,D and E. Points D and E are the inputs to the latch; C is the trigger input from an external event — positive true; A is the reset signal from the on-board switch; and B is the memory full signal from IC3. Link points X, Y and Z are used to select the required output signal.

The operation of this section must now be considered in the light of the modes of operation selected on the links.

Mode 1 — link A-D, B-E, X-Z (sample until memory full): this mode starts when the reset button is pressed and released. IC1b output is forced low by the reset line via D3; IC3 and 4 are made to start at zero and pulses are allowed through IC1d. Data sampling will occur until Q12 of IC3 goes high. At this time IC1a output is forced low by the signal from IC3 Q12 via D4. This will cause IC1b output to go high and stop further pulses passing IC1d.

Mode 2 — link A-D, C-E, X-Z (sample continuously, stop when trigger high): in this mode the reset button is pressed only to set the IC1a and b latch into the correct state. Data sampling then proceeds continuously until a high condition via D2 from SK1 pin 9 sets IC1a output low, and thus IC1b output high. This stops pulses passing IC1d as before. The memory now contains 2048 samples up to the trigger point, providing, of course, that more than 2048 samples have been processed since the reset button was pressed. Note that in this mode IC3 can stop with any count but IC4 will be all zeroes. This is because the reset input to it has been held high by IC1a and b latch until the trigger point. This condition can be used when reading data out to provide a trigger or sync signal to indicate where the original trigger signal occurred relative to the stored data.

Mode 3 — link A-D, C-E, X-Y (sample continuously, stop 1024 samples after trigger input high): this is possibly the most useful mode. The reset button is used to set the IC1a and d latch as before, but this time the output from IC1a holds IC4 in a reset condition. The Q11 output from this device is therefore low and enables pulses to pass IC1d as before. As in the previous mode, a high level on the trigger input will cause the IC1a and d latch to change state but this time all it does is to remove the reset condition from IC4. Sampling will continue but IC4 will be clocked as well as IC3. When 1024 more samples have been taken, The Q11 output of IC4 will go high and prevent pulses passing through IC1d. Using this mode means that data can be viewed both before and after the trigger event. The sync output will indicate the original trigger point as before.

Mode 4 — link A-B-E, C-D, X-Z (start on trigger, stop when full): in this mode, the reset button is used to set the IC1a and d latch with IC1a output low and IC1d high. It also resets IC4 via D5 and IC3 directly. Pulses are prevented from passing IC1d for the time being. When a trigger pulse occurs, IC1b output is set low and thus IC1a high. This then allows pulses to pass IC1d and data sampling will occur. After 2048 samples, IC3 Q12 will go high setting the latch back to its original state and preventing further operation. While sampling is taking place, IC4 would be held in its all-zeroes state by IC1a output and thus will indicate the trigger point as usual.

Unfortunately, in this mode if further trigger conditions are supplied extra samples will be taken at the trigger times and may corrupt the data, so multiple triggers should be avoided.

So far we have considered only how to get data into the unit. Now we must look at how to get it out again. There are two main ways that this can be achieved. The first is to use a computer with 24 I/O lines to overdrive the address and control lines and read out the data. In doing this it must set the $\overline{DIS}$able input to a low level. This prevents IC6a from producing clock pulses and pulsing the memory control lines. It also turns off the data output buffers in the ADC to allow the memory free access to the data path.

A second and much simpler method of examining the data is to attach a D to A converter on the data lines and use the internal counter IC3 to scan through the memory. In this configuration, the $\overline{DIS}$ pin on SK2 is held low inhibiting IC6a and the ADC data outputs and, via D6, holding the IC1a and d latch such that IC4 is released from the reset condition. $\overline{WE}$ is left open or connected to +5V, $\overline{OE}$ is held low or, in the case of the 5516 memory being used, connected on the PCB to $\overline{CS}$ line. A high frequency clock signal should be applied to the $\overline{CS}$ pin of SK2. While the signal is low, data is read out of the current location pointed to by the outputs of IC3 and should be stored in the DAC on the rising edge. The rising edge of this clock signal is inverted by Q1 and used to clock IC3 and IC4, in order to be ready for the next low part of the clock input. By this means, if the output of the DAC is displayed on an oscilloscope, a continuous waveform corresponding to the sampled data can be observed. The output from the SYNC pin on SK2 indicates the original trigger point by a high-to-low transition.

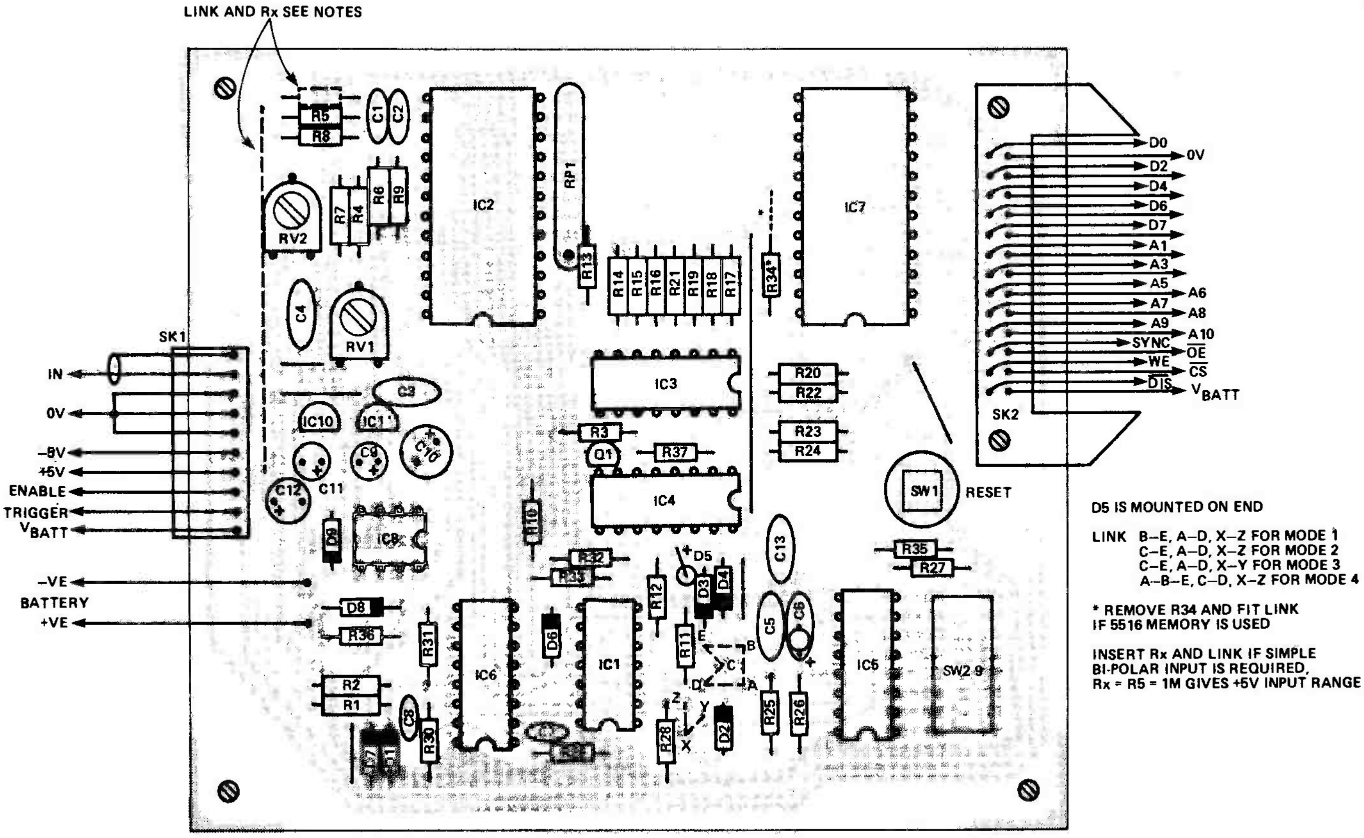


Fig. 3 The PCB overlay for the project.

complete the address counter is incremented ready for the next cycle.

