

Feative in Heckronics

TAKE COMPLETE CONTROL OF YOUR MUSIC with the

professional quality MIDI-controlled sampling unit

Once again, Powertran and E&MM combine to bring you versatility and top quality from a product out of the realms of fantasy and within the reach of the active musician.

The MCS-1 will take any sound, store it and play it back from a keyboard (either MIDI or Iv/octave). Pitch bend or vibrato can be added and infinite sustain is possible thanks to a sophisticated, looping system.

All the usual delay line features (Vibrato, Phasing, Flanging, ADT, Echo) are available with delays of up to 32 secs. A special interface enables sampled sounds to be stored digitally on a floppy disc via a BBC microcomputer.

The MCS-1 gives you many of the effects created by top professional units such as the Fairlight or Emulator. But the MCS-1 doesn't come with a 5-figure price tag. And, if you're prepared to invest your time, it's almost cheap!

Specification

Memory Size: Variable from 8 bytes to 64K bytes.

Storage time at 32 KHz sampling rate: 2 seconds.

Storage time at 8 KHz sampling rate: 8 seconds.

Longest replay time (for special effects): 32 seconds.

Converters, ADC & DAC: 8 bit companding, Dynamic range: 72 dB.

Audio Bandwidth: Variable from 12 KHz to 300 Hz.

Internal 4 pole tracking filters for anti-aliasing and recovery.

Programmable wide range sinewave sweep generator. MIDI control range: 5 octaves.

+1/V/octave control range: 2 octaves with optional transpose of a further 5 octaves.

POWEBIRAN.

Digital Delay Line



Introduced in 1982, Powertran's DDL has brought digital quality effects to thousands of musicians, Still available in kit form at only £179.00 + VAT.





Write or phone now to place an order Powertran Cybernetics Limited, Portway Industrial Estate, Andover, Hants SP10 3ET. Telephone: 0264 64455





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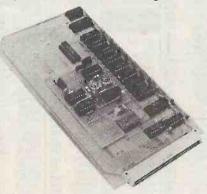


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Part two of Ray Lowe's not-quite-up-to-the-second design.

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TAG-END CAPACITORS: 64V: 2200 139p; 3300 198p; 4700 245p; 50V: 2200 110p; 3300 184p; 40V: 4700 180p; 25V: 2200 90p; 3300 98p; 4000, 4700 98p; 10,000 320p; 15,000 345p; 16V: 22,000 350p.

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POLYESTER RADIAL LEAD CAPACITORS: 250V 10n, 15n, 22n, 27n 6p; 33n, 47n, 68n, 100n 8p; 150n, 22d 10p; 330n, 470n 15p; 680n 19p; 1u5 40p; 2u2 48p. . 220n

TANTALUM BEAD CAPACITORS 35V: 0.1uF, 0.22, 0.33 15p 0.47, 0.68, 1.0, 1.5 16p; 2.2, 3.3 18p; 4.7, 6.8 22p 10 28p; 16V: 2.2, 3.3 16p; 4.7, 6.8, 10 18p; 15, 36p; 22 45p; 33, 47 50p; 100 85p; 10V: 15, 22, 26p; 33, 47 50p; 100 80p; 6V: 100 55p.

MYLAR FILM CAPACITORS 100V: 1nF, 2, 4, 4nF, 10 6p; 15nF, 22n, 30n, 40n, 47n 7p; 56n, 100n, 200n 9p; 50V: 470nF 12p.

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100V 100n, 120n 10p 150n, 180n 12p 220n, 270n 15p 330n, 390n 20p 470n, 560n 26p 680n 30p 1uF 34p 2u2 50p

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1uH, 2u2, 4u7, 10u, 22u, 33u, 47u, 100u, 220u, 330u, 470u 30p

1mH, 1m5, 2m2, 4m7, 10mH 35p

22m, 33m, 43m **6**0**p** 100m 75p

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SWITCHES TOGGLE: 2A, 250V SPST 35p DPDP 48p	(SPST) 4 way 65p; 6 10 way 125p (SPDT)	VITCHES i way 80p; 8 way 85p; 4 way 190p	VEROBOARD 0.1in 2½ x 3¼ 95p 2½ x 5 110p	VQ Board 195p DIP Board 395p Vero Strip 95p	IDC CONNECTORS PCB Plugs Female Fer	PANEL METERS	RELAYS
SUB-MIN TOGGLE SPST on/off 58p SPDT c/over 64p		SWITCHES e Stop type)	34 x 34 110p 34 x 5 125p 34 x 17 420p	PROTO DECs Veroblock 480p	with latch Header Co	ard 60 x 46 x 35mm 0-50µA 0-100µA	Miniature, enclosed, PCB mount. SINGLE POLE Changeover RL-91 205R Coil; 12V DC, (10V5 to
SPDT centre off 85p SPDT biased both ways 105p	i pole/2 to 12 way; 2 pole/2 to 3 w	ole/2 to 6 way, 3 pole/2 to	4% x 17 590p Pkl of 100 pins 55p Spot face cutter 150p	S-Dec 395p Eurobreadboard 590p	16 way 130p 150p 110p -	Op 0-500µA 0-1mA	19.5V), 10A at 30V DC or 250V AC 195p DOUBLE POLE Changeover, 6A 30V
DPDT 6 tags 80p DPDT centre off 88p DPDT biased both	ROTARY: Mains DP 2	250V 4 Amp on/off 68p	Pin insertion tool 185p VERO WIRING PEN	Bimboard 1 575p Superstrip SS2 1350p	26 way 175p 200p 150p 24 34 way 205p 236p 160p 32	0p 0-10mA 0-50mA	DC or 250V AC RL-100 53R Coil, 6V DC (5V4 to 9V9) 190p RL6-111 205R Coil, 12V DC (10V7 to
ways 145p DPDT 3 positions on/on/on 185p	ROTARY: (Mak-a-swit Make a multiway sw	ch) itch. Shafting assembly	+ spool 380p Spare spool 75p	DALO ETCH RESIST PEN Plus sparetip 100p	50 way 235p 270p 200p 39	0-500mA 0.aA 0.2A	19V5) 195p RL6-114 740R Coil, 24V DC (22V to 37V) 200p
4-pole 2 way 220p SLIDE 250V:	has adjustable stop.	Accommodates up to 9/12 way + DP switch). 90p	Combs 8p FERRIC CHLORIDE	ULTRASONIC	EURO CONNECTORS	0.25V 0.50V AC 0.300V AC	
DPDT 1A 14p DPDT 1A c/off 15p DPDT ½A 13p	WAFERS: (make belo	re break) to fit the above	1 lb bag Anhydrous 195p + 50p p&p	TRANSDUCER 40KHz 475 pr	Gold Flashed Female Socket Male	"S" "VU" 490p each	ASTEC UHF MODULATORS Standard 6MHz 375p Wideband 8MHz 550p
PUSHBUTTON 6A. with 10mm Button	way; 3 pole/4 way; 4 po Mains DP 4A Switch t	pole/12 way; 2 pole/6 ple/3 way; 6p/2 Way 65p o fit 45p	COPPER CLA		DIN41617 31 way 170p — — 1 DIN41612	75p 32.768KHz 100 100KHz 545	
SPDT latching 150p DPDT latching 200p SPDT moment 150p	Spacers 4p. Screen 6		Fibre Single glass side 6" x 6" 100	d sided 0 125p	2 x 32 A + B 275p - 220p 2 DIN41612 2 x 32 A + C 295p - 240p 3	100m 1MHz 275	BUZZERS miniature, solid-state 6V; 9V & 12V 70p
DPDT moment 200p Mini Non Locking Push to Make 15p	ROCKER: 5A/250V SI ROCKER: 10A/250V SI ROCKER: 10A/250V SI	SPDT 38p	6" x 12" 175		DIN41612 3 x 32 A + B + C 360p 385p 280p 3	1.6MHz 395	PIEZO TRANSDUCERS PB2720 70g
Push to Break 25p DIGITAST Switch	ROCKER: 10A/250V (OPST with neon 85p	DIL SOCKETS Low Wire	EDGE CONNECTORS	DIL PLUG (Header) Solder IDC 14 cm 40p 90p RIBBON CAI	1.8MHz 545 1.8432M 250 2.0MHz 225 2.4576M 200	LOUDSPEAKERS Miniature, 0.3W- 8Ω
Assorted Colours 75p each	Decade Switch Module B.C.D. Switch Module Mounting Cheeks (pe	298p	8 pin 8p 25p 14 pin 10p 35p 16 pin 10p 42p	2x6 way - 111p 2x12 way - 180p 2x15 way - 185p 2x18 way 210p 175p	16 pin 48p 105p price per 24 pin 88p 178p Grey (foot 3.12MHz 240	2", 2¼", 3" 80p 2½"40n 64n or 80n 80p 6" x 4" 8n 200p 7" x 5" 8n 225p
وق	TURNED PIN I	ow Profile DIL SOCKET	18 pin 16p 52p 20 pin 20p 60p 22 pin 22p 65p	2x22 way 215p 250p 2x23 way 175p — 2x25 way 285p 275p	40 pin 250p 255p 16 way 25p 20 way 30p	40p 3.6864M 300 50p 4.0MHz 150 4.032MHz 290	8" x 5" 8Ω 250p
GAS/SMOKE DETECTORS	Single ended DI 24 inches 145p Double ended DI	P (Header Plug) Jumper 185p 240p 380p P (Header Plug) Jumper	24 pin 25p 70p 28 pin 28p 80p 40 pin 30p 90p	2x28 way 190p — 2x30 way 310p — 2x36 way 360p —	ZIF TEXTOOL 28 way 55p DIL SOCKETS 34 way 80p 40 way 70p	80p 4.19430M 200 85p 4.433819M 100 90p 4.608MHZ 200	MONITORS
TGS812 or TGS813	6 inches 185p 12 inches 198p 24 inches 210p	205p 300p 485p 215p 315p 480p 235p 345p 540p		2x40 way 380p - Pitch 20 way 65p	24 pin 575p 50 way 100p 1 28 pin 695p 40 pin 845p	5.185MHz 300	● ZENITH — 12" Green, Hi- Resolution Popular £68
£6 each		370p 480p 525p (Ribbon Cable Assembly) or Socket Jumper Leads 36"	ANTEX SOLD	ERING IRONS CS17W 545p	'D' CONNECTORS	5.24288M 390 6.0MHz 140 6.144MHz 150 6.5536MHz 225	MICROVITEC 1431. 14" Colour RGB input. Connecting cable incl. £165
		n 26 pin 34 pin 40 pin 200p 260p 300p	C18W 550p; Spare Bits 85p; Iron Stand 175p;	XS25W 570p Elements 230p	9 15 25 way way way w Male	7.0MHz 150 7.168MHz 250 7.7328MHz 250	MICROVITEC 1451. 14" Medium resolution £265
	ORMERS	VOLTAGE REG 1A TO220 Plas + ve	GULATORS stic Casing	SOLDERCON PINS	Solder lugs 80p 105p 160p 2 Angle pins 150p 210p 250p 3 PCB pins 120p 130p 195p 2	50p 7.68MHz 200 8.0MHx 150 8.089333M 395	KAGA 12". Med-res, RGB Colour. Has flicker-free charac-
100mA pcb mounting, Ministure	12-0-12V; 15-0-15V @ 98p 9, Split Bobbin 9V-0.15A; 2x12V-0.12A;	5V 7805 50p 12V 7812 50p 15V 7815 45p	7905 50p 7908 60p 7912 50p	or DIL Sockets 100 pins 45p 500 pins 195p	Female Solder lugs 105p 160p 200p 3 Angle pins 185p 215p 290p 4 PCB pins 150p 180p 240p 4	40p 10.0MHz 175	ters. Ideal for BBC, Apple, VIC, etc £195 (car £7) • KAGA 12". As above but
2x15V-0.1A	235p 9V-0.3A; 2x12V-0.25A; 280p	18V 7818 45p 24V 7824 50p	7915 50p 7918 50p 7924 50p	ALUM BOXES	COVERS 80p 75p 75p 9	10.5MHz 250	Hi-Resolution £259 (car £7) Connecting Lead for KAGA
Standard Split Bobbin to 6VA: 2x6V-0.5A; 2x15V-0.25A	ype. x9V-0.4A; 2x12V-0.3A; 250p	100mA TO92 Plastic pac 5V 78LO5 30p 6V 78LO6 30p	kage 79LO5 5 0p	3 x 2 x 1" 85p 4 x 2½ x 2" 100p 4 x 2½ x 2½" 103p	IDC 25 way 'D' Plúg 385p; Socket 450	P 12.528M 300 14.31814M 170 15.0MHz 240	£5 Carriage £7 Securicor
0.5A; 2x15V-0.4A, 2x20 24VA; 2x6V-1.5A; 2x9V	V-1A; 2x9V-0.6A; 2x12V- V-0.3A 345p (35p p&p) -1.2A; 2x12V-1A; 2x15V-	8V 78LO8 30p 12V 78L12 30p 15V 78L15 50p	79L12 50p 79L15 60p	4 x 4 x 2" 105p 4 x 4 x 2½" 120p 5 x 4 x 1½" 99p		2) 16.0MHz 220 18.0MHz 180 175p 18.432M 150	
0.8A; 2x20V-0.6A 50VA: 2x6V-4A; 2x9V-2.5 2x20V-1.2A; 2x25V-1A; 2: Specially wound for Mu	385p (60p p&p) (A; 2x12V-2A, 2x15V-1.5A; x30V-0.8A 520p(60p p&p)	ICL7660 248p RC4194 375p RC4195 160p	TAA550 50p TDA1412 150p 78H05 + 5V/5V 550p	5 x 4 x 2½" 120p 5 x 2¾ x 1½" 90p 5 x 2¾ x 2½" 130p	36" long, Double Ended, M/M 36" long, Double Ended, F/F	10p 19.968MHz 150 195p 20.0MHz 200 £10 24.0MHz 170	BROTHER HR15
50VA: Outputs +5V/5 -12V at 1A 100VA: 2x12V-4A; 2	6A; +12V, +25V, -5V, 820p (60p p8p)	LM309K 135p LM317K 250p LM317KP 450p	78H12+12V/5A 840p 78HG + 5V to + 25V 5A 585p	6 x 4 x 2" 120p 6 x 4 x 3" 150p 7 x 5 x 3" 180p 8 x 6 x 3" 210p	36" long, Dauble Ended, M/F AMPHENOL CONNECTORS	24.930MHz 325 26.69M 150 27.648M 170	PRINTER A high quality Daisy Wheel printer
2x25V-2A; 2x30V-1.5A;	2x50V-1A 965p (75p)	LM323K 450p LM337 175p LM723 Var 30p	79HG - 2.25V to -24V, 5A 685p 78S40 225p	8 x 6 x 3" 210p 10 x 4 x 3" 240p 10 x 7 x 3" 275p 12 x 5 x 3" 280p	IDC Sol 24 way EEE 475p 47 36 way Centronix 525p 47	Op 48.0MHz 240	at the price of a Dot Matrix printer.
mai postal charge		78\$40 225p	1207	12 x 8 x 3" 295p	24 way Female 490p 45	0p 116.0MHz 300	Price £339 (car. £7)
CMOS 4072 4073 4000 201 4075	26 4538 25 4539	275 80 90 ELECTRONIC	s	COMPUTER	CORNER		RUM 32K UPGRADE
4001 25 4075 4002 25 4075 4006 75 4076	7 25 4543 3 25 4544	70 LEDs with clips 150 TIL209		ONITOR, Medium resolut	tion	RAM Upgrade K	K Spectrum to full 48K with our (it. Very simple to fit. Fitting
4008 60 408	2 25 4549 5 60 4553	400 TIL212 Yel. 1	EPSON RX	80 F/T Printer	£229 £245 £318	instructions supp	£22
4011 25 4089 4012 25 4093 4013 60 4094	9 125 4555 37 4556 70 4557	35 Amber 1 55 0.2" Bi colour 250 Red/Green 100	● KAGA/TAX	AN KP810 Printer	£435 £235 £339	SPECTRUM	CENTRONICS/RS232
4014 60 4095 4015 60 4096 4016 40 4097	100 4559 7 275 4560	120 Green/Yellow 115 395 0.2" Tri colour 180 Red/Green/Yellow 8	BROTHER	HR15 Daisywheel	£339 £339	PRIN ★ It was the first! It i	TER INTERFACE
4018 601 4093	110 4562	104 Hi-Brightness Red 5 350 High-Bri Green or 165 Yel 250 Flashing red	8 TEXEPRO	M ERASER — Erases up	to 25 Eproms. Has a built.in £30	★ Centronics and hand-shaking.	BI-DIRECTIONAL RS-232 with full M LLIST and LPRINT.
4042 43 4163 4021 58 4163	96 4569 96 4572 96 4580	175 0.2" red 5 45 Square LEDs, Red,	SPARE UV	Lamp Bulb	£6	★ Spfit-Speed Oper (Use it to communication)	ation for RS-232. unicate with the BBC MICRO or
4023 30 4175 4024 50 4194 4025 22 4408	105 4582 850 4583	125 Rectangle Stackable 99 LEDs 100 Red Green or Yellow 1		ran rold paper (1000 shi	eets) £7 (Carr. 150p)	★ Configuration pro	ace * & Microdrive compatible. ogram creates customised M/C driver
4026 90 4408 4027 43 4410 4028 45 4411	725 4585 750 4597	330 Green or yellow 2	THE ABOVE IT	MS. BE SATISFIED BE	DEMONSTRATION ON ANY OF	to suit your printer. * HI-RES screen SEIKOSHA, STAR, S	dumps in 2 sizes on EPSON, SHINWA, MANNESMAN TALLY, NEC,
4028 45 4411 4029 75 4412 4030 35 4418 4031 130 4419 4032 70 4422	5 590 40085 280 40097 770 40098	90 SFH205 Detector 11 45 TIL32 Infra Red 5 42 TIL78 Detector 5	8 OUR DESCRIP	TIVE MICRO PERIPHE	RALS LEAFLET.	an extra.	c. This is a STANDARD FEATURE! Not h TASWORD TWO and most pro-
4033 130 4440 4034 148 4440 4035 70 4450	900 40101 360 40102	130 TIL100 7 140 BARGRAPH, Red 10	i0 '5			fessional programs. Complete Unit incl. 8	Software tape + manual £29.95
4037 115 4490	395 40104 395 40105	412 segments 27 120 220 ISOLATORS 60 IL74 14		-		Special Interface Ca	able £8
4040 60 4502 4041 57 4503	80 40107 40 40108 99 40109	55 ILD74 14 325 ILQ74 27 100 TIL111/2/4 7	5	DISC DR	RIVES		
4043 42 4505 4044 50 4506	100 40114	235 ILCT6 Darlington 13 240 TIL117 12 194 4N33 Photo 75 Darlington 13	15	DRIVES CASED with			IICROCOMPUTER & CCESSORIES
4046 60 4506 4047 60 4510 4048 55 4511	55 40174 55 40175	75 Darlington 13 75 75 7 Segment Display 220 TIL312.3" CA 12	CS100 - S	win Cased with PSU, 40	O track, 5¼" S/S 100K £129 Track, 5¼" S/S 200K £265	IDDO:	Model B Only £3@5
4049 38 4512 4050 35 4513 4051 70 4514 4052 60 4515	150 40182 115 40192	80 TIL313.3" CC 12 75 TIL321.5" CA 14 95 TIL322.5" CC 14	0 CD400 - T	ingle Cased with PSU, 80 win Cased with PSU, 80 11 51/4" SLIM LINE DISC	7 Track, 5%" S/S 200K £175 track, 5%" S/S 400K £349	We stock th	ne full range of BBC
4053 60 4517 4054 85 4517 4055 85 4518	55 40194 7 275 40195 8 48 40244	70 TIL729/730 14 75 DL704.3" CC 12 196 DL707.3" CA 12	Double Side	d, Double Density, Track	Density 96 TPI, Track to track access	Drives (Top quality	Hardware & Software like, Disc Cumana & Mitsubishi), Diskettes, Paper, Interface Cable, Dust
4056 85 4519 4057 1000 4520 4059 435 4521	32 40245 53 40257 115 40373	196 FND357 Red 12 196 FND500 13 220 3" Green CA 15	MITSUBISHI Single Silmline, 51/4" Cased with PSU. DSDD. 1 Mega (400 K with BBC)			Covers, Cassette	Recorder & Cassettes, Monitors, y made Cables, Plugs & Sockets),
4080 68 4526 4081 500 4526 4082 986 4527	60 45106 65	220 6" Green CA 21 586 3" ± 1 Red CA 15 3" ± 1 Green CA 15 LCD 3½ Digits 49	60 (800 K with		£425	Plotter (Graphic Ta pen Kit, Joysticks	ablet) EPROM Programmer, Light- , Sideways ROM Board, EPROM
4063 85 4528 4066 45 4528	90 ORP12	120 LCD 3½ Digits 49 120 LCD 4 Digits 53 85 LCD 6 Digits 62 86 Reflective Switch 22	5 • 10 3M Disk	ettes Single side Doub	le density£13	ticated Watford's	ode ROM. The highly sophis- 16K BEEB DFS, WORDWISE,
4067 245 4530 4068 26 4531 4069 25 4532 4070 25 4534	2 65 BPX25	250 SLOTTED Optical 320 Switch similar to RS 225 Comp.'s 29	● 103M Disk	N.B Carriage on Drive	ole density £23		ware (Educational Application & etc, etc, Please send SAE for our
70/1 20	1.2.00			Camage on Only		document leader.	

ETI JANUARY 1985

MAIL ORDERS: Unit 1, Hill Farm Industrial Estate, Boxted, Colchester, Essex CO4 5RD. Tel. Orders: Colchester (0206) 36412. Telex: 987756.





ACCESS AND BARCLAYCARD **WELCOME**

MIN. D CONNECTORS

Plugs solder lugs Right angle	9 way 55p 90o	15 way 66p 135p	25 way 90p 200p	37 way 150p 350o
Sockets solder lu Right angle	9880p 120p	100p 180p	135p 290p	260p 420p
Covers	100p	90p	100p	110p

SCRs

ı	SOLDENING INONS	
١	Antex CS 17W Soldering iron	430
ı	2.3 and 4.7mm bits to suit .	85
ı	Antex XS 25W soldering iron	1530
ı	3.3 and 4.7mm bits to suit	85
ı	Solder pump desoldering tool	480
۱	Spare nozzle for above .	70
ı	10 metres 22 swg solder	100
ı	0.5kg 22 swg solder	750

Verobloc . 395 Veroboard Size 0.1 in matrix

CABLES			
20 metre pack sing ing cable ten differ			
Speaker cable .			10p/m
Standard screened	- 37		16p/m
Twin screened .	- 31	33	24p/m
2.5A 3 core mains			23p/m
10 way rainbow rit	boi	1	26p/ft
20 way rainbow rit	bai	1	47p/ft
10 way gery ribbon	١.		14P/ft
20 way grey ribbon			28p/ft

▶1N4001 1N4002 1N4006 1N4007 1N5401 1N5404

REGULATORS

78L05 78L12 78L15 7805 7812 7815 LM317K LM317T LM323K

DIODES

BY127 OA47 OA90 OA91 OA200 OA202

55

HARDWARE	
PP3 battery clips	
Red or black crocodile clips	. 1
Black pointer control knob	. 1
Pr Ultrasonic transducers	39
▶6V Electronic buzzer .	6
▶12V Electronic buzzer	7
▶PB2720 Piezo transducer .	7
▶64mm 64 ohm speaker .	70
▶64mm B ohm speaker .	7
20mm panel fuseholder	2
Red or black probe clip.	3
4mm terminals	3
12 way 'chocolate' block	2
ultra-min. 6 or 12v rel. SPDT	13
ditto, but DPDT	19

EURO CONNECTORS

TRIACS 400V 8A 400V 16A 400V 4A 50 BR100

Gold flashed Contacts: plug 64 way A+B 195 64 way A+C 220 96 way A+B+C 320

Rt. angle Wirew plug socke 195 230 220 270 320 330

	Polyester, radial leads, 250v, C280
ı	type: 0.01, 0.015, 0.022, 0.033 -
Н	6p. 0.047, 0.068, 0.1 · 7p; 0.15,
ı	0.22 - 9p; 0.33, 0.47 - 13p; 0.68 -
ı	20p; 1u - 23p.
Н	Electrolytic, radial or axial leads:
ı	0.47/63V, 1/63V, 2,2/63V, 4,7/63
ı	10/25V - 7p; 22/25V, 47/25V - 8o
ı	100/25V - 9p; 220/25V - 14p;
ı	470/25V - 22p; 1000/25V - 30p;
١	2200/25V - 50p.
ı	Tag and power supply electrolytics
ı	2200/40V - 110p; 4700/40V - 160

CAPACITORS

2200/40V - 110p; 4700/40V - 160
2200/63 V - 140p; 4700/63 V - 230
Polyester, miniature Siemens PCB:
1n, 2n2, 3n3, 4n7, 6n8, 10n, 16n, 7
22n, 33n, 47n, 68n, 8p; 100n, 9p;
150n, 11p; 220n, 13p; 330n, 20p;
470n 26p; 680n, 29p; 1u 33p;

vrap t	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:
65 95	15/16V - 30p; 22/16V - 27p; 33/ 16V - 45p; 47/6V - 27p; 47/16V
25	70p; 68/6V - 40p; 100/10V - 90p
45	Cer. disc. 22p-0.01u 50V, 3p eacl

Mullard ministura ceramic plate: 1.8pF to 100pF 8p sech. Polystyrene, 5% tol: 10p-1000p, 8p; 1500-4700, 8p; 6800 0.012u, 10p. Trimers: Mullard 808 series: 2-10 pri, 22p; 2-22pF, 30p; 5-5-65pF, 35p

pr , 22p, 2·	¿zpr,	30p, 5.5-05p	F,300
BRIDGE		2A 200V 2A 400V	40
RECTIF	ERS	6A 100V	45
1A 50V	20	6A 400V 96 VM18 DIL (
1A 400V	35	200V	50

CONNECTORS

SWITCHES

DIN	Plug	Skt	Jack	Plug	Skt						
			2.5mm								
3 pin	12p	10p	3.5mm	9p	9p						
5 pin	13p	11p	Standar	d16p	20p						
Phono	10p	12p	Stereo	24p	250						
1mm	12p	13p	4mm	18p	17p						
UHF (CB) Connectors:											
PL259	Plug	40p.	. Reduce	er 14p	٥.						
SO239	squa	re ch	BSSIS SKI	38p.							
SO239	S rou	ınd c	hassis sk	t 40p							
IEC 3	pin 2	50 V /	6A.								
Plug ch	assis	mou	inting .		380						
Socket	free	hang	ing		60p						
Socket	with	2m	lesd .		120p						

Submin toggle:
SPST 550, SPDT 60p, DPDT 65p,
Miniature toggle:
SPDT 80p, SPDT centre off 90p,
DPDT 90p, DPDT centre off 100p,
Standard toggle:
SPST 350, DPDT48p
Miniature DPDT glide 14p,

Rotary type aug.
1P12W, 2P6W, 3P4W all bog1P12W, 3P4W a

SOCKETS

TRANSFORMERS

12VA: 2x6V@1A; 2x9V0 2x15V@0.4A;2x2QV@0,3	
2x12V@0.3A;2x15V@0.	
Standard. Chassis Mounti 6VA: 2x6V@0.5A; 2x9V	@0.4A
6VA PCB Mounting 2x6V@0.5A;2x9V@0.4A 2x12V@0.3A;2x15V@0.3	25A 270p
3VA PCB Mounting 2x6V@0.25A;2x9V@0.1! 2x12V@0.12A;2x15V@0	

COMPONENT KITS

6VA: 2x6V@0.5 2x12V@0.3A;2x 12VA: 2x6V@1, 2x15V@0.4A;2x	15V@0.25A 240p A; 2x9V@0.6A	Double sided Spot face cutter Pin insertion tool Wiring pen Spare spool 75p Combs					
MICRO	27128-250 1225	6800	200	6522	330		
WITCHU	6116P3 480	6802	280	6532	520		
	6264P15 2980	6809	600	6561	540		
2716 310	4116P4 70	6810	140	8085A	320		
2532 380	4164-15 480	6821	140	8156	380		
2732 one time	41256-15 2850	6840	360	8251	350		
programmable	Z80A CPU 290	6850	165	8253	370		
360	Z80A P10 320	6852	240	8255	320		
2732 430	Z80A CTC 320	6875	500	8259	400		
2764-250 495	Z80A S10 B80	6880	100	MC1488	70		
2764 BBC 495	Z80A DMA 880	6502	370	MC1489	70		

35 70 95

VERO

١	1N914 ▶1N4148	4	400mWzen 1 3W zeners	6 13
ı	ОРТО			
ı	3mm red	_ 8	5mm red	8
ı	3mm green	11	5mm green	11
ı	3mm yellow	/ 11	5mm yellow	11
٠	Clips to suit	· 3p	each.	
п	Rectangular		TIL32	40
ı	red	12	TIL111	60
ı	green	17	T1L78	40
п	yellow	17	ORP12	85
п	1LD74	95	ILQ74	185
1	TIL38	35	TIL100	75
1	2NS777	45	Tri-color Le	d 35
1	Seven segme	ent di	splays:	
н	Com cathod	le.	Com anode.	

