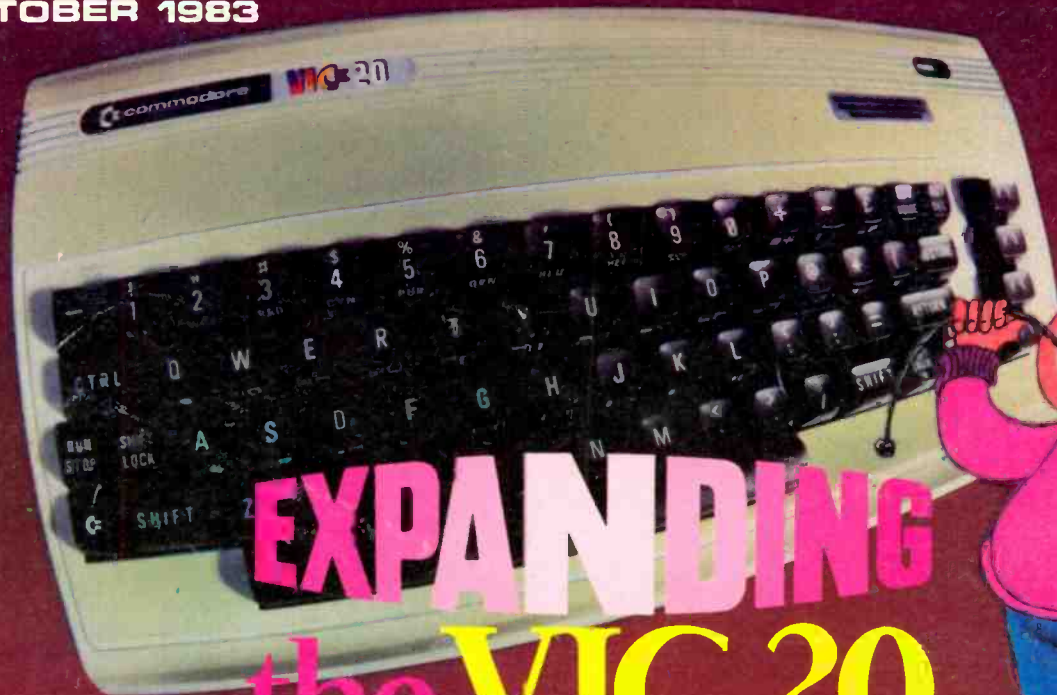


PRACTICAL

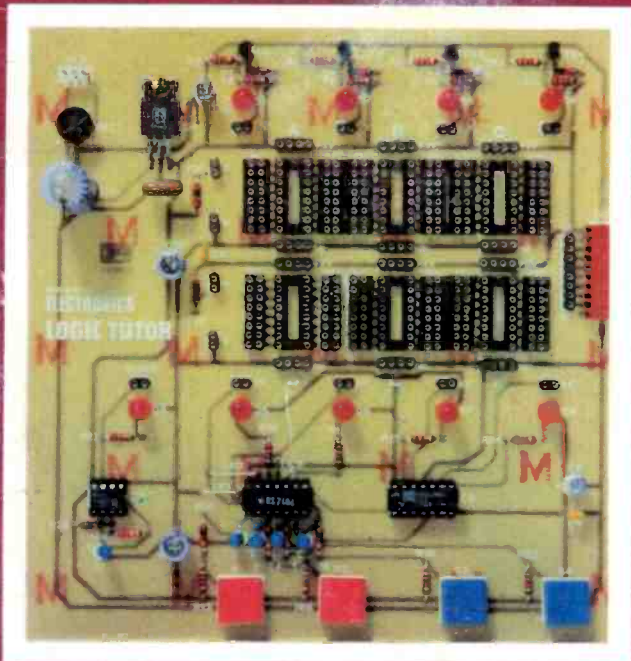
ELECTRONICS

OCTOBER 1983

90p



EXPANDING the VIC 20



Introduction to
DIGITAL ELECTRONICS
O & A LEVEL Part One

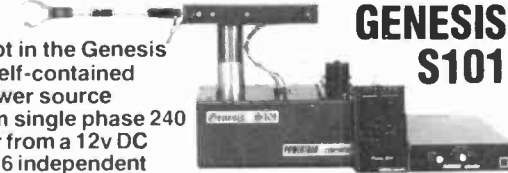
RELAXOMETER
4 1/2 DIGIT PANEL METER

Low-price robots from POWERTRAN

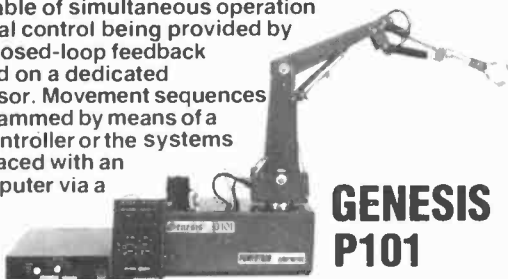
— hydraulically powered
— microprocessor controlled

The UK-designed and manufactured range of Genesis general purpose robots provides a first-rate introduction to robotics for both education and industry. With prices from as low as £425, even the home enthusiast can aspire to his or her own robot.

Each robot in the Genesis range has a self-contained hydraulic power source operated from single phase 240 or 120v AC or from a 12v DC supply. Up to 6 independent axes are capable of simultaneous operation with positional control being provided by means of a closed-loop feedback system based on a dedicated microprocessor. Movement sequences can be programmed by means of a hand-held controller or the systems can be interfaced with an external computer via a standard RS232C link.



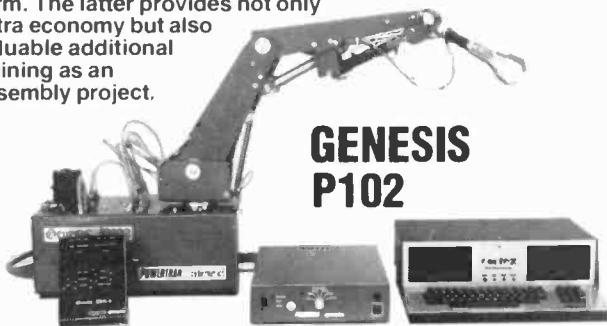
GENESIS S101



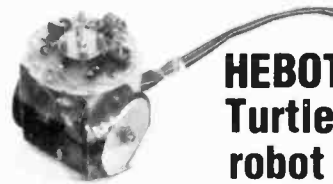
GENESIS P101

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

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



GENESIS P102



HEBOT II Turtle-type robot

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

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

HEBOT II

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

MICROGRASP



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

MICROGRASP

Weight 8.7kg, lifting capacity 100g
Robot kit with power supply £145.00

Universal computer interface board kit £48.50
23 way edge connector £2.50
AX81 peripheral/RAM pack splitter board £3.00

GENESIS S101

Weight 29kg, lifting capacity 1.5kg
4-axis model (kit form) £425

5-axis model (kit form) £475
5-axis complete system (kit form) £737
5-axis complete system (ready built) £1,450

GENESIS P101

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

GENESIS P102

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



POWERTRAN cybernetics

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PRACTICAL ELECTRONICS

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OUR NOVEMBER ISSUE WILL BE ON SALE FRIDAY, OCTOBER 7th, 1983
(for details of contents see page 11/6 Micro-file)

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VAT POLYESTER RADIAL LEAD CAPACITORS: 250V; 10n, 20n, 15n, 22n, 27n 6p; 33n, 47n, 68n, 100n 7p; 150n, 220n 10p; 330n, 470n 13p; 680n 19p; 1µ 23p; 1µ5 40p; 2µ 46p.