In the control logic there is also a group of devices whose function is to stop and start the whole process according to the particular operational mode required. These act by preventing the trigger pulses reaching the ADC once the memory is full or the trigger condition has occurred. By means of links, four separate modes of operation can be realised. These will be described in greater detail later in this article.

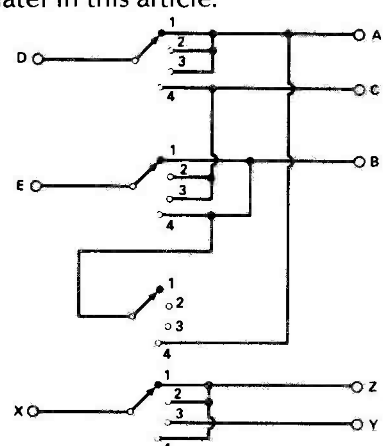


Fig. 4 If the links are a nuisance, you can use a 4P 4W switch instead (yes, we know it's not standard . . .).

The last part of the unit is the power supply, which is fairly conventional except that a voltage converter is used to get the negative supply for the ADC. This allows us to use a single 9 volt battery; in fact, the battery may be necessary only while transporting the unit, as power can normally be supplied via one of the connectors and anything from about 8 to 10 volts is suitable.

Read-out of data from the unit can be achieved in several ways, the simplest of which is to connect the data bus to the D to A converter and, with $\overline{OE}$ low and $\overline{WE}$ high, apply a series of narrow positive-going pulses to the $\overline{CS}$ input. This will result in the output from the D to A converter reproducing the original sampled input. This can then be displayed on an oscilloscope for visual examination. A synchronisation signal is available separately to indicate the trigger point on the original data.

Alternatively, a microcomputer with the capability of at least 24 I/O lines could be used to read all the data and even erase old data if required. Other methods could be used if less than 24 I/O lines are available but with reduced flexibility.

Construction

You should find that this project is reasonably easy to put together. All the components with the exception of the battery mount on the PCB.

The order of construction is not particularly critical, but we would recommend that you start with the resistors and the six wire links. The wire links should be made with insulated single strand wire to prevent accidental shorts. Next would come the diodes, making sure they are the right way round, followed by IC sockets, IC9 and 10, Q1, capacitors, variable resistors, switches and connector sockets.

When this stage is reached, check the power supply for continuity to the IC sockets and freedom from shorts to other places. Plug in IC8 and apply 8 to 9 volts to the battery terminals. You should be able to detect +5V across C13 and −5V across C4. If you do not, disconnect the battery and check D8, 9, IC8, 9, 10 for correct placement, etc.

Once the power supply section is operational, plug in IC5 and check, if you have access to a scope or logic probe, that pulses appear on pin 10. To do this, close SW2 and open SW3 to 9. This

PARTS LIST

RESISTORS (5% carbon film ¼ watt unless stated)

R1,2,9,36	1k0
R3,24,27,31–35,37	10k
R4,7,10–12,28–30	100k
R5,26,Rx	1M0
R6	100R
R8	220k
R13–23	4k7
R25	5k6
RP1	8 × 100k SIL resistor pack
RV1	22k min. horiz. preset
RV2	100k min. horiz. preset

CAPACITORS (min ceramic unless stated)

C1	270p
C2	68p
C3,4,5	100n
C5	330p
C6	100n — or as required
C7,8	100p
C9,11,12	10µ 16V electrolytic radial lead
C10	100µ 16V electrolytic radial lead

SEMICONDUCTORS

IC1	4001
IC2	8703 ADC (Teledyne)
IC3,4	4040
IC5	ICM7240
IC6	4528
IC7	6116 or 5516 see notes
IC8	ICL7660
IC9	78L05
IC10	79L05
Q1	VN10KM
D1–7,9	1N4148
D8	1N4001

MISCELLANEOUS

SK1	10 way 0.1in pitch PCB connector
SK2	26 way P.O. style IDC connector, rt. angle
SW1	min. PCB mounting keyboard switch
SW2–9	8 way single pole DIL switch

IC sockets: 8,14,4 × 16,2 × 24 way; 10 off 1 mm terminal pins; PP3 size 8.4 volt 110 mA-h Ni-Cd if req'd; PCB (see Buylines).

gives the fastest clock time — note that at least one switch must be closed for proper operation. Next insert IC1, 3, 4 and 6. Link A to D and Z to X. Temporarily connect SK1 pin 8 to pin 7 and with a thin piece of wire bridge pins 21 and 23 on IC2's socket. Power up the unit with the battery, etc., and press the reset button for a moment. It should now be possible to detect a count sequence on the address pins of SK2. Pulling SK2 pin 25 low should stop it, as should removing the link between SK1 pins 7 and 8.

With SK2 pin 25 low and the link removed from SK1, feed in a clock signal to SK2 pin 24: about 1kHz 3 to 5 volt TTL compatible will do. A count sequence should again be observed on the address pins of SK2.

Once this stage is reached successfully, remove the power source and plug in IC2 and 7. Be careful with these as they are sensitive to static damage and are also expensive. Note that if you use the 5516 CMOS RAM instead of the 6116 then R34 should be omitted and a link inserted between IC7 pins 18 and 20. By the way, you should also remove the thin wire between IC2 socket pins 21 and 23 before inserting IC2. You can now repeat the tests and you should get the same results. Check also that the power supply current is not more than 20mA (our prototype weighed in at 13mA). Your LOGGIT should now be ready for action.

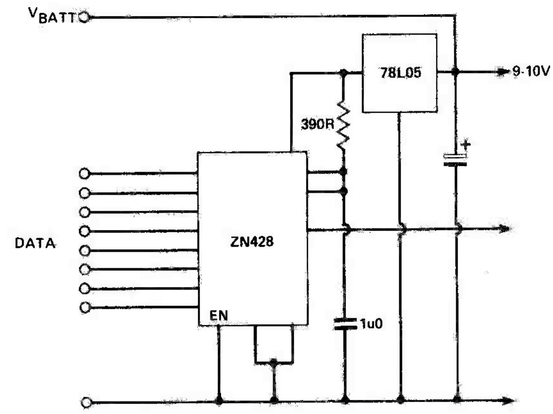


Fig. 5 Setting up circuit.

Setting Up And Use

The easiest way to set the unit up for use is with the circuit shown in Fig. 4. The DAC is connected to take the output from the ADC on the PCB without latching it. This works because the ADC holds the data from the last conversion until 5µs or so before presenting the new data. With this arrangement it is possible to monitor the ADC operation while making adjustments.

To make things easy while setting up, link A-D and X-Z only and press the reset button briefly. Make sure that Rx is present if you want to monitor a bipolar input. With R5 and Rx each at 1M0 and the other components as shown it should be possible to monitor a ±5V input, while omitting Rx will set the range at 0 to +10V. Increasing R5 (and Rx) will increase the full scale input voltage and vice-versa.

It is probably easier to set the circuit up initially if Rx is omitted. Short the analogue input to ground and adjust RV1 to the point just below where the output digital data changes from 0000 0000 to 0000 0001. Next apply the full scale input voltage and adjust RV2 to the point where the digital output has just changed from 1111 1110 to 1111 1111. Go back and check the first adjustment, and repeat both adjustments until they are correct. Next, ramp the input voltage slowly through its range and check that the DAC follows it with no sudden jumps, apart from those caused by the slow sample rate.