1			▶1N4001	3	400 V 4A 50 BH100 25
1	1	0 8 7	1N4007 1N5401	3 7 7 12	NEW 1985 CATALOGUE Our new fully illustra-
Combination	0 2 4 148	8	1N5406 400mWzen	17	Rapid information on over 3000 product lines at the most competitive prices in the market.
To your copy today	го				Catalogue I tage or free with orders
String S	ed				
Sult 30 each	reen				
gular: TIL32 40 12 TIL111 60 17 TIL28 40 17 ORP12 85 95 ILQ74 185 35 TIL100 75 egment displays: whode. Com anode. 0.3" 95 DL707 0.3" 95 00.5"100 FND5070.5"100 DILLED display.red 180 perbright LED 250mcd perbright LED 250mcd perbright LED 250mcd 20 COMPUTER CONNECTORS 24 way lee or ZX81 22 way lee EIDC. 450 36 way Centronia IDC. 450 36 way Centronia IDC. 490 10 way 14 34 way 58 16 way 25 40 way 68 20 way 28 50 way 99				v 11	* * * * * * * * * * * *
12 TiLi 1 60 17 11 70 17 17 17 18 17 17 18 17 18 17 18 18				40	COMPLITER CONNECTORS
17 TIL78 40 17 OPP12 85 95 ILQ74 185 35 TIL100 75 egment displays: shode. Com anode. 0.3" 95 DI-707 0.3" 95 00.5"100 FND5070.5"100 DILLED display.red 180 perbright LED 250mcd perbright LED 250mcd 180 Way Centronix IDC. 490 190 Way Centr	guiar				
17 ORP12 85 95 ILQ74 185 95 ILQ74 185 7 45 Tricolor Led 35 28 egment displays: 150.3" 95 DO.5"100 FND5070.5"100 01.LED display. red 180 10 LED display. red 180 10 LED display. red 180 10 perbright LED 250mcd 180 yes 12 4 way 184 10 way 14 34 way 58 16 way 25 40 way 58 16 way 25 40 way 69 20 way 28 50 way 9					
95 ILQ74 185 35 TIL100 75 45 Tri-color Led 35 egment displays: shode. Com anode. 0.3" 95 Dr.270 3 98 00.5"100 FND5070.5"100 DILLED display.red 180 perbright LED 250mcd perbright LED 250mcd 20 way 2 Experience price per foot 10 way 14 34 way 58 16 way 25 40 way 68 20 way 28 50 way 90					
35 TIL 100 75 7 45 Tri-color Led 35 egment displays: 24 way IEEE IDC. 450 36 way Centronix IDC. 490 RIBBON CABLE 0.03" 95 Drice per foot 0.15" LED display, red 180 10 way 25 40 way 58 16 way 25 40 way 58 16 way 25 40 way 99					
7 45 Tri-color Led 35 gyment displays: thode. Com anode. 0.3" 95 Dr. 107 0.3" 95 Dr. 107 0.3" 95 Dr. 107 0.3" 95 Dr. 107 0.3" 95 Dr. 100 FND507.0.5" 100 DILLED display.red 180 perbright LED 250mcd 20 way 25 40 way . 68 perbright LED 250mcd 20 way 28 50 way . 90					AMPLIENCE BLUCE
## asyment displays:	7				
thode, Com anode, 0.3" 95 DL707 0.3" 95 DL707 0.3" 95 DL070 3."95 DL050"100 FND5070.5"100 Grey Ribbon cable. Price per foot DIL LED diplays, red 180 16 way 25 40 way . 68 16 way 25 40 way . 68 20 way 28 50 way . 90	, Learne			u J J	
0.3 96 DL707 0.3 95 MD5070.5 100 FND5070.5 100 FND5070.5 100 DL LED display, red 180 16 way 14 34 way 58 16 way 25 40 way 68 20 way 28 50 way 90					
00.5"100 FND5070.5"100 Grey Ribbon cable. Price per foot 10 way 14 34 way 58 16 way 25 40 way 68 20 way 90					RIBBON CABLE
DIL LED display, red 180 10 way . 14 34 way . 58 16 way . 25 40 way . 68 20 way . 28 50 way . 90					Grey Ribbon cable. Price per foot
uperbright LED 250mcd 16 way 25 40 way 68 20 way 28 50 way 90					10 way , 14 34 way . 58
20 way 28 50 way . 90					
26 way . 38 60 way . 100	upero D	it ign t	LLD 250mcd	'	
	,				26 way . 38 60 way . 100

****	* 7
COMPUTER CONNECTO	RS
ZX81 2 x 23 way edge connec	
wire wrap for ZX81 1 SPECTRUM 2 x 28 way edge	50
connector wire wrap	200
	50
	190
RIBBON CABLE	
Grey Ribbon cable. Price per f	00t 58

		CININ	CUIU	AAD-T	
connector 150 / edge		РСВ	PCB	Socket	Edge
200		Plug	Plug		Conn.
		St.	Rt. an	a.	
450	10 way	70	70	70	_
490	16 way	75	80	80	-
	20 way	90	90	95	130
e per foot	26 way	105	110	115	155
	34 way	115	130	130	180
	40 way	140	140	145	210
	50 way	165	165	170	240
ey . 90	60 way	195	195	200	-

BOXES

SOCKETS Low Wife	COMPONENT KITS									
8 pm /r 28p 14 pm (r) 45p 16 pm (r) 5p 18 pin 12p 60p 20 pin 13p 68p 22 pm 15p 75p 24 pin 15p 95p 40 pin 15p 95p 40 pin 430p 28 pin 480p 40 pin 595p	An ideal opportunity for the beginner or the experienced constructor to obtain a wide range of components at greatly reduced prices. XM 1 Resistor kit, Contains 10 of each value from 4.7 ohms to 1M (total 6 80 resistors). Ceramic Cap. kit, 5 of each value - 220 to 0,01u (135 caps) Polysster Cap. kit, 5 of each value from 0,01 to 1u F (65 caps) Preset kit, Contains 5 of each value from 100 ohms to 1M (total 65 presets Nut and Bolt kit (total 300 items): 180p. 25 6BA X''' bolts 50 6BA washers 25 6BA X''' bolts 50 6BA washers 50 6BA nuts 25 4BA X'' bolts 50 6BA nuts 25 4BA X'' bolts LM358 50 LM3915 29E NESS7 130 TRACOM									
107611 9	LM358 50 LM3915 265 NE567 130 TDA1024 115									
LINEAR ICL7621 19										
555CMOS 80 ICL7622 20										
556CMOS 150 ICL8038 29										
709 35 ICL8211A 22										
741 16 ICM7224 78										
748 35 ICM7555 8										
AY31270 720 ICM7556 15										
AY38910 390 LF347 15										
AY38912 430 LF351 4										
CA3046 65 LF353 7	LM711 60 ML926 210 SN76477 380 TL170 50									
CA3080E 65 LF356 9										
CA3089 200 LMIOC 32	LM733 70 ML928 210 SP0256AL2425 ULN2003 80									
CA3090AQ 375 LM301A 3	LM741 16 ML929 210 Speech data 50 ULN2004 80									
CA3130E 85 LM311 4	LM747 60 NE529 225 THAROO 70 XR2206 365									
CA3140E 38 LM318 13	LM748 35 NE531 135 TBAR10 90 ZN414 80									
CA3160 95 LM324 4	LM1458 35 NE544 170 TBA820M 65 ZN423 135									
CA3136 100 LM3342 8										
CA3189 260 LM3352 12	LM3900 45 NE556 45 TCA940 165 ZN425E 350									
CA3240E 100 LM339 4										
ICL7106 680 LM348 6										
BC54	5 BFR40 23 2N1613 30 2N3906 10 ZN428E 450									
TRANSISTORS BC54	ZN459 205									
TRANSISTORS BC54										

CA3140E CA3160 CA3136 CA3189 CA3240E ICL7106	38 95 100 260 100 680	LM318 LM324 LM3342 LM3352 LM339 LM348	135 45 85 125 40 60	LM3 LM3 LM3	1458 2917N8 3900 3909 3914	45 85 265	NE531 NE544 NE555 NE556 NE565 NE566	135 170 20 45 115 140	TBA810 TBA820M TBA950 TCA940 TDA1008 TDA1022	90 65 220 165 320 490	ZN414 ZN423 ZN424P ZN425E ZN426E ZN427E ZN428E	80 135 130 350 300 600 450
TRANS	isto	RS	BC548 BC549 BC557	5 10 10	BFR40 BFR80 BFR81		2N221	8A 45	2N3906 2N4037 2N4058	10 45	ZN459 ZN1034E	285
AC125 35	BC1	158 11	BC558	10	BFX29				2N4060	10	TIP35C	405
AC126 30			BCY70	16	BFX84				2N4061	10	TIP36A	125 115
AC127 30			BCY71	16	BFX85				2N4062	10	TIP36C	130
AC128 30			BCY72	16	BFX86				40360	40	TIP41A	45
AC176 25		68C 10	BD115	55	BFX87	3			40361	50	TIP42A	45
AC187 25		69C 10	BD131	40	BFX88	3	3 2n2646		40362	50	TIP120	60
AC188 25			BD132	40	BFY50	2		4 28	40408	50	T1P121	60
AD142 120			BD133	50	BFY51	2			2N5457	30	TIP122	60
AD161 42			BD135	35	BFY52	2			2N5458	30	TIP141	110
AD162 42			BD136	35	BFY53	3			2N5469	30	TIP142	120
AF124 60			BD137	35	BFY55	30			2n5485	35	TIP147	120
AF126 50			BD138	35	BFY56	31			2N5777	45	TIP2955	70
AF139 40 AF186 70		82 10 82L 10	BD139	35	BRY39				2N697	20	TIP3055	60
AF239 55			BD140	35	BSX20	2:			2N698	40	T1543	40
BC107 10		83L 10		110	BSX29	3			2N706A	20	T1543	40
BC107B 12				110	BSY95				2N709	25	TIS44	45
BC107B 12		84L 10	BD222	85	BU205	161			2N918	35	TIS45	45
BC108B 12			BF180 BF182	35 35	BU206	201			TIP29	35	T1590	30
BC108C 12		12L 10	BF 182	35	BU208 MJ295	170			TIP29A	35	T1591	30
BC109 10			BF 185	25	MJE34				TIP29B	35	VN10KM	65
BC109C 12		13L 10	BF 194	12	MJE52				TIP29C	35	VN46AF	94
BC114 22			BF 195	12	MJE52				TIP30	35	VN66AF	
BC115 22		14L 10	BF196	12	MJE30				TIP30A	35	VN88AF ZTX107	11
BC117 22			BF 197	12	MPF10				TIP30B TIP30C	35 40	ZTX107	11
BC119 35			8F 198	15	MPF 10				TIP30C	35	ZTX109	11
BC137 40			BF 199	18	MPSAO				TIP31A	35	ZTX300	14
BC139 38			BF200	35	MPSAO				TIP316	40	ZTX300	16
BC140 29			BF244B	35	MPSA1	2 2	2N377		TIP31C	35	ZTX302	16
BC141 30			BF245	35	MPSA5				TIP32A	38	ZTX304	20
BC142 28			BF256B	45	MPSA5	6 30			TIP32C	40	ZTX341	20
BC143 30			BF257	32	MPSU0	5 5			TIP33A	65	ZTX500	13
BC147 10	BC4		BF258	30	MPSU0		2N3866		TIP33A	75	ZTX501	18
BC148 10	BC4		BF 259	30	MPSU5				TIP34A	70	ZTX502	18
BC149 10	BC5	17 30	BF337	35	MPSU5	6 5	2N3904		TIP34C	80	ZTX503	18
BC157_ 11	BC5	47 5	BFR40	35	2N1181	. 2:	2N390		TIP35A	105	ZTX504	25

							_
N 5% 4.7d etal film N 1% 10o	ohm - 10M ohm - 4M7 ohm - 1M oplies to 25	1+ 2p 3p 4p + per	25+ 1p 2p 3p	CRYST 100KHz 1MHz 1 8432M 2.0MHz 2.4576M 3.276M 3.579M 4.0MHz	235 275 200 225 200 150 95 140	4.194M 4.43MH 5.00BM 6.0MHz 6.144M 7.0MHz 8.0MHz 10.0MHz 12.0MHz	lz Hz Hz
TTL	7412 7413	25 36	7440 7442	25 74	7476 7480	40 50	74 74

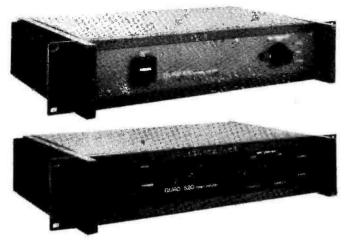
%W 5% 4 Metal filr %W 1% 1 25+ price value not	m Ophr appl	n - 1M les to 25	3p 4p i+per	2p 3p	2.0MHz 2.4576M 3.276M 3.579M 4.0MHz	225 200 150 95 140	7.0MHz 8.0MHz 10 0MHz 12.0MHz 16.0MHz	150 140 170 170 200	& sc 71 x 95 x	rews 46x22mm 71x35mm x90x55mm	86	4×2%×1 4×2%×2 6×4×2 7×5×2% 8×6×3	120
TTL		7412 7413 7414	25 36 60	7440 7442 7444	25 74 105	7476 7480 7483	40 50 65	74107 74109 74121	40 60 50	74157 74160 74161	80 90 90	74180 74181 74182	85 230 85
7400	25	7416	43	7446	130	7485	110	74122	50	74162	90	74190	120
7401	25	7417	43	7447	98	7485	38	74123	92	74163	90	74191	120
7402 7403	25 25	7420 7421	25 30	7448 7450	98 25	7489 7490	170 55	74125 74126	50 50	741 64 74165	115	74192 74193	120 110
7404	25	7422	30	7451	25	7491	80	74132	60	74167	200	74194	80
7405 7406	25 45	7427 7428	30 30	7453 7454	25 25	7492 7493	55 55	74141	80	74170 74173	170 100	74195	63 120
7407	45	7430	25	7460		7494	90	74145 74147	85 130		100	74196 74197	85
7408	25	7432	35	7472	35	7495	70	74148	105	74175	80	74198	195
7409 7410	25 25	7433	35 43	7473 7474	40 36	7496 7497	80	74150	130	74176 74177	80	74199	195
7411	25	7437	45	7475		74100	170 125	74153 74154	70 135	74179	90		
CMO	\equiv	4016	26	4034		4054	70	4081	18	4502	50	4529	80
CIVIO	S .	4017 4018	43 55	4036		4055 4069	70 400	4082	20 60	4503	45	4532	65
4000	18	4019	35	4040		4060	70	4085 4086	60	4507 4508	45 115	4534 4538	390 70
4001	18	4020	48	4041	55	4063	80	4089	120	4510	48	4543	65
4002	18	4021	55	4042		4066	24	4093	26	4511	50	4549	390
4006 4007	65 18	4022 4023	60 18	4043		4067	230 18	4094	70 70	4512	50	4553	215
4007	50	4023	35	4046		4068 4069	18	4095 4097	260	4514 4515	115 115	4555 45 56	50 50
4009	40	4025	18	4047		4070	22	4098	70	4516	48	4559	390
4010	40	4026	120			4971	18	40106	38	451B	48	4560	110
4011	18	4027	28	4049		4072	18	40109	100	4520	48	4584	38
4012	18	4028	40	4050		4073	18	40163	75	4521	110	4585	65

п	4001	18	4020	48	4041	55	4063	80	4089	120	4510	48	4543	65
П	4002	18	4021	55	4042	4.5	4066	24	4093	26	4511	50	4549	390
	4006	65	4022	60	4043	45	4067	230	4094	70	4512	50	4553	215
4	4007	18	4023	18	4044	50	4068	18	4095	70	4514	115	4555	50
п	4008	50	4024	35	4046	60	4069	18	4097	260	4515	115	4556	50
П	4009	40	4025	18	4047	52	4070	22	4098	70	4516	48	4559	390
И	4010	40	4026	120	4048	50	4971	18	40106	38	4518	48	4560	110
1	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
Н	4014	50	4030	18	4052	48	4076	60	40175	75	4527	60	7 - 6	
	4015	42	4031	125	4053	60	4077	24	40193	90	4528	45		
1			L\$20	22	LS75	38	LS123	70	LS161	60	L\$221	78	LS365	42
н	LS T	TL.	L521	22	LS76	28	LS125	37	LS162	60	LS240	105	LS366	42
П			L522	22	LS78	28	LS126	37	LS163	60	LS241	80	LS367	42
	LS00	22	LS26	22	LS83	68	LS132	53	LS164	70	L5242	80	L5368	42
ч	LS01	22	LS27	22	LS85	82	LS136	35	LS165	95	LS243	80	LS373	80
	LS02	22	LS30	22	LS86	, 35	L513B	48	LS166	88	L5244	80	LS374	80
	LS03	22	LS32	22	LS90	4 40	LS139	48	LS170	120	LS245	88	LS375	55
	LS04	22	LS37	22	LS92	50	LS145	92	LS173	80	LS247	77	LS377	100
ч	LS05	22	1.S3B	22	LS93	45	L\$147	130	LS174	60	LS251	55	LS378	88
М	LS08	22	LS40	22	LS95	58	LS148	115	LS175	60	LS257	55	LS390	82
1	LS09	22	LS42	60	LS96	120	LS151	55	LS190	75	LS258	55		
													LS393	82
Э	LS10	22	LS47	78	LS107	42	LS153	80	LS191	55	LS259	90	LS393	115
1	LS10 LS11	22 22	LS47 LS48	78 78	LS107 LS109	42	LS153 LS154	80 220	LS191 LS192	55 75	LS259 LS266	90 28		
	LS10 LS11 LS12	22 22 22	LS47 LS48 LS51	78 78 22	LS107 LS109 LS112	42 42 42	LS153 LS154 LS155	80 220 55	LS191 LS192 LS193	55 75 75	LS259 LS266 LS273	90 28 80	LS399	115
	LS10 LS11 LS12 LS13	22 22 22 35	LS47 LS48 LS51 LS55	78 78 22 22	LS107 LS109 LS112 LS113	42 42 42 32	LS153 LS154 LS155 LS157	80 220 55 48	LS191 LS192 LS193 LS195	55 75 75 60	LS259 LS266 LS273 LS279	90 28 80 55	LS399 LS541	115
-	LS10 LS11 LS12	22 22 22	LS47 LS48 LS51	78 78 22	LS107 LS109 LS112	42 42 42	LS153 LS154 LS155	80 220 55	LS191 LS192 LS193	55 75 75	LS259 LS266 LS273	90 28 80	LS399 LS541	115

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DIGEST



Professional Quads

Quad have produced a number of domestic hi-fi amplifier designs over the years, many of which have found their way into recording studios, theatres and other professional environments, but they have never produced an amplifier intended specifically for professional applications. Now, perhaps having noted the success of other companies who market Quad amplifiers in 19" rack format, Quad have introduced two rack-mounting amplifiers of their own, one single channel and one dual channel and both featuring XLR connectors for input and output.

The Quad 510 is a single channel power amplifier which can deliver at least 100 watts into any load from two to 100 ohms. A multipletapped output transformer allows

it to match a range of loads including 70 and 100 volt lines and a plugin card on the rear panel selects the appropriate taps. The input is 600 ohm bridging and both input and output are isolated so that amplifiers can be linked together to provide greater power outputs.

The 520 is a dual channel power amplifier which offers an output of 100 watts per channel into eight ohms and is available with optional balanced inputs. Both amplifiers use a refinement of the currentdumping concept which was used in the Quad 405 amplifier and for which the company received a Queen's Award for Technological Innovation. No specifications are quoted but the performance is said to meet the demands of the most critical listener and construction and reliability are said to be up to Quad's usual standards.

Quad Electroacoustics Ltd, St. Peters Road, Huntingdon, Cambridge PE18 7DB, tel 0480-52561.

Ferguson Monitors Developments

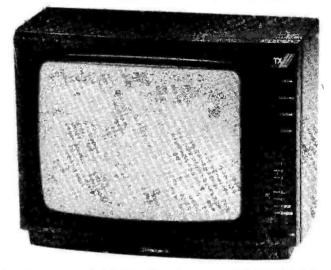
In what they see as a response to the demands of the technological revolution, Ferguson have introduced a 14" colour television set which has RGB and composite video inputs as well as the usual UHF aerial input. The new set is said to be designed with home computers, video games and video recorders in mind and its features include the ability to operate from a 12 or 24V DC supply.

The MCO1 14" TX monitor colour television is based on Ferguson's existing TX90 chassis which is mains-isolated and features a fast warm-up CRT. Eight light-action switches select the TV channel or the RGB or composite video input, allowing the connectors to be left permanently in place at the rear of set and all switching to be carried out from the front.

The tuning presets associated with the channel selectors are concealed behind a hinged panel at the front of the set. A 3.5 mm output socket allows the MC01 to be used with headphones and a foldaway aerial is also built-in.

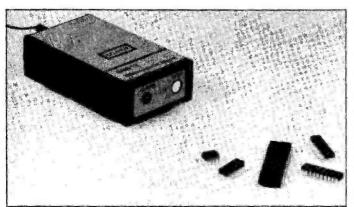
The RGB input features automatic sync polarity sensing and accepts TTL and analogue input signals. The composite video input has an adjustable pre-set gain control to ensure optimum performance over a range of input signal levels and both inputs accept a sound signal for reproduction through the set loudspeaker. Special leads will be available to connect the MC01 to most popular makes of home computer and there will also be a range of leads for use with Ferguson Videostar video recorders.

The MC01 is described as compact and lightweight and is said to offer low energy consumption. An optional adaptor allows the set to run from battery or other low-voltage DC supplies and adjusts automatically for 12 or 24V opera-



tion. Ferguson say that the set will typically run for about eight hours from a fully-charged standard (40A/h) car battery.

The company have also established an advisory service which they say is designed to help dealers and customers with queries relating to compatibility and upgrading on home computers. The service can be contacted on 01-807 3060. Thorn EMI Ferguson Ltd, Cambridge House, Great Cambridge Road, Enfield, Middlsex EN1 1UL, tel 01-363 5353.



Static Alarm

Dage Eurosem have introduced a bench-top alarmunit which detects the presence of high voltage levels and gives an audible and visual warning. The alarmis intended for use wherever CMOS and other static-sensitive devices are being handled and requires no physical or electrical connection to the device or the operator.

The EVA-12 triggers when in the presence of voltages above 400V and will typically detect a hazard

of 4-13kV (equivalent to a person walking across a vinyl floor) from a distance of between sixteen and thirty inches. The warning takes the form of an audible bleep and a flashing LED and continues for five seconds before the unit zeroes itself and returns to the alert mode. It measures 76 x 38 x 25mm (3x 1.5 x 1") and runs from a 9V battery giving a typical operational life of six months.

For further information contact Dage (GB) Ltd, Eurosem Division, Rabans Lane, Aylesbury, Buckinghamshire HP19 3RG, tel 0296-

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Wire Wrapped 6 p Red/White/Black	.01uF 5p
	.022uF
11 Colours 4p Hook up 7/2 11 Colours 3p Heavy Duty 32/2 4 Colours	.047uF
11 Colours 3n	47uF 150
Heavy Duty 32/2	POLYSTYPENE
4 Colours 15n	22nF .13n
4 Colours15p TINNED COPPER	47pF 8p
INNED COPPEH per 402 reel SWG 16	68 pF
SWG 16 80p	100pF
SWG 18 85 p	150pF 8p
SWG 20 95p	220pF 8p
SWG 22 95p	330pF 8p
SWG 24 95p	470pF 8p
EN COPPER	560pF Bp
per 20z Heel	680pFBp
SWG 16 80n	1500pF
SWG 18 90n	2200pF 8p
SWG 20 90 n	3300 pF 8p
SWG 22 90n	4700 pF 8p
SWG 24 105p	5600pF 10p
SWG 26105p	6800pF10p
SWG 28105p	.01 uF
SWG 30 110p	.022 uF 19 p
SWG 32110p	.047 uF 25 p
SWG 34 115p	.1uF
SWG 36125p	POLYESTER
SWG 38 125p	.01uF <u>.</u> 8p
SWG 40150p	.015uF8p
FIGURE 8	.022uF8p
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Per Foot	1uE 9p
10 Way 20n	15uF 15n
20 Way 40n	22uF 11n
Per Foot 10 Way 20p 20 Way 40p 34 Way 80p MAINS	33 uF 16 p
MAINS	
	.47 uF
Per Metre	.47uF
2 Core	.47uF
2 Core	.47uF
Per Metre 2 Core Oval 3A20p	.47uF
Per Metre 2 Core Oval 3A20p	474F 166p 684F 26p 14F 28p 2.24F 49p ELECTROLYTIC UF/V
Per Metre 2 Core Oval 3A20p	.47uF 16p .68uF 26p .1uF 26p .2.2uF 49p ELECTROLYTIC uF/V 1/63 8p
Per Metre 2 Core Oval 3A20p	470F 16p 68uF 26p 1uF 28p 2.2uF 49p ELECTROLYTIC uF/V 1/63 8p 2.2/50 9p
Per Metre 2 Core Oval 3A20p	47UF 16p 68UF 26p 1UF 28p 2.2UF 49p ELECTROLYTIC UF/V 1/63 8p 2.2/50 9p 4.7/63 9p
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Per Metre 2 Core Oval 3A20p	470F 16p 68uF 26p 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
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Per Metre 2 Core Oval 3A20p	470F 16p 68uF 26p 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 10/63 13p 22/10 8p 22/10 8p 22/10 10p 22/10 8p 22/11 10p 22/25 10p 22/25 10p
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Per Metre 2 Core Oval 3A. 20p Round 6A. 35p Round 6A. 50p Round 1A. 60p POWER 1 mm T&E. 45p 1.5mm T&E. 45p 2.5mm T&E. 45p 2.5mm T&E. 150p 6mm T&E. 150p TV Coax. 40p SCREENED Single Round. 17 p Twin Round. 20p Figure 8 Min. 20p Figure 8 Std. 30p 4 Core. 70p SPIRAL WRAP %"	47µF 16p 68µF 26p 1µF 28p 2.2µF 49p ELECTROLYTIC UF/V 1/63 8p 2.2/50 9p 4.7/63 9p 10/16 8p 10/25 10p 10/63 13p 22/10 8p 22/16 10p 22/25 10p 22/35 11p 22/63 15p 47/16 11p 47/16 11p 47/16 13p 47/16 15p 100/10 11p 100/16 13p 100/25 15p
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Per Metre 2 Core Oval 3A. 20p Round 6A. 35p Round 6A. 35p Round 6A. 50p Round 1A. 60p POWER 1mm T&E. 45p 1.5mm T&E. 45p 2.5mm T&E. 90p 6mm T&E. 150p TV Coax. 40p SCREENED Single Round. 17 p Twin Round. 20p Figure 8 Min. 20p Figure 8 Std. 30p 4 Core. 70p SPIRAL WRAP %" 15p WIDE RANGE OF CABLE MARKERS, SLEEVING, TIES, FIXINGSIN STOCK-PHONE FOR DETAILS.	47\(14\) 16p 68\(14\) 26p 1\(14\) 26p 2\(14\) 26p 2\(14\) 49p ELECTROLYTIC \(16\) 3 8p 10\(16\) 3 9p 10\(16\) 6 8p 10\(16\) 6 10p 2\(21\) 11p 2\(21\) 15p 2\(21\) 15p 4\(71\) 10p 4\(71\) 10p 4\(71\) 10p 4\(71\) 13p 100\(16\) 25p 2\(20\) 15p 100\(16\) 25p 2\(20\) 16g 2\(20\) 26g 2\(20\) 33p 4\(70\) 16g 2\(20\) 23p 4\(70\) 16g 2\(20\) 33p
Per Metre 2 Core Oval 3A. 20p Round 6A. 35p Round 6A. 35p Round 6A. 50p Round 1A. 60p POWER 1mm T&E. 45p 1.5mm T&E. 45p 2.5mm T&E. 90p 6mm T&E. 150p TV Coax. 40p SCREENED Single Round. 17 p Twin Round. 20p Figure 8 Min. 20p Figure 8 Std. 30p 4 Core. 70p SPIRAL WRAP %" 15p WIDE RANGE OF CABLE MARKERS, SLEEVING, TIES, FIXINGSIN STOCK-PHONE FOR DETAILS.	470F. 16p 68uF. 26p 1uF. 28p 22uF. 49p ELECTROLYTIC uF/V 1/63. 8p 22/50. 9p 47/63. 9p 10/16. 8p 10/25. 10p 10/63. 13p 22/10. 8p 22/16. 10p 22/16. 10p 22/25. 10p 22/63. 15p 47/63. 15p 47/10. 11p 47/16. 11p 47/16. 11p 47/16. 11p 100/16. 13p 100/16. 13p 100/16. 13p 100/16. 15p 220/16. 15p 100/25. 15p 100/35. 19p 100/35. 19p 100/35. 19p 100/35. 19p 100/35. 19p 100/35. 25p 220/16. 23p 220/63. 33p 47/0/16. 23p 47/0/16. 346p
Per Metre 2 Core Oval 3A. 20p Round 6A. 35p Round 6A. 35p Round 6A. 50p Round 1A. 60p POWER 1mm T&E. 45p 1.5mm T&E. 45p 2.5mm T&E. 90p 6mm T&E. 150p TV Coax. 40p SCREENED Single Round. 17 p Twin Round. 20p Figure 8 Min. 20p Figure 8 Std. 30p 4 Core. 70p SPIRAL WRAP %" 15p WIDE RANGE OF CABLE MARKERS, SLEEVING, TIES, FIXINGSIN STOCK-PHONE FOR DETAILS.	470F 16p 68uF 26p 1uF 26p 1uF 26p 22uF 49p ELECTROLYTIC UF/V 1/63 8p 10/35 8p 10/35 10p 10/63 13p 22/10 8p 22/16 10p 22/35 11p 22/16 10p 22/35 11p 22/16 11p 47/10 10p 47/16 11p 47/25 13p 47/10 10p 47/16 11p 47/25 13p 47/10 10p 22/35 11p 22/35 15p 47/10 10p 22/35 15p 47/10 10p 22/35 15p 47/10 15p 47/10 15p 47/10 15p 47/10 15p 47/10 15p 47/10 15p 47/25 13p 47/35 15p 100/10 11p 100/10 11p 100/10 11p 100/10 15p 100/25 15p 100/63 25p 220/16 23p 220/25 20p 220/35 23p 470/16 23p 470/25 27p 470/35 31p 470/35 31p 470/35 31p 470/35 31p 470/35 31p
Per Metre 2 Core Oval 3A. 20p Round 6A. 35p Round 6A. 35p Round 6A. 50p Round 1A. 60p POWER 1mm T&E. 45p 1.5mm T&E. 45p 2.5mm T&E. 90p 6mm T&E. 150p TV Coax. 40p SCREENED Single Round. 17 p Twin Round. 20p Figure 8 Min. 20p Figure 8 Std. 30p 4 Core. 70p SPIRAL WRAP %" 15p WIDE RANGE OF CABLE MARKERS, SLEEVING, TIES, FIXINGSIN STOCK-PHONE FOR DETAILS.	470F 16p 68uF 26p 1uF 26p 1uF 26p 22uF 49p ELECTROLYTIC uF/V 1/63 8p 10/16 8p 10/25 10p 10/63 13p 22/16 10p 22/16 10p 22/35 11p 22/63 15p 47/10 10p 47/16 11p 47/16 11p 100/16 13p 100/25 15p 100/25 15p 100/25 20p 220/35 23p 220/16 23p 470/16 23p 470/16 23p 470/16 23p 470/16 24p 1000/10 24p 1000/10 24p 1000/10 24p 1000/10 24p 1000/10 24p
Per Metre 2 Core Oval 3A. 20p Round 6A. 35p Round 6A. 35p Round 6A. 50p Round 1A. 60p POWER 1mm T&E. 45p 1.5mm T&E. 45p 2.5mm T&E. 90p 6mm T&E. 150p TV Coax. 40p SCREENED Single Round. 17 p Twin Round. 20p Figure 8 Min. 20p Figure 8 Std. 30p 4 Core. 70p SPIRAL WRAP %" 15p WIDE RANGE OF CABLE MARKERS, SLEEVING, TIES, FIXINGSIN STOCK-PHONE FOR DETAILS.	47UF 16p 68UF 26p 1UF 28p 22UF 49p ELECTROLYTIC UF/V 1/63 8p 10/16 8p 10/25 10p 10/63 13p 22/10 8p 22/16 10p 22/25 10p 22/16 10p 22/25 10p 22/35 11p 22/63 15p 47/10 10p 47/16 11p 47/16 11p 47/16 11p 47/16 11p 100/16 13p 100/25 15p 100/35 19p 100/63 25p 220/16 23p 47/016 23p 47/016 23p 47/016 23p 47/016 24p 1000/16 24p 1000/16 29p 1000/16 29p 1000/16 29p 1000/16 29p
Per Metre 2 Core Oval 3A. 20p Round 6A. 35p Round 6A. 50p Round 1A. 60p POWER 1 mm T&E. 45p 1.5mm T&E. 45p 2.5mm T&E. 45p 2.5mm T&E. 150p 6mm T&E. 150p TV Coax. 40p SCREENED Single Round. 17 p Twin Round. 20p Figure 8 Min. 20p Figure 8 Std. 30p 4 Core. 70p SPIRAL WRAP %"	470pF

	0 - 000 (00
3	Coax Skt Surf. 30 Coax Skt Flush. 25 Coax Line Skt. 45 Coax Coupler. 45 Car Aerial Plug. 10 NC Plug. 100 BNC Round Skt. 100 BNC Square Skt. 100 BNC Str. Adapt 140 BNC T Adapt 140 UHF Plug PL259 50 VHF Plug PL259 50 Small Reducer. 20
	FM Aerial Plug 20 NC Plug 100 BNC Round Skt 100
	BNC Square Skt 100 BNC Free Skt 110 BNC Str. Adapt 140
	BNC T Adapt 300 VHF Plug PL259 50 VHF Plug PL259 50
A STATE OF THE PARTY OF THE PAR	Lorgo Dodugos 20
1000/63	VHF Round Skt 50 VHF Square Skt 50 Elbow Adapt PO
2200/2555 p 2200/3574 p 3300/2574 p	Straight Adapt 60 UHF T Adapt 160 Female T Adapt 160
3300/3592p 4700/1059p 4700/1674p	XLR Line Plug 180 XLR Chassis Skt 330 XLR Line Skt 230
2200/16 48p 2200/25 55p 3300/25 74p 3300/25 74p 3300/35 92p 4700/10 59p 4700/10 59p 4700/25 103p NON-POLARISED 1uF 25p 2.2uF 25p 3.3uF 25p 4.7uF 25p 6.8uF 50p 10uF 25p 22uF 35p 3.3uF 40p 10uF 25p 22uF 35p 33uF 40p 100uF 70p 170uF 40p	XLR Chassis Plug.160 DIN Plugs 2 pin10 3 pin15
2.2uF	4 pin
10uF	5 pin 360° 30 6 pin
47 uF	8 pin
OTHER CAPACITORS IN STOCK LE SILVERED MICA	5 pin A
1% POLYSTYRENE POLYCARBONATE MYLAR TANTALUM	7 pin
TRIMMER, VARIABLE eta eta	D-Type Plug 9W 80 15W 150 25W 150
CRYSTALS 100k	PL259 Rt Ang. 90 VHF Round Skt. 50 Elbow Adapt. PO Straight Adapt
2M	Plug 9W PO 15W PO 25W PO
4.19304M320p 4.433619M320p 6.144M130p	Covers 9
10M	15
26.59M. 200p 26.64M. 200p 26.69M. 200p	2.5 mm
26.74M	IEC Chassis Plug.90 IEC Chassis Skt 90 IEC Line Plug
27.045M 200p 27.045M 200p 27.145M 200p 27.195M 200p	P646 165 P430 125 P649
27.245M 200p 27.255M 200p CONNECTORS	P650 110 P635 100 P636 130
Cros Clips	P551 300 P552 100 SA2403 160
1 mm Socket 15p 2 mm Plug 20p 2 mm Socket	SA2404
3mm Socket	SA2019A 150 SA2020 140 SA2020
	5/12/05 / _ · · · · · · · · · ·
Jack Plug 2.5 mm. 15p Jack Plug 3.5 mm. 15p Jack Skt 2.5 mm. 15p Jack Skt 3.5 mm. 15p	MANY OTHER CONNECTORS ADAPTORS & LEADS IN STOCK
Jack Skt Line 2.5 mm 25 p	0.000
Jack Plug ¼" Mono.20p Jack Plug ¼" Stereo.30p Jack Skt ¼" Mono.25p Jack Skt ¼" Stereo.35p	LED Std Red. 10 Green 18 Yellow 15 LED Min Red 10 Green 18 Yellow 18
Jack Skt Line Mono.25 p Jack Skt Line Stereo.30 p Coax Plug15 p	Green