ELECTROLYTIC CAPACITORS (Values in µF): 500V: 10F; 52p; 47µ; 63V: 0.47, 1, 1.5, 2.2, 3.3, 8p; 47 9p; 100 15p; 150 22p; 220 33p; 330 47p; 470 68p; 630 100p; 1000 150p; 2200 220p; 4700 330p; 10000 470p; 22000 680p; 47000 100p; 100000 150p; 220000 220p; 470000 330p; 1000000 470p; 2200000 680p; 4700000 100p; 10000000 150p; 22000000 220p; 47000000 330p; 100000000 470p; 220000000 680p; 470000000 100p; 1000000000 150p.

TAG-END TYPE: 6A: 4700 245p; 3300 198p; 2200 139p; 50V: 3300 154p; 2200 110p; 40V: 4700 160p; 25V: 4700 90p; 10000 320p; 15000 345p.

TANTALUM BEAD CAPACITORS: 35V: 0.1µ, 0.22, 0.33, 0.47, 0.68, 1, 1.5, 1.8p; 2.2, 3.3, 4.7p; 6.8, 22p; 10 28p; 16V: 2.2, 3.3, 4.7p; 4.7, 6.8, 10, 18p; 15 36p; 22 30p; 33, 47, 100 75p; 220 88p; 10V: 1.5, 2.2, 3.3, 4.7 35p; 100 55p.

SILVER MICA (pf) 2, 3, 4, 7, 8, 8.2, 10, 12, 18, 22, 27, 33, 39, 47, 50, 56, 69, 75, 82, 95, 100, 120, 150, 180 5p; 220, 250, 270, 330, 360, 390, 470, 600, 800 & 820pF 21p; 1000, 1200, 1800 30p each; 3300, 4700 60p each.

CERAMIC CAPACITORS: 50V Range 1pF to 8800pF 4p; 10nF, 15n, 33n, 47nF 5p; 100nF/30V 7p.

POLYSTYRENE Caps: 10pF to 1nF 8p; 1n5 to 12nF 10p.

RESISTORS 5-LL Package: 7 Commoned, 1000Ω, 680Ω, 1K, 2K, 4K, 7K, 10K, 47K, 100K 24p; 8 Commoned: 9-LL Package: 150Ω, 180Ω, 220Ω, 330Ω, 1K, 2K, 4K, 6.8K, 10K, 22K, 47K, 100K 26p.

TRANSISTORS

AC127/8	38	BC477/8	40	MJE371	100	TI543	32	2N3702/3	10	2SC2314	85
AC176	28	BC167/7	40	MJE2955	99	TI544	45	2N3704/5	10	2SC2465	125
AC187/8	32	BC647/8	12	MJE3055	70	TI588A	50	2N3706/7	10	2SC2547	30
AD127/8	30	BC107/8	40	MPP102	40	TI590	30	2N3708/9	10	2SD234	75
AD149	79	BC566/7	15	MPS103/4	40	TI593/3	32	2N3710	10	2SK45	90
AD161/2	42	BC568/9	15	MPSA05	30	VN101/8	80	2N3711	179	2SK288	225
AF118	95	BCY70	16	MPSA12	22	VN106A	55	2N3712	195	2SK383	225
AF139	40	BCY71/2	20	MPSA16	30	VN107	78	2N3713	210	2SK385	225
AF239	55	BD131/2	48	MPSA56	30	VN108A	96	2N3714	22	2N128	112
BC107/8	10	BD133	60	MPSA56	30	VN109	12	2N3715	38	3N140	112
BC108/9	12	BD136/7	40	MPSA56	30	ZTX101	28	2N3716	45	40521	150
BC108/9	12	BD138/9	40	MPSA56	30	ZTX102	28	2N3717	15	40531	130
BC109	10	BD140	40	MPSA56	30	ZTX103	28	2N3718	15	40561/62	70
BC109/8	12	BD245	45	OC23	270	ZTX104	28	2N3719	78	40412	90
BC109C	12	BD285A	125	OC28/36	220	ZTX105	28	2N3720	18	40467	130
BC147/8	9	BD964/5	125	OC41/42	75	ZTX106	28	2N3721	45	40468	85
BC148C	10	BF198/9	18	OC76	50	ZTX107	28	2N3722	15	40473	78
BC149	9	BF200	30	OC81/82	50	ZTX108	28	2N3723	25	40474	90
BC149C	12	BF224	25	OC83/84	40	ZTX109	28	2N3724	15	40475	90
BC157/8	10	BF244A	28	TI29A	32	ZTX110	28	2N3725	25	40476	90
BC159	11	BF248B	29	TI29C	38	ZTX111	28	2N3726	25	40477	90
BC167A	10	BF258B	32	TI29D	38	ZTX112	28	2N3727	25	40478	90
BC169C	10	BF259B	32	TI29E	38	ZTX113	28	2N3728	25	40479	90
BC171/2	11	BF594/5	30	TI29F	38	ZTX114	28	2N3729	25	40480	90
BC173	11	BF39/40	23	TI29G	38	ZTX115	28	2N3730	25	40481	90
BC177/8	16	BF491/79	23	TI29H	42	ZTX116	28	2N3731	25	40482	90
BC179/81	20	BF480/81	25	TI29I	42	ZTX117	28	2N3732	25	40483	90
BC182/3	10	BFY90	106	TI29J	42	ZTX118	28	2N3733	25	40484	90
BC182L	10	BFX29/84	28	TI29K	42	ZTX119	28	2N3734	25	40485	90
BC182L	10	BFX85/86	28	TI29L	42	ZTX120	28	2N3735	25	40486	90
BC183L	10	BFX87/88	28	TI29M	42	ZTX121	28	2N3736	25	40487	90
BC184L	10	BFY50/51	23	TI29N	42	ZTX122	28	2N3737	25	40488	90
BC186/7	26	BFY52	23	TI29O	42	ZTX123	28	2N3738	25	40489	90
BC12/3	10	BFY56	32	TI29P	42	ZTX124	28	2N3739	25	40490	90
BC12L	10	BFY59	32	TI29Q	42	ZTX125	28	2N3740	25	40491	90
BC131L	10	BRY39	40	TI29R	42	ZTX126	28	2N3741	25	40492	90
BC14	10	BSX20	20	TI29S	42	ZTX127	28	2N3742	25	40493	90
BC121L	10	BSX29	34	TI29T	42	ZTX128	28	2N3743	25	40494	90
BC23/7	10	BU105	170	TI29U	42	ZTX129	28	2N3744	25	40495	90
BC307B	14	BU205	190	TI29V	42	ZTX130	28	2N3745	25	40496	90
BC308B	16	BU206	200	TI29W	42	ZTX131	28	2N3746	25	40497	90
BC327/8	15	BU207	200	TI29X	42	ZTX132	28	2N3747	25	40498	90
BC341	15	MD9001	250	TI29Y	42	ZTX133	28	2N3748	25	40499	90
BC441	34	MJ2955	70	TI29Z	42	ZTX134	28	2N3749	25	40500	90
BC461	34	MJ2956	54	TI29AA	42	ZTX135	28	2N3750	25	40501	90

POTENTIOMETERS: Carbon Track. 0.25W Log & Linear Values. 500Ω, 1K & 2K (LIN ONLY) Single 30p; 5KΩ-2MΩ single gang 70p; 5KΩ-2MΩ single gang D/P switch 30p; 5KΩ-2MΩ dual gang stereo 88p.