When you have got this far, you can insert Rx if you wish and adjust RV1 to the point where the digital output just changes from 0111 1111 to 1000 0000 when the analogue input is grounded.

To use the unit for data collection, set up the mode on the links as described and the sample rate on the switches (and C6/R26 if necessary). The PCB can then be plugged into a suitable connector on which pins 7 and 8 are connected. A supply of 8 to 10 volts should be made available on pin 10, or the unit's battery used. The analogue signal should be applied to pin 2 and the trigger signal, if used, to pin 9. Press the reset button and the unit should start working.

Once the data has been collected, the unit must not be disconnected from its power source or the data will be lost. The simplest way to ensure this is to keep a PP3 sized Ni-Cd battery connected to the terminals on the PCB permanently. If this is the case, the unit can be disconnected from the monitoring point and taken away to the readout unit. So long as the PP3 Ni-Cd is reasonably charged, the unit should be able to retain data for a few hours. Note that power can also be supplied via SK2 while reading the data out.

In order to get sensible output pictures on an oscilloscope it is desirable to ensure that several samples are taken in the period of the fastest fluctuation of the monitored voltage.

BUYLINES

Nothing we have used here should cause any problems for our UK readers. All the components are readily available from advertisers in this magazine, such as Watford, Technomatic, Rapid, and others. The PCB is, as ever, available through the ETI PCB service.

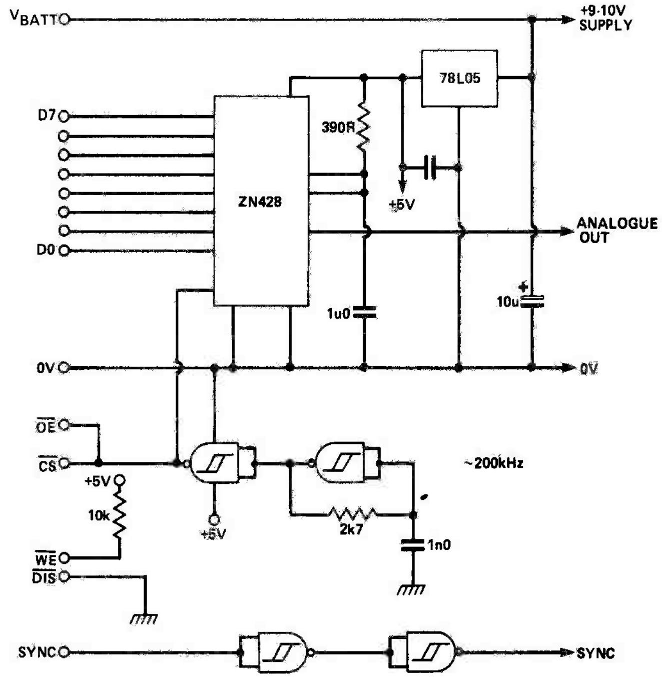
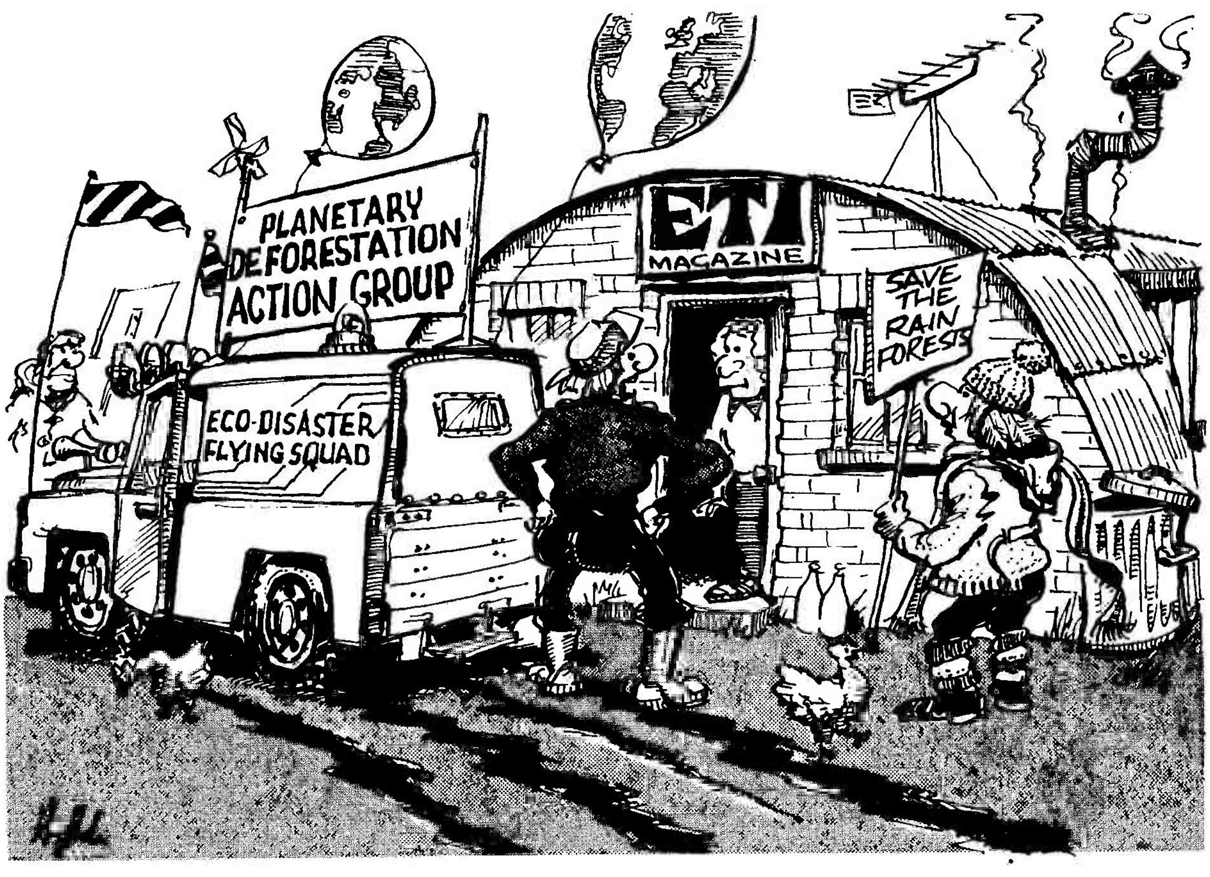


Fig. 6 Using a DAC to produce an oscilloscope display. Another alternative would be to use switches (fully de-bounced) to make the LOGGIT step through data points one at a time, and use this to drive an analogue or digital meter (via a DAC) or suitably buffered LEDs (but you've got to really love hex for that . . .).

ETI



"OK YOU LOT – WE'VE COME TO GET THIS DIGITAL LOGGER PROJECT STOPPED!

DESIGN ICS ON YOUR MICRO!

It will come — but don't hold your breath waiting for a package to run on your trusty ZX81! TI has recently announced a design-it-yourself facility for professional computers.

By TI's reckoning, the semi-custom IC market will expand from the $100 million share it has now to around $990 million in 1990 (a growth from 10% to 30% of a total market that is itself growing). That, in anyone's terms, is big money, but there is a very low penetration of semi-custom ICs to the smaller companies in Europe that, whilst making up 80% of the total in number of all European electronics companies, hold only 40% of the manufactured equipment market.

These companies have a turn-over of $1m per year, or less, so cannot afford their own in-house semi-custom design team, nor can they afford to have a semiconductor manufacturer design special purpose devices for them. In fact, with such a small turn-over, a large company like TI is kept too busy by its big customers to be particularly worried.

None the less, 40% of the electronic equipment market is not to be sneezed at, especially when this could translate into an extra $660m of semi-custom ICs! Something had to be done, but it would not have to cost the small companies too much, and it also would have to be relatively cheap on TI's design time.