30p	LED WP Std	31
25p	LED WP Std Min LARGE RANGE OF	3
45p	LARGE RANGE OF	
45p	PANELLAMPHOLL	DERS
15p	DE LUXE LED's,	
20p	etc etc	
00p	FUSEWARE	
	20mm Panel Holde	- 45 r
00p	1¼" Panel Holde	- 50r
10p	20mm Chassis Hold	or44-
40p	11/4" Chassis Holds	117
00p	Lin Holder	14
50p	Fuen Clies	
50p	20mm FUECE	J
20p	2011111 FUSES	
20p	100mA 150mA 25	OUMA
20p	500 MA, 1A, 1.5A, 2	Α,
90p	3A, 5A	9p
50p	20mm Antisurge F	uses
50p	500mA, 1A, 2A	12 բ
POA	1½" FUSES	
60p	100mA, 150mA, 25	50 mA
60p	500mA 1A 2A 3A	
60p	5A 10A 13A 15A	9p
8 0p	1" Fuses 2,3,5,13	A15
330p	RESISTORS	
230p	⅓W 5% E24	25
60p 60p 60p 80p 330p 330p 10p 15p 35p 35p	20mmPanel Holde 1/4" Panel Holde 1/4" Chassis Holde Lin Holder Fuse Clips 20mm FUSES 100mA 150mA 25 500mA 1A 1.5A 2 3A 5A. 20mm Antisurge F 500mA 1A 2A 1/2" FUSES 100mA 150mA 25 500mA 1A 2A 1/2" FUSES 100mA 150mA 25 500mA 1A 2A 5A 10A 13A 15A 1" Fuses 2.3.5.13 RESISTORS /WW 5% E24 4W 1/4 E24 1W 5% E12 3W 5% E12 3W WW 282-1R 3W WW 285-18 3W W	7 t
10p	1W 5% E12	. 10
15p	3W 5% E12	. 10
35p	3W WW R22-1R	. 30 i
15p	3W WW 2R2+	. 20
20p	7W WW	. 30
30p	10W WW	. 35 r
40p	25W WW	170r
20p	WW Pots 3W	
60p 10p	High Quality	275 c
10p	10B. 25B 50B 10	OR.
20p	250R 500R 1K 5	ĸ.
15p	250R, 500R, 1 K, 5 10 K, 50 K	, ,
15p	SEMICONDUCTO	IRS
20p	SOFTENSIVE	
20p	IS THE BANGE	
20p	OFLISTED	
150	SEMICONDUCTO	DC.
300	DI EASE SEAID	no.
80p	LARGESAE	
50p	EOD DETAILS	
60p 10p 15p 15p 20p 20p 20p 15p 30p 50p	TOK, SUK SEMICONDUCTO SO EXTENSIVE IS THE RANGE OF LISTED SEMICONDUCTOI PLEASE SEND LARGE S.A.E FOR DETAILS TRANSISTOR MOI	INITO
50p POA POA	TO2	100
DOA.	TOSE	100
POA POA	DIL SOCKETS	. IUL
DOA.	B DIE SOCKETS	0-
POA POA POA	14 pin	91
POA	14 pin	111
200	10 pin	12
200	16 pin	101
20p	20 pin	1/ 5
30p	22 pin	. 20p
30p	24 pin	21p
POA 20p 20p 30p 30p 50p 15p 15p 15p	28 pin	24 p
60p	40 pin	. 35 p
1.15p	HANGE OF HEAT	
15P	SINKS AVAILABLE	
95p	PHONE FOR QUOTA	AHON
.90p	SPEAKERS	
90p	Miniature Buzzer	
70p	6V or 12V	. 90p
50p	Ultrasonic	600 p
70p 50p 65p 25p	Iransducers	Pall
25P	Elliptical 5 x3	1986
10p	6 X4	262p
10p 100p	7" X4"	314p
00p	/ X5	338F
30p	O XO 5 VV	200 b
300p 100p	LARGE SAE FOR DETAILS TRANSISTOR MOI TO3 TO36 DIL SOCKETS 8 pin 14 pin 16 pin 18 pin 20 pin 22 pin 24 pin 28 pin 40 pin 40 pin 70 pin 7	321 P
OOP	9 Xb	43] p
	miniature 1"	- SOP
95p 50p	1 72	POD
50 p	1 4/4	90p
50p 200p	2	. aop
200p	21/4"	. 90p
150p	2½ BH	90p
40p	2½ 64H	100b
180p	Hound 5" 4W	174p
95p	5" 25W	409 p
	5" 60W 1	587 p
	51/4" 10W	476p
	5½" 15W	/71 p
'	6" 5W	297 p
	6" 5W	297 p
	6. 60M 1	632 p
	6½ /W	423p
100	8. PM	359p
10p 18p	8" 10W	423F
100	8 20W	963 p
100	8"60W1	346 p
18p 15p 10p 18p	9 % Wind with the second of th	700 p
18p	10" 20W 1	113p
18p	4.01.0.01**	

12" 150W 4336p 12" 150W 4336p 12" 150W 7185p 15" 150W 7185p 15" 250W 8735p 18" 200W 8735p 2" 897p	12" 100W 12" 150W 15" 150W	4073p 4336p 7165p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	15" 200W 18" 200W MOTOROLA P	8735 p £108 IEZO
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	TWEETERS 2"	231p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	2"x6" Horn 2"x5"	938p 795p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	3¼"	624p 1435p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	2 Way 15W 2 Way 100W	188p 690p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	3 Way 25W 3 Way 40W 3 Way 60W.	193p 338p 502p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	4 Way 80W SWITCHES Toggle Std SPS	626p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	DPDT	62p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	SPDT c/off	63p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	4PDT c/off 4PDT c/off	11/p 209p 244p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	Push to make Push to break Key 5W SPST	20p 20p 259p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	Rotary IPI2W 2P6W 3P4W	62p 82p 62p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	4P3W Slide Min DPDT Std DPDT	62p 22p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	DIP 4W 6W 8W	105 p 128 p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	10W Microswitch	184p 83p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	6-0-6 @ 100mA 6-0-6 @ 250mA	167p 185p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	9-0-9 @ 250mA 12-0-12 @ 50	185p mA155p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	12-0-12 @ 1000 12-0-12 @ 250 0-12/0-12 @ 500	mA188 p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 160VA 35V 1500p 500VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	12-0-12 @ 1A 0-12-15-20-24-	538 p 30 @ 1 A
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	6-0-6 @ 2A 9-0-9 @ 2A	440p 476p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	12-0-12 @ 2A 0-12/0-12 @ 0-12-15-20-24-	538p 2A 538p 30 @ 2A
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	90-0-20 @ 2A . 30-0-30 @ 2A .	900p 745p 933p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	12-0-12 @ 3A . 0-15 @ 3A 6-0-6 @ 4A	721p 647p 538p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	9-0-9 @ 4A 12-0-12 @ 4A . 0-15 @ 6A	687P 845p 949p
9V 950p 12V 950p 15V 950p 18V 950p 18V 950p 18V 1150p 9V 1150p 12V 1150p 22V 1120p 30V 1200p 30V 1200p 120VA30V 1300p 160VA35V 2000p 500VA35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	6-0-6 @ 8A 12-0-12 @ 8A TOROIDS:	980p 1615p
15V 950p 18V 950p 50VA 6V 1150p 9V 1150p 12V 1150p 15V 1150p 00VA 18V 1200p 22V 1200p 160VA 36V 1300p 160VA 35V 1500p 300VA 35V 2000p 500VA 35V 2650p ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT		
ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	15V	950p 950p 1150p
ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	9V 12V 15V	. 1150p . 1150p . 1150p
ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	80VA 18V 22V 30V	1200p 1200p 1200p
ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT	120VA 30V 160VA 35V 300VA 35V	1300p 1500p 2000p
ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT		
VOLTAGES SHOWN.	ALL TOROIDS I TWO IS SECONDARIES VOLTAGES SHO	HAVE SOLATED AT

12" 60W

2882 n

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.

NEWS: NEWS: NEWS: NEWS: NEWS: NEWS

High Density 'D' Connectors

S ouriau have introduced a range of sub-miniature 'D' type connectors which have a closer pin-spacing than existing sub-miniature types and offer correspondingly higher numbers of contacts. Plugs and sockets with up to 78 ways are available, and in spite of their small size the connectors offer a performance which is generally comparable with that of other sub-miniature 'D' connectors.

Designated the 8635 series, the new connectors come with either 15, 26, 44, 62 or 78 contacts and are rated at 1000 volts RMS, 5A per contact maximum. No overall current rating for a connector is specified. The contacts are size 22 crimp on 0.76mm (0.03") centres and the operating temperature range is from -55° to +150°C. The insulation material is a self-extinguishing thermosetting plastic manufactured to UL class 94 V-O and the shell is made from cadmium plated steel.

The connectors can be supplied in both rigid and float mounting versions and are also available with interfacial and back-end sealing gaskets. 8635 crimp connectors can also be ordered against equivalent MIL C-24308A (S*MA) series part numbers. For further information contact Souriau (UK) Ltd, Knaves Beech Industrial Estate, Loudwater, Nr High Wycombe, Buckinghamshire, tel 06285-24981.

Music For The Newbrain

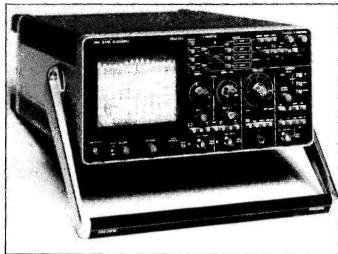
W ould the reader who sent us the above project please get in touch with the editorial office — we've lost your name and address!

● Japanese component manufacturer Alps is setting up a new plant which will create 230 jobs when it opens in Milton Keynes next year and up to 400 jobs when it reaches full production. The plant will produce parts for video recorders. In a separate statement, Cirkit have announced an increase in the range of Alps parts that they stock. The new lines will include microminiature Tactile switches, data entry switches, keytops and slide and rotary potentiometers. Cirkit Holdings PLC, Park Lane, Broxbourne, Hertfordshire EN 10 7NQ, tel 0992-444111.

New Philips DSO

hilips have introduced a portable digital storage oscilloscope capable of sampling signals with a clock rate of up to 125 MHz. The dual-channel instrument has four memories, the contents of which can be displayed simultaneous or individually, and the user is able to program the trigger level control and all other trigger functions as well as all other switch functions.

The PM 3315's input circuitry enables analysis of repetitive signals to well over 60 MHz. Fast 125 MHz sampling allows single-shot capture up to 30 MHz with accurate reproduction. Even higher single-shot bandwidths are possible using computer data-analysis by means of the integral IEEE488/IEC625 bus interface. A digital delay facility makes possible optimal use of the available memory depth by triggering from



nine screen divisions before the desired position to 9999 divisions

Tomeet the requirements of the fast growing world of TV applications, the PM 3315 also offers stable TV frame or field triggering. Other facilities include a plotmode output for an X-Y recorder and a chart-recording mode

allowing maximum internal storage of up to 40 hours. Control capability covers all front panel settings, including timebase and attenuator.

The PM 3315 costs £5195 plus VAT and is available from Philips Test and Measuring, Pye Unicam Ltd, York Street, Cambridge CB1 2PX, tel 0223 358866.



Long-Life Rechargeables

Y uasa have launched a range of lead-acid sealed recharge-able batteries which they claim have a life expectancy of ten years. The batteries have been designed with un-interruptible power supply applications firmly in mind and are said to be explosion proof and capable of retaining a high capacity under float-charge conditions.

The new range is designated the XL series and uses the same construction method as the existing NP range to make them completely leakproof. They are available in 6 and 12 volt versions with capacities of 66, 88 and 110 Ah and 33, 44 and 55 Ah respectively. They require constant-voltage charging and their nominal cell voltage is 2.23V. A low specific-gravity electrolyte has been used to re-

duce float voltage and selfpoisoning, allowing the batteries to be used for long periods under float charge conditions without loss of capacity. A venting arrangement on the top of the batteries allows gases caused by overcharging to escape but will not allow flames to re-enter, thus removing the risk of explosion present with some vented cells.

The XL range was designed specifically for telecommunications applications and the battery sizes meet these requirements rather than being directly compatible with similar batteries used in other sections of industry. They are expected to find applications in computers, test equipment, medical equipment and un-interruptible supply applications as well as in the telecommunications field.

Yuasa Battery Sales (UK) Ltd, Hawksworth Industrial Estate, Swindon, Wiltshire SN3 1DZ, tel 0793 486818.

The Little Chill

P CA are marketing a range of equipment cooling fans which have a fixing plate size of only 80mm (3.15") square. Features claimed include low mechanical noise, zero electrical noise, low weight and long life, and the fans are expected to find wide application in domestic products as well as in office equipment, test gear and industrial equipment, etc.

The fans are available in 6, 12 and 24V DC versions and operate at a speed of 4000 RPM to achieve an air flow of 0.95m³/minute. The mechanical noise is less than 21 dBA and PCA claim that electrical noise has been entirely eliminated. The full weight is 170 grams and the anticipated life expectancy is 10,000 hours for most models.

For further details contact P. Caro & Associates Ltd, 2347 Coventry Road, Sheldon, Birmingham B26 3LS, tel 021-742 1328.



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CRICELECTRONICS LTDOOD

40 CRICKLEWOOD BROADWAY LONDON NW2 3ET 01-452 0161/01-450 0995 TIx:91497

PRICES SUB TO CHANGE	JECT	/ISA		6		\sim	Ju.	01-4	LON 152 O161	IDON N /01-45	W2 3E O O99	T 5 Tlx:9	14977
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10M? 47/3V WE24 2p 47/6.3V WE24 3p 47/16V WE12 6p 100/3V WE12 12p WETAL FILM LTRA STABLE LYTI LOW NOISE Mai	20p 7453 34p 7454 75p 7460 32p 7470 7472 7473 IRO- CS 7475	35p 74 35p 74 49p 74 49p 74 49p 74 49p 74 49p 74	4LS126 49p 4LS132 65p 4LS133 45p 4LS136 45p 4LS138 55p 4LS139 55p 4LS145 99p 4LS147	4015 55p 4016 35p 4017 52p 4018 55p 4019 55p 4020 75p 4021 52p 4022 52p 4023 39p	R02513UC 7.50p SAA5000 6.13p SAA5010 6.13p SAA5012 6.13p SAA5020	2N5298 1 68 2N5401 57 2N5415	P BC441 BC447 P BC448 P BC460 BC461 BC478 P BC479	37p BU226 4 33p BU326S 2 33p BU406 1 39p BU407 1 38p BU408 1 42p BU409 1 38p BU500 3 38p BU500 3 38p BU500 3	45p IN4004 5%p 63p IN4005 6p 45b IN4006 6%p 1N4007 7p 49p IN4148 3p 65p IN5401 13p 156p IN5402 14p 75p IN5404 16p	3 25p K06(600) 4 10p BYW64 35A 400W 4 50p	3 40p LM725CN 3 19p LM741CH 99p LM741CN 28p LM741CN14 1 20p	ZN409 2 25p ZN414 1 00p ZN1034 1.99p TRANS- FORMERS	WIRE PRICES PE METRE Solid
0.0 TO 1M.0 Panas E24 6p AXIALS OW OHMIC ILAZE 1 2W UFG V 0.2 2WU to 4.7 6 8.2.0 4.7 10 4.4 11p 4.7 3E IRE WOUND 1 10	onic 7480 (Wires 7481	95p 74 95p 74 95p 74 95p 74 95p 39p 74	1.35p 4LS151 65p 4LS153 65p 4LS154 1.99p 4LS157 55p 4LS158 69p	4024 49p 4026 1.50p 4027 39p 4028 47p 4029 75p 4030 35p 4031 1.25p 4032 65p 4034 1.39p	3.79p SAA5030 6.04p SAA5040 11.36p SAA5041 15.14p SAA5050 6 38p	2N5448 31	BC547 PBC548 PBC549 BC550C BC557 PBC559 BC560C	16p (RF530 4 17p J300 29p J310 19p MJ802 4 MJ900 3 18p MJ901 3 29p MJ1000 2	32p IN5407 19p 95p IN5408 20p 88p BA102 49p 88p BA115 29p 25p BA133 51p 22p BA138 36p 121p BA156 41p	& wonderful devices in stock, inc var. shapes & sizes of LEDS	LM747CN 69p LM748CH 99p LM748CN 55p LM1877 7.95p LM1886 7.44p LM1889 4.65p	Post inclusive prices cheaper to callers All 240V Primary Split Bobbin 100mA	wire MAINS SPEAKEI Twin 1 Amp Twin 2½ Am 3 Core
12 SERIES 2 2 2 6 6 6 7 W 0.47 0 2 2 1 6 6 6 8 33p 3.3 6 1 W 1 D 3 3 K 37p 4.7 5	3 10p 7491 3 10p 7492 0 13p 7493 0 34p 7494 0 13p 7495 3 14p 7496 15 10p 7497 0 13p 74100	65p 74 65p 74 65p 74 65p 74 55p 74 55p 74 55p 74 199p 74	4LS161 75p 4LS162 75p 4LS163 75p 4LS164 75p 4LS165 1 09p 4LS166 1 95p	4035 95p 4036 2 75p 4038 85p 4040 59p 4041 55p 4042 49p 4044 49p 4045 59p	SAA5070 16.21p 8726 1.09p 8728 1.09p 8795 1.09p 8797 1.09p 811S95 2.35p 81LS96 2.35p 81LS97 2.35p	2N5657 1.99 2N5684 13 95 2N5884 5 95 2N5886 5.95 2N6027 60	BC640 P BC650 BC651 P BCY70 BCY71 BCY72 BD131 P 8D132	37p MJ1001 3 37p MJ1800 3 45p MJ2500 2 47p MJ2501 2 31p MJ2955 33p MJ3000 2 25p MJ3001 2 63p MJ4502 4 63p MJE340	25p BA157 28p 379p BA158 34p 33p BA159 38p 663p BA182 49p 99p BA201 23p 63p BA202 29p 663p BA316 27p 25p BA317 28p 75p BA318 31p	G Green Y Yellow Large diffused 1 + R5D 10p G5D 16p Y5D 15p	LM2902 2.78p LM2907N 3.96p LM2907N8 3.96p LM2917N 3.20p LM2917N8 3.20p	6-0-6 1.50p 9-0-9 1.70p 12-0-12 1.85p 15-0-15 1.95p 1A as above 3.75p 20.0 20V 0.125A 3.75p 12 0 12V	2½ Amp 3 Core 13 Amp 62p SCREENE Single Stereo Mini Stereo 4 Core 4 Screens
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SIEMENS 220 1 1 1 1 1 1 1 1 1	0 13p 74192 6 13p 74193 0 14p 74194 74195 0 23p 74196 6 28p 74197 0 39p 74198 6 51p 74221	99p 99p 79p 79p 1 19p 1 19p 2 25p	3 09p 4LS324 3 25p 4LS325 1.65p	4526 65p 4527 65p 4528 65p 4529 125p 4532 65p 4534 349p 4536 249p 4538 75p	7905T 65p 7912T 65p 7915T 65p 7924T 65p 7924T 65p	40408 1,75 40410 199 40411 4.29 40594 1.40	BD580 1. BD711 1. BD712 1. BDX32 3. BDX33A 1. BDX33C 1. BDX34A 1. BDX34A 1.	35p 11P110 50p TIP112 50p TIP115 59p TIP117 1 29p TIP120 59p TIP122 29p TIP127 59p TIP130 1 35p TIP130 1	79p TIC236D(12A) 85p 1 25; 89p 1 TIC246D(16A) 1,49p 79p TIC253D(20A) 85p 99p 1 TIC263D(25A) 66p 2,95p 69p 1 TIC263D(25A)	ICL7107 9.50p ICL7611 97p ICL8038 3.50p ICM7555 1.10p	TA 7222 1.75p TA 7227 5.82p TBA500 2.97p TBA510 2.95p TBA520 2.57p TBA530 2.55p TBA540 2.72p TBA550 3.25p	Enough to make over 1 litre 1,69p. ETCH RESIST TRANSFERS 1 Thin lines 2 Thick lines 3 Thin bends 4 Thick bends	No 51 (Med No 52 (Lge) SOLDEF 125gms 18swg 2: 22swg 3
hr 13p 4700 1 hr 10p 4700 1 hr 16p 4700 6 hr 16p 4700 6 hr 25p 10000 1 hr 32p 10000 8	6 1.09p 3 2.99p 74LS00 74LS03 74LS03 0 74LS04	28p 74 28p 74 28p 74 28p 74 28p 74	1 35p 4LS348 1.95p 4LS352 1 19p 4LS353 1.19	4555 35p 4556 49p 4560 145p 4566 199p 4569 1.65p 4584 55ρ	2N2219 33p 2N2219A 36p 2N2222 29p 2N2222A 33p 2N2369A 35p 2N2369A 35p	AC125 99 AC126 35 AC127 35 AC128 39 AC141K 39 AC142K 39 AC176K 49 AC176K 49	p BDX678 6. p BDY54 2. p BDY56 2. p BDY56 1. p BDY57 5. p BDY58 6. p BF 179 BF 180 p BF 198	35p TIP 135 28p TIP 137 39p TIP 140 199p TIP 142 191p TIP 145 33p TIP 145 83p TIP 162 46p TIP 2955 18p TIP 3055	16p DIACS 19p BR100,DB3, 21p 22p 29r 22p 22p 29r 81p ZENER'S	1.49p LF347 1.78p LF351 75p LF353 1.15p LF355 1.25p LF356 1.35p LF357 1.65p LF398 5.60p LM301AN 45p LM301AN 45p	2 87p 1BA570 2 37p 1DA1002 3 39p 1DA1003 4 35p 1DA1010A 2 25p 1DA1022 4 95p	5 DIL pads 6 Transistor pads 7 Dots & holes 8 0. 1" edge connectors 9 Mixture Any sheet of above 39p GRADE DNE	PLUGS SOCKF1 'D' Connect 25 Way
(10mm) 40p OLYESTER OV RADIAL (C280) IF 15nF IF, 33nF IF, 68nF ONF 7p 7401 ONF, 200nF 7402	74LS08 74LS09 74LS10 74LS11 74LS12 74LS13 29p 74LS14	28p 74 28p 74 28p 74 28p 74 28p 74 32p 74 49p 74	4LS373 95p 4LS374 95p 4LS378 95p 4LS386 49p	CPUs 6502 3.49p 6502A 5.45p 6800 1.99p 6802 2.49p 6802 2.49p 6809 6.49p 8035 5.49p	2N3054 65p 2N3055 65p 2N3055H 1 89p 2N3439	AC 188K 49 AD 161 55 AD 162 55 BC 107 16 BC 107A 17 BC 1078 19	BF200 BF244A BF244B	18b TISA3 761p VN10KM 761p VN46KF 755p VN66KF 75p ZTX107 77p ZTX109 77p ZTX109 77p ZTX300 79p ZTX301 79p ZTX303 76p ZTX304 68p ZTX3104	69p in stock. 15p Pls enquire. 400 to 500mW 16p E24 Series 15p 2.4 to 47 V 7p 16p 1.3 Watt 17p E24 Series	LM307N 45p LM30BN 99p LM309K 1.99p LM317T 1.75p LM317K 2.80p LM317HVK 10.80p LM324 pls.ask LM335Z 1.60o	TDA1097 4 99p TDA11151 1 95p TDA2002 3.25p TDA2003 3.25p	GLASS PC8 SINGLE- SIDED 178×240mm 1.85p 420×195mm 2.55p 420×245mm 3.75o	Solder Male 1.1 Female 2.0 PCB Wire-Wra Male 1.1 Female 2.0 Covers 1.1 Phono plui Blk, Red, Gri
7403 7404 7405 7405 7405 7406 7407 7407 7408 7409 7409 7409 7409 7409 7410	29p 74LS22 29p 74LS22 29p 74LS22 35p 74LS28 39p 74LS30 39p 74LS30 29p 74LS33 29p 74LS33 29p 74LS34 29p 74LS34 29p 74LS44 45p 74LS44	28p 7. 28p 7. 28p 7. 28p 7. 28p 7. 28p 7. 28p 7. 28p 7.	74LS393 1.09p 74LS395 99p 74LS396 2.95p 74LS398 1.95p 74LS399	8039 4.99p 8080A 3.55p 8085 on order 280A CPU 2.95p Z80B CPU 7.59p MEMORIES	2N3440 99p 2N3441 1.49p 2N3442 1 59p 2N3553 2.65p 2N3702 16p 2N3703 16p 2N3704 16p	BC108B 18 BC108C 20 BC109 17 BC109B 18 BC109C 21 BC140 36 BC141 43 BC147 15 BC148 15	p 8F2568 p 8F256C p 8F257 p 8F258 p 8F259	59p ZTX312 69p ZTX313 39p ZTX314 41p ZTX320 45p ZTX330	18p 3.3 to 82V 14p 22p 22p 24p 27p 22p 27p 22p 26p W01(100) 28p W02(200) 34p 25p 25p W02(200) 34p 25p 25p W02(200) 34p 25p 25p 25p 25p 25p 25p 25p 25p 25p 25	LM348N 99p LM349N 1.09p LM379S 5 50p LM380N14 pls.ask LM380N8 pls.ask	3 15p TDA2030 2.85p TDA2611 2.50p TDA7000 3.45p TL061 51p TL062 77p	DALO ETCH RESIST PEN + spare nib 1,29p PHOTO SENSITIVE PC8 1st Class Epoxy Glass	Wt or Yell Line Skts Chas Sktx 1 Dual Skt Quad Skt
500V 35p 7412 1413 1414 1414 1415 1415 1416 141	59p 74LS51 35p 74LS64 50p 74LS55 29p 74LS73 29p 74LS74	85p 28p 7 28p 7 28p 7 29p 35p 7 45p 7	1 25p 74LS490 1.49p 74LS540 1.39p 74LS541 1.39p	2532-300n 3.49p 2532-400n 3.45p 2564 6.49p 2708 2.99p 2716 3.45p 2732 4.35p	2N3705 16p 2N3706 16p 2N3707 16p 2N3819 35p 2N3820 80p 2N3866 1 120p 2N3903 19p 2N3904 19p	BC149 16 BC157 39 BC158 37 BC159 44 8C160 55 BC161 59 BC169 13 BC169C 23 BC177 29	p BF457 p BF458 p BF459 p BF960 1, p BF961 1. p BFR90 2. p BFR91 2. p BFS61 p BFS61	48p 2TX341 59p 2TX450 65p 2TX500 09p 2TX501 55p 2TX502 25p 2TX503 75p 2TX504 99p 2TX510 99p 2TX531	22p W04(400) 33r 18p 2 amp type 19p Square with hole 22p S02(200) 50r 22p S04(400) 55c 26p S04(400) 55c	LM382N 1.79p LM383T 3 40p LM384N 2.90p LM386	TL071 47p TL071 47p TL072 62p TL074 1.50p TL081 47p TL082 55p TL084 1.20p TL494 3,99p	for better results than spraying expose to UV Single sided 100 x 160 2.10p 106 x 220 2.50p 203 x 114	24pin 4 28pin 5 40pin 5
35V 14p 7425 35V 14p 7426 35V 14p 7427 35V 14p 7428 5V 14p 7430 35V 14p 7430 35V 18p 7433 16V 18p 7433 35V 20p 7438	35p 74LS76 35p 74LS78 39p 74LS83 39p 74LS85 29p 74LS95 29p 74LS92 29p 74LS93 29p 74LS93 35p 74LS93	35p 69p 75p 35p 49p 55p 75p	1 95p 74LS641 1 95p	2764 5.19p 27128 19 95 4116-150n 1.25p 4118 4.65p 4164 4.99p 6116 4.95 6810 1.55p MIS LOGIC IC's	2N3905 19p 2N3906 19p 2N4036 72p 2N4037 66p 2N4240 3,00p	8C178 29 BC179 31 BC182 15 BC182L 15 BC183L 15 BC183L 15	p BFT66 2. p BFX29 p BFX30 p BFY50 p BFY51 p BYF52 p BSV81 2.	75p ZTX650 44p ZTX651 44p ZTX651 2TX652 36p ZTX653 36p ZTX750 36p ZTX751 65p ZTX752 29p ZTX753	36p 38p 5quare with hole 42p 45p 9W01(100) 37p 95p 41p 45p 9W02(200) 99p 47p PW04(400) 1.30p	2.43p	UAA 180 2.49p	2.40p 2.33 x 220 5.20p Double sided 00 x 160 2.20p 100 x 200	TOGGLE (MIN) SPST SPOT DPDT DPDT DPDT C:



Photo-Electric Switch With Integral **Amplifier**

S igma have introduced a photo-electric sensor which has a built-in amplifier. The unit can be used to detect liquid levels, passing objects, etc, requires no special cable to prevent noise problems and will operate with cable lengths of up to 50 metres.

The PM-07 is a retro-reflective sensor which will detect transparent, translucent and opaque objects at distances of up to 25mm (1") with no physical contact. It operates from a 12-24V DC supply and has a response time of less than 5ms. The case measures 7.5mm square by 38mm long and the operating temperature range is from minus 10° to plus 55° centigrade.

Further information is available from Sigma Ltd, Spring Road, Letchworth, Hertfordshire SG6

4AJ, tel 04626-3841.

Blue LFDS

R ed, yellow and green LEDs using crystalline semiconductors such as gallium phosphorus and arsenic have been available for more than a decade, but LEDs which emit blue light have been expensive and have not been generally available. Two years ago, Siemens devised a method of manufacturing 'bluelight chips' at a considerably lower price, albeit without matching the price level of LEDs in the other colours, and having sounded out the market have decided to include the fourth colour in their 1985 product range.

The new blue LED, type SLB 5410, operates at 480nm and uses silicon carbide (SiC) as the source material. SiC has emerged as the optimum semiconductor for blue light only after years of research, and although it is costly to produce, it has significant advantages over ZnSe or GaN. The SLB 5410 has a forward voltage of typically 4V at 20mA, the corresponding figures being 10V at 20mA for ZnSe or GaN types. Typical output levels are 4mcd at 20mA measured in the optical central axis at a half-angle of eight degrees, and the device is mounted in a standard 5mm plastic package.

The purity and reproductability of the blue LED's 480nm radiation are unmatched. Further characteristics are high impulse stability,

a narrow spectral bandwidth and a very low ageing rate. These features make the LED suitable for use as a radiation source in spectroscopic, biophysical or medical applications, as a calibration source for TV camera and photographic equipment, and, later on, possibly even as a means for producing the blue luminous dots on flat screens.

The blue LED is less suitable for use as a mere on/off indicator than its red, yellow and green counterparts because, quite apart from higher costs, the angle of radiation and the intensity are lower than in conventional LEDs.