SLIDER POTENTIOMETERS 0.25W Log and linear values 60mm track 5KΩ-500KΩ Single gang 70p.

PRESET POTENTIOMETERS 0.1W 50Ω-2.2M Mini Vert. & Horiz. 7p; 0.25W 220Ω-4M Vert. & Horiz. 12p.

RESISTORS Hi-stab, Miniature, 5% Carbon. RANGE Val. 1-99 100+ 0.25W 2102-4M7 E24 3p 1p; 0.5W 2102-4M7 E12 3p 1p; 1W 2102-10M E12 6p 1p; 1% Metal Film 5Ω-1M 8p 6p.

LM324	30	SBG4209	895	2N4232	130	8251A	400	Z80ACTC	260	74142	175	LS04	15	LS195	38	4016	20	4457	380
LM334Z	90	SG4042	295	2N4242E	130	8253	250	Z80ACTC	260	74143	175	LS05	15	LS196	48	4017	32	4490	350
555 CMOS	80	LM335	128	SL490	350	2N425E-8	345	8255	495	7400	14	LS08	15	LS197	58	4018	45	4500	675
702	75	LM339	47	SL6270	150	2N426E-8	300	8256A	550	7401	14	LS09	15	LS221	55	4019	25	4501	250
709C 8 pin	35	LM348	60	SN76103N	350	2N427E-8	590	8257A	400	Z80ADMA	895	LS10	15	LS240	60	4020	42	4502	60
710	14	LM349	115	SN76023N	350	2N428E	410	8259	395	Z80ADMA	675	LS11	15	LS241	60	4021	40	4503	40
741	14	LM358	60	SN76033	350	2N429E-8	210	8271	400	Z80AP10	260	LS12	15	LS242	55	4022	44	4504	75
747C 14 pin	65	LM377	175	SN76407	420	2N458	325	8281N	90	74511	10	LS13	15	LS243	55	4023	43	4505	185
808C 8 pin	38	LM379	480	SN76488	480	2N1034E	385	Z80S10-1	850	7405	16	LS14	28	LS244	58	4024	32	4506	35
753 8 pin	185	LM380	75	SP8629	299	2N1040E	665	8282	450	Z80AS10	900	LS15	15	LS245	85	4025	15	4507	35
810	185	LM381N	148	TA7120	125	2N4234E	850	8283	450	7407	20	LS16	15	LS247	55	4026	10	4508	130
9400C	350	LM382	116	TA7130	125	8284	360	8284	395	7408	16	LS17	15	LS248	55	4027	20	4510	48
AY-1-1320	225	LM384	160	TA7204	195	8287	360	74500	24	7409	18	LS22	15	LS249	55	4028	39	4511	48
AY-15056	90	LM387	120	TA7208	195	8287	360	74502	24	7410	18	LS23	15	LS251	55	4029	45	4512	45
AY-15051	160	LM387	120	TA7222	150	1702	350	8288	350	7411	18	LS26	15	LS252	36	4030	15	4513	199
AY-16720	210	LM389	95	TA9A90	395	1802CP	650	8289	350	7412	18	LS27	15	LS253	36	4031	12	4514	115
AY-3-1270	730	LM393	45	TA9A621	296	2114L-200n	95	8272	150	7413	18	LS28	15	LS258	35	4032	80	4515	125
AY-3-8912	420	LM394CH	290	TA9A661	190	2147-3	425	82810	120	7414	24	LS29	15	LS259	60	4033	125	4516	65
AY-5-1230	625	LM725CN	325	TA9A700	275	2532-3	300	82811	350	7416	20	LS30	15	LS260	22	4034	140	4517	275
AY-5-1317A	630	LM1871	325	TBA1205	70	2708	590	82816	700	7417	20	LS31	15	LS261	22	4035	140	4518	275
CA3011	170	LM2917	195	TBA540	275	2716-5V	250	9364AP	550	7422	20	LS40	15	LS273	54	4037	115	4520	50
CA3012	175	LM3302	70	TBA5500	300	2732	295	9602	220	7423	20	LS41	15	LS275	125	4038	110	4521	90
CA3014	275	LM3900	50	TBA641	290	2764	390	AM26L531C	125	7425	20	LS42	15	LS276	125	4039	280	4522	125
CA3018	86	LM3909	85	TBA651	190	27128-4	425	AM26L532A	125	7426	20	LS43	15	LS279	30	4040	280	4522	125
CA30111	120	LM3910	85	TBA680	190	27128-4	425	AM26L533A	125	7427	20	LS44	15	LS280	30	4041	40	4526	60
CA3020	210	LM3914	200	TBA8105	95	27128-250n	225	AV162L533A	125	7428	20	LS45	15	LS283	40	4042	40	4527	60
CA3023	210	LM3915	200	TBA820	95	27208	590	AY-3-1515	300	7429	20	LS46	15	LS284	40	4043	40	4528	60
CA3028A	95	LM3916	150	TBA9200	200	4118-250	325	AY-5-1013	300	7432	20	LS47	15	LS285	40	4044	40	4529	150