The solution has been to adapt an existing software package, TI's Transportable Design Utility (TDU) which has been used with success on a number of different main-frame computers. After adaptation, this suite of programs can now run on a fairly heavy-weight micro, such as an IBM XT/PC or TI's own Professional Computer, with 512K of RAM, and 10M Winchester disk (this isn't a complete list of requirements — contact TI for more details if you're seriously interested).

The package allows you to describe the hardware you want to integrate using TI's hardware description language (HDL) and the test patterns you want it to fulfil using test description language (TDL). With some software packages available from other suppliers, but which do not come with the basic package from TI, you can get the facility to actually draw circuit diagrams on the screen. However, TI say that once you are used to it, it is as easy to use HDL to describe a circuit lay-out as it is to draw a circuit diagram.

The software will then check that you have followed the appropriate electrical rules — in particular, it will check fan-in, fan-out and output contention in the design. It also checks to see if the circuit you have designed is easily testable. Finally, it simulates the action of the circuit, and checks to see that the results you get are the same as your expectations.

The major stage that the software does not do for you is to lay out the IC. To do this, you will have to send a disk containing the circuitry description to TI, who will then use their main-frame to finish the job. However, what you have got at this stage is a finished circuit that, when integrated on silicon, will work.

There are several different ranges of semi-custom logic sold by TI, and the software will support the full range, from SN54/74 HCMOS standard cell family, which is second-sourced by Signetics, to the recently introduced TAHCXX HCMOS gate arrays. Further, TI say that any future semi-custom products will be supported.

This all sounds very expensive, you may think. But it isn't — the basic software will cost $500 for the software itself and all current product information. 'Active' customers, ie those who are actively engaged in designing with semi-custom logic, will receive support and latest releases free of charge.

The basic idea of the system is to transfer the most costly and time-consuming part of the design process — getting a circuit that will work using the standard cells of a semi-custom logic family — to the customer's own personal computer. The final stage, the laying out of the mask, has to be done on a main-frame at the moment, so can only be done by TI themselves. However, there should still be a very significant saving for the small customer for whom semi-custom logic may be presently far too expensive.

The software package described here, the PC TDU, will be available from TI as of the 1st December 1984. TI are at Manton Lane, Bedford, MK41 7PA.

Making A New IC

The design of new ICs is done with a great deal of help from computer-aided design packages. In fact, the PC TDU package from TI is a cut-down version of the software TI themselves use to design their own devices. Obviously, their in-house packages must be able to deal with non-standard logic cells, whereas PC TDU deals only with standard cells.

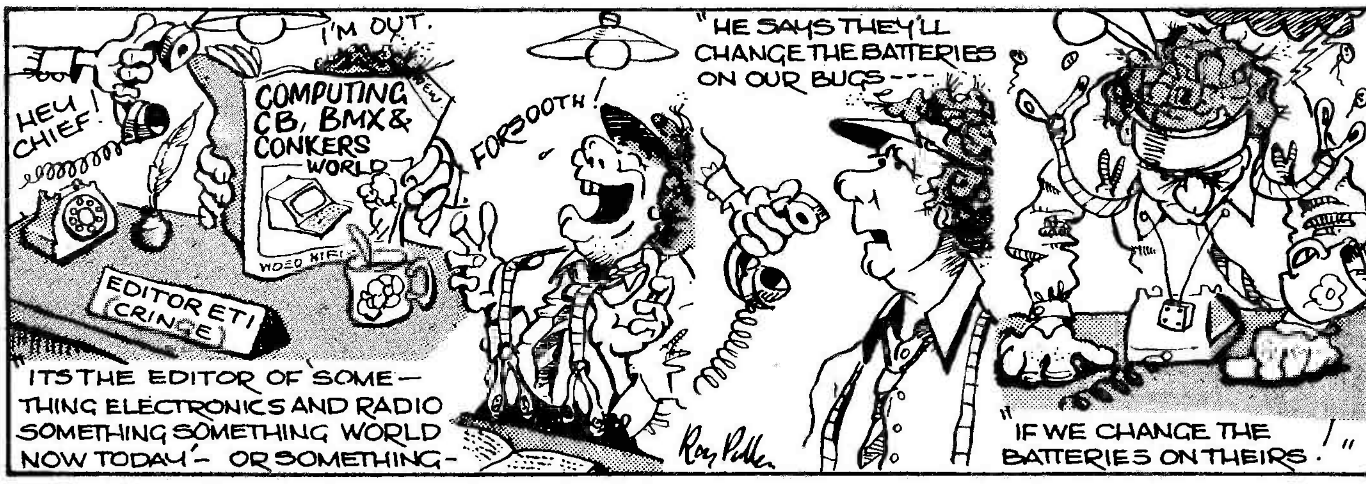
All the circuit design and checking is done with the help of the computer, up to and including the die lay out. However, it has been found that no computer algorithm can substitute for a design engineer's experience in this last stage, particularly when trying to avoid parasitic devices — only certain levels of checking can be performed by computer, so there is a substantial human involvement in the exact details of the final layout, in contrast to semi-custom layout, which can be almost entirely automated.

The end of the design effort is the programme tape, which is used to produce the masks for the different diffusion and metalisation stages of the IC's production. After photo-reduction, these are used to make a batch of prototype wafers.

Before the wafers are sliced up, the individual dies are 'probed' to see if they can perform certain tests. If this is satisfactory, the wafer is then sliced and the individual ICs packaged.

The next phase is to determine whether the prototype ICs do what they should. They are checked against the provisional data sheet, to see if either or both require ammendment — only in 1% of cases does the actual IC have to be changed.

Production now begins, and there's a new IC on the market!



ETI

DIGITAL FRAMESTORE

Have you been framed? If not, you'd better get building! Leading off with construction details, Daniel Ogilvie then proceeds to give details of how the framestore can be used.

Boards with plated through holes are available for the framestore or you may construct your own by means of the layouts provided.

The normal care should be taken to ensure the correct orientation of all ICs and transistors — especially for the more expensive ones. Note that the dynamic RAMs have their positive and negative supply pins swapped compared with convention.

For the power supplies, the −5V and +6V should have linear, not switching, regulators to ensure that switching noise does not adversely affect the high bandwidth video stages. The higher-current 5V can be provided by a switching supply, to ensure a low heat dissipation: the framestore can draw up to 4A.

Construction should begin with the control board. There is no need to socket any of the ICs, and indeed it is preferable not to, as the high capacitance of poor sockets can affect the timing of fast pulses. The ZNA134 is resilient but may be socketed if your nerves are not up to soldering it.

LI is one turn of 18swg wire wound on a HB pencil (you should obtain similar performance from a B pencil but this has not been tried).

You should ensure that the links in the board are set to the 640 position (there are five of these) and then the board may be powered up; you may cross all your fingers and toes if you wish while doing this.

If you have access to a scope check that the output waveforms appear correct. Of particular importance are the relative timings of 0, RAS, CAS, W, TP and S/L (see

PARTS LIST — ADC/DAC BOARD

RESISTORS (all ¼W 5%)	
R1,22	75R
R2	220R
R3,7	22R
R4,13,20	1k0
R5,19	100R
R6,11,15	3k3
R8,18	330R
R9,17	10R
R10,16	1k5
R12	56k
R14	68k
R21	680R
CAPACITORS	
C1,2,5,12	10u 16V axial electrolytic
C3	4n7 ceramic
C4,6,7,8,11	100n ceramic
C9,10	1n0 polystyrene
C13	1u0 polyester film
SEMICONDUCTORS	
IC1	TDC1014
IC2,4	OP-07
IC3	74LS221
IC5	TDC1016J
IC6	74LS04
Q1,3	2N2369A
Q2	2N4393
Q4	2N3906
ZD1,2	ZN423
D1	1N914
D2	1N4001
MISCELLANEOUS	
PCB; IC sockets for ADC and DAC only; wire, solder, etc.	