Siemens Limited, Siemens House, Windmill Road, Sunburyon-Thames, Middlesex TW167HS. tel 09327-85691.





Safety Cap

N ot being the sort of company to bottle things up, Siemens have written to tell us about their latest innovation. They have introduced a range of tantalum electrolytic capacitors which are designed to overcome the risk of fire presented by conventional electrolytics when they are fed a voltage of the wrong polarity.

If an electrolytic capacitor is operated with reverse polarity, perhaps because of a fault in a piece of equipment, it will heat up

rapidly and may even explode. This effect is even more marked in tantalum capacitors which have a much higher charge density than other electrolytics. In an extreme case it is possible for the piece of equipment in which the capacitor is installed to catch fire as the result of such a fault.

Siemens have overcome this hazard by incorporating a fuse into their new B 45185 series of tantalum capacitors. The fuse takes the form of a solder wire link in the cathode lead, and if the capacitor is operated with reversed polarity this link will quickly heat up and melt and the capacitor will fail harmlessly. They are available in four types with capacities ranging from 100n to 330uF and with voltage ratings from 6.3 to 50 volts. The single-ended rectangular plastic package has climatic protection which meets the requirements of category FKE of the DIN 40040 standard and has been designed with automated assembly in mind.

For further information contact Siemens Ltd, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex TW167HS, tel 09327-85691.

- Semiconductor Supplies International have brought out the autumn issue of their catalogue. Its 32 A4 pages list transistors, diodes, rectifiers, microprocessors and other ICs, LEDs, capacitors and resistors. Copies are available from Semiconductor Supplies International Ltd, Dawson House, 128-130 Carshalton Road, Sutton, Surrey SM1 4RS, tel 01-643 1126.
- The new Electrovalue catalogue actually came out last month but we couldn't find room to mention it. Never mind, it's valid until the end of January 1985 so it's still worth sending off for, and its 44 A5 pages list their largest ever range of general components, computers and accessories, books and test equipment. Copies are available free of charge from Electrovalue Ltd, 28 St. Judes Road, Englefield Green, Egham, Surrey TW20 0HB, tel 0784-33603.
- Once again, the quarterly figures show an increase in the number of business failures in the electrical industry. Business information company Dun & Bradstreet Ltd

tell us that there were 585 company liquidations in the industry in the first nine months of 1984, a four per cent increases over the figure for the same period of 1983. Bankruptcies among firms, partnerships and individuals in the industry totalled 88 over the same period, a 22% increase over the 1983 figure. A small glimmer of hope appears in the news that the computer manufacturing industry (micros to mainframe) has strengthened its financial position in the last five years with only 23% of firms now considered by Dun & Bradstreet to be financially vulnerable compared with 45% in 1979.

 Miller-Stephenson Chemicals have produced a spray-on conductive coating which is intended to absorb RFI and EMI over a broad frequency range. The coating is sprayed from an aerosol can, dries in fifteen minutes, is effective within minutes and provides over 78dB attenuation at 1MHz, 49dB at 10MHz and 21dB at 100MHz. For details contact the distributors, D. Fraser & Company, 129 Kylepark Drive, Uddingston G71 7DD, tel 0698-813476.

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BBC Micro Computer System

ACORN COMPUTER SYSTEMS: BBC Model B Special offer£320 (a) BBC Model B + Econet£389 (a) BBC Model B + DFS£399 (a) BBC Model B + DFS + Econet.£450 (a)	BBC FIRMWARE: 1.2 Operating System ROM £7.50 (d) BASIC II ROM
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KAGA TAXAN

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KP910 £369 (a) BROTHER HR15 £345 (a)

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KAGA TAXANR232 with 2K Buffer £85 (b) KP810/910 Ribbon £6.00 (d)

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RS232 with 2K Buffer £65 (b) Ribbon £2.50 (d)
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9.5" x 11" £13 (b) 14.5" x 11" £18 (b)
Self Adhesive Labels 2%" x 17/16"
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MODEMS

All modems listed below are BT approved

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MIRACLE WS2000:
The ultimate world standard modem coverall all common BELL and CCITT standards up to 1200 Baud Allows communication with virtually any computer system in the world. The optional AUTO DIAL and AUTO ANSWER boards enhance the considerable facilities already provided on the modem. Mains powered £129(b). Auto Dial Board/Auto Answer Board £30(c) each. Software lead £4.50.

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Complies with CCITT V23 1200/75
Duplex and 1200/1200 Half Duplex standards that allow communications with
VIEWDATA services like PRESTEL, MICRONET etc. as well as user to user communications. Mains powered £64(b).
BUZZ BOX:
This pocket sized modern complies with

BUZZ BOX:
This pocket sized modem complies with V21 300/300 Baud and provides an ideal solution for communications between users, with main frame computers and bulletin boards at a very economic cost. Battery or mains operated, £52(c). Mains adaptor £8(d).

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High quality discs that offer a reliable error free performance for life. Each disc is individually tested and guaranteed for life. Ten discs are supplied in a sturdy cardboard box. Price per pack of ten:

40T SS DD £15 (c) 80T SS DD £22(c)

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tinued optimum performance of the	drives	J disposable cleaning discs	ensures con- £14.50(c)
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1431 Std Res	£175 (a)
1451 Med Res	£215 (a)
1441 Hi Res	£399 (a)
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Above monitors are now available in plastic or metal cases KAGA Super Hi Res Vision III RGB Monitor£345(a)

MONOCHROME MONITORS12".

MONOCHROME MONHORS 2.		
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Kaga Green KX1201 G Kaga Amber KX1201 A	£116	(a)
Sanyo Green DM8112CX	£99	(a)
Sanyo Green DM8112CX	. £21	(c)

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27128-25					£18
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GANG OF EIGHT INTELLIGENT FAST **EPROM COPIER**

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All erasers with built in safety switch and mains UV1B erases up to 6 eproms at a time. . . . £47(c)

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ways	Plug	tacle	Conn.				
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34	200p	160p	320p				
40	220p	190p	340p				
50	235p	200p	390p				

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Ang Pins 120 180 230 350 Solder 60 85 125 170 IDC 175 275 325 -FEMALE: FEMALE:
St Pin 100 140 210 380
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	2 :: 6-way (commodore)	_	300
	2.c10-way	150p	_
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	2 x 18-way	-	140
	2 x 23-way (ZX81)	175p	220
	2 x 25-way	225p	220
	2 x 28-way (Spectrum)	200p	
_	2 x 36-way	250p	_
	1 x 43-way	260p	-
	2 x 22-way	190p	-
- 1	2 x 43-way	395p	-
/	1 × 77-way	400p	500
	2 x 50-way(\$100conn)	600p	-

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DIN 41612 DIN 41612
2 × 32 way St Pin 230p 275p
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3 × 32 way St Pin 260p 300p
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IDC Skt A + B 275p
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(solder) 500p(IDC) 475p
36 way skt Centronics
(solder) 550p(IDC) 500p
24 way plug IEEE (solder)
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14 pin	40p	100p	
16 pin	50p	110p	
18 pin	60p		
20 pin	75p	-	
24 pin	100p	150p	
28 nin	200 n		

200p

40 pin

MISC CONNS 21 pin Scart Connector.200p 8 pin Video Connector.200p

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ICKENZIE 2" 85 WATT R.M.S. C1285GP Lead guitar/keyboard/Disco. 'ally voice coil. Ally centre dome. Res. Freq. 45Hz. Freq. Resp. to 6.5KHz. Sens. 98dB. PRICE £24.99 £3.00 P&P ea.

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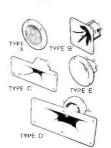
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+ 40p P&P.
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LEVEL CONTROL Combines on a recessed mount-

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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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ACTIVE BASS LOUDSPEAKER



The active loudspeaker design which appeared in the last four issues was ideal for those starting from scratch, but what about those who already have a loudspeaker system and simply want to improve it? Jeff Macaulay has been active on their behalf too.

ith one or two notable (and expensive) exceptions, domestic loudspeakers are almost incapable of reproducing sounds below about 50Hz. The reasons for this are not too difficult to find. Even with the best of today's drive units a large cabinet is required to give extended bass response, and this is just not practical for modern-day lounges very few of which could be described as palatial.

True, it is possible to squeeze a few more hertz out of a small sealed box, but only at the expense of efficiency. The result is that amplifiers rated at nearly a kilowatt are required to produce anything like 'live' sound levels. Even a modest amount of bass boost will cause the midrange to go soggy, and the result in the bass register is just a boomy mess! So what is the solution?

Instead of giving your bank manager the pleasure of collecting vast amounts of interest on a loan for a new pair of speakers why not build the Neptune? It has been designed as a small add on unit which will extend the response of your existing speakers down to below 30Hz. That is a whole octave lower than 99% of the speakers on the market can manage, and for a modest outlay to boot.

Design Philosophy

Before delving deeply into the circuitry involved it will be as well to consider the design philosophy behind this project. As is well

known, the deepest note that a speaker system can produce is limited by the size of the cabinet into which it is mounted. This is because any driver has a fundamental resonance due to the mass of the cone and the compliance of the speaker surround.

Imagine the cone mass as a weight suspended on a spring, which represents the surround compliance, and you can easily visualise the system. Place the driver in a sealed box and the air trapped inside effectively stiffens the compliance, making the resonant frequency higher. The smaller the volume of the box the higher the resonance and the less bass you get out of it.

To get around this difficulty some radical thought is necessary. Below the resonant frequency the

response of the driver dies away at 12 dB/octave. If we were to boost the signal at that rate below the resonant frequency we would obtain a flat response.

This is the method used here. Such a speaker would be useless above the resonant frequency of the cabinet because the response with the filter added rolls of at 12dB/octave above resonance (see Fig 1). However, this response is exactly what is required for an add on bass unit as it will complement the falling response of the existing speakers.

As most of the money spent on a pair of speakers is invested in extending the response below 100Hz, it would be pointless to waste what we have already paid for. The Neptune has therefore been designed as a bass augmenter.

Having decided the form our

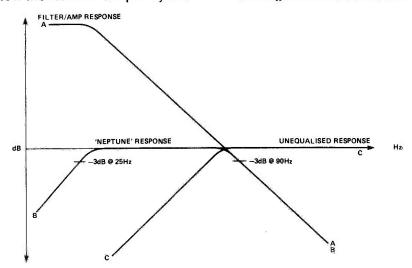


Fig. 1 Response curves for the Neptune system.

bass speaker is to take there remains to be considered the matter of quantity and quality of output.

Unlike reflex and horn enclosures the sub-resonant principle has the advantage of not using resonant effects to obtain the desired response. In a reflex cabinet, for example, the extension in bass response is obtained at the expense of 'hangover'. That is, the cabinet is still resonating after the note has stopped. This effect can be minimised by competent design but it still gives this type of enclosure a bad name.

The quantity of bass generated by a pair of 8" (200mm) speakers operating in tandem is easily quantifiable, but to appreciate the problem some understanding of the principles involved is required. If you were to look at the typical power versus frequency curve of speech and music you would find that the peak output occurs at around 200Hz, the lower midrange. Above and below this frequency the power requirement falls off rapidly, and at the lowest frequency of interest to us, 30Hz it is some 12dB down on the mean output at

This means that, if the speakers are required to give a mean output of 96dB SPL, the output required from the woofer would be some 84dB SPL. This the Neptune can easily give provided it is positioned on the floor and against a wall to take advantage of sound reflection from these surfaces.

The KEF B200A was chosen for this project for two reasons. First, they are blessed with a long and linear cone excursion and second the choice of a well known and respected drive unit will satisfy those who would pick holes in anything!

There is a tried and tested alternative, the Altai stocked PF81HR which has a similar performance in this application to the B200A's but is somewhat cheaper. For those on a budget these are recommended. Later upgrading simply means changing them for the B200's (see buylines).

In order to easily interface the speaker with existing stereo systems, a dedicated amplifier is required along with the active filter. These are mounted within the cabinet so that interfacing is reduced to plugging the unit into the mains and one of the speaker outlets. You might think that outputs from both channels would be required but this is not so. To ensure that bass signals are not presented out of phase from normal speakers, the bass content of stereo records is mixed down to mono below 100Hz. The signal of interest is therefore identical in both channels and can easily be obtained from one! This also has the advantage of preventing possible crosstalk between channels at higher frequencies and the woofer therefore has no deleterious effects on the stereo image.

To avoid hum loops the speaker electronics are not separately earthed. The unit is automatically earthed when

BUYLINES

A designer-approved kit of parts for this project is available from Bewbush Audio, 26 Hastings Road, Pound Hill, Crawley, Sussex RH10 4AT. The kit includes all of the electronics and two PF81HR drive units but not the woodwork. It costs £49.95 inclusive. The electronics alone can be supplied as a kit for £29.95 but note that Bewbush will not supply individual parts. B200A drive units are available from Wilmslow Audio and the Autona UL60 amplifier module is available from Bi-Pak. None of the other components should present any problems. PCBs will be included with the kits but are also available through our PCB Service.

connected by the amplifier earth. For this particular application nothing spectacular is required of the amplifier, especially as the bandwidth ceases at 90Hz! All that is necessary is the appropriate output power, about 30W, and

HOW IT WORKS

The full circuit of the woofer is shown in Fig. 2. Input signals are applied to the gain control RV1 via SK1. Q1 in conjunction with R1/2/3 and R4 forms a simple virtual earth amplifier. The gain is set by the ratio of R2 to R1 whilst C1 isolates the base of Q1 from DC ground.

The amplified signal from the collector of Q1 is DC coupled into the second stage formed around Q2. This transistor used in the emitter follower mode and provides a low impedance drive for the amplifier module.

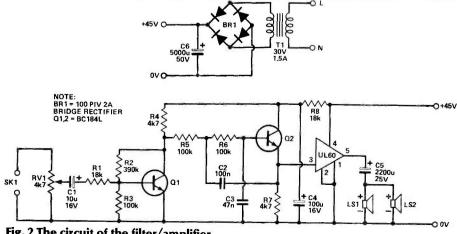
In order to equalise the output to the woofer a Butterworth filter is used. R5/6 and C2/3 form the second order network with a -3dB point below 20Hz. The Q of the filter with the chosen component values is close to the optimum 0.7. Filters of this Q give the

maximum rolloff rate consistent with low ripple in the passband.

R8 and C4 form a simple but decoupling effective network to provide the circuit with a ripple - free power line. To prevent any nasty and expensive damage to the drivers, the output is AC coupled by C5. In order to maintain a high damping factor down to low frequencies a large value electrolytic is required here.

Finally we come to the power supply proper which is thoroughly conventional. The mains voltage is both isolated and stepped down by the transformer T1. The raw secondary AC output is full wave rectified by BR1 and smoothing is provided by C6.

Notice that the drivers are wired in parallel. This means that the impedance seen by the power amplifier is some 4 ohms.



PROJECT : Active Bass Loudspeaker

sufficient voltage gain. To avoid reinventing the wheel, a ready built power amp module is used.

Construction

This breaks down neatly into three parts, the electronics, the mechanics and the cabinet, and construction of the electronics should be tackled first.

The layout of the filter/amplifier PCB is shown in Fig. 3. PCB pins or veropins were used in the prototype for connections to the board, and if you plan to do likewise it is a good idea to insert them before assembling any other components. Push them well home and then solder them to ensure a good connection. If you do not wish to use pins, simply solder flying leads onto the board in the normal way, enlarging the holes if necessary to allow the wires to pass through. The rest of the PCB assembly should present no problems, the only point to watch being the polarity of the various electrolytic capacitors and semiconductors.

The next stage of the construction is to drill the heatsink and mount the PCB assembly and the amplifier module. The details are given in Fig. 4. Note that 10mm spacers have been used between the PCB and the amplifier, but if these are not available simply use nuts instead. It is important that there is good thermal contact between the amplifier heatsink and the main heatsink, so de-burr the mounting holes and make sure that no metal filings get trapped between the two surfaces when you assemble them. Finally, attach the bridge rectifier and C5 to the heatsink with 4BA nuts and bolts.

That takes care of the easy stuff -

PARTS LIST - ELECTRONICS =

RESISTORS	(all 1/4W, 5%)
R1,8	18k
R2	390k
R3,5,6,	100k
R4.7	4k7
RV1	4k7

CAPACITORS

C1 '	10u, 16V electrolytic
C2	100n polyester
C3	47n polyester
C4	100u 16V
_	electrolytic
C5	2,200u 25V
	electrolytic
C6	5000u 50V
	electrolytic

SEMICONDUCTORS

MISCELLANEOUS

KEF B200A drive
units (or Altai
PF81HR - see text)
30V, 1.5A mains
transformer
two-pole input
socket to choice

PCB; veropins or similar; Autona UL60 amplifier module; 6" x 4" heatsink; 10mm spacers; 'P' clip or strain relief bush; aluminium for control panel; capacitor clamps for C5 and C6; nuts, bolts, cable, etc.

the next stage is to assemble the cabinet itself. The cutting details are given in the cabinet parts list. You can purchase a large sheet of veneered chipboard and cut it up

yourself, but unless you have a good saw-bench and are resonably skilled in using it you will probably be better off purchasing the materials ready cut. Most DIY stores possess facilities to do this but you would do well to ask around and find somewhere with both the equipment and the skilled staff necessary to do a really good job. Even a smalll error will make construction much more difficult and the problems inherent in producing a neat end result and making it airtight will be multiplied considerably.

The cabinet has been designed for maximum rigidity, a fundamental requirement if rattles and buzzes are to be avoided. The rigidity is achieved by splitting the cabinet into two with an internal partition, and the panels are glued and screwed together with 11/4" self-tapping screws.

Another requirement of this design is that the cabinet should be airtight. In practise this is not a problem as long as all the joints are filled with an appropriate filler. A good seal around the drivers is also imperative but this is automatically achieved by using the gaskets provided.

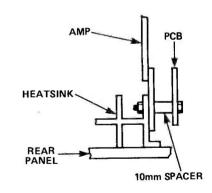


Fig. 4 Mounting arrangements for the amplifier module and PCB.

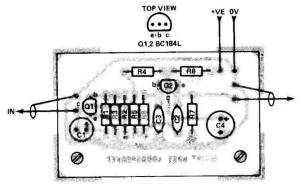
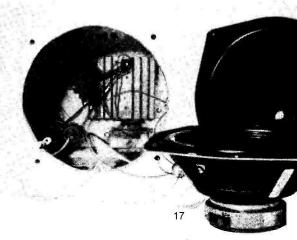


Fig. 3 The overlay diagram of the filter PCB.

ETI JANUARY 1985



PARTS LIST - ____

PANELS

(All 5/8" veneered chipboard)

Short sides (A) Long sides (B) Partition (C) 9" x 9" (2 off) 20" x 9" (2 off)

Partition (C) 73/4" x 9" (1 off) Front and back (D) 183/4" x 9" (2 off)

MISCELLANEOUS

Glue; woodscrews; veneer strip if desired (to cover exposed edges of panels); speaker cloth/protective grille as desired.

Assuming one has all the panels to hand construction can commence. Start by labelling each panel with the appropriate letter on its worst side, see Fig. 5. Find the partition panel (C) and drill a ¼" (6mm) hole in it to take the wires from the drive unit. The position of this hole is far from critical, and anywhere near the centre of the panel will be fine!

Mark out the position of the screw holes on the panels and drill 1/8" (3mm) pilot holes through these positions. Choosing the best face, countersink these to take the screw heads. If a countersink is not available a good job can be done with a 3%" twist drill turned by hand against the hole. The control panel aperture in the rear panel should also be cut at this stage.

It is best to mount the heatsink, capacitors and transformer onto the back panel before assembling the cabinet. Attach them using 5%" long No. 6. self-tapping screws and tighten down well to avoid the risk of strange buzzes etc caused by loose fittings. The interwiring of these parts is shown in Fig. 6, and 16/0.2 or a similar fairly heavy gauge wire should be used for all except the signal leads which must be single screened cable and the power leads between the PCB and amplifier which can be ordinary hook-up wire.

The cabinet itself can now be assembled. Start with the two long sides (B) and glue and screw these into position against the rear panel (D). Similarly attach the two short sides (A) and finally the partition (C). In each case the screws should

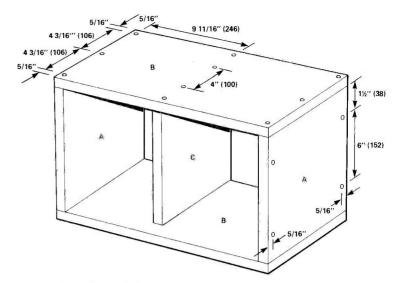


Fig. 5 Construction of the cabinet.

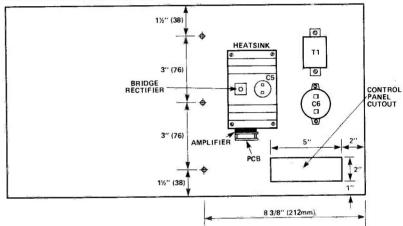


Fig. 6 The positions of the principal components on the rear panel,

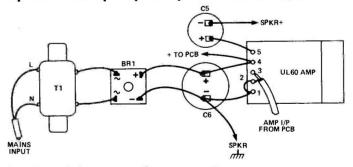


Fig. 7 Interwiring of the rear panel components.

be tightened into their countersunk holes until the heads are just below the surface of the wood.

Cut out a suitable piece of aluminium to form the control panel and drill holes to suit the potentiometer and input socket you plan to use. Wire these leaving 9" or so of free lead, drill suitable mounting holes in the rear panel of the cabinet and attach the control panel using self-tapping screws. Cut the free lead to length and solder it to the appropriate points on the PCB.

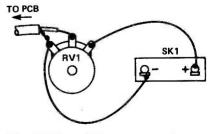


Fig. 8 Wiring of the components on the control panel.

Drill a 1/4" (6.3mm) hole in the rear panel, thread the mains lead through it and use a 'P' clip or other

PROJECT: Active Bass Loudspeaker

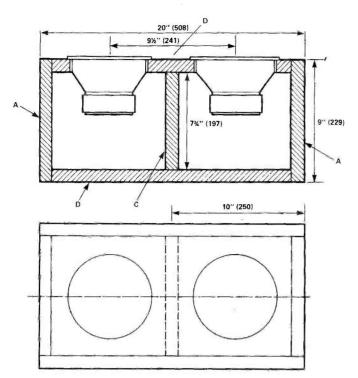


Fig. 9 Front panel and drive unit mounting details.

retaining device to provide strain relief. Don't just tie a knot in the cable! Seal the hole around the cable with a suitable glue or filler so that the finished cabinet will be airtight. Complete the rear panel wiring by soldering leads to C5-ve and ground and leave the ends of these long ready for connection to the drive units.

Attention can now be turned to the front panel. Mark out the positions for the two drive units and use the template provided with them to mark the cut-outs and the mounting holes. The drive unit apertures can be cut by hand but it is much quicker to use a jig-saw attachment on a power drill. If the B200s are used, note that they are provided with 'T' nuts and drill the mounting holes out to ½" to accomodate these.

Assemble the prepared front panel into the cabinet and glue and screw it into place. Draw out the loudspeaker leads through one of the drive unit apertures, solder them onto one of the drive units and solder a second pair of leads in parallel. Return this second set of leads into the cabinet, pass them throught the hole previously drilled in the central partition and draw them out through the second drive unit aperture. Solder them onto the second drive unit, taking care to observe phasing, and the internal

wiring is complete. The unit should be left in this condition, with the drive units connected but not installed in the cabinet, while the initial testing is carried out.

Connect a lead to the input of the Neptune and fit a plug to the mains lead. Set the potentiometer on the control panel at minimum and switch on. Apart from the switch-on 'plop' no noise should be heard unless the ear is placed very close to one on the drive units. If there is no 'plop' or worse, if a loud hum appears, switch off immediately and check the wiring.

If all is well, advance the potentiometer towards maximum and touch the signal input terminal. This should produce a loud buzz. Again, if nothing happens, switch off and check the wiring carefully.

If this test, too, is successful, mount the two drive units in place. Don't forget to use the gaskets provided so as to ensure an air-tight seal. When this has been done, gently press one of the drive unit cones inwards using even pressure around the voice coil. The other cone should move outwards. If it doesn't, check carefully around the cabinet until you find the air leak responsible and plug it.

Installation

No mains switching has been

provided on the Neptune because most modern stereo amplifiers are equipped with mains outlets and it is intended that one of these should be used. Such mains outlets are usually wired through the amplifier's on-off switch, so connecting the Neptune in this way removes the need to switch it on separately every time the stereo system is used. If your amplifier has such a socket, it is merely necessary to fit the appropriate plug to the mains lead, the most usual type being a shaver plug or an American-style twin flat-pinned plug. Leave about three metres or so of mains lead on the Neptune so that you can experiment with its positioning.

If your amplifier does not have a mains outlet, you will either have to fit an on-off switch to the Neptune or settle for plugging and unplugging the mains lead each time you use your stereo system. A mains switch could be added quite simply by enlarging the control panel slightly. Whichever approach you use, if the Neptune is switched independently of the amplifier you should always switch the amplifier on first and then the Neptune, never the other way around.

Connecting the input of the speaker to the output of your amplifier should pose no problems. With any luck you will have pressterminals on the amplifier into which the extra pair of leads can easily be inserted. If not, you will either have to make up an adaptor or add an extra socket on the back of your amplifier. Remember that you only need a connection from one channel of the amplifier and that it doesn't matter which one.

To set the unit up you will need a source of some description, preferably one offering signals containing male speech. A radio tuner set to Radio Four is probably best. Adjust the potentiometer on the control panel until there is no trace of 'boomyness' on the speech, then try the unit out with a music source. The bass response should have improved dramatically.

Experiment with the position and gain of the Neptune until you are satisfied with its performance. Remember that the best position is likely to be against the wall and floor and away from corners.

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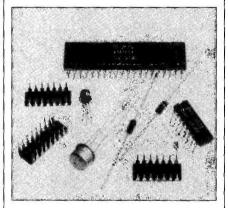
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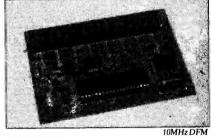
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IC RELIABILITY

How reliable are standard ICs? What makes them not work properly?

onventional wisdom has it that, after early failure, ICs are by and large pretty damn reliable. However, that doesn't mean that there aren't rogue or 'problem' devices — for example, see the telex reproduced here, about a device which was successfully used by a contributor to 'Electronics Monthly', but which has subsequently been withdrawn by the manufacturer.

84-10-30 14:21

*
8811896ASP G
23272 GIMOST G
30 OCT 84 ATTN: H ARMSTRONG TLX LON 3505

REF: AY-3-1270
REGRET TO INFORM U THAT I AM UNABLE TP PROVIDE U WITH A SOURCE FOR ABOVE PRODUCT OUE TO REASONS OF DEVICE RELIABLITY.

RGDS I MCCALL
JW
NNNN*
8811896ASP G
23272 GIMOST G

Elsewhere in this issue, we carry details of a 'fix' for our original 64k DRAM card. This 'fix' was made necesary because we had a number of readers telling us that they couldn't get the dratted thing to work, and we couldn't get one that we had recently built ourselves to go — even after ammending the PCB in a couple of places!

Added to this we also had informal indications (ie, nothing you could quote anyone on) that the DRAM controller IC, 74LS608, was a 'problem device'. So what makes a 'problem device'? We talked to Texas Instruments, the manufacturers of the device in question, to find out their side of the story.

Firstly, no one was aware of a specific problem with the '608, and we wouldn't identify the person who had told us that it was a 'problem device'. Although they could not locate any documentation to confirm it, there was the suggestion that there might have been some revisions to the die at a relatively early stage in the production run.

Looking at the DRAM card circuit, TI's engineers were not that happy about the delay sections formed by R1, C1, D1 and R2, C2, D2. The problem is that IC17a and b, the devices that immediately follow the delay circuits, are not Schottky devices, so the rise times from them would not be particularly fast, and this could cause problems with edge-triggered inputs. However, this was unlikely to be the cause of the problem here.

We then discussed the problems associated with the power-up of this and any other MSI device. This discussion was prompted by the section in the original article which suggested that some earlier production devices may have had problems with the power-on reset circuitry (which ties up with the suggestion that there may have been some revision of the die).

One of the problems with this and other computer add-on projects is that it is not possible to predict how power will be applied to the circuit — for instance, it may come on very quickly, there may be transients associated with ringing (although we hope that this sort of problem would be dealt with by most monolithic regulators), or the power might come on very slowly. The last of these is one possible cause of the problems with the DRAM card.

Different sections of a large or medium scale integrated device will start to function at different supply voltages. So if the supply voltage builds up very slowly after switch-on, it is possible, even likely in some cases, that fault conditions will develop that lead to a latch-up which will persist even when full power is applied to all sections.

Another problem is associated with ringing on input (or even output) lines. Readers will know how easy it is for a square-wave to acquire ringing — all it takes is a little unwanted inductance here, a little stray capacitance there, and bingo!, the square wave is ringing like Big Ben!

In a TTL (or CMOS) circuit, this can cause havoc. The problem is that the ringing excursions can take the input (or output) voltage above or below the positive or negative supply lines, respectively. This is a more manageable problem in discrete component circuits, because you always know what the real circuit is; however, with integrated circuits, there are always parasitic devices; eg transistors or thyristors, that have

— The TI Scare-

Readers will remember that a little while back, it was alleged that possibly faulty chips had been sold on defence contracts. Quite a stir was created, with the story making the evening TV news and front pages of several papers.

The truth is a little more mundane, but in its own way equally alarming. According to a letter in the trade press (Electronics Times, 25 Oct) from Peter Van Cuylenburg, Tl's MD, the ICs were properly tested. However, the tests did not conform to those laid down in the specifications for the devices, but, according to Mr Cuylenburg and to the Pentagon, the tests carried were actually more appropriate to the way the devices were to be used than the tests laid down in the specification.

However, no-one has yet explained how the wrong tests came to carried out and how it came to be that this was not picked up at a much earlier stage. This failure is, if anything, considerably more worrying than a few rogue devices finding their way into the system.

been produced inadvertently while making the wanted devices. This is as a direct consequence of all the devices on an IC being made on the same piece of silicon, and much of the design effort in laying out an IC is devoted to avoiding problems from parasitic devices.

The objective will be to ensure that, under normal operating conditions, the parasitic devices will all be biassed off. However, input and output conditions which exceed the supply lines — such as occur with ringing - can cause a parasitic device to come on, leading to the generation of a false logic state, or even to complete latch-up.

For example, some MOS DRAMs are very sensitive to over-shoot and under-shoot, and will latch up completely due to the presence of parasitic thyristors. However, so long as the signal lines do not exceed the supply lines, these devices will be perfectly reliable.

Whilst we're on the topic of supply lines, another problem is that they tend to be rather noisy, particularly in TTL circuits where fairly high currents are being switched. For this reason it is not good practice to tie any IC inputs to the positive supply line — although we

all do it. The safest option is to design around this in the first place, where this is possible, but otherwise tie inputs to the output of a spare gate, or use a pull-up resistor. Again, this is a particular problem with edgetriggered inputs, where noise on the supply line can lead to false triggering.

So do problem devices exist after all? TI are confident that all their devices meet the published specifications. That said, there will inevitably be some devices that will be rather more sensitive to circumstances of their use than one would like. Obviously, when introducing a new device, a semiconductor manufacturer cannot imagine — let alone test — all possible applications or circuit lay-outs. Basically, it is all too easy to inadvertently exceed the specification of an IC without realising it, and it will be only after extensive testing that you will find out what is going wrong. Fortunately, most devices are reasonably tolerant of minor violations on most of the specs.

Meanwhile, TI and ourselves will be investigating the 64k DRAM card further, to see what has been causing the problem. We'll let you know of the outcome when we have something to report. ETI

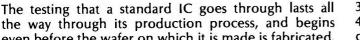
3. Functional test (does it work in a circuit?)

4. Parametric test (does it live up to the fine print in the data sheet?).

Any dies that fail this test get a red dot of ink, and are discarded at the next stage, where the wafer is sliced up into dies and packaged. After packaging, every single IC goes through the same test programme again. Only after this do the ICs get 'symbolised' (ie, labelled).