SPEAKERS 8Ω, 0.3W, 2", 2.25", 2.5", 3" 0.3W, 2.5" 401; 641; or 801 80p	OPTO LEDs Including Clips TL209 Red 3mm TL1211 Green 3mm TL1212 Yellow TL1220 2" Red 0.2" Yel. Grn. Amber Rectangular LEDs with two part clip. R, G & Y Rectangl. Stackable LEDs Triangular LEDs R&G 0.2" Flashing LED Red 0.2" B colour LEDs Red/Green Green/Yellow 0.2" Tri colour LEDs Red/Green/Yellow 0.2" Red High Bright High Bright Green or Yellow 10A/200V 215 10A/600V 298 25A/200V 240 2A/600V 395 6A/400V 95 6A/600V 125 10A/200V 215 10A/600V 298 25A/200V 240 2A/600V 395 6A/400V 95 6A/600V 125 VM18 50	0.5" LIQUID CRYSTAL DISPLAYS 10 3 digit 495 12 4 digit 530 14 6 digit 625 14 14 14 14 29 18 18 18 66 56 80 80 59 59 65 46 52 118 54 45 65 46 52 118 90	VOLTAGE REGULATORS 1A 2020 Plastic Casing 5V 7805 40p 7905 45p 12V 7812 40p 7912 45p 15V 7815 40p 7915 45p 18V 7818 40p 7918 45p 24V 7824 40p 100mA T092 Plastic Casing 5V 78L05 30p 79L05 — 6V 78L62 30p — 8V 78L32 30p — 12V 78L12 30p 79L12 60p 15V 78L15 30p 79L15 60p ICL7660 248 LM317K 320 78H05 5V/5A 550 LM317P 99 78H12 12V/5A 580 LM323K 500 78HG+5 to LM337T 175 +24V 5A 599 LM723 35 79HG-2.25V to TB6258 75 -24V 5A 685 RC4194 375 LM309K 120 RC4195 160	DIL SOCKETS Low Wire profile wrap 8 pin 8p 25p 14 pin 10p 35p 16 pin 10p 42p 18 pin 16p 52p 20 pin 20p 60p 22 pin 22p 65p 24 pin 25p 70p 28 pin 28p 80p 40 pin 30p 99p ZIF DIL SOCKET 24 way 575p 28 way 750p 40 way 975p DIL PLUGS (Headers) Pins Solder IDC 14 38p 95p 16 42p 100p 24 88p 138p 28 100p 140p 40 195p 218p RIBBON CABLE (price per foot) Ways Grey Colour 16 25p 40p 20 30p 50p 26 40p 65p 34 60p 85p 40 70p 90p 50 100p 135p 'D' CONNECTORS: Pins 9 15 25 37 way way way way way MALE Solder 80p 110p 160p 240p Angle 150p 210p 250p 385p Strait 170p 160p 220p 310p FEMALE Solder 105p 160p 200p 338p Angle 65p 215p 290p 440p Strait 175p 200p 300p 420p COVERS 80p 75p 75p 90p IDC 25 way Plg. 385p, Slt. 450p	25 WAY 'D' CONNECTORS (RS232) Jumper lead Ribbon Cable 18" Single End Male 475p 18" Single End Female 510p 36" Double Ended M/M 995p 36" Double Ended F/F £10 36" Double Ended M/F £10 IDC CONNECTORS (Speed block type) PCB Speed with latch Strt. Angle Pins Pins 2 rows 10 way 90p 99p 85p 120p 16 way 130p 150p 110p 195p 20 way 145p 160p 125p 240p 26 way 200p 175p 200p 320p 34 way 205p 236p 169p 340p 40 way 220p 250p 190p 420p 50 way 235p 270p 200p 470p EURO CONNECTORS Gold flashed contacts DIN 41617 31 way 170p — 175p DIN 41612 2x32 way 275p 320p 220p 285p DIN 41612 2x32 way 295p 340p 240p 300p DIN 41612 3x32 way 360p 385p 260p 395p FEMALE SOCKETS Strt. Angle 170p — 175p MALE PLUGS Strt. Angle 220p — 220p TRANSFORMERS (mains Prim. 220-240V) 3-0-3V, 6-0-6V 100mA; 9-0-9V 75mA; 12-0-12V 75mA; 15-0-15V 75mA 6VA; 2x6V-5A; 2x9V-4A; 2x12V-0-3A; 2x15V-25A 220p 12VA; 2x4V5-1.3A; 2x6V-1.2A; 2x12V-5A; 12V-1A 12V-1A; 15-8A 15-8A; 20V-6A 20V-6A 330p (60p p&p) 50VA; 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V- 1.5A; 2x20V-1.2A; 2x25V-2A; 2x30V-0.8A 2x40V-0.5A 65p (60p p&p) 100VA; 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x30V-1.5A; 2x40V-1.2A; 2x50V-1A 920p (60p p&p) JUMPER LEADS Ribbon Cable Assembly DIL Plug (Headers) Single Ended Lead, 24" long Length 14pin 16pin 24 pin 40 pin 24" 145p 165p 240p 325p Double Ended Leads 6" 185p 205p 300p 465p 12" 195p 215p 315p 490p 24" 210p 235p 345p 540p 36" 230p 250p 375p 595p IDC FEMALE RECEPTACLE Jumper Leads 36" 1 end 160p 200p 260p 300p 2 ends 290p 370p 480p 525p
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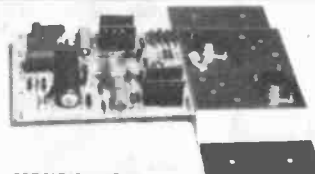


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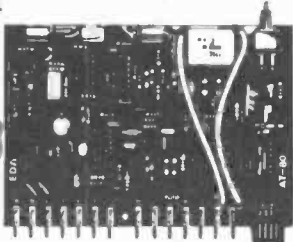
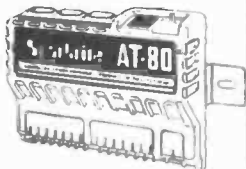
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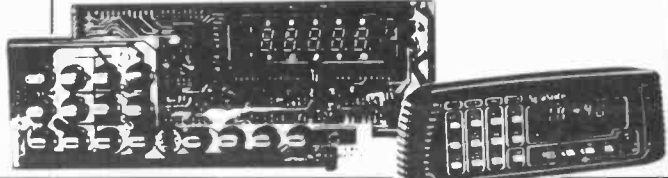


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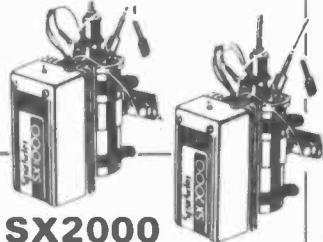
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 - Full Imperial and Metric calibrations
 - Over 300 components to assemble
- A real challenge for the electronics enthusiast!



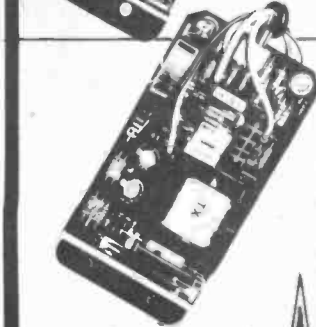
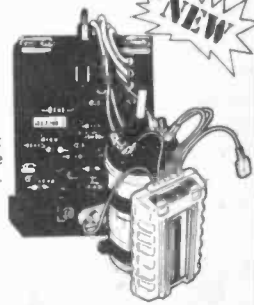
SX1000 Electronic Ignition

- Inductive Discharge
- Extended coil energy storage circuit
- Contact breaker driven
- Three position changeover switch
- Over 65 components to assemble
- Patented clip-to-coil fitting
- Fits all 12v neg. earth vehicles



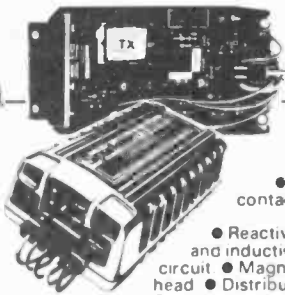
TX1002 Electronic Ignition

- Contactless or contact triggered
- Extended coil energy storage circuit
- Inductive Discharge
- Three position changeover switch
- Distributor triggerhead adaptors included
- Die cast weatherproof case
- Clip-to-coil or remote mounting facility
- Fits majority of 4 & 6 cyl. 12V. neg. earth vehicles
- Over 145 components to assemble.



SX2000 Electronic Ignition

- The brandleading system on the market today
- Unique Reactive Discharge
- Combined Inductive and Capacitive Discharge
- Contact breaker driven
- Three position changeover switch
- Over 130 components to assemble
- Patented clip-to-coil fitting
- Fits all 12v neg. earth vehicles

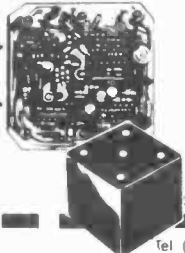


TX2002 Electronic Ignition

- The ultimate system
- Switchable contactless
- Three position switch with Auxiliary back-up inductive circuit
- Reactive Discharge
- Combined capacitive and inductive
- Extended coil energy storage circuit
- Magnetic contactless distributor triggerhead
- Distributor triggerhead adaptors included
- Can also be triggered by existing contact breakers
- Die cast waterproof case with clip-to-coil fitting
- Fits majority of 4 and 6 cylinder 12v neg. earth vehicles
- Over 150 components to assemble

All SPARKRITE products and designs are fully covered by one or more World Patents

SPECIAL OFFER
"FREE" MAGIDICE KIT WITH ALL ORDERS OVER £45.00



MAGIDICE Electronic Dice

- Not an auto item but great fun for the family
- Total random selection
- Triggered by waving of hand over dice
- Bleeps and flashes during a 4 second tumble sequence
- Throw displayed for 10 seconds
- Auto display of last throw 1 second in 5
- Muting and Off switch on base
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- Over 100 components to assemble

SPARKRITE 82 Bath Street, Walsall, West Midlands, WS1 3DE England.