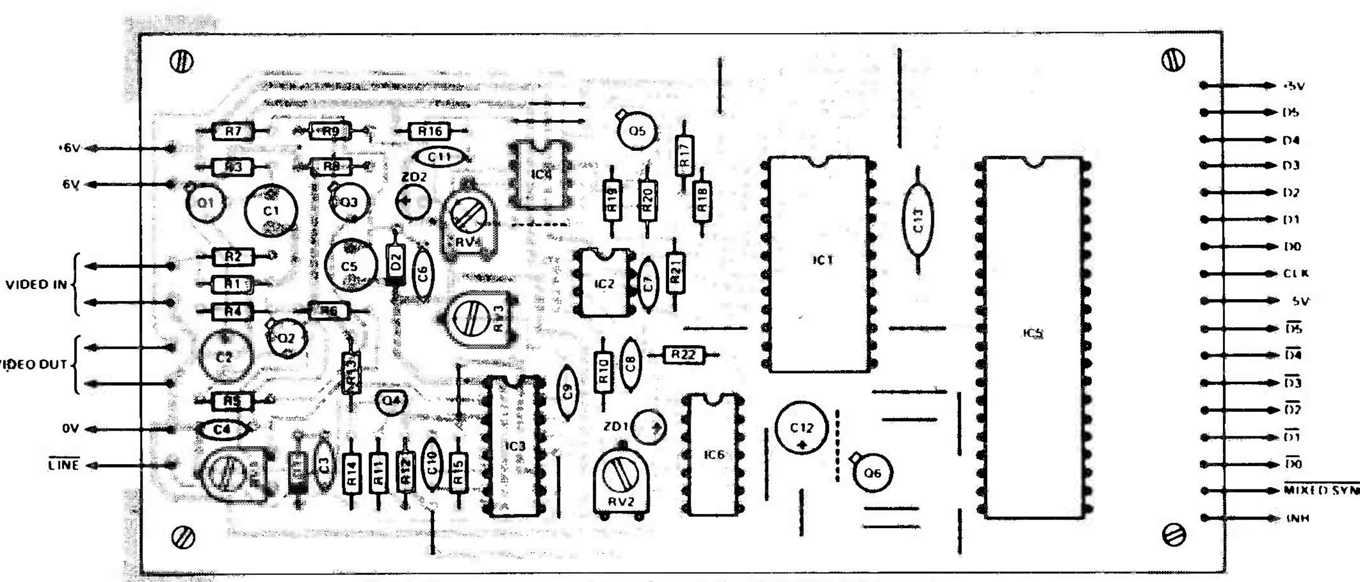


Fig. 9 The component overlay of the ADC/DAC board.

timing diagram, p63, ETI Dec '84). Remember the write output will appear only when the load switch is operated or one of the auxiliary load inputs is held low.

Construction should continue with memory boards. Each board will store one bit and six are required for the complete framestore.

The RAM's specified are Motorola MCM6664L20. These are cheap and contain an auto-refresh function which can be useful for the processor interface but is not necessary under normal use as a framestore. There should be no problem in using any other 200ns 64K × 1 DRAMs, but this is suggested only if you have some DRAMs to hand. If buying specially, the Motorola parts should be ordered unless a significant price difference is apparent, and we would suggest that eight of the alternatives should be tried first. They may be installed one bit at a time to help space the cost. All of the address and control inputs are paralleled up via the IDC connector. ICs 13 and 15 need not be inserted if the processor interface is not to be constructed.

The dynamic RAMs should be soldered in and not socketed: the capacitance of the sockets can cause excessive overshoot on the driving waveforms resulting in false writes to the RAMs. If the processor interface is to be installed, the link of the MPU line to 0V should be put in to enable the address multiplexers. This line would normally be driven by the interface board.

When one of the memory boards has been constructed and checked, connect it to the control card via the IDC connector and power both of them up. If possible, connect a 'scope to the serial output of the board. On switch on, this will be random, but the A0 address line may be connected to the serial input to the DRAM board and the load switch operated. The DRAM should now provide a regularly spaced waveform across one line. Other boards may now be paralleled up and checked similarly.

Finally the ADC/DAC card can be constructed. The ADC and DAC may be socketed if you wish. Before inserting the DAC set RV4 to achieve −1V at its reference input (pin 4). After turning off the power, the DAC may be inserted and the board connected and powered up. Load the A0 address line again and connect the serial output of the memory board to the MSB of the DAC.

The video output can now be connected to a video monitor. Other test inputs can be applied if you wish — remember they must be synchronized to the framestore to prevent tearing or rolling.

Finally the ADC can be inserted and the test input can be applied to the video input or a camera connected. The camera must be synchronized to the framestore to ensure a stable picture using the 75 ohm line and field drive outputs. The gain of the video input may be varied by means of RV1 which alters the reference to the ADC. An offset may be applied to the input by means of RV2. The framestore should now be up and running.

Due to the complexity of the project it is difficult to give any guidelines on fault finding should the worst occur. However to encourage contruction the author is willing to offer a trouble-shooting service and will undertake the repair of any one board for £20 plus any parts necessary. This will not apply to any construction that does not use the PTH boards.

And Now, A Few Tricks

Normally the data from the framestores memory is passed to the DAC and on to the video monitor. Suppose instead we insert a fast RAM between the memory and the DAC, and use the data from the memory to address a location in the high speed RAM, the resultant data read being passed to the DAC. We have six bytes coming from the framestore's memory which can address one of 64 locations and we require a six-bit byte to come out. This 64 × 6 memory must also be fast — ideally faster than one of our clock cycles (78ns). We also need access to the RAM from outside so we can modify its contents; this can be provided by two, two-input multiplexors on the address inputs. This circuit is, in fact, a humble look-up table, and the circuit of the complete lookup table is shown in Fig. 10.

The RAM chosen is configured in a 256 × 9 bit format and has an access time of 45ns. Adding the delay through the multiplexors (about 5ns) means that the data coming to the DAC will be latched in one clock cycle later. This is not important, although we must delay the inhibit signal to the DAC (NDIS) similarly or we will lose the right hand column of the screen and will display rubbish in the left hand column. The required delay is created by IC2. Access to the RAM by our processor is quite conventional. The CS input from the MPU is the decoded 64-bit address location for the lookup table. When CS is low, the multiplexors switch the address lines to the lookup table over to the MPU address lines. The CS signal is rated with our R/W line to provide a write input to the lookup table, and it also disables the output drivers of the lookup

Fig. 10 The not-so-humble lookup table.

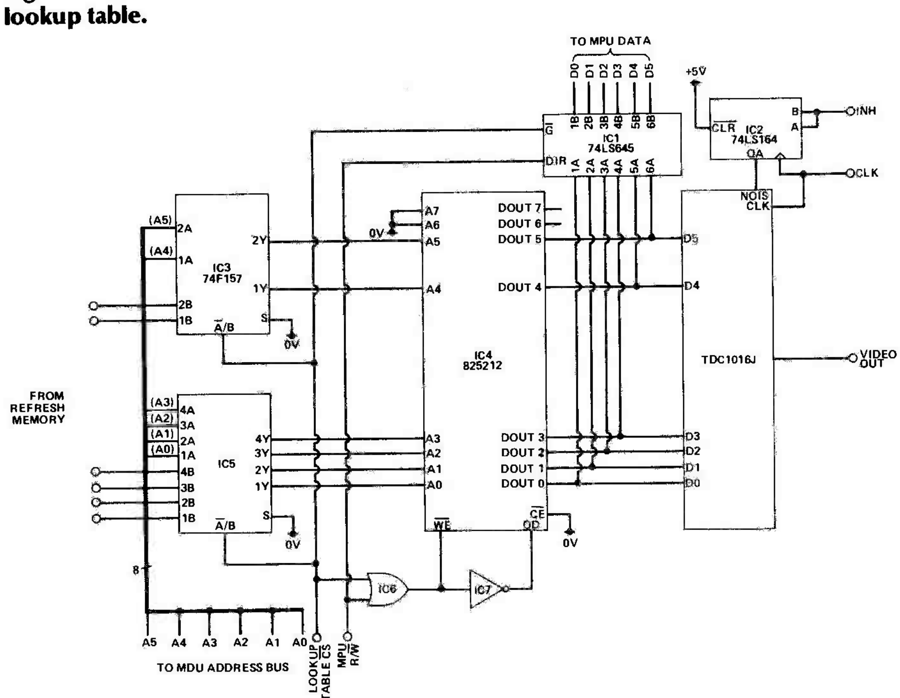


table which enables us to load data in via the tri-state buffer, IC1.