The next stage is only carried out on military equipment or on larger dies, eg microprocessors; this is testing at an elevated temperature, and temperature cycling. This tests for two things: firstly, it will check to see that the die is properly mounted, otherwise the expansion and contraction will detach it; and it also accelerates early failures.

In fact operating at an elevated termperature greatly decreases the life of all devices, and one of the quality control tests that a competent manufacturer will be doing is testing samples of all devices at an elevated temperature to see how long they last. This can then be extrapolated back to devices used at normal temperatures to see if there is any sort of longevity problem with them.



the way through its production process, and begins even before the wafer on which it is made is fabricated. The selection of materials, the growing of the crystal, the slicing of the crystal up into wafers and the growing of an epitaxial layer on the wafer are all closely monitored.

At every stage of the diffusion of dopants into the wafer checks are carried out on the resistivity of the silicon — obviously, this is influenced by the amount of impurity which has been absorbed.

Next, checks are performed on the test geometries that are placed on each wafer for no other reason. If you see a wafer before it is sliced up, you will notice that four or so dies are actually different from the rest these are the test geometries, and simple go/no-go measurements can be carried out on these to detect gross faults.

The finished wafer then passes to a test bed where each die is tested as follows:

1. Basic electrical test;

2. Truth table check (does it do what it is supposed to do?):

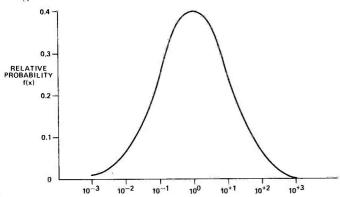


Fig. 1 Typical IC failure rate against time — the actual timescale will vary, though.

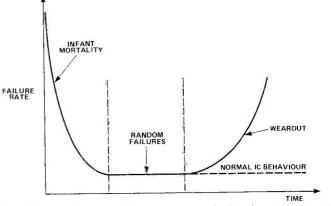


Fig. 2. Long-term failure rate — electronic components should not wear out unless there are problems.

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MW RADIO KIT Based on ZN414 IC, kit in cludes PCB wound aeria crystal earpiece and all components to make ensitive miniature radio Size: 5.5 x 2.7 x 2 cms.
Requires PP3 9V battery. IDEAL FOR BEGINNERS 20kV MULTIMETER 19 rangs including 10A dc. Resistance to 10M, ac & dc volts to 1kV. Battery checker and continuity buz-zer. Size: 135 x 89 x 40mm. (405 104)

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Based on SAB0600 IC the kit includes all
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DIGITAL MULTIMETER 19 ranges including dc current to 10A, resistance to 20M, ac & dc

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volts and npn/pnp transistor gain. Full overload protection. Comes with test leads, battery and case. Size: 175 × 93 × 42mm [405 204]

20KV MULTIMETER 20kV MULTIN multimeter with 23 range quality multimeter with 23 range quality and to 1400 years and to 1200 years and to 1200 years and to 1200 years and 8 scale. Transistor gain and 48 scale. Transistor gain scales, battery tester. dB scale. Transistord dB scale. Scales, battery leakage scales, 56mm. €16.95 Size: 155 (405 106)

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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 switching controlled devices. the controlled device. General instructions and applications are supplied. The kits are coded and provide a high degree of security and noise immunish. MK 18 Transmitter Kit.— for use with MK 11/MK12 receivers. Requires PP3 battery. Size: 8×2×13cms. Range approx. 60 ft. £6.80

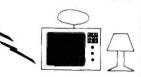
60 ft. E6.80
Keyboards for MK18
MK9 4-way for use with MK12 £1.90
MK10 16-way for use with MK12 £5.40
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MK11 Receiver Kit — mains powered.
Provides 10 latched plus 3 analogue outputs ideal for controlling audio amplifiers,
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MK14 AC Power Controller Kit — for (phase) controlling AC loads from MK11 analogue outputs, eg lamp dimming.

MK19 Stereo Amplifier Controller Kit for remote control of bass, treble and volume (or balance) by MKII. Includes a one of Volume to balance by with, 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 remains powered Latched version is for applications re-quiring 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

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701 115 Additional Relays

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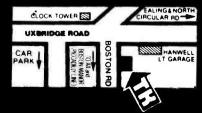
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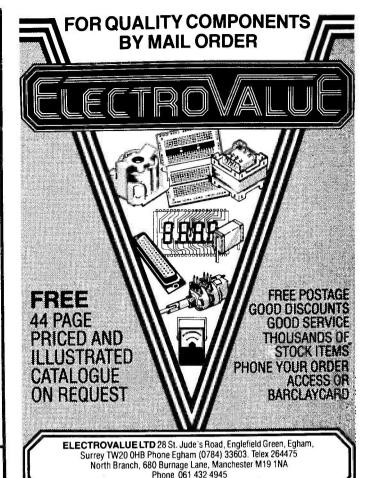
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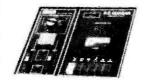
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SPECIFICATIONS:

Max output power (RMS): 125 W. Operating voltage (DC): 50 - 80 max. Loeds: 4 - 16 ohm Frequency response measured @ 100 watts: 25Hz - 20KHz. Sensitivity for 100w. 400mV @ 47K. Typical T.H.D. @ 50 watts, 4 ohms: 0.1%. Dimensions: 205x90 and 190x36mm.

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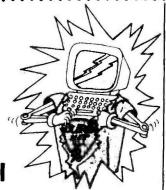
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DRAM BOARD UPDATE

Ahh! Doesn't it take you back to the balmy days of September 1983 when ETI first published its 64K DRAM board? The sheer technical excellence of the design, the excitement as you completed your very own memory card, the horror when you found it didn't work. Never mind, says Phil Walker, memories are re-made like this....

n September 1983 we ran a design for a 64K DRAM board to connect to the Microtan 65 system or indeed any 6502 processor system. Although the original worked satisfactorily we received a number of letters from readers who could not get theirs to work. At first it looked as though there was a faulty batch of the 74LS608 controller chip around which the design was based but after a while it became apparent that it was "a problem device".

To overcome the shortcomings of the original design and to simultaneously incorporate some new features, last month's Experimenter's DRAM Card was designed. This removed the need for special ICs by using standard components. The only unusual items were the 4416 16K x 4 bit dynamic RAMs which were used because they allowed the PCB to be only partially populated when a significant proportion of the address space was not required.

Once this board was working on the author's 6502 system — which runs at 1.25MHz, a little faster than the tangerine — it seemed reasonable that we should go back and do something for all those people who had built the 1983 project. To this end we have designed a small PCB which contains all the necessary control logic to replace both the 74L5608 and two other devices on the original board.

This PCB is mounted 'piggy-

This PCB is mounted 'piggyback' fashion on the PCB once all the original control ICs and timing components have been removed. All the original features relating to address space allocation are retained and the same PROM can be used. One thing which may be of interest to non-Tangerine users is that there is no longer any need for the φ 1 signal to be provided as all timing is taken from the edges of the φ 2 signal.

The Circuit

This is identical in most respects to the control logic in last month's project. One significant difference is that the incoming select signal from the PROM is high to enable rather than low. However, since

HOW IT WORKS

This is very much the same as for last month's Experimenter's DRAM Card project but we shall go through it briefly in relation to the original design.

All timing is performed relative to the rising and falling edges of the φ 2 signal from the 6502 processor. φ 2 is buffered by IC22a and by means of the delays in IC22b, C21 and 22. IC23 is triggered on both edges of 02 to produce the RAS pulse. The width of this pulse is controlled by RV21 in conjunction with C23 and R23.

A delayed version of the RAS signal is used as the MUX signal to operate the row/column address multiplexers. Shortly after this IC24a is clocked, and if $\varphi 2$ is currently high and the inverted SEL line is low, the CAS output will go low and stay low until $\varphi 2$ goes low at the end of the processor access period. This keeps the data at the outputs available for longer when a read cycle is required. If $\varphi 2$ was low then the CAS output will stay high and a refresh operation will occur.

If all other conditions for a processor access cycle have been satisfied, to write data to memory the R/W line will be low. This condition is gated with the state of the inverted φ 2 signal in IC22c and with the MUX signal in IC22d. This ensures that the WE low condition is only asserted at the

requisite time.

At the end of each RAS pulse IC24b is clocked to sample the state of the $\varphi 2$ signal. The outputs of IC24b are used to enable and disable the address buffers and allow the processor or refresh addresses onto the memory chip address pins at the appropriate times. Doing it this way rather than with the $\varphi 1$ and $\varphi 2$ clock signals allows more settling time for the buffers and the refresh address counter before the RAS strobe occurs to start the next operation.

The last piece of circuitry to describe is the power-on-reset. This is produced by IC1b and c together with C25 and R21. D21 allows C25 to discharge rapidly when the power is turned off. By means of this circuit, IC23 and 24b are held in a defined state for a short while after power is applied. This allows the internal circuitry of the memories to become operational. This operation is required when power is applied, not when the processor is reset. Note also that eight RAS only cycles should by performed after the power-on-reset before the memories are fully operational. However this will usually be taken up by the system initialisation routines reading from ROM.

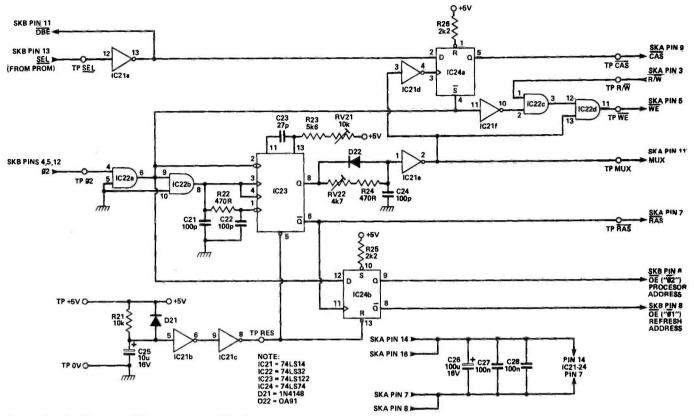


Fig. 1 Circuit diagram of the new control logic.

there is no G pin on the 4164 devices, the inverter which previously provided this signal can now be used to invert the SEL line and enable the data buffer at the appropriate time.

The other difference is in the WE circuitry. The lack of the G pin on the 4164 means that, if we want to connect the data - in and data - out pins of the memory chips to the same data bus as in the original

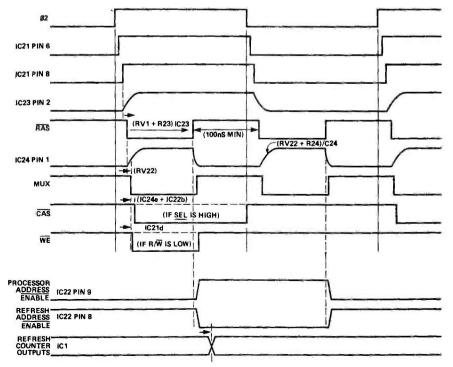


Fig. 2 Timing diagram for the control logic showing how all of the signals are derived from φ 2.

design, the write cycle must be the so-called 'early write' detailed in the data sheet. This requires that the WE signal go low before the CAS signal goes low. If this is not done the data outputs of the memory chips will become active and may try to drive the data bus into a state opposite to that of the bus buffer.

Construction

Construction of the PCB itself is quite straightforward. Remember that there are four wire links to be inserted as this is a single sided board. If height is likely to be a problem then solder the ICs directly into the PCB but otherwise use sockets. The other components are simple to install but the usual care should be taken to get polarities correct.

Assembly onto the main board should be postponed until the add-on board has been tested. You will need access to a signal generator giving a 1MHz TTL compatible square wave signal and an oscilloscope with which to see the results.

Connect a suitable +5V supply to the board and check that the current drawn is not more than

PROJECT : DRAM Update

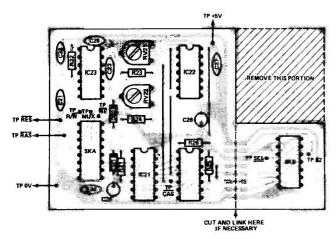


Fig. 3 Component overlay of the PCB.

100mA or so. Connect the SEL testpoint to 0V and a 1MHz square wave TTL compatible signal to the φ 2 test point and monitor the signals on the RAS, CAS and WE test points. Only RAS should show any activity at this stage and its low time should be set to about 300ns by means of RV21 (one half to three-quarters clockwise rotation). Both the CAS and WE signals should be high. A worthwhile check at this stage is to see that SKB pins 6 and 9 are switching at the same rate as the φ 2 signal but phase shifted from it. Also check that the MUX signal at SKA pin 11 is similar to the RAS signal but slightly delayed from it (RV22 should be set to approximately one quarter of its clockwise rotation). Note that the RAS and MUX signals are at twice the φ 2 frequency.

So far we have checked that IC21e, 22a & b, 23 and 24b are working. Now set the SEL test point to +5V, or just open circuit the link you previously inserted, and check that the CAS test point shows low pulses but only while φ 2 is high. The RAS to CAS delay time can be adjusted by means of RV22 if required but will only be critical if you have a slow processor.

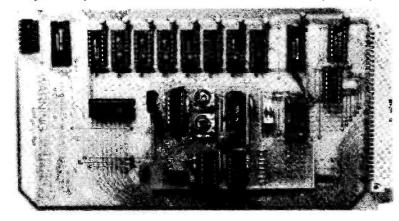
There are only two other sections to check. Monitor the WE output and check that, with the R/W

input open circuit or logic high, this output is also permanently high. Applying a logic low or 0V signal to the input should cause the WE output to produce a series of low pulses, at the same rate as φ 2 but with the same width as the MUX low signal. The WE pulses should only occur when φ 2 is high.

The last thing to check is the power-on-reset. If possible, monitor the RES test point and the voltage across C25. Temporarily short circuit C25 and check that the test point stays high for a few milliseconds after the short is removed.

By now you should have a fully tested board and will be ready to connect it to the original DRAM. First disconnect all the wires you used in the testing phase and connect 22 SWG tinned copper wires to the SKA and B positions. Cut these off flush with the top side of the board but leave them about 25mm (1 inch) long on the wiring side.

Next remove IC16, 17 and 18 from the original PCB together with their sockets and R1 to 6, C1 to 6 and D1 to 3. If you have not corrected the original PCBs you should now connect IC1 pins 2 and 12 to 0V, IC3 pin 9 to IC4 pin 9 and the tracks going to EC2a and 2b to EC3a and 3b respectively instead.



PARTS LIST _______ RESISTORS (1/4 watt 5% carbon film)

R21	10k
R22, 24	470R
R23	5k6
R25, 26	2k2
RV21	10k miniature horizontal
	preset
RV22	4k7 miniature horizontal
	preset

CAPACITORS

100p silver mica or
polyestyrene
27p silver mica or
polystyrene
10u 16V tantalum bead
100u 6V tantalum bead
100n ceramic disc

SEMICONDUCTORS

IC21	74LS14
IC22	74LS32
IC23	74LS122
IC24	74LS74
D21	1N4148
D22	OA91

MISCELLANEOUS

PCB; 4 off 14 pin DIL Sockets if required; thin sheet of insulating material.

In order to fit the PCB into the Microtan rack we found it necessary to remove C7 and trim the through-board link near IC1 pin 14.

Having done all necessary corrections, the time has come to put the two PCBs together. First remove all of the ICs from both boards and put some thin insulating sheet under the new PCB to prevent shorts to tracks on the top of the old board. Now carefully feed the wires from SKA through the holes vacated by IC16 and the wires from SKB through those left by IC18. Make sure that none of the wires are misplaced or strained and carefully ease the two PCBs as close as possible to each other. Solder the wires on the underside of the old PCB and clip off excess length.

Insert all ICs (except 16, 17 and 18) and the assembly should be ready for use. If necessary, some adjustment may be made to RV21 and RV22 but this will usually not be necessary if the other stages have been carried out.

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Absolutely everything here is readily available from any number of different suppliers and the PCB is available from our PCB service.

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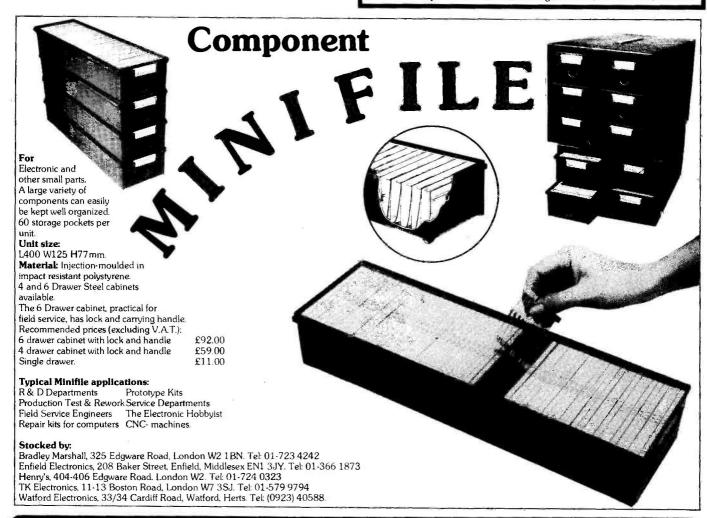
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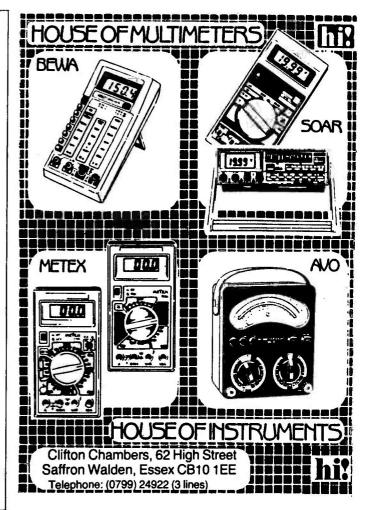
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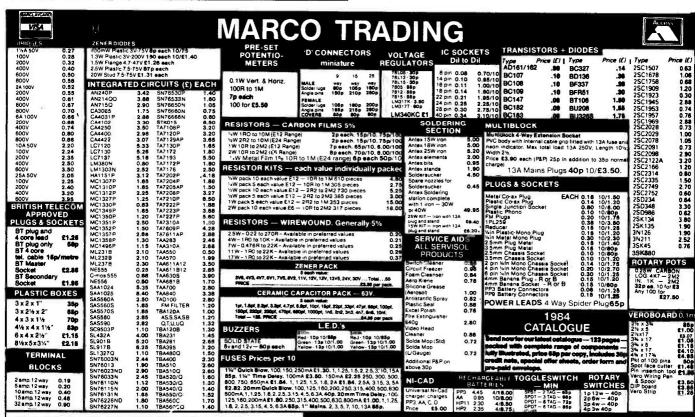
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THE OTHER END OF THE SCALE

Single-bit microcomputers are alive and well - and will soon be living in your washing machine or TV. James McGuigan, System Engineer at Motorola Semiconductor Products Sector, East Kilbride, introduces the MC6804P2 single - chip microcomputer.

single-chip microcomputers are set to invade our homes! Like Greek warriors, they'll be hiding inside Trojan horses, although these horses will look more like washing machines and TV sets.

Actually, it's all very logical and nothing to worry about. Mechanical controls are unreliable and expensive to make, and for some time electronic controls have been replacing them in a large range of applications. What could be more logical than using a single-chip microprocessor to replace a board-full of TTL or CMOS, and, at the same time,

upgrading the 'intelligence' of the control unit.

This invasion will be self-reinforcing: the more devices use the single-chip microcomputers, the cheaper and better known they will become, and so more devices will use them. Prime targets will be TVs and videos, games, toys, cameras, motor vehicles, power tools and domestic appliances. For example, the device here could be used to control a TV set, tuning in the channel selected via a phase-locked loop, controlling the sound level by a voltage-controlled potentiometer, and accepting instructions from a remote control unit.

Motorola's involvement in single-chip microcomputers started with them second-sourcing MOSTEK's MC3870. Motorola's first 'home-grown' single-chip device was the MC6801, which was on the market in 1978.

As you might expect, the MC6801 had quite a lot of the same circuitry the MC6800 microprocessor - why re-invent the wheel when you can use something that you know works? Additional circuitry included program memory (ROM) and data memory (RAM), besides input/output ports, a serial communications interface and a multifunction timer.

In 1979, the availability of improved chip fabrication techniques allowed the size of the chip die — the actual piece of silicon on which all the clever stuff is mounted — to be reduced. The technology used is refferred to as HMOS (High density n-MOS) and involved the use of interconnections on the silicon of 3.9 um width (by comparison, Motorola are presently preparing themselves to use tracks of 1 um or smaller). The size of the die makes quite a difference to the price of the final IC, so this change allowed the price to fall.

Also in 1979, Motorola introduced the MC6805P2. This was essentially a development from the 6801; it had been found that most applications did not require as sophisticated a register set as the 6801 provided, and so these were reduced. The RAM and ROM were reduced in size, and the timer was simplified, and the serial interface

was dropped.

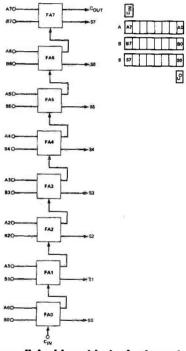


Fig. 1 Eight-bit parallel adder with ripple-through carry.

There are now a series of devices in the 6805 family, all with different bells and whistles added to make them more appropriate to particular control or other applications.

All Change

The MC6804P2 represents a major change in direction for Motorola's single-chip computers. Not only has any resemblance to the 6800 been abandoned, but the whole basis for the architecture has been changed. The major difference is that the 6804 uses serial rather than parallel architecture. However, Motorola have managed to work the trick of making the 6804 appear to be an eight-bit device to the user. The whole purpose of this is to reduce the diesize, which, as we've already observed, reduces the cost of the finished IC. Let's take a closer look at what having serial architecture actually means.

Conventional microprocessors manipulate data in lots of eight bits, ie bytes. For example, the central processing unit (CPU) and data bus are eight bits wide. An address bus and program counter (PC) of 12 bits wide can access up to

4096 bytes (4K) of data.

With the 6804 family all the hardware is actually only one bit wide. All data transfers, arithmetic and address operations are carried out serially one bit at a time. This means that the CPU, data bus, address bus, program counter, timer and prescaler are all only one bit wide.

Consider, for example, an eight-bit arithmetic and logic unit (ALU). Within this ALU we have an eight-bit adder to add two eight-bit numbers A and B (and possibly a carry-in bit as well). The adder will have eight sum bits

and a carry-out bit as its output.

The eight-bit adder will be made up of eight separate single-bit full adders as shown in Fig. 1, which shows a 'ripple-through' adder configuration. First of all the least significant bits A0 and B0 are added to Cin. The sum appears at SO and any carry 'ripples' through to be added to the sum of A1 and B1. This carries on until the eight-bit sum of A and B is calculated.

The eight-bit adder described above uses eight singlebit full adders plus three registers to hold A, B and their sum — this is a lot of hardware and consequently expensive. However, it is possible to make do with just one single-bit full adder as shown in Fig. 2. This serial adder is made up of one single-bit full adder, three shift registers

and a D-type flip-flop.

When two eight-bit numbers are to be added, they are loaded into shift registers A and B. The least significant bit is to the right and the most significant bit is to the left. On each clock pulse, registers A and B are shifted one bit to the right. The bits which 'fall out' of the registers provide the inputs to the adder along with Cin. The adder's sum output is shifted into the SUM shift register. Any carry from this single-bit addition is latched by the D-type flip-

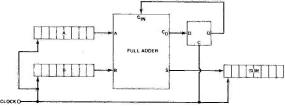


Fig. 2 Eight-bit serial adder using only one full adder.

Obviously, the serial method is somewhat slower but there is an enormous saving in hardware and, consequently, space. Consider now the above principles applied to microprocessors. If we can reduce the amount of on-chip hardware then considerable savings can be made in chip size. A smaller chip size means that more can be fabricated on to a silicon wafer. In turn, this means increased productivity and cheaper processors.

Of course, the serial approach is always going to be slower than parallel design but there are many applications in which speed is not critical. In any case, with the 6804 provision has been made to permit the use of very high clock speeds: the maximum external oscillator

frequency for the 6804P2 is 11MHz.

The following description applies mainly to the MC6804P2 version with mask-programmed program ROM; however, the soon to be released MC68705P3 EPROM version is similar to the point of pin-compatibility. Also, a wide range CMOS (as opposed to NMOS) devices are planned and these will also be very similar.

In More Detail

Figure 3 shows the MC6804P2 block diagram. The CPU contains the ALU, control, stack and registers. Memory consists of three areas: program ROM (1K), data memory (64 bytes ROM and 32 bytes RAM) and the stack. The timer circuitry is made up of prescaler, counter and control

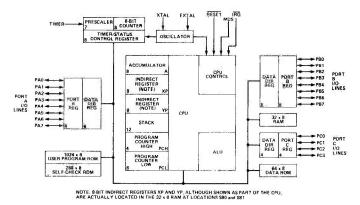


Fig. 3 MC6804P2 block diagram.

registers and oscillator circuitry. The 6804P2 also has 20 versatile I/O lines.

The CPU is similar to that of the 68705P3. However, there are some differences. The eight-bit accumulator is memory-mapped at address \$FF and has indirect registers which replace the index register on the 68705P3. The indirect registers are memory-mapped at locations \$80 and \$81.

There are only two condition code flags on the 6804P2, C and Z, and there is no condition code register. The flags used for normal processing and interrupts are different. With interrupts, the processor automatically uses the interrupt-mode flags and, on return from interrupt, the normal-mode flags are used. Previous flag states will be used when switching from one set to another.

The stack is used to store subroutine and interrupt return addresses. It is a hardware stack, 12 bits wide and four levels deep (ie equivalent to a 48-bit shift register). Its last-in, first-out (LIFO) configuration eliminates the need

for a stack pointer.

A crystal, R-C network or external signal can be used to generate the system clock. A mask option selects either

the crystal or R-C network oscillator circuit.

The oscillator frequency is divided (internally) by four to produce the internal clock. This in turn is divided by twelve to produce a machine cycle. A machine cycle is the smallest unit needed to execute any operation and an instruction may need two, four or five machine cycles to execute.

To facilitate testing, a signature analysis circuit has been included on the chip. The circuit consists of two eight-bit shift registers (memory-mapped at addresses \$OA and \$OB) configured to perform a Cyclic Redundancy Check on the ROM. The CRC registers can also be utiliséd as a pseudo random number generator as a result of continuous CRC calculations being performed.

Memory

The 6804P2 has 1K of program memory which contains all instructions to be executed, immediate data and interrupt vectors. Figure 4 shows the 6804P2 memory map. Data space comprises 64 bytes of ROM for constants and tables, all 32 bytes of RAM and the I/O, timer and CRC registers. This configuration is different from the 68705P3 where program and data memory are combined in a von Neuman architecture (ie there is no distinction between program and data storage except that some areas — the EPROM sections — cannot normally be written to).

Note that only the PC is stored on the stack. Any other registers have to be saved in RAM by means of software and reloaded at the end of the subroutine or interrupt routine. On a stack push the bottom register always 'falls out' of the bottom of the stack. The stack should not be pulled more than four times in succession without any

pushes.

FEATURE: Single Chip Computer

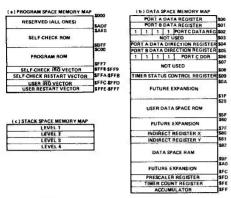


Fig. 4 MC6804P2 address map.

Timer

Timer circuitry for the MC6804P2 is shown in Fig. 5. The timer comprises an eight-bit timer counter register (TCR) with a seven-bit prescaler and a timer status control register (TSCR). These registers are all memory-mapped and are readable and writeable.

The TCR is clocked towards zero by the prescaler output. The prescaler is used to provide longer or shorter timer intervals by dividing the input clock. The prescaler tap is selected by bits 0-2 of the TSCR — giving a range of divide-by-1 to divide-by-128.

PSI, bit 3 of the TSCR, is used to initialise the prescaler (to \$FF) and inhibit counting when logic zero. The TCR is also inhibited but its contents are unchanged. When PSI = 1 the prescaler begins to count.

Unlike the 68705P3, the 6804P2's timer can operate in both input and output modes. Bit 5 of the TSCR, TOUT, selects output when high and input when low.

As an input, the TIMER pin is connected directly to the prescaler input. Therefore the prescaler is clocked by the signal on the TIMER pin. The prescaler then clocks the TČR which sets bit 7 of the TSCR (TMZ) when it reaches zero. TMZ can be tested by software to perform a timer function whenever it goes high.

Operation in the output mode is somewhat similar to that for input mode. With TOUT = 1, the TIMER pin is connected to the DOUT latch and the prescaler is clocked by the internal sync pulse. The positive-going TMZ transition latches the DOUT bit and provides it as an output for the TIMER pin. Note that TMZ can be set by writing zero to the TCR or by setting TMZ directly.

Interrupt And Reset

Processing can be interrupted by applying a logic low signal to the IRQ pin. Whether the negative-going edge or the actual low level is sensed is determined by a mask option. With the 68705P3, however, we have a choice of interrupt handling.

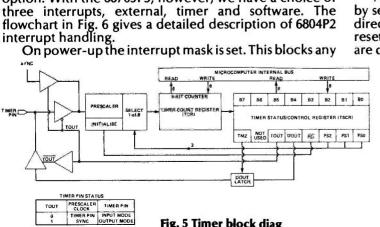


Fig. 5 Timer block diag

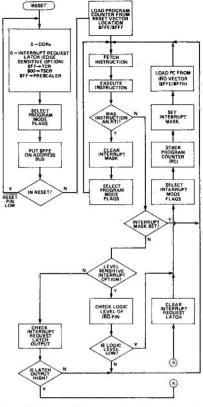


Fig. 6 Reset and interrupt processing flowchart.

'ghost' interrupts from occurring. To clear the interrupt mask the programmer should jump-to-subroutine (JSR) to an initialisation routine as the first instruction in a program. This initialisation routine should be terminated with an RTI instruction instead of TRS since RTI will not only restore the PC, but will also clear the interrupt mask.

During power-up a short delay — to allow the internal oscillator to stabilise — is needed before allowing the RESET line to go high. The configuration in Fig. 7 provides sufficient delay.

Interrupt and reset vectors on the 6804P2 are actually JMP instructions to the interrupt or reset routine which are placed at fixed addresses in the Program ROM. With the 6804P2, a vector fetch forces an address value into the PC, whereas with the 68705P3 a vector fetch forces an address value directly onto the address bus. Figure 8 shows the manner in which resets should be programmed.

Input / Output Ports

All 20 I/O lines are programmable as inputs or outputs by setting the corresponding bit in the appropriate data direction register (DDR) low or high respectively. On reset the port data registers are not initialised but all ports are configured as inputs. To avoid undefined levels it is a

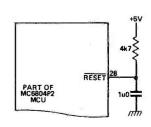


Fig. 7 Power-up reset delay.

FEATURE: Single Chip Computer

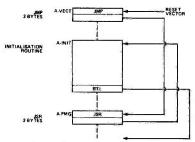


Fig. 8 Program flow after reset vector fetch.

good idea to write to the data registers before writing to the DDRs.

When programmed as outputs, the latched output data is readable as input data regardless of the logic levels at the output pin due to output loading. Figure 9 shows typical port circuitry.

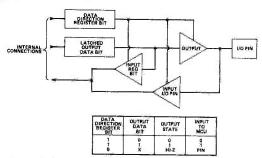


Fig. 9 Typical !/O port circuitry.

All ports are LSTTL compatible as inputs and outputs. Port B outputs can also drive LEDs, with suitable current-limiting resistors. The user can select one of two mask options (for all ports) as either pullup resistors for CMOS output compatibility or open-drain output; see Fig. 10 for typical port connections.

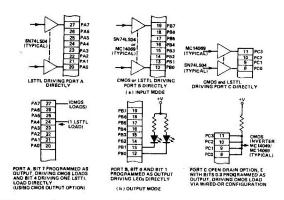


Fig. 10 Typical port connections.

Software And Instruction Set

The MC6804P2 has a rather unique, byte-efficient, instruction set. There are 41 instructions with opcode and 17 assembler-recognised instructions. Figure 11 shows the 6804P2 opcode map. The instruction set is similar to the 68705P3 including true bit manipulation plus a 'move immediate data' instruction.