SPARKRITE, 82 Bath St., Walsall, W. Midlands WS1 3DE
Tel (0922) 614791 Allow 28 days for delivery

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ITX 1002	£22.95
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AT 80	£32.95
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MAGIDICE	£9.95

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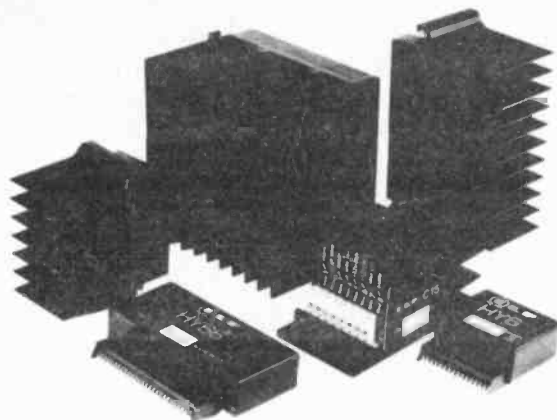
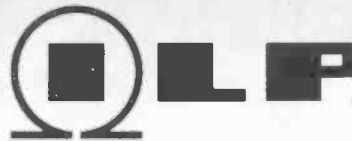
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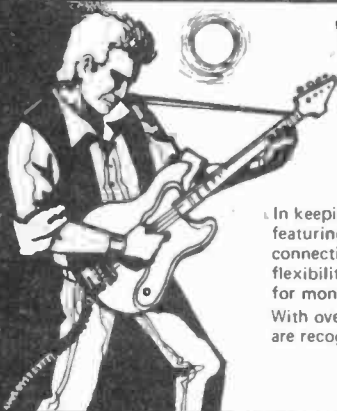
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AMPLIFIERS



Over the last few years we have received feedback via the general public and industry that our products are from Taiwan, Singapore, Japan, etc... ILP are one of the few 'All British' electronics Companies manufacturing their own products in the United Kingdom. We have proved that we can compete in the world market during the past 12 years and currently export in excess of 60% of our production to over twenty different countries — including USA, Australia and Hong Kong. At the same time we are able to invest in research and development for the future, assuring security for the personnel, directly and indirectly, employed within the UK. We feel very proud of all this and hope you can reap some of our success.

I.L.Potts — Chairman



WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.

With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.



BIPOLAR MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION		Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
			T.H.D. Typ at 1KHz	I.M.D. 60Hz/7KHz 4:1				
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 x 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

Protection: Full load line. Slew Rate: 15v/ μ s. Rise time: 5 μ s. S/N ratio: 100db. Frequency response (-3dB) 15Hz - 50KHz. Input sensitivity: 500mV rms. Input Impedance: 100K Ω . Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre-amp	Mic/Mag. Cartridge/Tuner/Tape/Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre-amp	Mic/Mag. Cartridge/Tuner/Tape/Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre-amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre-amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre-amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

Mounting Boards

For ease of construction we recommend the B6 for modules HY6-HY13 £1.05 (inc. VAT) and the B66 for modules HY66-HY78 £1.29 (inc. VAT).

POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

Model Number	For Use With	Price inc. VAT
PSU 21X	1 or 2 HY30	£11.93
PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.83
PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Please note: X in part no. indicates primary voltage. Please insert "0" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION		Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
			T.H.D. Typ at 1KHz	I.M.D. 60Hz/7KHz 4:1				
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).

Slew rate: 20v/ μ s. Rise time: 3 μ s. S/N ratio: 100db. Frequency response (-3dB) 15Hz - 100KHz. Input sensitivity: 500mV rms. Input Impedance: 100K Ω . Damping factor: 100Hz >400.

'NEW to ILP' In Car Entertainments

C15

Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

£9.14 (inc. VAT)

Robust construction.

Mounts anywhere in car.

Automatic switch on.

Output power maximum 22w peak into 4 Ω . Frequency response (-3dB) 15Hz to 30KHz. T.H.D. 0.1% at 10w 1KHz. S/N ratio (DIN AUDIO) 80dB. Load Impedance 3 Ω . Input Sensitivity and impedance (selectable) 700mV rms into 15K Ω 3V rms into 8 Ω . Size 95 x 48 x 50mm. Weight 256 gms.

C1515

Stereo version of C15.

£17.19 (inc. VAT)

Size 95 x 40 x 80. Weight 410 gms.

Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

TOROIDALS

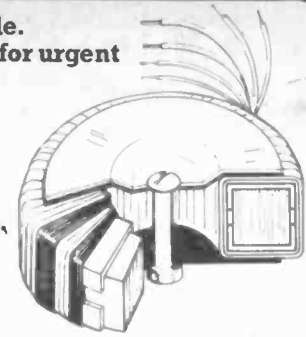
The toroidal transformer is now accepted as the standard in industry, overtaking the obsolete laminated type. Industry has been quick to recognise the advantages toroidals offer in size, weight, lower radiated field and, thanks to I.L.P., PRICE.

Our large standard range is complemented by our SPECIAL DESIGN section which can offer a prototype service within 7 DAYS together with a short lead time on quantity orders which can be programmed to your requirements with no price penalty.

*Gold service available.
21 days manufacture for urgent deliveries.

*Orders despatched within 7 days of receipt for single or small quantity orders.

*5 year no quibble guarantee.



TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE	TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE	TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
15 VA 62 x 34mm 0.35Kg Regulation 19%	0x010	6+6	1.25	£5.12 + p & p £0.78 + VAT £0.89 TOTAL £6.79	120 VA 90 x 40mm 1.2Kg Regulation 11%	4x010	6+6	10.00	£7.42 + p & p £1.72 + VAT £1.37 TOTAL £10.51	300 VA 110 x 50mm 2.6Kg Regulation 6%	7x013	15+15	10.00	£10.88 + p & p £2.05 + VAT £1.94 TOTAL £14.87
	0x011	9+9	0.83			4x011	9+9	6.66			7x014	18+18	8.33	
	0x012	12+12	0.63			4x012	12+12	5.00			7x015	22+22	6.82	
	0x013	15+15	0.50			4x013	15+15	4.00			7x016	25+25	6.00	
	0x014	18+18	0.42			4x014	18+18	3.33			7x017	30+30	5.00	
	0x015	22+22	0.34			4x015	22+22	2.72			7x018	35+35	4.28	
	0x016	25+25	0.30			4x016	25+25	2.40			7x019	40+40	3.75	
	0x017	30+30	0.25			4x017	30+30	2.00			7x020	45+45	3.33	
(encased in ABS plastic)					160 VA 110 x 40mm 1.8Kg Regulation 8%	5x011	9+9	8.89	£8.43 + p & p £1.72 + VAT £1.52 TOTAL £11.67	500 VA 140 x 60mm 4Kg Regulation 4%	8x016	25+25	10.00	£14.38 + p & p £2.40 + VAT £2.52 TOTAL £19.30
30 VA 70 x 30mm 0.45Kg Regulation 18%	1x010	6+6	2.50	5x012		12+12	6.66	8x017			30+30	8.33		
	1x011	9+9	1.65	5x013		15+15	5.33	8x018			35+35	7.14		
	1x012	12+12	1.25	5x014		18+18	4.44	8x026			40+40	6.25		
	1x013	15+15	1.00	5x015		22+22	3.63	8x025			45+45	5.55		
	1x014	18+18	0.83	5x016		25+25	3.20	8x033			50+50	5.00		
	1x015	22+22	0.68	5x017		30+30	2.66	8x042			55+55	4.54		
	1x016	25+25	0.60	5x018		35+35	2.28	8x028			110	4.54		
	1x017	30+30	0.50	5x028	110	1.45	8x029	220	2.27					
50 VA 80 x 35mm 0.9Kg Regulation 13%	2x010	6+6	4.16	5x029	220	0.72	8x030	240	2.08	625 VA 140 x 75mm 5Kg Regulation 4%	9x017	30+30	10.41	£17.12 + p & p £2.55 + VAT £2.95 TOTAL £22.62
	2x011	9+9	2.77	6x012	12+12	9.38	9x018	35+35	8.92					
	2x012	12+12	2.08	6x013	15+15	7.50	9x026	40+40	7.81					
	2x013	15+15	1.66	6x014	18+18	6.25	9x025	45+45	6.94					
	2x014	18+18	1.38	6x015	22+22	5.11	9x033	50+50	6.25					
	2x015	22+22	1.13	6x016	25+25	4.50	9x042	55+55	5.68					
	2x016	25+25	1.00	6x017	30+30	3.75	9x028	110	5.68					
	2x017	30+30	0.83	6x018	35+35	3.21	9x029	220	2.84					
80 VA 90 x 30mm 1Kg Regulation 12%	3x010	6+6	6.64	6x019	40+40	2.81	9x030	240	2.60	ALSO AVAILABLE Sizes up to and including 5KVA are manufactured to order.				
	3x011	9+9	4.44	6x026	40+40	2.81								
	3x012	12+12	3.33	6x025	45+45	2.50								
	3x013	15+15	2.66	6x033	50+50	2.25								
	3x014	18+18	2.22	6x028	110	2.04								
	3x015	22+22	1.81	6x029	220	1.02								
	3x016	25+25	1.60	6x030	240	0.93								
	3x017	30+30	1.33											

The benefits of ILP toroidal transformers

ILP toroidal transformers are only half the weight and height of their laminated equivalents, and are available with 110V, 220V or 240V primaries coded as follows:

IMPORTANT: Regulation — All voltages quoted are FULL LOAD. Please add regulation figure to secondary voltage to obtain full load voltage.

For 110V primary insert 0 in place of X in type number

For 220V primary (Europe) insert 1 in place of X in type number

For 240V primary (UK) insert 2 in place of X in type number

Also available at Electrovalue, Maplin.

NEW PRODUCTS

HYBRID REGULATOR MODULES

The HR314 and HR614 regulated power supplies provide a constant 13.8 volt d.c. output at up to 3 Amp or 6 Amp respectively. The modules are encapsulated to an integral heatsink and are fully short circuit protected making them suitable for home or bench running of CB, car stereos or any 12 volt d.c. equipment required for many hobby or professional applications.

HR314 £10.23 inc. VAT

HR614 £18.51 inc. VAT

TECHNICAL SPECIFICATIONS

MODULE	HR314	HR614
Output Voltage	+13.8v ±5%	+13.8v ±5%
Output Current	Up to 3A	Up to 6A
Current limit (nominal)	3.5A approx	7A approx
Maximum Input Voltage	+30v	+30v
Minimum Input Voltage	+16v	+16v
Maximum Input Voltage for nominal output current	+20v	+20v
Maximum output current at 30v Input	1.8A approx	3.5A approx
Output ripple (100Hz) See Note 1	<10mV rms	<10mV rms
Size in mm.	76 x 68 x 40 high	120 x 78 x 40 high

POWER SUPPLY UNITS: comprising toroidal transformer plus 90 x 50 x 55 mm high printed circuit board containing smoothing and rectification

PSU31X Suitable for running one HR314 at full rated current. £13.17 inc. VAT

PSU56X Suitable for running one HR614 at full rated current. £19.13 inc. VAT

For 110v operation insert 0 in place of X — brown primary leads.

220v (Europe) operation insert 1 in place of X — pink primary leads.

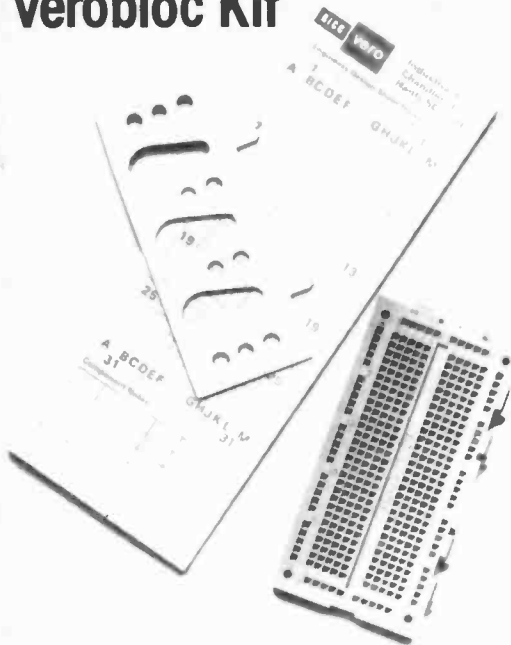
240v (UK) operation insert 2 in place of X — orange primary leads.

For mail order please make your crossed cheques or postal orders payable to ILP Electronics Ltd. Barclaycard/Access welcome. Trade orders standard terms.



Post to: ILP Electronics Ltd, Graham Bell House, Roger Close, Canterbury CT2 7EP, Kent, England. Telephone (02271) 54778 Telex 95780

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Try the new prototyping method of building and testing circuits with the British-made Verobloc kit. It consists of:

1. Verobloc.
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3. A component mounting panel for the larger components, i.e. switches, etc.

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We are exhibiting at the following exhibition, so why not come along and see the products for yourself.

- Personal Computer World, The Barbican, September 28-October 2. Stand No. 159.

Our new catalogue containing over 150 new products is available from mid-October.