The writing to the lookup table should usually be performed during the blanking (inhibited) period of the display to prevent interference on it.

Normally the lookup table is loaded up such that a normal picture is obtained. All address locations are loaded up with a byte corresponding to the address bus value, i.e. address 0 is loaded with 0, address 1 is loaded with 1, etc, and address 63 is loaded with 63. The incoming data from the framestore memory just addresses a similar valued byte which is converted by the DAC. This gives us complete control of the grey-level structure of the image. If we want to highlight a pixel value or a range

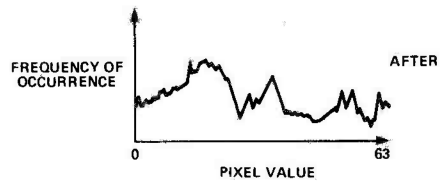


Fig. 13 Enhanced histogram.

Fig. 11 Picture before enhancement.

Fig. 14 Enhanced picture.

of pixels we can load the corresponding address value with peak white; for example to highlight grey level 24 we load up the lookup table address 24 with the byte 63 to turn it white.

Have a look at Fig. 11. Fig. 12, shown underneath, is a histogram of that picture which has been obtained by counting the numbers of pixels in that image for any particular grey level. As you can see, relatively few different levels are used. In the image there is little in the dark grey or black tones and little approaching peak white. Because the picture contains few grey levels, it appears flat and little detailed information can be obtained from it. We could improve this by stretching the histogram over our full 63 grey level range. The increments between the pixels are greater, of course, but more detail is apparent. The resultant histogram is shown in Fig. 13 and by loading the lookup table with the new values we obtain the

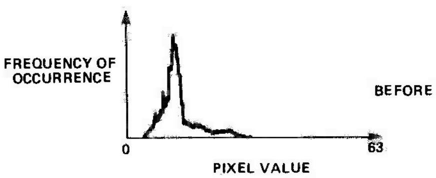


Fig. 12 Histogram of grey levels.

Fig. 15 Psuedo-colour look-up table.

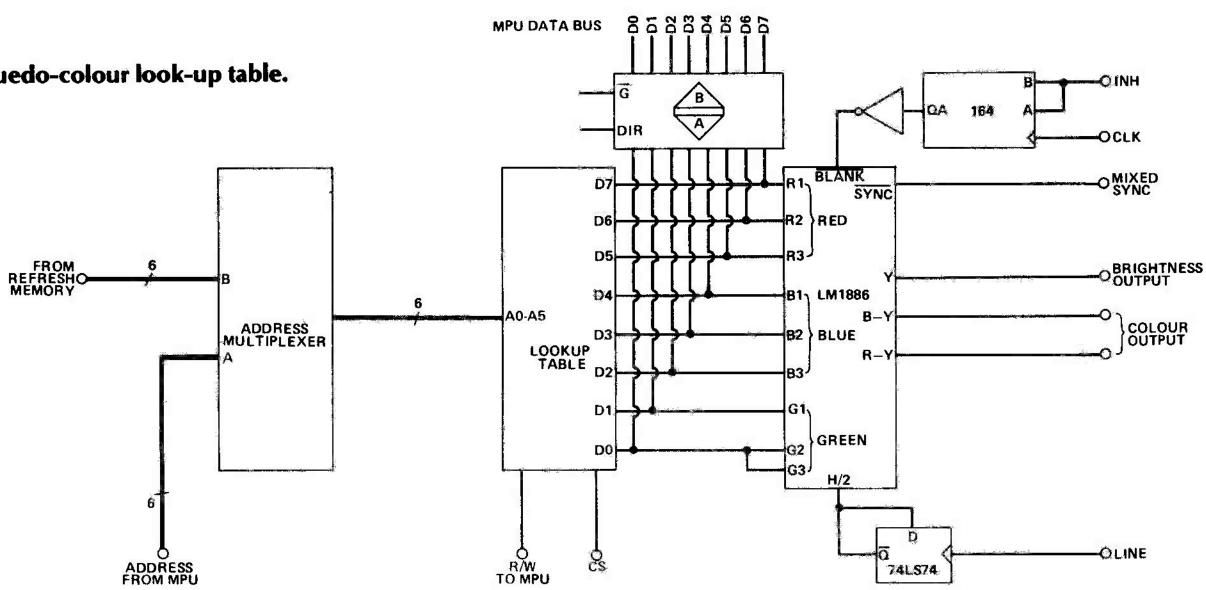


photo shown in Fig. 14. The lookup-table has only manipulated the output of the framestore and is therefore non destructive — we can restore the lookup table to its original values at any time to obtain our original image. On top of that we have only to write to 64 locations which can be done during the field blanking period and allows us to perform virtually real time image processing. One further use of the lookup table is to provide a pseudo-colour output. For example our highlighted pixel (value 24) could have been turned a different colour which might have highlighted features or differences more efficiently. The six bit output of the framestore can be used to address a video DAC with colour capability. An example of this is shown in Fig. 15, using the National Semiconductor LMI889. This IC will accept a nine-byte binary input and provide a r-y and b-y output to drive a modulator or monitor directly. Readers are referred to the National Semiconductor linear book for detailed information on the device.

A more effective (and expensive) colour display can be obtained by the use of three look-up tables and three DACs, and this is illustrated in Fig. 16. Each look-up table is dedicated to driving either the red, green or blue output. If we load each look-up table with our initial values (1 to 1, 2 to 2 etc) we will obtain our grey scale output. However we can turn the image into a green, red or blue display by writing zeros into the corresponding lookup tables (e.g. to obtain a blue image we should write zeros to the red and green lookup tables and leave the blue as it is).

In fact it can be shown that we can turn any grey level into any one of $(2^2)^3 = 262,000$ colours. We can only display any 64 of them at one time, of course.

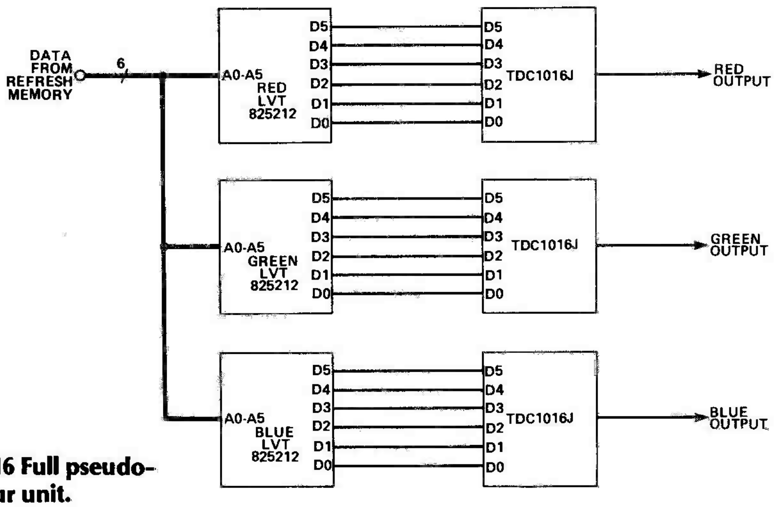


Fig. 16 Full pseudo-colour unit.