BSET/BCLR can set or clear any register or RAM bit. BRSET/BRCLR can be used to test any bit in data space (including ROM) and branch or not as a result of the bit's state. The C-flag is set to the value of the bit referenced by BRSET/BRCLR. Bit manipulation allows the user to have individual flags and to handle the I/O bits individually with ease.

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										s-d	s-d			ADO	ADD	A			
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										14	s-d			н	INC dir	E			
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Fig. 11 6804P2 op-code.

The 'move immediate data' instruction transfers immediate data into data RAM and has the format 'MVI ADDRESS DATA'. Previously, on the 68705P3, data had to be loaded and stored through the accumulator. This takes up 4 bytes of ROM but only 3 on the 6804P2 when the MVI instruction is used.

The implied instructions shown in Fig. 12, exist because the accumulator and indirect registers are in RAM. For example, bit manipulation of bit 7 of the accumulator and indirect registers can give pseudo-ops such as BRSET 7,\$80 for 'branch if X minus' (BXMI), BCLR 7, \$FF for 'ensure accumulator positive' and ADD \$FF for ASLA.

The 6804P2 has nine addressing modes. In summary these are immediate, direct, short-direct, extended, relative, bit set/clear, bit test and branch, register-indirect and inherent. Most of these modes are similar to those used on the 68705P3. However, short-direct, relative (-short), register-indirect and inherent addressing modes use only one byte.

There is no indexed addressing as on the 68705P3 but register-indirect addressing is the same except that an offset cannot be used. This addressing mode works on



RAM location \$80 and \$83, ie the X and Y indirect registers and two others. A typical register-indirect instruction is CMP (X) which compares the contents of the accumulator with the contents of the address pointed to by the indirect X-register.

Summary

The Mc6804P2 is the first of a new family of Motorola single-chip microcomputers. Its unique architecture means that it can offer eight-bit power at a four-bit price.

As mentioned earlier, EPROM versions will soon be available and are ideally suited for use by hobbyists for a wide range of applications. Anyone used to working with Motorola's M6805 family will find the new 6804 range surprisingly simple to use.

(For further details of other single-chip microcomputers, we suggest 'Single Chip Microcomputers', Edited by Paul F. Lister, published by Granada publishing Ltd, ISBN 0-246-12106-8).

THE ETI READERS' SURVEY

Survey time is here again, and this time there's the chance to win ten free subscriptions for one year. The draw will take place on the 1st of February, so don't delay getting your form to us.



ere is the ETI survey! We'd be most grateful if you could answer our questions as best you can.

We'll be using the information in two ways. Firstly, to see what you think of the magazine and the ways you think that it could be improved. Secondly, we want to persuade more advertisers that ETI is the place to sell their goods.

on this second point, we have had to ask some personal questions. Please be reassured that any personal information you give us will be treated as confidential, and not stored in any data retreival system or communicated in any way.

All that we need are some (suitably impressive!) statistics on our readers.

That said, we know that some people like to keep the details of their salary private between them and their employer, so we've included a 'mind your own business option' on this question. If any other questions offend, please don't feel obliged to answer them — we'd prefer that you returned the survey form with some bits left out rather than not at all. However, all the information you can give us will be of use.

Finally, one piece of information we will need is your name and

address, because otherwise we won't know where to send the free subscription if you win one. If you do leave off your name and address, we'll just draw another name out of the hat.

Name	••••
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Yorkshire		money		No, but can usually get	
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Harlech/HTV				No, rarely work at all	
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			ries will be entertained.	75173N	1 44	ED CONTROLLERS		FAIRCHILD 74HC251N 1.03 74L522 0.25 4033 2.40 4078 0.25 FAST 74HC255N 1.03 74L5221 1.08 4034 1.00 4081 0.25 74HC257N 1.03 74L5240 1.40 4035 0.54 4082 0.25 74HC06PC 0.60 74HC266N 0.92 74L5241 1.40 4040 0.65 4085 0.64 74H08PC 0.65 74HC27N 0.80 74L5242 1.36 4041 0.36 4086 0.44 74H08PC 0.65 74HC27N 0.80 74L5243 1.36 4042 0.76 4093 0.33 74H19PC 0.65 74HC28N 3.26 74L5243 1.36 4042 0.76 4093 0.33 74H19PC 0.57 74H232 0.40 74L5245 1.95 4044 0.62 4502 0.88 74H138PC 0.52 74HC333N 2.40 74L5245 1.95 4044 0.62 4502 0.88 74H138PC 0.52 74HC333N 2.40 74L5248 1.16 4045 2.00 4507 0.47 4138PC 1.26 74HC393N 1.78 74L5249 1.16 4046 0.77 4508 0.99 74H138PC 1.26 74HC393N 1.78 74L5259 0.78 4047 0.50 4510 0.60 74H138PC 1.26 74HC4002 0.64 74L5253 0.78 4048 0.40 4511 0.60 74H138PC 1.26 74HC4002 0.64 74L5253 0.78 4048 0.40 4511 0.60 74H138 1.26 74HC4002 1.66 74L5253 0.78 4048 0.40 4511 0.60 74H138 1.27 74HC4002 1.66 74L5253 0.78 4049 0.50 4512 0.44 74H138 1.17 74HC4024 1.20 74L5253 0.78 4050 0.49 4514 1.74 74H138 1.17 74HC4002 1.66 74L5265 0.30 4053 0.66 4518 0.44 74H138 1.39 74HC4001 1.46 74L5266 0.35 4054 1.30 4519 0.25 74H189 3.20 74HC4514 3.76 74L5259 0.75 4055 0.72 4520 0.87 74H199 3.20 74HC4514 3.76 74L5259 0.75 4056 0.50 0.68 4521 0.34 74H2403 0.64 74L5283 0.25 4056 0.50 4526 0.50 74HC4514 3.76 74L5283 0.25 4056 0.50 4526 0.50 74HC538N 1.72 74L533 0.25 4056 0.50 4526 0.50 74HC4514 3.76 74L5283 0.25 4056 0.40 4528 0.40 4528 0.40
6502 FAMILY	8086 FAMILY	- 1	MEMORIES — EPROM 2532-300ns 4.95	75174	2.82	F.D. CONTROLLERS 8272 39	5 00	FAIRCHILD 74HC251N 1.03 74L522 0.25 4033 2.40 4078 0.25 6AST 74HC253N 1.03 74L5221 1.08 4034 1.00 4081 0.40
-02 2 50	0000	!	2532-450ns 3.95	75175 75182	0.50	FD1771P 30	0.00	74HC257N 1.03 74LS240 1.40 4035 0.54 4082 0.25 74F00PC 0.60 74HC266N 0.92 74LS241 1.40 4040 0.65 4085 0.66
502A 4.95	8088-2 2	2.50	2564-300ns 6.95 2708-450ns 3.95	75183	0.50	FD1791 1. FD1791-02 1	5.50	74F04PC 0.60 74HC273N 2.24 74LS242 1.36 4041 0.36 4086 0.4
520 2.25 520A 2.45				75188 75189	0.86 0.86	FD1793 1	8.40	74F08PC 0.65 74HC27N 0.80 74L5243 1.36 4042 0.76 4093 0.3; 74F109PC 0.65 74HC280N 3.26 74L5244 1.40 4043 0.64 4099 0.50
522 3.40	8251A	7.50	2716-3 RAIL 7.95 2732-350ns 4.95	75451BP	0.22	FD1793-02 1: FD1795 2:	1.00	74F11PC 0.52 74HC32 0.40 74L5245 1.95 4044 0.62 4502 0.8
22A 4.45 32 5.45	18255A-5	7 ററ	2/32-430115 4.43	75452BP 75453BP	0.29 0.22	FD1797 2	1.00	74F138PC 0.52 74HC373N-2.40 74L5248 1.16 4045 2.00 4507 0.4: 74F138PC 1.26 74HC374N 2.40 74L5249 1.16 4046 0.77 4508 0.94
32A 5.95	8259A	5.60	2704-20013 7.53	75454BP	0.22	WD1691 14	4.00	74F139PC 1.26 74HC393N 1.78 74L5251 0.78 4047 0.50 4510 0.6
				7546 8 N 75491N	0.88	WD2143 1:	2.00	74F151 · 1.26 74HC4002 0.64 74LS253 0.78 4048 0.40 4511 0.6 74F153 · 1.26 74HC4017 1.16 74LS257 0.78 4049 0.50 4512 0.4
	80C86 4	5.65	2/C64-25UNS 10.95	75492N	0.41	DATA CONVERTERS		74F157 1.30 74HC4020 1.46 74LS258 0.78 4050 0.49 4514 1.7
000	80C88 4 82C52 1	5.65	27C64-300ns 10.45 27128-250ns 19.00	AY-3-1015 AY-3—1270	3.50	ZN425E-8 ZN425J-8	3.76	74F158 1.17 74HC4024 1.20 74LS259 1.77 4051 0.52 4515 1.8 74E161 2.34 74HC4040 1.46 74LS26 0.30 4052 0.48 4516 0.6
	82C54 1	9.04	27128-300ns 16.00	AY-3-8910	6.40	ZN426E-8	1.90	74F164 1.68 74HC4060 1.46 74L5261 2.60 4053 0.66 4518 0.4
300 2.15	82C55A21 82C59A 1	2.98i	MEMORIES RAM	AY-5-3600 DP8304	8.84	ZN427E-8 ZN427J-8 1.	6.68	74F175
	82C82	5.26	4116-150ns 1.28	L203	0.99	ZN428E-8	5.10	74F189 5.10 74HC4511 2.51 74LS273 1.35 4060 0.68 4521 1.3
2005 6 35	IOZCOMA I	8.94 5.80	4116-200ns 1,20 4164-150ns 4,45	LF398 LM301AN	3.80	ZN428J-8	9.70	74F190 3.20 74HC4514 3.76 74L5279 0.77 4063 0.60 4522 0.8 74F191 3.20 74HC4514 3.76 74L528 0.25 4066 0.50 4526 0.5 74F194 1.68 74HC4514 3.04 74L528 1.00 4068 0.25 4527 0.5 74F194 1.68 74HC4518 0.36 74L528 1.00 4068 0.25 4527 0.5 74F20PC 0.52 74HC51N 0.64 74L5290 0.86 4069 0.40 4528 0.4 74F244 3.16 74HC53N 2.40 74L529 0.86 4070 0.40 4532 0.40 45
8U9P 6.25		ı	4416-200ns 4.70	LM308AN	0.94	ZN432CJ-10 2	0.79	74F194 1.68 74HC4543 3.04 74L5283 1.00 4068 0.25 4527 0.5
810 1.70 821 1.70			4532-200ns 2.45 4564-150ns 4.45	LM308N LM311N	0.56	ZN432E-10 1:	3.00	74F20PC
840 3.70	FAMILY	- 1	8118-100ns 1.95	LM317MT	0.80	ZN433C/~10 Z	0.98	74F241 2.42 74HC534N 2.40 74L530 0.25 4071 0.40 4541 0.8
845 6.45 850 1.70	Z80ACPU	2 001	81256-150pc - 25.00	LM317T	1.06	ZN4261-8 ZN429E-8 ZN432CJ-10 2: ZN433E-10 1: ZN433CJ-10 2: ZN434 2: ZN435 :	4.38	74F241 2.42 / 74HC583AN 2.40 / 74L530 0.25 4071 0.40 4541 0.87 74F243 2.80 / 74HC588N 1.72 / 74L532 0.25 4072 0.40 4543 0.66 74E244 2.96 / 74HC58N 0.64 / 74L533 0.30 4073 0.40 4553 2.40
862 3.75	Z80ADMA	∠.99 7.95	8416-LP-200ns 6.40	LM319N LM324N	0.50	ZN440 5	5.00	74F244 2.96 74HC58N 0.64 74L533 0.30 4073 0.40 4553 2.44 74F245 6.08 74HC595N 1.84 74L5365 0.55 4075 0.46 4555 0.46
B75 4.95 BB00 4.30	Z80API0	2.99	8417-200ns 6.00	LM337T	1.20	ZN441 4	6.80	74F251 1.26 74HC597N 1.72 74LS366 0.55 4076 0.48 4556 0.4
	Z80ASI0-0 Z80ASI0-1	7.95 7.95	0417-LP-20005 6.40	LM339 LM339N		ZN447 ZN448E	6.66	74F253 1.26 74HC73N 0.84 74LS367 0.55 4077 0.40 4585 0.4 74F257 1.26 74HC74N 0.84 74LS368 0.55
8B10 1.88 8B21 3.70	Z80ASI0-2	7.95	MEMORIES — RAM	LM348N	0.64	ZN448J 1	2.48	74F258 1.34 74HC75N 0.92 74LS37 0.25 CRYSTALS
BB40 6.60	Z80BCPU	5.95	*ZERO POWER ZKXB	LM350T LM358N		ZN449 ZNA134J 2	2.72	74F280 1.74 74HC76N 0.64J74LS373 1.50 A111B 1MHz 4.51 74F283 1.74 74HC85N 2.02 74L5374 1.50 A111B 1MHz 4.51 74F283 1.74 74HC85N 2.02 74L5374 1.50 A111B 1MHz 4.51
8B50 1.58 8B54 7.95	780RPI0	5 05	CMOS*	LM3900	0.68	ZNA234E	9.40	74F32PC 0.52 74HC86N 0.80 74L5375 0.75 A113A 1.008MHz 4.0
0634 7.33	Z80BSI0-01	9.95	MK48Z02B-150ns 32.00 MK48Z02B-200ns 24.00	LM393N LM725CN	3.00			74F352 1.26 74HCU04N 0.80 74LS377 1.50 A116A 2.4576MHz 2.074F353 1.26 74LS378 1.22 A110B 2.4576MHz 2.074F358 1.22 A110B 2.4576MHz 2.07476 1.22 A110B 2.4576MHz 2.07476 1.22 A110B 2.4576MHz 2.07476 1.22 A110B 2.4576 A110B 2.4576 1.22 A110B 2.22 A110B 2.4576 1.22 A110B 2.22 A110B 2.22 A110B 2.22 A110B 2.22 A110B 2.22
	Z80BSI0-21	9.95	MK48Z02B-200ns 24.00 MK48Z02B-250ns 23.00	741CP				174,5379 1.50 A137A 6MHz 1.76
			BIPOLAR PROMS	LM747CN LM748CN	0.60	ZN404 ZN423	0.50	74E370 1 93 74LS00 0.25 74LS38 0.25 A140A 8MHz 1.2
	Z80SI0-1 Z80SI0-2	6.00	TRP185030N 1.54	MC1413P	0.80	ZN458	0.92	74F381 6.62 74LS01 0.25 74LS390 1.10 A173A 0.8304MHz 2.0
			TDD105 AD2D 1 39	IMC1416	0.80 10.10	ZN458A ZN458B	0.92	74E309 3 16 74LS03 0.25 74LS03 0.25 A182A 19.6608MHz 2.5
805 FAMIL			TODO ACAIN: A CO	MC14411 MC14412	14.20	ZNREF 025	1.90	74F399 2.70 74L304 0.25 74LS42 0.85 DU SIZTS TIN
1C1468052P 1C146818P	1	2.60 7.20	TBP24S81N 5.50	IMC1458CPI	0.35	ZNREF 040 ZNREF 050	1.90	745533 3 16 74L508 0.25 74L549 4.00 1 1 100-
IC146823P		8.80	TDD3/ISA/IN / /A	MC1495L MC1496P	6.30 0.70	ZNREF 062	1.90	174F534 3 16 14L309 0.23 74L540 1 00 07670807 8 PIN 0 07 0 05
1C68705KT3 1C68705R3L		5.00 0.00	TRD281 22NI 3 10	IMC1/23P	0.40	ZNREF 100	3.05	74F537 6.02 74L510 0.25 74L551 0.25 07071402 14 PIN 0.09 0.07
C68705U3L		6.00	T00300166N 10.00	MC3242A MC3302P	6.30 0.48	BUFFERS		1/4F539 4.38[174] 0.23[74[555 0.25]070/1802 18 PIN 0.15 0.10
8000 FAM	III Y	- 0	TRD28542NI 4 50	IMC3340P	2.30		1 10	74F64PC 0.52 74LS112 0.54 74LS670 2.30 07073002 20 PIN 0.19 0.14 74F74PC 0.58 74LS113 0.42 74LS73 0.30 07073202 22 PIN 0.21 0.15
C68000G10		0.00	TDD DOCACN A CA	MC3357P MC3423PL	0.01	811597	1.10	74F74PC 0.58
1C68000L8	5	ი იი	TDDDCCA 43NI 4 CO	MC3441AP	2.00	811 598	1.10	74L512 0.25 74L575 0.50 0.50 0.672302 28 PIN 0.26 0.17 14L576 0.35 0.074002 40 PIN 0.29 0.18 14L576 0.35 0.074002 40 PIN 0.29 0.18
IC68008L8 IC68230L8				MC3446AP MC3447P	2.90	8T26A 8T28	1.10	HIGH 74L5122 0.75 74L576 0.35 00074002 40 PM 0.29 0.18
C68451L8	6	7.00	18P285A86N 8.62	MC3448A	3 99	18T28A	1.10	74LS124 2.30 74LS83 0.90 DIL SKTS GOLD
1C68901P	7	5.00	AM27519PC 1.92	MC3470P	6.44 7.76		1.10	
19900 FAN			AM275197UC 15.00	MC3480 MC3487	1.80	8T98	1.10	74HC00N 0.42 74LS13 0.46 74LS00 0.42 0836:402 14 PIN 0.2
MS9901-95		4.50			0.25	ODTOISO: ATORS		74HCUZN 0.42 74L3132 0.73 74 S91 1 30 05561803 18 DIN 0.3
ИS9902 ИS9918		4.50 5.00	AM27535DC 22.00	NE556CP R032513-L	9.40	OPTOISOLATORS		74HC04N 0.44 74LS138 0.77 74L392 0.00 68082202 20 PIN 0.2
MS9 9 27	1	1.60	MEMORIES E2 PROM	RO32513-U	9.40	4N26	0.75	74HC107N 0.78 74LS14 0.80 74LS32 0.7 105362402 24 PIN 0.4
MS9928 MS9929	,	3.00	X2804AP-300ns 14.95	TL010-CP TL061-CLP	0.44	4N33	0.90	74HC109N 0.50 74L5145 1.23 CMOS 35052802 28 PIN 0.4
M59937		6 70	IX28U4AP-35UNS 13.45	TL062-CP	0.47		5	1/4HC UN 0.041/4L3140 1.3014000 C
MS9980 MS9995	1	7.20	X28U4AP-45Uns 12.75	TL064-CN TL066-CP	0.95	UM1111	2.95	174HC113N 0.86 74LS151 1.10 4000 0.25 DTL 3N 13 VV/VVRAP
VIJ3737		0./١	X2816AP-350ns 25,00	TL071-CP	0.28	UM-1233	3.45	74HC132N 1.28 74LS153 1.10 4001 0.52 TURNED PIN 74HC137N 1.81 74LS155 0.77 4000 0.25 0000000 8.00N
			X2816AP-450ns 22.50	TL072-CP TL074-CN	0.56 1.10	VOLTACE BEC		74HC137N 1.81 74LS155 0.77 4002 0.25 9090802 8 PIN 0.3 74HC138N 1.20 74LS156 0.77 4006 0.90 9091402 14 PIN 0.7 74HC138N 0.78 74 54 55 7 6.5 100 9091402 14 PIN 0.7
			LINEAR/INT, DEV.	TL081-CP	0.29	VOLTAGE REG.	0.75	74HC139N 0.78 74LS157 0.62 4507 0.25 9091602 16 PIN 0.8
				TL082-CP TL084-CN	1 02	7805 7812	0.75	74HC151N 1.16 74L5158 0.62 4908 0.92 9091802 18 PIN 0.8 74HC153N 0.90 74L5160 0.80 4009 0.25 9092002 20 PIN 1.0
			HCI-55564-5 10.66	TL084-CN TL091-CP		7815	0.75	74HC157N 1.02 74LS161 0.80 4010 0.25 9092202 22 PIN 1.1
			(Speech Synthesis)	TL092-CP TL094-CN	0.72	78H05SC 78H12ASC	7.50 8.95	74HC158N 1.02 74L5162 0.80 4011 0.30 9092402 24 PIN 1.2 74HC160N 0.9074L5163 0.80 4012 0.25 9092802 28 PIN 1.5
			AM7911DC 34.88	TL487-CP	0.59	78HGASC	9.95	74HC161N 0.90 74LS164 1.10 4013 0.45 9094002 40 PIN 1.7
			25L52518PC 3.60	TI 489-CP	0.59	78L05 78L12	0.30	74HC162N 1.51 74L5165 1.30 4014 0.50 74HC163N 1.51 74L5166 1.95 4015 0.65
			25L52538PC 2.72 25L52539PC 2.72	TL494-CN TL496-CP TL507-CP	0.59	78L15	0.30	74HC163N 1.51[74L5166 1.95 4015 0.65 ZIF SOCKETS 1.13 4016 0.46]
			25LS2S39PC 2.72 26LS31PC 2.62	TL507-CP	1 22	78S40DM 78S40PC	7. 5 0	74HC165N 2.2474LS174 1.30 4017 0.63 08082402 24 PIN 5.7 74HC173N 1.35 74LS175 0.96 4018 0.46 08082802 28 PIN 6.9
H_{I-1}		.	26LS32PC 2.62	ZN450-E ZN451-E	7.40	7905	0.95	74HC174N 0.80 74L5181 2.09 4019 0.39 08084002 40 PIN 8.2
HI-I		TS	6402 6.40	7N451-KIT	29.95	7912	0.95	74HC175N 0.78[74LS190 0.98]4020 0.45
HI-I	onen					7915	0.95	0.70 1.20 1.20 1.20 1.70 1.
HI-I	onen		751U/BN 0.69	į.		LM309K	0.95	74HC195N 1.28 74LS192 1.10 4022 0.42
HI-I comp	onen		75110/BN 0.69 75110AN 0.86 75150P 0.86			LM309K LM317K	2.45	74HC195N 1.28 74L5192 1.10 4022 0.42 74HC20N 0.40 74L5193 1.10 4023 0.34
HI-I	onen		75107BN 0.69 75110AN 0.86 75150P 0.86 75154N 1.05			LM309K LM317K LN323K LM338K	0.95 2.45 4.95	74HC175N 0.78 74LS190 0.98 4020 0.45
Hi-1 compo	onen		751107BN 0.66 75110AN 0.86 75150P 0.86 75154N 1.05 75159 2.30 75160AN 2.60			LM309K LM317K LN323K LM338K	0.95 2.45 4.95 4.50	74HC19SN 1.28 74LS192
HI-I compo	5		751107BN 0.69 75110AN 0.86 75150P 0.86 75154N 1.05 75159 2.30			LM309K LM317K LN323K LM338K	0.95 2.45 4.95 4.50	74HC237N 1.80174L3194 0.78 4024 0.86 74HC240N 1.38,74LS195 0.78 4025 0.25

Components GILRAY ROAD, DISS, NORFOLK. TEL: 0379 4131

INSULATION DISPL		CABLE ASSEMBLIES	DIP JUMPERS	BBC34 BBC345		
CONNECTOR SYSTE		IDC JUMPERS	Single Ended	BBC345W		
HEADERS SHROUDED	OPEN — STRAIGHT	SINGLE ENDED	— 24" cable 14 pin 1.73	BBC 34D BBC 345/80		
90°	90° PINS	36" cable IDC soo	cket 16 pin 1.90	8BC34D/80		
	0.65 0.47	10 way 1.72	24 pin 2.73	DISC DRIVE		
	0.83 0.59 0.92 0.65	14 way 2.07 16 way 2.22	40 pin 3 96	BBC30P		
20 way 1.36	1.13 0.77	20 way 3.14	Double Ended	BBC 31SP		
	1.40 0.95 1.78 1.19	26 way 3.75 34 way 3.98	6" cable 12" cable 18" cable 14 2.74 2.84 2.94	0045.0		
40 way 2.28	2.07 1.37	40 way 4.23	16 3.03 3.14 3.25	BBC34P BBC34SP		
	2.54 1.67 3.02 1.96	50 way 5.36 60 way 6.36	24 4.18 4.36 4.55 40 5.89 6.18 6.47	BBC 34DP		
				MECHANIS		
	UGS D-TYPE	DISC DRIVE CONNE 34 way card edge to 34 wa		F8501		
10 way 0.88 14 way 14 way 1.06 16 way	0.92 PLUGS 1.06 9 way 1.38	34 way card edge to 2 × 34		FB504		
16 way 1.16 24 way	1.60 15 way 1.85	34 way card edge to 34 wa 34 way card edge to 2 × 34				
20 way 1.38 40 way 26 way 1.66	2.40 25 way 2.52	BBC Power Cable — Single				
34 way 1.94 KANS		BBC Power Cable — Dual D	rive 4.75	MD-1DC/B MD-2DC/B		
40 way 2.08 CONNS 50 way 2.78 10 way	A POR INIDED IN CA	BLE (PRICED PER FO	OT) BBC MICRO	MD-2FC/B		
60 way 3.34 10 way		GREY RAINBOW	CONNECTORS	SPECIAL OF		
20 way	1.37	0.16 0.25 0.16 0.25	DIN PLUG 7 PIN 10.4			
CARD 26 way	1.67 14	0.21 0.35	DIN PLUG 6 PIN 0.4	DBC-OID		
EDGE 40 way	2 22 12	0.22 0.37 0.23 0.39	DIN PLUG 5 PIN 180° 0.41 DIN PLUG 5 PIN DOMINOE 0.41			
10 way 1.84 D-TYPE	20	0.28 0.48	POWER PLUG (36" CABLE) 3.00	MDT25/3		
20 way 3.14 SOCKE		0.34 0.60 0.35 0.62	ANALOGUE INPUT PLUG 2.2: 5 WAY DIN 5KT 180° -0.9:	DTCO/F		
34 way 4.90 9 way		0.45 0.80	5 WAY DIN SKT DOMINGE 0.9			
40 way 5.52 15 way	2.02 40	0.52 0.92	6 WAY DIN 5KT 0.90			
50 way 6.68 25 way 60 way 8.06 37 way		0.64 1.14 0.76 1.35	7 WAY DIN SKT 0.90 15 WAY DIN SKT (2.1)			
			15 7771 511 511	1431		
Connecting cables	•	•		1441		
		cting cables for popular micro tested to ensure trouble free		1431/AP/MS		
				BBC COMP		
Part number Video cables	Description		Computer	SBB03		
CON100	Phono piug to phono	nhin (2M)	1.20	SBB04		
CON101	Phono plug to BNC pl		2.9			
CON102	BNC plug to BNC plug	(2M)	3.95	5NB08		
CON107 CON108	6 pin DIN to open end 6 pin DIN to 6 pin DIN		BBC 1.05 BBC 1.50	JINDOS		
CON119	Phono plug to coax pi	lug	1.3	5N811		
CON160	DIN plug to 2 phono p	olugs	Dragon 1.20	SNB12 SNB13		
Cassette recorder c	ables			5NB14 5NL01		
CON109 CON110	7 pin DIN to open end		BBC 1.25 BBC 2.50	5NL02		
CON111	7 pin DIN to 5 pin DIN	nm + 1 × 2.5mm J/plug + 2.5mm J/plug	BBC 2.50 BBC 2.50			
CON118 CON117	5 pin DIN to 2 × 3.5m		Spectrum/ZX 2.50 Dragon 2.50			
		nm + 1 × 2.5mm J/plug	Dragon 2.50	RX80 RX80F/T		
Parallel printer cab	iles			F X 80		
CON1 30	36 way plug to 36 wa		Sirius/Apricot 18.00			
CON131 CON132	36 way plug to 36 wa 36 way plug to 36 wa		Sirius/Apricot 26.50 18.00			
CON133	36 way plug to 36 wa	y socket (5M)	26.50	LETTER QU		
CON144 CON145	36 way plug to 25 wa 36 way plug to 25 wa	y male D type (2M) y male D type (5M)	IBM/TI PC 19.00 IBM/TI PC 27.50			
CON134	36 way plug to 25 wa	y male D type (2M)	RML/Apple 19.00	HR25		
CON135 CON142	36 way plug to 25 wa	y Male D type (5M)	RML/Apple 27.50 Dragon 13.95			
CON139	36 way plug to 20 wa 36 way plug to 26 wa	y IDC socket (2M)	8BC 9.95	PRINTER SO		
CON140	36 way plug to 26 wa	y IDC socket (5M)	BBC 22.95	11241P160		
CON141 CON143	36 way plug to 34 wa 36 way plug to 34 wa		TR580 Lev 1 18.50 TR580 Lev 2/	11241P2CI		
	, ,	,	Memotech 10.95	- III 370K IOU		
RS232 Cables				11370R2NC 11370R2CI		
CON106	25 way male D type to	o 5 pin DIN	BBC 5.8	12235P1605		
CON128	'Universal' R5232 cab	le (pins 1-8, 20 connected		. HR1R		
CON164	and 20 jumpered as n 'Universal' R5232 cab		15.95 20.95			
CON120	25 way male to male	1-25 connected (2M)	16.99	MX80		
CON121 CON122		1-25 connected (5M)	22.50 32.50			
CON122 CON123		1-25 connected (10M) 1-25 connected (30M)	68.00 68.00	HR5R		
CON124	25 way male to fema-	e 1-25 connected (2M)	15.45	HR15R		
CON125 CON126		le 1-25 connected (5M) le 1-25 connected (10M)	21.00 31.00			
CON127	25 way male to fema	le 1-25 connected (30M)	66.50)		
CON129 CON162	25 way male to 9 way	y male	Spectrum 15.99 Mackintosh 15.99			
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	23 Way male to 3 pm					
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DARTNO	DESCRIPTION	00050
PART NO.	DESCRIPTION AND ACCESSORIES	MAIL ORDER PRICE
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BBC30 BBC315	Single 100k TEC 40 track single sided Single 100k TEC (expandable to dual) 40 track	£99.95 £115.00
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BBC345W	double sided Single 400k TEC 40/80 track switchable double sided	£194.00 £184.00
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BBC31DP	Single 100k TEC (expandable to dual) 40 track with P.S.U. Dual (2 × 100k) TEC 40 track single side with P.S.U.	£250.00
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.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	24. 11.0 Eddy 3 5 Mide (11.10)/E,000)	10.00

DIGITAL FRAMESTORE

Now we come to the two nitty-gritty bits of the circuitry - the conversion to and from digits, and the storage and retrieval of the digits in a hurry. Daniel Ogilvie shows how its done.

ith a clock rate of 13MHz we have 1/13MHz = 78 ns to convert the data and store it in memory. Of the readily available ADCs, the National Semiconductor ADC0800 takes 10 μs; obviously, we will have to look for something rather more exotic for the ADC here.

Most common ADCs work by the successive approximation technique, which requires a number of clock cycles to obtain a digital representation of the incoming analogue signal. Even at high frequencies, the number of clock cycles would take an unacceptable length of time; for instance, if we were able to clock the ADC0800 at 10MHz, it would still require 40 clock cycles to complete a conversion, which would mean that we would have to allow 4µs for each conversion — still far too slow.

Successive approximation ADCs contain just one comparator, see Fig. 4, and what they do is to try the different bits in the latch, starting with the most significant and working down to the least significant, to see which should be on in the final result.

An alternative technique is used by flash (or parallel) converters; here, there are lots of comparators all tied to the input and to different points in the resistance ladder. The encoder logic has to decide which is the highest comparator which is on. The time taken for conversion is just the propagation delay of the comparators and the encoder. However, the big disadvantage of these ADCs is the complexity, as there has to be a comparator for every possible output word. So, for an n-bit converter, there have to be 2ⁿ comparators, and this also means

that there have to be more resistors in the chain, and that the encoding logic has, necessarily, to be that much larger.

There are a number of flash converters on the market, the Ferranti ZN440 and the RCA CA3300 for example. The type we are going to use is the TRW TDC1014, which is a six-bit converter. Both eight-bit and four-bit versions are available and could be used instead; however, the four-bit version will not offer sufficient resolution for any serious application and the eight-bit version is very expensive, in effect containing four times the logic and comparators of the six-bit version. The six-bit version is a compromise.