BICC Vero Electronics Limited,
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Chandlers Ford, Hampshire,
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at £5 per kit inclusive of VAT for a total of £ _____
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- KD615 16 range 10A DC 2 meg plus Hie tester £39.95
- SIFAM 2200B 21 range 2A AC/DC 20 meg Bench Models £39.95
- TM355 29 range LEO 10A AC/DC 20 meg Thandar £86.25
- TM356 26 range LEO 10A AC/DC 20 meg Thandar £97.75
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- SIFAM 2500 24 range LEO 2A AC/DC 20 meg £99.95

MULTIMETERS (UK C/P 65p)

- NM102BZ 20K/V 10A DC 22 range & cont. buzzer £13.50
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- MET600B 8 digit LED bench 3 ranges 600 MHz £132.25
- MET1000 8 digit LED 3 ranges 1 GHz £182.85
- TF040 8 digit LCD 40 MHz Thandar £126.50
- TF200 3 digit LCD 200 MHz Thandar £166.75

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HOME LIGHTING KITS

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

TDR300K Remote Control £14.30
Dimmer

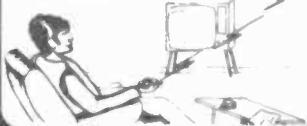
MK6 Transmitter for above £4.20

TD300K Touchdimmer £7.00

FS300K Touchswitch £7.00

TDE/K Extension kit for 2-way switching for TD300K £2.50

LD300K Rotary Controlled Dimmer £3.50



ELECTRONIC LOCK KIT XK101

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

ONLY £10.50

Electric lock mechanism for use with latch locks and above kit **£13.50**

"OPEN-SESAME"

The XK103 is a general purpose infra-red transmitter/receiver with one momentary (normally open) relay contact and two latched transistor outputs. Designed primarily for controlling motorised garage doors and two auxiliary outputs for drive garage lights at a range of up to 40 ft. The unit also has numerous applications in the home for switching lights, TV, closing curtains, etc. Ideal for aged or disabled persons.

The kit comprises a mains powered receiver, a four button transmitter, complete with pre-drilled box requiring a 9V battery and one opto-isolated solid state switch kit for interfacing the receiver to mains appliances. As with all our kits, full instructions are supplied.

ONLY £23.75

XK113 MW RADIO KIT

Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5.5 x 2.7 x 2cms. Requires PP3 9V battery. IDEAL FOR BEGINNERS. **£5.00**

3-NOTE DOOR CHIME

Based on the SAB0600 IC the kit is supplied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 x 71 x 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete. AN IDEAL PROJECT FOR BEGINNERS. Order as XK 102. **£5.00**

MICROPROCESSOR CONTROLLED MULTI-PURPOSE TIMER

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

FEATURES INCLUDE

- 7mm LED 12 hour display
- Day of week, on and output status, time alarm
- 8 open collector outputs for 8-way relays, that's a lot!
- 50 60Hz mains operation
- Battery back-up saves stored programme, just 10 minutes time keeping during power failures (batteries not supplied)
- Display blanking during power failure for correct use battery power
- 18 programme time sets
- Powerful everyday function enabling output to switch every day but use only one time set
- Useful sleep function - turns off output for one hour
- Direct switch control enabling output to be turned on immediately or after a specified time interval
- 20 function keypad for programme entry
- Programming verification at the touch of a button
- Plastic box with attractive screen printed front panel 150 x 100 x 55mm

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MINI KITS

MK1 ELECTRONIC THERMOSTAT
Uses LM3511 IC to sense temperature (80°C max) and track to switch heater (1kW) Mains powered. **£4.00**

MK2 SOLID STATE RELAY
Switches 240V ac motors, lights, heaters from logic computer circuits. Zero voltage switching, opto isolated. Supplied without trace. **£2.68**

MK4 PROPORTIONAL TEMPERATURE CONTROLLER
Uses "burst fire" technique to maintain temperature to within 0.5°C for photography, incubators, wine making, etc. Max. load 3kW (240V ac). Temp. range up to 90°C. **£5.56**

MK5 MAINS TIMER
Mains powered timer enabling a load up to 1kW at 240V ac to be switched on or off for a variable time from 20 mins to 35 hrs. Longer or shorter periods possible with minor component changes. **£5.00**

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

NEW! MK19 DC CONTROLLED AUDIO AMPLIFIER
May be used with virtually any stereo audio amplifier to control bass volume, treble and balance remotely without using a wire link or the MK11 infra red receiver. A 1 of 10 decoder with LEDs is also included for remote input selection display. (See remote control kits) **£10.70**

COMPONENTS

a wide range in stock including:

LINEAR ICs	ICs	REGULATORS	MEMORIES
555 17	LM3911 120	4501 26	4511 55
556 40	LM3912 210	4512 55	4514 115
741 15	LM3915 220	78L05 12	78L05 12
742 35	LM3916 110	78L09 12	78L09 12
743 35	LM3917 110	78L15 60	2114 80
743 35	LM3918 110	78L20 60	6810 125
743 35	LM3919 110	78L25 60	2715 200
743 35	LM3920 110	78L30 60	2732 400
743 35	LM3921 110	78L35 60	2804 100
743 35	LM3922 110	78L40 60	2804 100
743 35	LM3923 110	78L45 60	2804 100
743 35	LM3924 110	78L50 60	2804 100
743 35	LM3925 110	78L55 60	2804 100
743 35	LM3926 110	78L60 60	2804 100
743 35	LM3927 110	78L65 60	2804 100
743 35	LM3928 110	78L70 60	2804 100
743 35	LM3929 110	78L75 60	2804 100
743 35	LM3930 110	78L80 60	2804 100
743 35	LM3931 110	78L85 60	2804 100
743 35	LM3932 110	78L90 60	2804 100
743 35	LM3933 110	78L95 60	2804 100
743 35	LM3934 110	79L00 60	2804 100
743 35	LM3935 110	79L05 60	2804 100
743 35	LM3936 110	79L10 60	2804 100
743 35	LM3937 110	79L15 60	2804 100
743 35	LM3938 110	79L20 60	2804 100
743 35	LM3939 110	79L25 60	2804 100
743 35	LM3940 110	79L30 60	2804 100
743 35	LM3941 110	79L35 60	2804 100
743 35	LM3942 110	79L40 60	2804 100
743 35	LM3943 110	79L45 60	2804 100
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743 35	LM3990 110	81L80 60	2804 100
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743 35	LM3992 110	81L90 60	2804 100
743 35	LM3993 110	81L95 60	2804 100
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743 35	LM3995 110	82L05 60	2804 100
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743 35	LM3997 110	82L15 60	2804 100
743 35	LM3998 110	82L20 60	2804 100
743 35	LM3999 110	82L25 60	2804 100
743 35	LM4000 110	82L30 60	2804 100
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743 35	LM4004 110	82L50 60	2804 100
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SECURITY

Build your own system and SAVE POUNDS!

DIGITAL ULTRASONIC DETECTOR US 5063



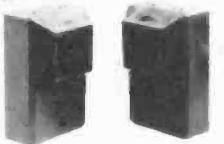
- 3 levels of discrimination against false alarms
 - Crystal control for greater stability
 - Adjustable range up to 25ft.
 - Built-in delays
 - 12V operation
- This advanced new module uses digital signal processing to provide the highest level of sensitivity whilst discriminating against potential false alarm conditions. The module has a built-in exit delay and timed alarm period, together with a selectable entrance delay, plus many more outstanding features. This advanced new module is available at

ULTRASONIC MODULE US 4012



- Adjustable range from 5-25ft.
- This popular low cost ultrasonic detector is already used in a wider range of applications from intruder detectors to automatic light switches and door opening equipment, featuring 2 LED indicators for ease of setting up, the unit represents outstanding value at

INFRA-RED SYSTEM IR 1470



Consisting of separate transmitter and receiver both of which are housed in attractive moulded cases, the system provides an invisible modulated beam over distances of up to 50ft, operating a relay when the beam is broken. Intended for use in security systems, but also ideal for photographic and measurement applications, the system is available at

POWER SUPPLY & RELAY UNIT PS 4012

Provides stabilised 12V output at 85mA and contains a relay with 3 amp contacts. The unit is designed to operate with up to 2 ultrasonic units or 1 infra-red unit IR 1470. Price £4.25 + V.A.T.