Due to circumstances beyond our control, we cannot give the other two overlays this month, so we'll give them next month, when we'll also describe methods of interfacing the frame store to a computer. **ETI**

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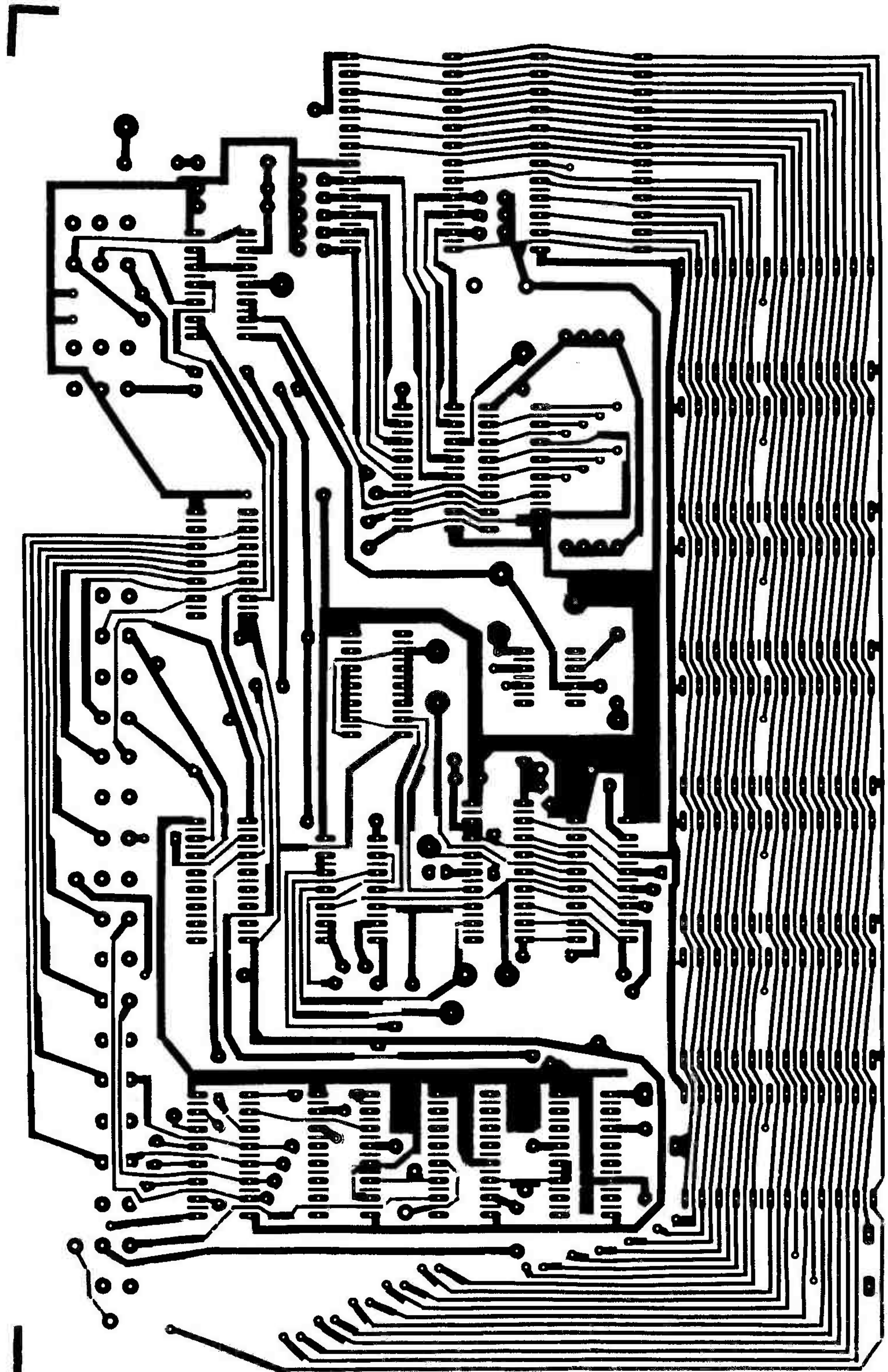
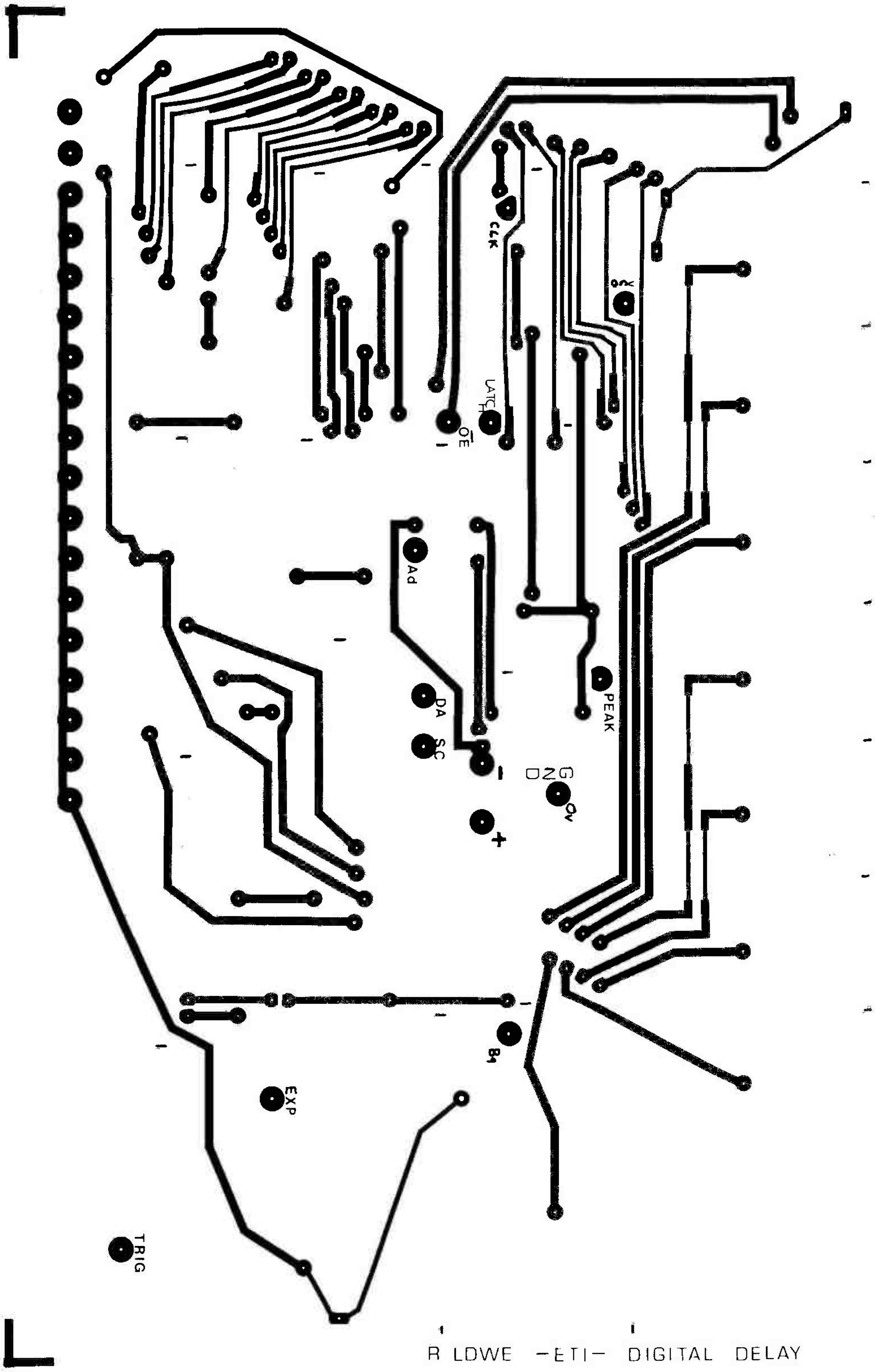
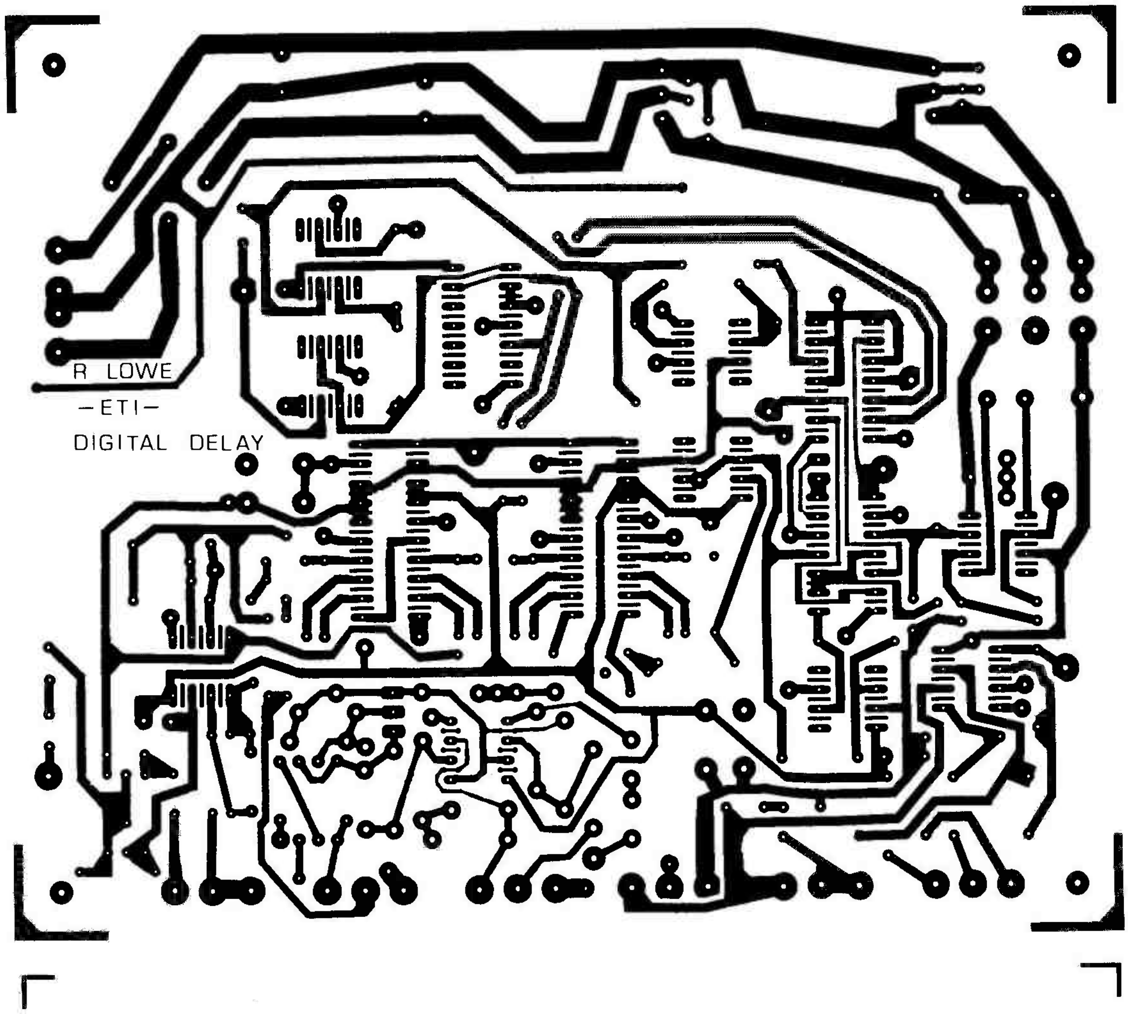