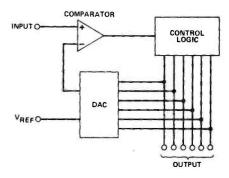
The ADC is the single most expensive item in the framestore. It does contain a lot of very fast logic, including 64 latched comparators, for example. Its cost is about £100, and as we have seen there is no way round this. The framestore can, of course, be built without the ADC and used only to display images loaded by computer — not exactly a framestore then though is it?

The Dynamic Ram

The DRAM is a significantly cheaper memory cell per byte than static RAM. It would be possible to design the framestore using fast (better than 70ns) access time static RAM, which would consume over 100 16K × 1, for example. These would require a second mortgage to acquire (£10/chip). So if only for financial reasons the DRAM would appear to be the right choice and the 64K × 1 variant is the cheapest and most convenient available for us. However they do require more thought and circuitry to drive them. The problem of their slow access

time is discussed below. We will consider briefly here how to get data in and out of them.

You have probably noticed that the 64K × 1 DRAM comes in a 16-



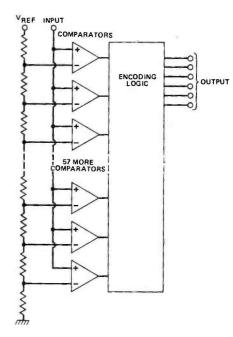


Fig. 4 Two ways of converting analogue to digital: (a) sucessive approximation ADC; (b) 'flash' converter ADC.

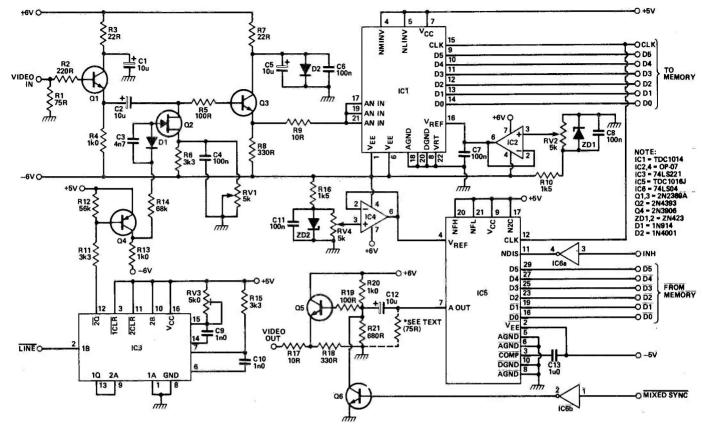


Fig. 5 Circuit diagram of the converter section.

HOW IT WORKS - ADC/DAC

R1 terminates the video signal at the appropriate 75 ohms. Q1 buffers the video, and the signal is then AC coupled to driver transistor Q3 via C2 and R5. Q3 is needed because the input to IC1, the ADC, is quite capacitive (100p).

The DC level of the signal is determined by the clamping action of Q2, as follows. IC3 is a dual monostable, and it generates a $2\mu s$ pulse $3\mu s$ after the LINE signal goes low, which is every $64\mu s$. This pulse is ded via Q4 to the gate of Q2, which turns this transistor on, shorting the negative end of C2 to the voltage set up by R6 and RV1.

The portion of the video waveform when this is happening is known as the 'back porch', and, by definition, it is reference black. So R6 and RV1 set the reference black level for the video signal. Clamping the waveform every 64µs ensures that the tone of the image remains consistent across the screen.

The ADC is IC1, a TDC1014), which converts continuously at 13MHz. 10ns after the rising edge of the clock input, the video input is latched into its comparators and compared with the voltage fed to the reference input. This latching operation means that the input does not have to be held steady while the conversion is taking place.

On the falling edge of the clock signal, the comparator outputs are fed to a 63-to-6 decoder. The outputs from the comparators essentially form a bargraph representing the video signal size: for example, if the video input is half the reference voltage, then half the comparators will be on and half will be off. The conversion logic takes the bargraph output and converts it into a six-bit binary word.

The binary word is latched into the ADC output on the next rising edge of the clock and the data becomes available 30ns later. There is what is known as a one pipeline delay in the output, and the ADC takes in new data whilst converting the previous data.

The reference voltage is provided by ZD1 and this is buffered by IC2. RV2 allows the reference voltage to be changed which gives some control over the gain of the ADC; the lower the reference voltage, the lower the threshold between adjacent comparators in the ADC, so the smaller the change in the input signal that is required to change from one output binary word to the next.

IC5 is the DAC, TDC 1016. It acquires data from the memory on the rising edge of the clock input provided that the data has been set up 20ns beforehand. The reference input,

provided by ZD2 and buffered by IC4, is used, with the digital data, to decide the size of the output voltage. The output of the DAC can be forced to 0V (black) by the NDIS input and this is done outside the stored picture area to prevent rubbish being displayed.

The output of the DAC can drive the standard 75R line, but will provide only 500mV output swing, which will give disappointing contrast on a monitor, which would be improved by amplifying the output. On the other hand, without termination, the output voltage swing can be 1 V but fast edges of the video could cause some slight overshoot, although it is unlikely that such edges would be generated by anything other than a computergenerated image.

In the circuit shown, we leave the choice of whether or not to terminate the output from the DAC with 75R up to you; the resistor required to do this is shown dotted. The black level of the output is set by the ratio of R20 to R21 and when a MIXED SYNC pulse is present, this point is shorted to 0V by Q6 to provide a composite output.

Q5 provides a 75R drive capability for the video. No low-pass filtering has been used to reconstitute the video output, as this will almost certainly be performed by the monitor.

time (the access time) after CAS the pin package and yet would require 16 address lines to select all of its bits $(2^{16} = 64K)$. This is because the consider the memory as a grid with bit we require. On the falling edge of RAS the row address is latched The CAS line also turns on the outtwo lines (row address select, RAS, data will appear on the Q output. and horizontal rows to access the bytes and strobed into latches by and column select, CAS). You can and a little later we take CAS low two latches selecting the vertical which latches the other address. put drivers and therefore some address is sent in two eight-bit

If we wish to write data in we must ensure the data is valid and

HOW IT WORKS

store converts analogue to digital or The memory chips used cannot possibly work at the speed at which the frameregisters to convert eight serial bits from each of the six data bits into a parallel data word, which is then stored memory can read or write at one eighth of the speed that the ADC or DAC are working at; however, this does have the vice versa; so the design here uses shift in parallel in memory. Thus the effectively memory cards are required. disadvantage that

are paralleled with the other memory cards, except SI, the serial data input bit from the ADC, SO, the serial data out the same bit on the DAC, and Fig. 8 shows the circuit for just one storage card; all the connections to this MPUD, which is connected to one bit of the processor data bus.

After the RAS hold time of the dynamic RAM the upper address lines are enabled and CAS is strobed low. The 16-bit address bus is multiplexed to eight bits by the two 'LS257 two-to-one multiplexers. The select line is the LO output of the control card. After the CAS access time of the RAM has read. RAS is strobed low when the elapsed the Q outputs of the DRAM The dynamic RAM is usually being lower address bits (A0-A7) have settled

oulse. It will be noticed that there is written in on the rising edge of the and is referred to as the precharge generate a write pulse; the data is DRAM to restore the memory cel when driving DRAMS and so the otal cycle time (read or write) is to its steady state after an access, a dead time between successive accesses. This is required by the ime. This has to be allowed for the RÁS access time + the precharge time.

DRAM uses a capacitor to store sometimes 4ms) and to prevent us which is called refreshing. Refresh the data bit which loses its charge losing data, it has to be read and written over a period of time, over a period of time (2ms or

MEMORY CARD

eight-bit data is then clocked out of the shift register whilst the RAM is register formed by two 'LS195s. This become valid. These are synchronously oaded into the eight-bit data shift accessing the next bit.

The address inputs to the RAM have 33R resistors in series with them to damp possible destructive negative voltage excursions on the address lines due to the high capacitance of the DRAM inputs and the PCB tracks.

Should we wish to load data into the RAM we need to pull down the write line to the RAM at the appropriate time; this is handled by the control card. Data from the ADC is clocked into the shift registers. When eight bits have latch on the rising edge of the transfer pulse. The data is then valid and held been loaded, the Q outputs of the shift register are loaded into an eight-bit for the next write cycle of the DRAM.

Any additional I/O on the board is or MPU access and will be discussed in a future article.

an MPU a little easier. However any 64K The type of RAM shown is Motorola MCM6664. This has an on-chip refresh counter which can make interfacing to satisfactorily as there are no critical 200ns DRAM should work

address bus. However when DRAM and providing a sequential address written again at the end of the read cycle. We are continually accessing picture and therefore by ensuring is performed by strobing RAS low (0 - 128 or sometimes 256) on the is read it destroys the data in the cell which must be automatically the DRAM to display the stored the RAS addresses are the loworder address lines, refresh is automatically performed.

Speedy Shifting

DRAMs that allow us to access four-78ns. We have (I hope) justified our required resolution we need a sixstatic RAM, but the fastest DRAM comes expensive (there are some bit word to be converted by the that we can procure is 100ns and bit data in 50ns but that does not choice of DRAM instead of fast satisfy our requirement either). ADC and stored in the RAM in To store a picture to our

overcome this deficiency and the numble shift register. We can use answer comes in the form of the Some way must be found to

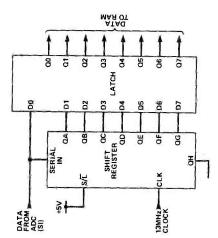


Fig. 6 Assembling eight successive bits into a parallel data word.

store the fast data from the ADC he shift register to temporarily and parallel load this into the dynamic RAM.

The access time of the DRAM is

registers are loaded into a latch. We clocked into the shift register which reduced by the number of bytes in 78ns) of stable data to load into the meantime is loading the next 8 bits in Fig. 6. The data from the ADC is is configured in a shift right mode. When eight bits of data have been the shift register. This is illustrated received, after eight clock pulses, now have eight clock cycles (8 X the eight Q outputs of the shift DRAM. The shift register in the of data

13MHz. The dynamic RAM then has 8 × 78ns = 624ns to provide the to retrieve data from the DRAMs. If we strobe the DRAMs such that the Fig. 7. The full dynamic RAM timing We can arrange a similar system next data byte. This is illustrated in data is available at their Q outputs, diagram was published last month we can parallel load this into the shift register and clock it out at when the control card was discussed.

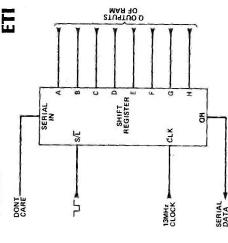
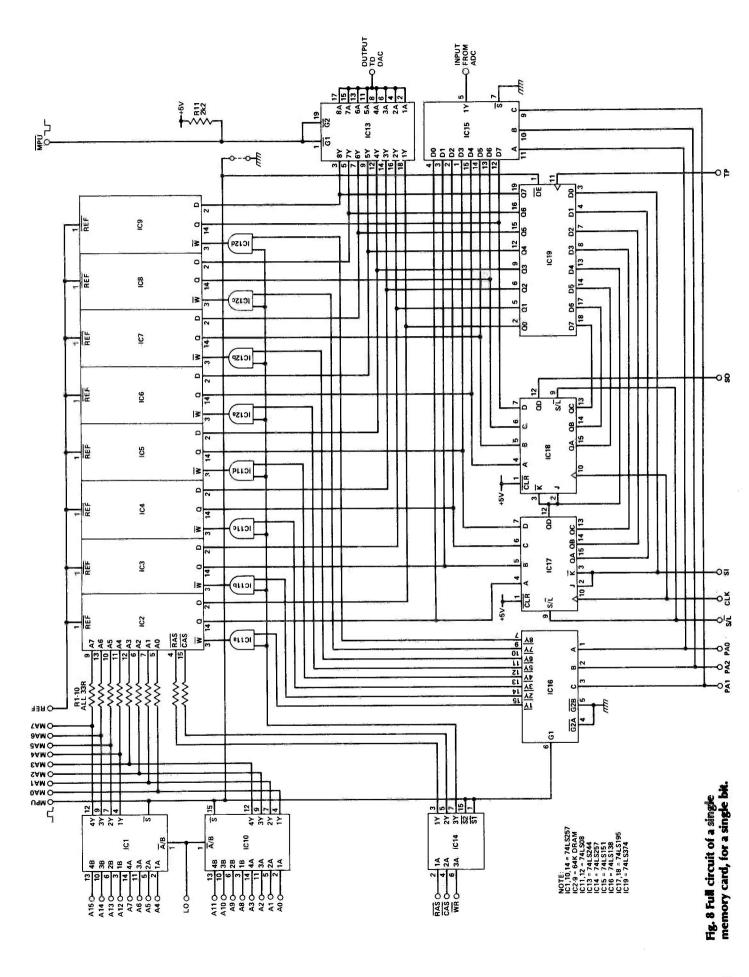


Fig. 7 Re-converting the parallel data word into a stream of eight bits.



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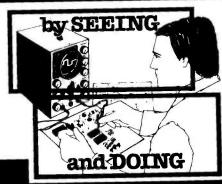
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SYSTEM FAILURE

The UK's defence industry isn't delivering - either in terms of reliability, which is this report's main concern, or in commercial and export terms. Dave Bradshaw has been talking to a very experienced engineer, working in defence, to find out why.

ike it or not, each adult in the UK contributes several hundred pounds a year to the defence industry (the exact figure is not easy to calculate). A large proportion of our electronics engineers are employed in this industry, either directly or indirectly, and much the largest share of all research is conducted

for military purposes.

With all this effort going on, it is important to ask whether we are getting value for money, because it would represent a huge waste of resources if we were not. To give value for money, a military system must work, ie it must be reliable. But there are are very serious question marks against the reliability of some systems. For example, when the Belgrano was sunk during the South Atlantic conflict, conventional torpedoes were used even though the submarine which did the sinking was believed to have 'Stingray' torpedoes aboard. Why? Could it be that the sub's captain didn't trust the high-tech torpedoes to do the job?

The problem with torpedoes is that if the first one misses, it gives the enemy warning that an attack is being mounted, which in turn gives time for preventative action to be taken. So a very high degree of reliability is necessary for torpedoes. On the other hand, another high-tech weapon, the Exocet, was used with devastating effect. Here, the circumstances are different, because if the weapon fails, it might not alert the enemy, but just crash into the sea. Even if the attacker is unlucky enough to alert the attacked, there is still ample time to launch another missile, because the target is slow-moving and the attacker is much faster.

So 'reliable' can mean different things in different

circumstances. When there was a scare over some chips manufactured by TI not having been correctly tested, BAe publically stated that they had used the chips in question in the Rapier missile, and that the missile had an 80% success rate which was considered to be very good. In weapons terms, Rapier is a low-complexity,

high-reliability weapon.

An example of about the most complex weapons system in service at the moment is the Tornado multi-role combat aircraft. Each major 'service' on a Tornado takes about three months, and that will involve the stripping down of all the systems and sub-systems, and the thorough testing of them all, both individually and in an assembled state. However, by the time the Tor-nado has landed after its first flight, it has several systems that are not fully functional, and it has to go for further repairs. The F1-11 has similar problems.

It requires a major maintenance effort to keep aircraft like this functional. By contrast, the Harrier is very robust and simple, despite having a particularly highly stressed engine. And we've given Harrier technology away to the USA, because we preferred to concentrate

on Tornado.

The remainder of this report will look at the factors that affect the reliability of military hardware. One of the problems we have encountered, though, is that while there are countless examples of blunders committed in defence contracts, the actual examples we might be able to give are all covered by the Official Secrets act. In the vast majority of these cases, the details of the mistakes have very few if any defence implications. They do have very large implications for the companies involved in defence. It would be in the long term public interest if details were known - but they cannot be released. Perhaps this is one of the reasons why the British defence industry is losing ground in competing for orders against the Israeli and French industries?

Specification

The specification is basically the document in which the customer says what is required. It is one of the most critical stages in the procurement of a piece of military equipment, and mistakes made here can be difficult if not impossible to rectify. There are a number of 'golden rules' — many of them little more than common sense — which should be followed, but which are all breached to a greater or lesser extent for much of the time. Let us take a look at the rules. They are:

1. The specification must say exactly what the customer wants. There is no room for vagueness, as this will inevitably by exploited in one way or another by one or

more parties to the deal.

2. The buyer must understand the specification and all the implications of what is being asked for. This may seem obvious, but contracts are usually drawn up by

non-technical staff, at least in part.

3. The contractor, designer, developer and producer must all understand the specification; again, there is a problem of the contract being negotiated by non-technical staff, with the result that it may be inconsistent or open to several different interperetations in key areas.

4. The specification must be complete and must not leave anything out. Here there is the problem of the wrong priorities being emphasised in the drawing up of the spec, but there are additional problems. Military contracts generally run for around ten years from start to completion, but in 1984 it is impossible to predict what circumstances equipment will find on the (hopefully theoretical) battlefields of 1994. Also the sheer complexity of military items can make it virtually impossible to describe them fully - imagine trying to write a full description of a multi-role combat aircraft.

Another problem associated with the contracts running for so long is that you cannot be sure that the device will be used as it is designed to be used. If the design work is done ten years before deployment, the

actual way it will be used cannot be predicted.

6. The device must be testable, and this must be built into it from the start. Inevitably, there will be aspects that cannot be tested, and it must be understood how

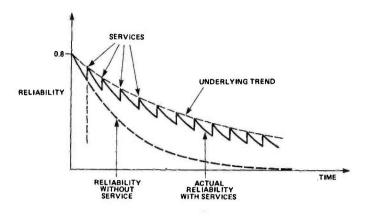


Fig. 1 Reliability declines with servicing.

much cannot be tested and how important that is to the system.

7. It must be possible to test the device without degrading it too much. One of the ironies with large-scale systems is that testing them actually makes them less reliable

in the long run, see Fig. 1.

Let us pursue this question of testing a bit further. Large-scale weapons systems have some sort of self-test capability (ie BITE, built-in test equipment). Others, like missiles, will have an associated test box, so that you can plug the missile into a box of tricks that will then put the missile through its paces, testing the main routines that the missile's equipment will have to perform in actual use. This test might be a daily, weekly or monthly ritual, depending on the device in question.

Such a test can only give a partial check on the system, so periodically the whole missile will be taken apart, all the sub-systems in it tested, then it will be reassembled and given a full system test which will, so far as is possible without actually firing the missile off at a target, test the full system under simulated systems

conditions.

There are several problems here. Firstly, without firing the missile, you can't fully test it - and there are major aspects of the operating environment you just cannot simulate. For example, you cannot simulate the launch satisfactorily. There are so many combinations of conditions that the missile may encounter that you cannot test them all.

There is a whole range of one-shot devices in any system that cannot be tested; these range from the warhead itself to explosive bolts. Testing these destroys them and they can only be replaced with similar items

which, again, you can't test without destroying.

A further problem with mechanical parts of the system is that even after testing you cannot be sure that they will work. An example would be the wings and engine air-intake on a cruise missile. There are so many variables involved here that can prevent these from working, for example dirt or debris that entered the mechanisms during testing, or small mechanical deformations accidentally introduced in re-mounting the missile. All that you can say is that the mechanical bits worked when tested, but you cannot be sure that they will work the next time they're called upon.

There are particular problems with integrated circuits. After each step of building an IC — and this includes the different diffusion stages of the wafer — the IC is tested and Inspected, to see that everything has been done properly. Once the IC is capped (encapsulated) you cannot go back to check on earlier stages, so you're confined to just checking to see that it

behaves, so far as you can test, in line with its specifications.

Burnt Out?

One of the principles behind the reliability verification of systems is that of burn-in. The idea is to make sure that the large numbers of early-life failures that occur with any device - be this individual ICs or a large-scale system - occur on the test bench rather than the battle-field. Failure early in the lifespan is somewhat tastelessly referred to as 'infant mortality'. These are usually caused by gross failure mechanisms due to manufacturing shortcomings (eg, dry joints, unsecured components, poor insulation, etc).

The idea is to create the worst possible operating conditions in which the device must operate, and subject it to these conditions for a period of time — typically 168 hours (one week) for high reliability ICs — and see if it fails. Individual devices, eg ICs, are burnt in, then they're assembled into boards and burn-in repeated, then the boards are assembled in sub-systems and the burn-in repeated, and finally the whole system is

assembled and burnt in.

If the burn-in procedures are not adhered to fully, faults will get through and end up appearing in the finished items of equipment. Combined with the effects of long-term degradation, such infant mortality faults can appear to be random failures - except that these 'random' failures would be occuring rather more often than would be expected. However, it is difficult to distinguish between random failures and a quality

control problem due to inadequate burn-in.

Manufacturers are under quite a lot of commercial pressure to curtail burn-in where possible. It costs a great deal of money and ties down resources. For example, assembling even the smallest system could take four weeks and tie up environmental testing facilities for that length of time as one week will be required for each stage — burning-in the components, the boards, the sub-systems and the system as a whole, albeit in different sections of the factory, or in different factories.

Even with an apparently adequate 'burn-in' programme, we still come back to the problem that you cannot adequately reproduce the full operating conditions. For example, the way components are mounted can count for a lot. If they are mounted in such a way that they can vibrate, it is not unknown for them to go into a very destructive mechanical resonance during, say, the launch of a missile.

Contracting

The commercial arrangements surrounding military contracts have strong repercussions on the reliabilities of the eventual products. Until recently, all contracts used to be on a cost-plus basis - the contractor would be paid as much as was spent on a particular project plus an agreed profit margin. As you might imagine, this was a licence to print money for the contractor, but it also encouraged very bad habits on the part of the customer.

The main problem was that the military would continue to change the specification of the equipment required right the way through the contract's life. These changes would be called 'enhancements', although they would frequently be incompatible with the

original specification. These 'enhancements' might be trivial - for example, the moving of a bracket - but they might also be quite large. An accumulation of apparently trivial changes can amount to a major design

change.

During the typical contract life of ten years, the military would be going back to the contractor with 'enhancements' for virtually the full life of the contract, almost as a matter of course. Over ten years there will be a considerable change in the technology available, and the military wants to see the latest in technology incorporated into their toys. 'Enhancements' have the result that the system at the end of the project could be completely different from the concept at the start. Obviously, it has considerable repercussions for the reliability of the system if there are a number of 'bolton' extras added at different stages of the design and development.

Fixed Cost?

To overcome some of these problems, the present minister of defence, Michael Heseltine, has introduced what at first seems like a step in the right direction (no pun intended). The fixed - price contract is, in theory, exactly what it says — the contractor will get a fixed amount of money for doing a fixed job. This was introduced mainly to prevent the sort of price escalation that has been so common in defence contracts, but as a side-effect it should have got rid of the con-

tinuously varying spec. It hasn't.

The problem is that the eventual users of the equipment are still treating these contracts as cost-plus, and are demanding 'enhancements' from the contractors. Contractors are all too pleased to provide the enhancements requested—and even to make a few suggestions of their own—because, not unexpectedly, it will mean an increased price for the work. The customer can hardly object to this, and in any case, there could be no question of taking away the contract from one company and moving it to another, because that would extend the wait before the equipment comes into service.

Even if the military do not want 'enhancements', the contractor can easily find ways to increase the price because the specification and contractual terms are generally very loose, as is the monitoring of contracts. Just how loosely military contracts are monitored here can be judged in comparison to the way that NASA and

ESA monitor their contractors' behaviour.

For example, if you are a sub-contractor to NASA, periodically you will recieve a visit at very short notice from a technical expert. The warning you get could be 24 hours or less. The expert will want to see all the work you are doing, how it is progressing, and will want to know the reasoning behind all the procedures you have adopted. Engineers who have been through this process describe it as 'very testing'. However, it would be unthinkable for the MoD to adopt a similar process here.

Splitting It Up

Fixed price contracts are not the end of the changes the Government are introducing. The next stage is the putting out of every major stage of the contract to tender. So different companies would have the opportunity to bid at each of the stages; in a typical case, these are: feasibility study; project definition; development; initial production; and quantity production.

The new system has only just been introduced, so it is not yet possible to see how it will work out in practice. The idea is to make contractors competitive in price at every stage of the process, but the major fear is that it might result in significantly less reliable end-

products.

The problem is that if different contractors do different stages in the process, there is a lack of the engineering continuity which is essential for high reliability through feasibility, definition, development and production. As has already been mentioned, contracts are not normally drawn up by technical staff, although there is technical involvement. The more separate contracts are placed, the more contracts have to be written and the more the problems associated with this come to matter. However, on top of this there are always many things that even competent engineers do not write down - these range from apparently insignificant details to underlying assumptions; indeed, it is more likely to be the latter, rather than the former, that don't get written down.

Even if everything of importance does get written down, the experience and enthusiasm of the engineers involved in the project cannot be transferred from one contractor to another. In particular, if an engineer gets involved in a job which is then taken away, it is unlikely that the next engineer will, at least initially, have the

same experience and motivation.

One effect that may not be all that bad is that the switch to part-contracts may lead companies to develop — or buy-in — ranges of off-the-shelf components instead of developing new ones. For example, to produce a generator, the fastest solution is to use off-the-shelf components of engine, dynamo and voltage regulator, whereas at the moment a contractor would automatically design a special-purpose unit from scratch. The reason for this change is that contractors will have to bid for a large number of jobs at any one time — all of them of shorter duration than at present — and it will not be known what the next contract will require. So the flexibility of off-the-shelf units will be necessary.

Finally, an inevitable consequence of part-contracts will be that contractors will spend more on making proposals. Each proposal costs time and money, and the customer will end up paying for this in the long run. At present, it is not uncommon for the cost of making a proposal to be buried in the costs of existing contracts—the system is so slack that contractors can allocate engineers' time to virtually anything they like. Whether fixed price contracts will eventually make it more difficult for costs to be hidden remains to be seen, but it is thought unlikely that it will make much difference.

Design Discipline

A good example of the importance of design discipline has been documented for the cruise missile programme. The sub-contractor doing the software ran into problems, but instead of properly analysing the trouble, the approach adopted was to throw more money at it by bringing in more software engineers. This just compounded the problems. Prof. C. Brooks of the University of N. Carolina's computing department describes the nature of working on software with the following analogy: "The bearing of a child takes nine months, no matter how many women are assigned."

FEATURE

Many software tasks have this characteristic because of the sequential nature of debugging." In other words, you can't rush writing software, but that doesn't stop defence contractors trying.

In general, contractors start their FMECA study far too late in the life of contracts. FMECA stands for Failure Mode, Effects and Criticality Analysis, and it is concerned with looking at the likely shortcomings of the design in a very critical and analytical way. Starting this process any later than the early stages of design and development can greatly reduce its effectiveness. However, contractors will often not start this procedure until they've already realised that there is a problem ie, they're already in trouble and they're clutching at remedial straws. They throw money at the problem as a substitute for proper planning in the early stages.

Ideally, it should be written into any contract that the FMECA programme should start at some short interval - say 30 days - after the development contract has been awarded. This would then have to be very closely monitored to make sure that it really did happen. Very often an inquiry as to the progress on FMECA will result in the contractor hurriedly starting it up — but at too late a stage to have any real impact. The contractor will then pretend to the customer that the FMECA programme had been in hand all the time and they can get away with it because the MOD(PE) does not monitor effectively.

Short Term Contracts

It should be possible to carry through most military contracts in a much shorter time than they presently occupy. We would suggest that a target of two years not ten — should be aimed for. A number of advantages would be incurred by going for much shorter time scales.

Firstly, the contractor and the customer would have to stick to the original specification. This would have the effect of 'freezing' the technology used at the time of design — but with only a two-year time lapse, this technology would still be in-date and not nearly

obsolete, as would be the case with a ten-year contract. Secondly, there would be a general reduction in price. Besides fixed price actually meaning that, the massive overheads incurred by having a job going on for so long would be reduced, as would the expenses involved in meetings. The main losers would be hoteliers, restaurants, travel agents and air-lines.

Finally, there would be the real opportunity to learn by mistakes. You can actually have an item of equipment out and in use at the time that you are looking at either the Mk.2 version, or at the next generation of

equipment.

As far as we can see, it is sheer inertia that is stopping this sort of development, not technical complexity. If compact disc players can be designed and developed, using entirely new technology, in the space of a couple of years or so, then why not a new command, control, communication system for the army? Yet the Ptarmigan system has been under development by Plessey for the last 12 years and is still not fully deployed.

Conclusion

The way that the defence industry is organised at the moment, the products work despite the system, and mainly because of the dedication of individuals. A major reorganisation would result in a much less costly more effective industry, which would, in the long term, be better for all concerned.

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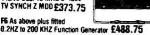
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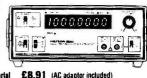
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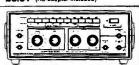
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DISTORTION **METER**

Writing in his Audio Design article in the August issue of ETI, John Linsley Hood offered to describe a simple yet sensitive distortion meter, assuming, that is, the editor didn't mind! Needless to say, the editor didn't mind at all.

he ideal audio power amplifier, along with other pieces of audio signal handling gear which are not intended to modify the frequency response of a system, is well described by the old adage 'a straight piece of wire with gain'. This implies that such equipment does not modify or impair the nature of the signal being handled, except to amplify or add muscle power.

However, if this is the specification, how do we check to see how well or badly this requirement is being met? This is, alas, something on which there is very little agreement between audio engineers or circuit designers. So, before we consider the hardware, we need to examine the job we

want it to do.

In simple terms, what we want is that the output from an amplifier should be identical to the input, except that it might be bigger or smaller or perhaps with one part of the frequency spectrum enlarged or diminished with regard to another. This is an awkward bit, so let us leave that on one side for the moment and look just at the simple flat-frequency-response

When people first considered this problem, their thoughts turned to the examination of a continuous, fixed frequency sine waveform somewhere in the middle of the audible band, say at 1000Hz. The logic of this was that any distortion of this waveform would lead, as could be shown by mathematical analysis, to the generation of harmonics of the input signal, and these could be isolated and measured.

The problem with this approach is that it is highly artificial. We simply do not listen for instruction or enjoyment to steady single tones. Nevertheless, the technique is a useful one, especially if the output from the distortion meter can be examined on an oscilloscope. Quite a lot of information about its defects — yes, there are always some, if one looks hard enough — can then be gained, which allows the effects of changes to be assessed.

The most common of this kind of distortion meter is the simple 'notch filter', which will remove the incoming sine-wave signal and leave only the waveform impurities which have been added by the hardware we are testing.

The sort of result we would get

from this kind of test on an amplifier with cross-over distortion, or one driven into clipping, is shown in Fig. 1, a and b. What the distortion meter is showing us, in both cases, is what kind of a waveform would have to be added to the distorted output in order to get back to the waveform with which we started. Clearly, there is a difference between these, which can point the experienced worker in the right direction to remedy the defect, especially if the input signal and distortion meter output waveforms can be displayed at the same time on a double-beam oscilloscope.

The most conspicuous audible effect of the presence of large amounts of 'low order' harmonic distortion, (ie. mainly 2nd and 3rd) is that, as its name suggests, harmonic tones are added, which make the system sound rather shrill. Those of us with long

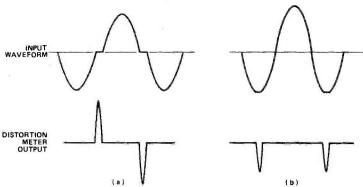


Fig. 1 Examples of the waveforms obtained by using a notch filter on distorted sine-waves.

memories will recall the sound of output pentode valves, which generated generous quantities of 3rd harmonic distortion, and for which the palliative was to stick a 10n capacitor across the primary of the output transformer. Triodes were much preferred, since they mainly generated only 2nd harmonic distortion, and this was lower down in the frequency spectrum and therefore much less squawky.

Also, as one might guess, these 'low order' harmonics generate spurious waveforms which do, in fact, harmonise with the input signal; once one gets beyond the 3rd harmonic in the 'odd' series, or beyond the 6th in the 'even' one, the tones become increasingly dissonant and objectionable to the

listener.

This was one of the reasons why the first transistor amplifiers (whose residual crossover distortion produced 7th, 9th, 11th, and other audibly dissonant odd harmonics) were so much worse, even at a 0.1% distortion figure, than the valve units they replaced.

However, back to valves. When, in the early post-war years, designers began to consider seriously the requirements for high quality audio systems — at that time largely based on triode valve output stages, operated in pushpull to cancel as much of the even order harmonics as possible attention was drawn to the other defect, shown in Fig. 2. This was associated with non-linearity in the handling of the signal, and was the so-called intermodulation distortion, which led to a muddling of the tonal quality.