Unfortunately, we don't have space to publish both this month's foil patterns and the ones held over from last month. The patterns shown here and overleaf are for the Digital Delay Line from last month, and we will try and publish this month's patterns next month.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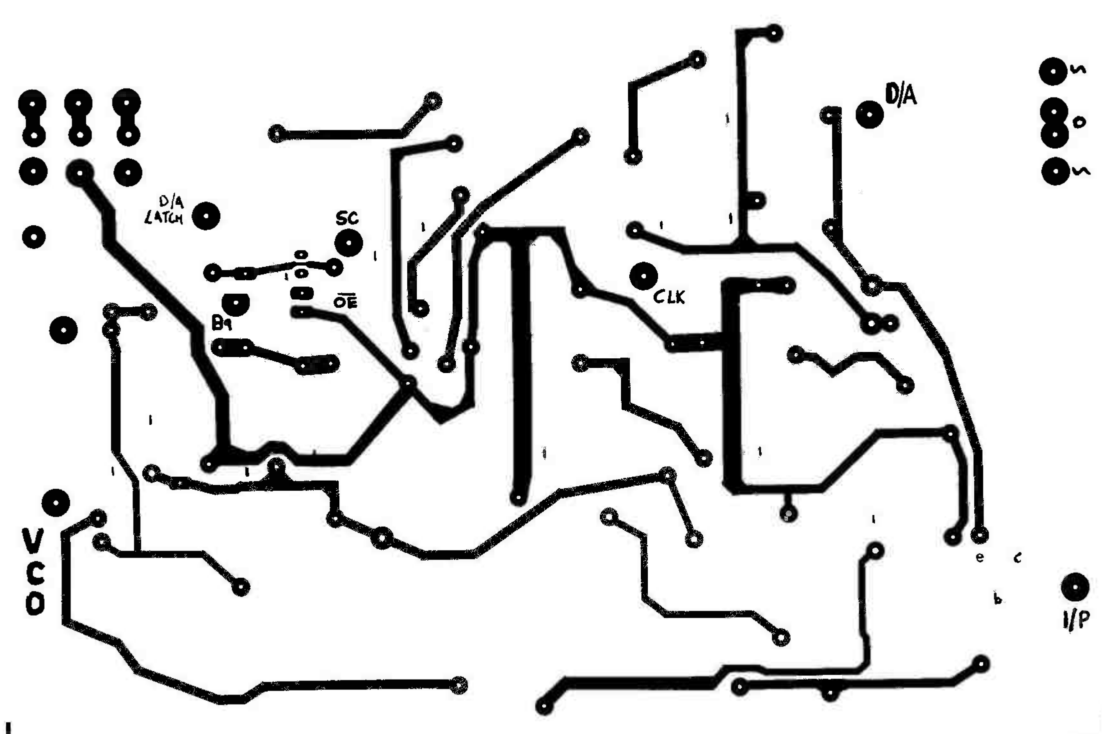
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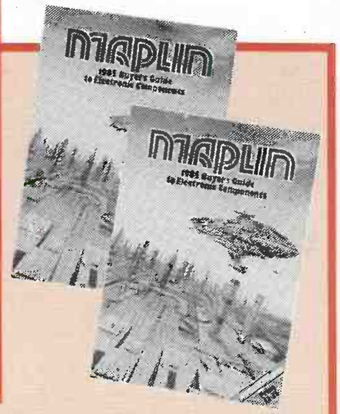

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