If we take two separate and distinct audio signals as shown in Fig. 2a, and add them together as shown in Fig. 2b, and if we pass them through an amplifying stage having the sort of non-linear inputoutput characteristic shown in Fig. 2c, the result will be similar to that shown in Fig. 2d, in which the gain of the amplifier is reduced as it swings into its upper voltage

region.

The worse the non-linearity, the more the intermodulation effects between initially separate and distinct input signals. Also, as you can see from Figs. 2e and 2f, a different kind of non-linearity will produce a different kind of intermodulated output. Once again, the effects due to high order defects such as crossover distortion are worse, audibly, than those due to smooth bends in the trans-

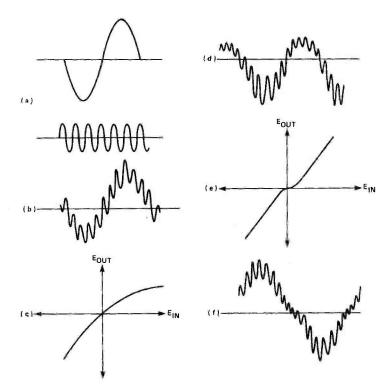


Fig. 2 The introduction of intermodulation distortion as a result of passing two signals through a stage having non-linear characteristics.

fer characteristics of the system — which provides yet one more reason why designers try to minimise the generation of the higher order harmonics.

The way in which intermodulation distortion is measured is by passing a pair of signals through the system, and then measuring the sum and difference products caused by the non-linearity of the system. For example, if two sinewave input signals are introduced, one, say, at 70 Hz and one at 3000 Hz, the result of the non-linearity in the amplifier would be to generate additional spurious signals at 2930 Hz and 3070 Hz. If these are filtered out and measured, the amount of distortion in the amplifier can be assessed.

Looking at this in practical terms, if the transfer curve of the amplifier is as shown in Fig. 2c where the gain of the system decreases as it swings more positive, and if we assume that the 3000 Hz signal is a small one riding piggyback on the much larger 70 Hz one, then, as the 70 Hz signal moves the operating point of the system from lower left to upper right, so the 3000 Hz signal will get bigger or smaller as shown in Fig. 2d.

This is helpful as a yardstick in assessing amplifier quality in that it simulates the effect of typical audio signals which are composed of many different parts, all happening at once, and, in a poor

amplifier, with lots of intermodulation distortion, all getting jumbled up together into a kind of audio porridge.

The snags are two. The first of these is that it takes quite good audio filtering in the test instrument to separate out the 2930 Hz and 3070 Hz signals from the 3000 Hz one, which makes such meters expensive. The second snag is that, having got the answer in terms of the amount of intermodulation distortion, the designer isn't given much assistance in finding just where the problem lies. The simple THD meter, with a display on an oscilloscope, is much better in this respect.

A more recent technique, adopted by the French CCIR committee, employs two high frequency signals, such as 19,950 Hz and 20,050 Hz. These give a frequency product appearing at 100 Hz, and it is easy to filter this out from the 20 kHz equal-amplitude carriers.

The argument offered in favour of this approach is that amplifiers, even nowadays, are much less good at 20 kHz in terms of their linearity than they are at, say, 1000 Hz. The counter argument is, of course, that we don't have ears like bats, so we are more interested in how the system behaves at 1000 Hz than what it does at 20 kHz.

Another very up-market technique is to put in a high-purity sine-

PROJECT: Distortion Meter

wave signal, or indeed as many of these as one feels inclined to use, and then display the output of the amplifier as a sweep of the frequency spectrum on a spectrum analyser. This is a development of the earlier 'Frequency Analyser' technique, in which the magnitudes of the outputs at various harmonic frequencies related to the input sinewave frequency could be displayed on a meter for individual analysis.

While spectrum analysis gives a very effective display of the amplifier output — 50 Hz warts and all — and the better modern ones are usable down to a noise threshold of –90 or –100dB (0.003—0.001%), in all fairness, it is a bit difficult to see what one has got on the display or print-out if it is much below –80dB (0.01%).

All this kind of kit is very nice, and mouth-watering to contemplate if one is setting up a 'cost no object' test laboratory, but it is a bit remote from the more frugally financed DIY enthusiast. So what can one do for oneself?

The THD Meter

The most useful piece of gear which one can organise simply, and which will give amplifiers a clean bill of health — or otherwise as the case may be — is a simple Total Harmonic Distortion measuring instrument or THD meter for short.

This operates by 'notching out' the fundamental frequency of the input sinewave and leaving the distortion products, together with any hum and noise there may be in the amplifier output, to be measured on a millivoltmeter. The main snags with this approach are that it will show these hum and noise components as harmonic distortion in the final output to the meter, yet they are nothing to do with the linearity of the system as a whole and are likely to be completely innocuous, audibly, if one can't hear them from the normal sitting position when listening to the system.

Fortunately, it is a simple enough matter to identify which is which, even without access to the oscilloscope, by merely disconnecting the signal source from the amplifier, looking at what remains in numerical terms, and subtracting this from the original result. In order to get a result which is not over-generous to the unit on test, this must be done as an RMS subtraction — I will come to that later.

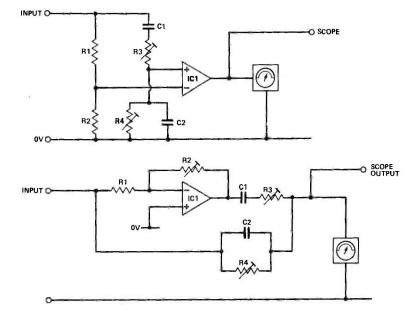


Fig. 3 a and b — Two possible arrangements of the Wien network.

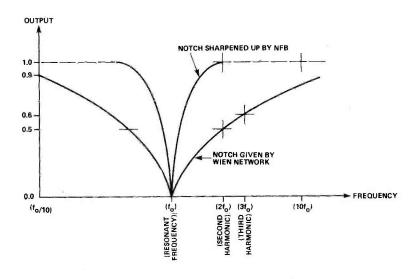


Fig. 4 The notch produced using the arrangement of Fig. 3b.

It is not a difficult matter to generate quite a good notch in a frequency response and tune it precisely to coincide with the frequency of one's test waveform, and there are several circuit choices available for doing this. Of these, the two most convenient and therefore the most commonly used are the RC 'parallel T' and the various arrangements of the Wien network, which I have shown in Fig. 3.

The interesting thing about the Wien network, C1,C2,R3 and R4 in Fig. 3a, is that it has zero phase shift and an attenuation of just 3 times at one specific frequency. If one makes R3 and R4 adjustable, this frequency can be altered. If C1 and C2 are not quite the same — in theory C1=C2 and R3=R4—the attenuation will not be exactly 3x, but this could be compensated

for by an adjustment to R1 or R2.

The differential amplifier I hav

The differential amplifier I have shown as IC1 would need to be a very good one for this kind of circuit to work well, so the alternative arrangement I have shown in Fig.

3b is preferable.

In this, the amplifier IC1 is used simply to invert the phase of the signal and amplify it by 2x. This utilises the feature of the Wien network that the impedance of C1,R3 is twice that of C2,R4 at the frequency where the phase shift produced by each part of the network is equal. So, if IC1 applies a signal to the upper half of the network which is exactly twice the size of that applied to the lower and of opposite phase, the output will come to a null at some frequency dependent on the values of C and R chosen, as I have shown in Fig. 4.

If we want just to remove the input signal frequency, without attenuating the harmonics, the skirts of the notch must be steeper than those produced by the simple arrangement shown in Fig. 3. However, we can do this by applying a bit of negative feedback around the loop, as I have shown in schematic form in Fig. 5.

To tune the notch frequency so that it exactly coincides with the input signal frequency, we need to be able to adjust the value of either the Cs or the Rs in the network. Since the operating frequency is given by the equation

$$F_0 = \frac{1}{2\pi} \sqrt{\text{C1 C2 R3 R4}}$$

the values of C are too large, unless a very high impedance circuit is employed, to allow the use of a twin gang variable capacitor. In fact, if we want the value of R3 and R4 to be 10k, C1 and C2 will need to be 16n for a notch frequency of 1 kHz. Lower frequencies would require proportionally larger values of capacitors.

It is possible to make such a system with an air-spaced twingang capacitor, but the necessarily high values of R make the whole unit very sensitive to 'hum' pickup. Overall, I think it is easier to use variable resistors, which are easier to get and a lot more

compact.

The necessary slow-motion adjustment can be obtained by the use of two resistors in series. one ten times the value of the other, when the high value resistors (as ganged pairs adjusted together) can be used as the coarse frequency adjustment, and the lower ones for fine trimming. This principal could be extended, of course, to employ three such twin gangs in series, to allow a very fine adjustment indeed.

Since the resistor which adjusts the gain of IC1 in Fig. 3, (R2), is a single potentiometer, a ten-turn variable resistor can be used in this position to adjust the gain of this limb so that a complete notch is obtained, with no residues of the input frequency remaining.

The final part of the system is a wide bandwidth millivoltmeter, to display the value of the distortion and noise residues remaining when the input sine-wave is

removed.

Since we live in the real world, and there will inevitably be some hum pick-up somewhere in the

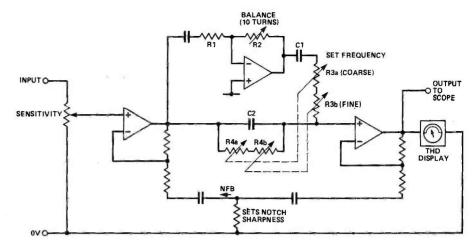


Fig. 5 Wien network with negative feedback to produce a sharper notch.

system we are testing, it is useful to incorporate a 50 Hz filter which can be switched in. Also, while we are doing that, we may as well include some HF filtering options so that we don't measure the THD over too wide a frequency 'window', with its associated noise components.

Finally, it is very helpful, in tests where one is taking the measuring instrument to the gear being tested, to have a built-in signal source of adequate quality.

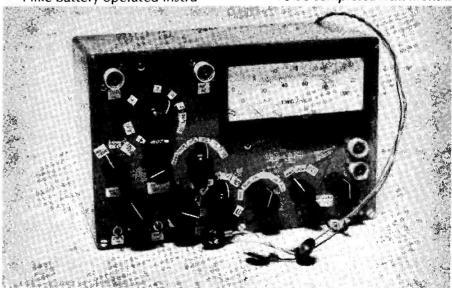
I am going to describe a relatively simple and low cost THD meter which incorporates the general ideas described above, and I propose to show this circuit in two forms, one a laboratory standard quality instrument operated from a mains input supply, and one a somewhat simpler unit operated from a single 9V battery, which will be rather easier to make if the demands made upon it are less stringent.

I like battery operated instru-

ments myself because they are highly portable and don't cause problems with earth loops. However, if one wants high performance, it is impractical to demand very lower power consumption at the same time. If one then accepts a higher battery drain — say 10-25mA — it is expensive if one forgets to switch the instrument off after use, while any 'auto off' function may well switch it off right in the middle of a measurement, which is infuriating,

Hence the two versions of the unit. I have deliberately tried to make the battery operated system as economical in current consumption as possible without resorting to exotic ICs, and in both cases I have organised things so that the millivoltmeter is available as a separate input, so that it and the oscillator can be used on their own as a means, for example, of measuring frequency response.

To be completed next month.



The prototype, looking much the way most prototypes do at this stage in their development!



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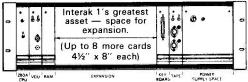
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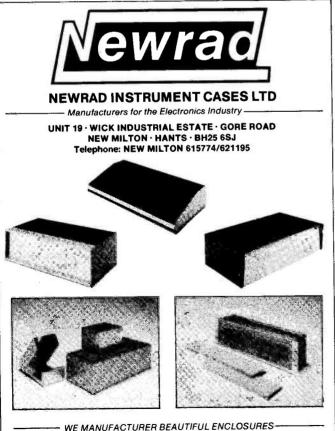
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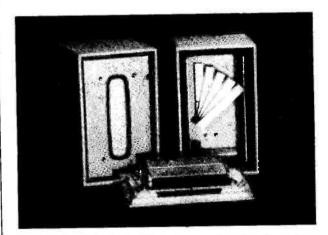


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DIGITAL DELAY LINE

Without further ado, we pass into the constructional stage of the project. Design and development by Ray Lowe.

irst of all, before commencing construction, read all the article (including last month's part) thoroughly and don't rush at the construction when you do begin!

To keep costs down, we haven't used through-plated holes on the PCBs (these would add around 50% to the price of the PCBs); however, this does mean that rather a large

number of through-links have to be made. We would suggest spending an hour or so inserting and soldering all the linking pins, then all those components which have their leads used for throughconnections, afterwards carefully checking that you've got all the connections right.

A tip here is to support the board above the work surface and

insert lengths of tinned wire through the hole positions before soldering them in a batch. Check very carefully for solder bridges between tracks at every opportunity — a fine-tipped iron and fine solder are strongly recommended as parts of the boards are a bit crowded! Making your own PCBs is not recommended for this reason, unless you have access to

OOPS!

We suffered a loss of sync between the component numbering on the circuit diagram and the 'How It Works' text for the digital section, published last month. In the text:

IC24 becomes IC26 IC26 becomes IC25

IC27 becomes IC36

IC29a becomes IC33a

IC29b becomes IC33d

IC29c becomes IC33c IC29d becomes IC33b

IC30 becomes IC24c

IC30d becomes IC24a

IC32, 33 becomes IC28, 29 IC35 becomes IC32

IC37 becomes IC30

SW11-SW8 should read SW1-SW8

SW9 becomes SW11

SW11 becomes SW9

D7 becomes ZD1

D8 becomes D6

R65 becomes R61

R69 becomes R62

On the circuit diagram, the junctions of R51-54 and R55-58 should be tied to +5V, not 0V, the line from the 0₀ output of IC31 should be labelled CK, and this line also has a spurious unlabelled junction with IC32 that shouldn't be there. We are sorry for any confusion this may have caused!

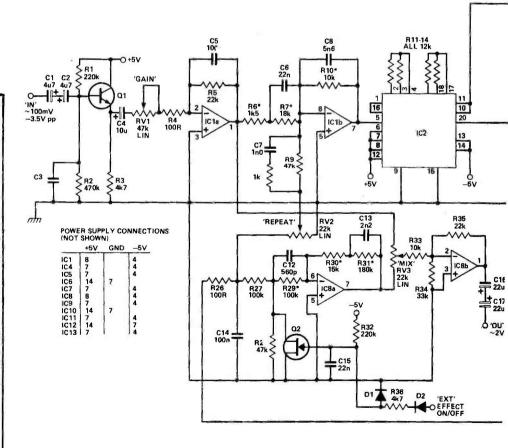


Fig. 8 Circuit diagram of the analogue section.

HOW IT WORKS — ANALOGUE SECTION

C1, C2 provide non-polarised AC-coupling to emitter follower Q1's base, which is biased by R1, R2. C3 provides HF filtering; Q1 is a low noise device. IC1a is connected as an inverting amplifier. Since the emitter follower has low output impedance, the stage gain is set by RV1 as R5/RV1 approx. DC blocking is provided by C4 so that IC1a's output swings about 0V plus offset voltage. C5 limits the HF response; strict bandwidth limiting is desirable to minimise aliasing and overal system noise.

The amplified original signal is passed to RV3 and to the inverting preemphasis stage around IC1b. R6, R7, C6 provide roll-on starting at about 400 Hz whilst R10, C8 start roll-off at around 3.2 kHz, thus mid range lift is produced.

The pre-emphasised signal is (low pass) anti-alias filtered by three MF10 second-order switched capacitor filter stages connected in series, giving -36dB/Octave cut off in total. The corner frequency of the filter is 1/50th of the square wave clock frequency applied to pins 10, 11. In this way, the Nyquist sampling criteria is always satisfied since the sampling frequency is synchronised to the cut off frequency via the system clock.

Some clock breakthrough occurs in the filters and this is removed by R19 and C9; subsonics are removed by R20 and C10. The fully filtered signal is buffered by IC4 such that it swings about 0V. IC4 and IC5 are chosen to have a low input offset voltage of about 1mV for a reason which will become apparent when you read on!

The buffered signal is fed to a 'signal polarity' comparator with hysteresis to elminate noise-induced switching in the absence of a signal. IC9 is the comparator, comprising a high-performance op-amp with a high slew rate — so high that its output can swing between power rails within a microsecond, and respond very quickly indeed to the polarity of the signal on its inverting input. No frequency compensation is required in this application. R37 and R38 give approx 6.5 mV of hysteresis, which is sufficient if you consider that the polarity assigned to a 0 V signal is irrelevant.

signal is irrelevant.

D3 and R39 stop IC10b's data input from going -ve; IC10 is a dual positive-edge triggered D-type flip-flop. IC10b latches the comparator output state on receipt of every SC (start conversion) pulse. Q and Q control CMOS switches IC6 a,b such that either the inverted or uninverted signal, respectively, is selected at any sample time, so that the signal reaching IC6c is wholly positive (rectified).

The Q values of IC10b form bit nine of the data word for a sample A/D con-

version. The bit nine 'bus' direction is controlled by the OE control line. IC6c and C11 form a sample-and-hold, updated on every SC pulse, and in conjunction they also perform low-pass filtering.

IC7 is a FET input op-amp with low offset voltage and low offset vs. temperature coefficient (FET inputs generally have higher offsets than bipolar). It also has very high input impedance so as not to load C11; however when switch IC6c is open this means that the non-inverting input/C11 node is at a very high impedance with respect to ground and is therefore suselectromagnetic interceptible to ference. Including R23 reduces this impedance from something like 100 Mohm to 680 kohm and interference is much reduced. R23 shorts the switch instead of going straight to ground in order that the discharge of C11 is minimised. IC7 acts as a voltage follower with gain of three, and the offset is nulled by adjustment of PR1. This output is A/D converted into data

bits '1' to '8'.

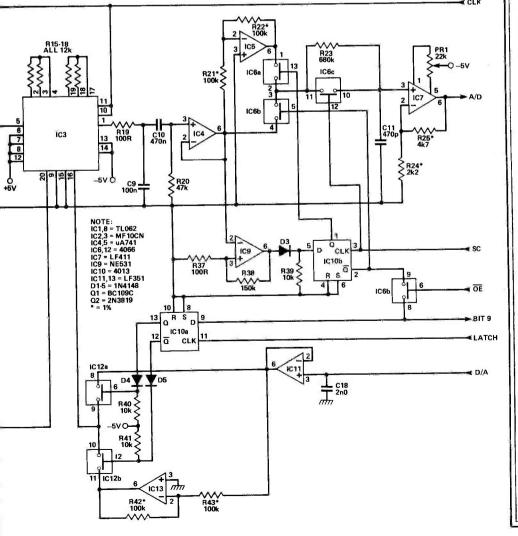
The delayed signal from the D/A is low pass filtered by C18 in conjunction with the D/A's 4k output impedance, to remove HF breakthrough, and the signal is then buffered by IC11. It is then accurately inverted by IC13, R42, R43. Analogue switches IC12 a,b select either the erect or inverted signal dependant upon the sign of 'bit nine' latched into IC10a by the D/A latch pulse. The sign of 'bit nine' is used in a way such that any signal, irrespective of original polarity, is only inverted once throughout the entire A/D & D/A conversion process, thus minimising signal degradation.

The signal entering the second-order low pass filter stage of IC4b at pin 16 has been reconstructed to be bipolar about 0V with 5V P-P amplitude. IC3b rounds off the step-like waveform. The delayed but still pre-emphasised signal appears together with clock breakthrough at pin 20. Breakthrough is removed by R26 and C14.

A fraction of the signal is fed back to be delayed again by applying it to the summing point of IC1b. The feedback fraction, which determines the echo decay rate, is governed by RV2. R8, R9 and C7 counter the effect of roll-off on each extra traversal through this stage, however a slight treble cut remains, but this is useful because it tends to mask the quantisation distortion which builds up with each conversion process. R8 also prevents IC1b from going into H5 oscillation, as might happen if C7 were slightly inductive (it would be across the inputs when RV7 is fully off).

The delayed signal is also fed to the output mix control RV3 via deemphasis amplifier/buffer IC8a. Normally, Q2 has a -ve gate potential which holds its channel resistance very high. When -ve bias is removed, by shorting EXT to 0V, the resistance falls to several hundred ohms which in conjunction with R27, severely attenuates the signal ie, shuts off the echo

The desired blend between original and delayed signals is set by RV3 and the output is buffered by IC8b. Non-polarised DC blocking for the output is done by C16 and C17. The output can drive low impedance headphones directly.



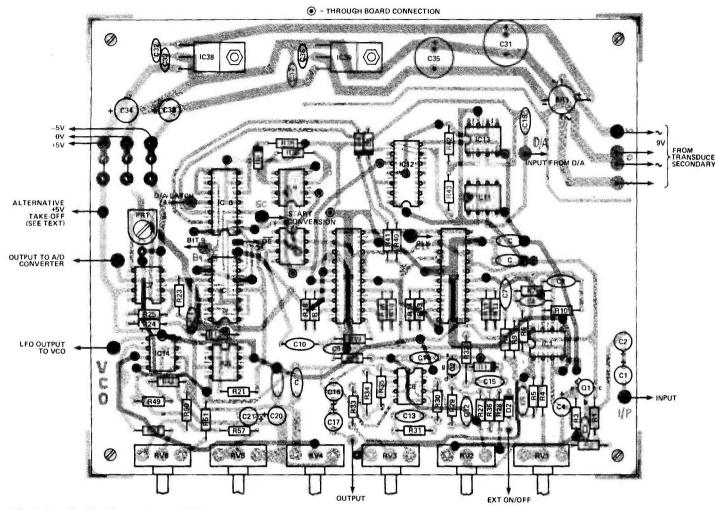


Fig. 9 Overlay for the analogue PCB.

9 Overlay for the analogue PCB. PARTS LISTPARTS LIST							
RESISTORS (1/4W	5%)	RV4	1M0 lin	IC10	4013		
R1, 32	220k	RV5	220k lin	IC11, 13	LF351		
R2	470k	PR1	22k horiz preset	IC14	TL062		
R3, 25*, 36	4k7	CAPACITORS (n	netalised plate ceramic	IC15-23	6116 (any speed)		
R4, 19, 26, 37	100R	or 5% polystrene		IC24	4001		
R.5	22k	C1, 2	4u7 10V elec	IC25	4068		
R6*	1k5	C3	33p	IC26, 27	4051		
R7*	18k	C4	10u 10V elec	IC28, 29	4040		
R8*	1k0	C5	100p	IC30	4046		
R9, 20, 28	47k	C6	22n	IC31, 32	4017		
R10*, 33, 39-41	10k	C7	1n0	IC33	4011		
R11-18	12k	C8	5n6	IC34	4002		
R21*, 22*, 27, 29*		C9, 14	100n mylar	IC35	ZN427E		
42*, 43*	100k	C10	470n	IC36	uA741		
R23	680k	C11	470p cer	IC37	ZN428E		
R24*	2k2	C12	560p poly	IC38	7805		
R30*	15k	C13	2n2	IC39	7905		
R31*	180k	C15	22n mylar	Q1	BC109C		
R34	33k	C16, 17	22u 10V elec	Q2	2N3819		
R35	22k	C18	2n0 cer (or 2 x 1n0)	D1-6	1N4148		
R38	150k	C19, 20	100u 10V elec	ZD1	5V6 400mW zener		
R44	680R	C21-28	100p	LED1	min red LED		
R45	4k7	C29	1u0 5V elec	BR1	35V/1A bridge		
R46	3k9	C31, 35	2200u 16V elec		rectifier		
R47	15k	C32, 33, 36, 37	50n (or 47n) ceramic	MISCELLANEC			
R48	18k	C34, 38	10u 10V elec	SW1-11	DPDT push		
R49, 50	100k		acitors — all 100n		switches, latching,		
R51-58, 61, 64	10k	ceramic			PCB mtg		
R59, 60, 62	100k	SEMICONDUCT	ORS	SW12	Mains switch		
R63	15k	IC1, 8	TL062	T1	9-0-9V 3VA (min)		
R65	82k	IC2, 3	MF10CN		mains tranformer		
R66	390R	IC4, 5	uA741	Case to suit;	mains fuse and holde		
R67	470R	IC6, 12	4066	input, output a	and ext sockets to choice		
RV1	47k lin	IC7	LF411		5V regulator; mains cab		
RV2, 3, 6	22k lin * = 1%	IC9	NE531	gland.			

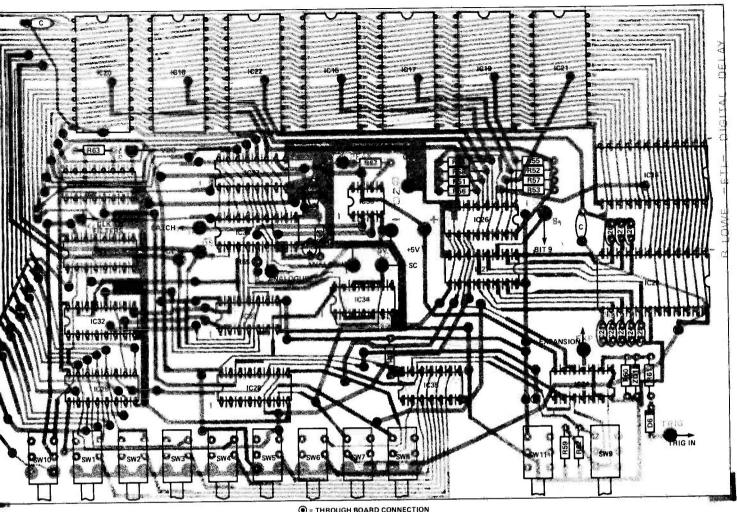


Fig. 10 Overlay for the digital section.

photo-etching gear.

Construct the PSU section first. What we would suggest doing is mounting the mains switch, the mains fuse and the transformer all in the case to start off with. As you'll be fiddling round with the boards, doing the assembly and setting up, it will probably be best not to mount the boards in the case until you have got the unit going properly, so initially link the transformer secondaries to the analogue board using longish lengths of wire. In any case, whatever you do, you must exercise suitable precautions for the mains side of the circuit. Clamp the mains cable firmly, so that it cannot pull free even with a strong pull. Use a suitable mains fuse, in a substantial panel-mounting fuse holder. Use the mains earth to earth the case and all other metalwork (except the regulator heatsinks, if you haven't used an insulating kit on them). There must be adequate clearances and/or insulation around the mains sections and associated components. On this last point, you will almost certainly find yourself

= THROUGH BOARD CONNECTION

operating the unit without the lid on at some stage, so use heathshrink wrap, etc, to make sure that you can't accidentally touch live parts.

After the PSU section is constructed, connect it up to the mains and check that it does deliver + and -5V. Then commence construction of the other sections of the circuits by inserting all the IC sockets (after, of course, disconnecting the unit from the mains!). Then re-connect the mains and check that + or -5V appears across the correct pins. Insert resistors, capacitors, transistors and switches, checking all the time for secure joints and for solder-bridges. With the mains re-connected, check that the current drain is negligible and that the supply rails are at the correct voltage.

With the supply off, plug in the chips one at a time, starting with the least expensive, then reconnect the supply and check that the current drain is sensible and nothing gets too hot (although, with all the ICs inserted, the positive regulator will run warm).

Unplug the unit between tests, and remember to discharge your fingertips before handling the CMOSyou can do this by touching an earthed metal case in your work

The last items to insert are the A-to-D, the D-to-A, the switched capacitor filters and the memory chips. To check operation of the unit, only two memory ICs are needed, IC15 and IC23, and as S-RAMs are not cheap, it might be prudent to check that the unit is fully functional before you insert any more memory.

The final job before testing is to do all the inter-wiring between the PCBs and any controls, etc, not mounted directly on the PCBs, and to secure the boards firmly in the case.

Setting Up

If all goes well, the unit should be operational as soon as it is switched on, however there is no harm in looking over one final time to see if there's anything you've missed. Do make certain that all is safe on the mains side - not just

for your own sake, but for the sake of the equipment you'll be connecting the unit to.

Circuit operation is quite easily checked using an oscilloscope—see the timing diagram, Fig, 4 (given last month). However, the following is a suggested procedure for those constructors without access

to a scope.

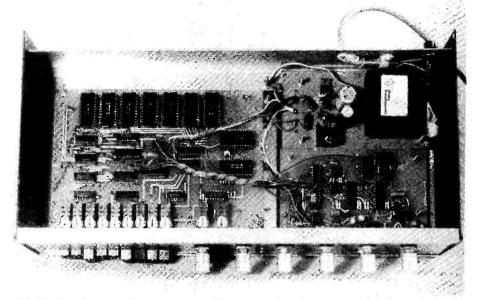
Connect the output from the unit to an amplifier and speaker. and apply an input signal. The first check is to see if the peak indicator glows with the gain and bandwidth set to maximum (although, this does depend on your input signal being above 200mV or so) — if this doesn't work, the first point to check is the LED polarity. Next, check that with the mix control fully anti-clockwise, the original signal is heard; this will show whether or not there is signal continuity through the analogue board. If no signal is heard, go back and check your construction.

With the shortest delay setting, the mix control fully clockwise, repeat control fully anti-clockwise, freeze and percussion switches out, and the LFO depth control off, check that a delayed signal is heard. It may be distorted, but at the moment this is nothing to worry

about.

Remove the input signal and adjust PR1 so that the unit's output is now silent for all bandwidth settings; check that distortion is at a minimum on low-level signals.

The unit should now be ready for mounting in the case. Any case should do, more or less, provided it is big enough to take the boards; however, you might wish to have details of the expansion board before choosing the case, and these will be given next month.



The insides of the prototype: a general-purpose PSU PCB was originally used, with a few mods here and there, so please don't look too closely! Also not recommended is duplicating the author's mains cable relief arrangements!

The one critical area is the cutout to take the PCB-mouted components; a suggested panel layout-out is shown in the photograph.

Once completed, and with the full memory complement that you've decided to use, the unit should be ready for use. So don't

delay further . . .

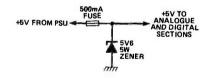


Fig. 11 A suggested modification to make sure that a PSU over-voltage doesn't do too much damage.

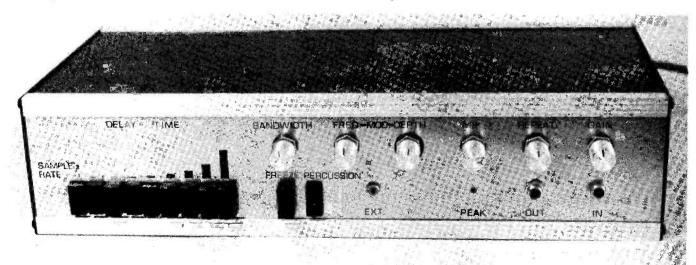
BUYLINES

Rather surprisingly with the esoteric devices used in this project, the one semiconductor which might cause a few problems is a humble op-amp—the LF411 (IC7), which was eventually traced to Maplin. A substitute type could be used here, but at the risk of increased cross over type distortion (a very low offset device is required). All the other semiconductors are available from Watford, Cricklewood, Technomatic and Rapid to name but a few, as well as Maplin.

The switches SW1-9 must have the correct lead spacing (0.15" between pins, 0.2" between rows) to fit on the PCB, but this should not create too many problems (for once, RS types are not suitable, as these fit a 0.1" matrix). The ones in the prototype were from

Cirkit.

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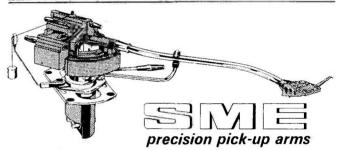
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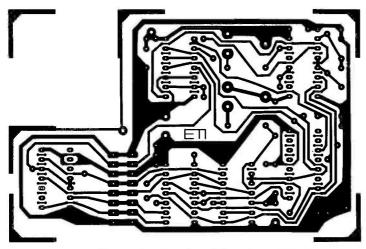
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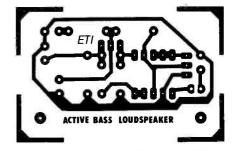
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PCB FOIL PATTERNS





The Active Bass Loudspeaker PCB.

The PCB layout for the DRAM board modification.

Please note that due to lack of space we have been unable to reproduce the Digital Delay Line foil patterns here. We hope to include them next month.

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