SIREN MODULE SL 157

Produces a loud penetrating sliding tone which, when coupled to a suitable horn speaker, produces S.P.L.'s of 110dbs at 2 metres. Operating from 9-15V, the module contains an inhibit facility for use in 'break to activate' circuits. Price £2.95 + V.A.T.

5 1/2" HORN SPEAKER HS 588

This weather-proof horn speaker provides extremely high sound pressure levels (110dbs at 2 metres) when used with the CA 1250, PS 1865 or SL 157. Price £4.95 + V.A.T.

3-POS. KEY SWITCH 3901

Single pole, 3-pos. key switch intended for use with the CA 1250. Price £3.43 + V.A.T.

All modules are supplied with comprehensive instructions. Units on demonstration. Shop hours 9.00-5.30 p.m. Wed. 9.00-1.00 p.m. SAE with all enquiries.

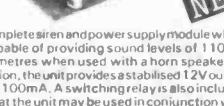
ALARM CONTROL UNIT CA 1250



- The heart of any alarm system is the control unit. The CA 1250 offers every possible feature that is likely to be required when constructing a system whether a highly sophisticated installation, or simply controlling a single magnetic switch on the front door.
- Built-in electronic sirens drives 2 loud speakers
 - Provides exit and entrance delays together with fixed alarm time
 - Battery back-up with trickle charging facility
 - Operates with magnetic switches, pressure pads, ultrasonic or I.R. units
 - Anti-tamper and panic facility
 - Stabilised output voltage
 - 2 operating modes - full alarm/anti-tamper and panic facility
 - Screw connections for ease of installation
 - Separate relay contacts for switching external loads
 - Test loop facility

Price £19.95 + V.A.T.

SIREN & POWER SUPPLY MODULE PSL 1865



A complete siren and power supply module which is capable of providing sound levels of 110dbs at 2 metres when used with a horn speaker. In addition, the unit provides stabilised 12V output up to 100mA. A switching relay is also included so that the unit may be used in conjunction with the US 5063 or US 4012 to form a complete alarm.

HARDWARE KIT HW 1250



This attractive case is designed to house the control unit CA 1250, together with the appropriate LED indicators and key switch. Supplied with the necessary mounting pillars and punched front panel, the unit is given a professional appearance by an adhesive silk screened label.

HARDWARE KIT HW 5063



This hardware kit provides the necessary enclosure for a complete self-contained alarm system which includes the US 5063, PS 1865, loud speaker type 305 and key switch 3200. Attractively styled, the unit when completed, provides an effective warning system without installation problems.

ULTRASONIC MODULE ENCLOSURE



Suitable metal enclosure for housing an individual ultrasonic module type US 5063 or US 4012. Supplied with the necessary mounting pillars and screws etc. For US 5063 order SC 5063; for US 4012 order SC 4012.

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SETS INCL. PCBs, ELECTRONIC PARTS, INSTRUCTIONS. MOST ALSO INCL. KNOBS, SKTS, WIRE, SOLDER, BATTERIES NOT INCL. BUT MOST WILL RUN FROM 9V TO 15V DC SUPPLIES. FOR FULLER DETAILS SEE CATALOGUE (SEE BELOW).

	STD UNIT	BLK UNIT
AUTOWAH: Guitar-triggered wah-wah	SET 58	£14.01 £16.41
BASS BOOST: Increases volume of lower octaves	SET 138-B	£9.40 £11.80
CALL SIGN: Programmable 8-note musical call sign	SET 121	£14.23 £16.23
CHORUS UNIT: A solo voice or instr. sounds like more!	SET 162	£31.59 £34.49
COMPARATOR: LED level indicator for 2 channels	SET 129	£16.73 £18.73
COMPRESSOR: Limits & levels maximum signal strength	SET 133	£12.37 £14.77
ECHO UNIT: With double tracking	SET 168	£44.82 £47.72
FREQUENCY DOUBLER: Raises guitar frequency by 1 octave	SET 98	£11.75 £13.75
FREQUENCY-GENERATOR: Multiple waveform test osc	SET 128	£19.15 £22.05
FUNKY-WOBULO: Novelty voice modulator for funny effects	SET 149	£12.78 £14.78
FLANGER: Fascinating delayed-feed back effects plus phasing	SET 153	£22.54 £25.44
FUZZ: Smooth distortion whilst keeping natural attack & decay	SET 91	£11.68 £14.08
GUITAR EFFECTS: Multiple variation of level & filter modulation	SET 42	£16.58 £18.38
GUITAR OVERDRIVE: Fuzz plus variable filter quality	SET 56	£21.17 £24.07
GUITAR SUSTAIN: Extends effective note duration	SET 75	£11.77 £14.17
HARMONOLA: Versatile 3 octave organ*	SET 125-T	£166.97 —
HUM CUT: Tunable filter for reducing low frequency noise	SET 141	£12.02 £14.42
JABBERVOX: Voice disguiser with reverb & tremolo	SET 150	£23.64 £25.44
MAD-ROJ: Variable sirens, incl. police, galaxy machine-guns etc	SET 146	£10.47 £12.47
METRONOME: With audible & visual beat & down-beat marking	SET 143	£13.98 £15.98
MICROPHONE PRE-AMP: with switchable bass & treble	SET 144	£9.12 £11.52
MINISONIC (PE) MK2: 3-oct versatile music synthesiser*	SET 38	£181.92 —
MIXERS: Several - details in catalogue (see below)		
NOISE LIMITER: reduces tape & system hiss	SET 145	£10.59 £12.99
PHASER: with automatic & manual rate & depth controls	SET 164	£20.20 £24.10
REVERB: Analogue unit with variable delay & depth controls	SET 122	£20.39 £22.19
RHYTHM GENERATOR: 15 switchable rhythms (NEW UNIT)	SET 170	£38.27 £41.17
RING MODULATOR: for intermodulating 2 separate sine freqs.	SET 87	£13.62 £15.42
ROBO BOX: Versatile Robot type voice modifier	SET 165	£21.89 £24.79
ROGER 2-GONG: 2 gongs sounded at end of transmission	SET 126-LS	£12.55 £14.55
ROGER BLEEP: Single bleep sounded at end of transmission	SET 127-LS	£10.07 £12.47
SCRAMBLER: Codes & decodes transmissions authorised chans	SET 117	£21.81 £23.61
SEQUENCERS: 128-note keyboard controlled (keyboard incl.)	SET 76	£110.99 £114.59
18 note (up to 64-bit pattern) panel controlled	SET 86	£53.15 £56.95
SPEECH PROCESSOR: for clearer transmission	SET 110	£12.10 £14.50
STORM EFFECTS: Automatic & manual wind, rain & surf	SET 154	£16.72 £19.62
SWEEP GENERATOR: Audio test unit	SET 169	£16.42 £18.22
SYNTHESISER INTERFACE: allows instrument to trigger synth	SET 81	£9.59 £11.99
TREMULO: Deep tremolo with depth & rate controls	SET 136	£10.71 £13.11
TREBLE BOOST: Increases volume of upper octaves	SET 138-T	£9.24 £11.64
TONE CONTROL: bass & treble cut, gain & range (6 controls)	SET 139	£13.82 £16.72
VIBRATO: variable rate & depth plus additional phasing	SET 137	£23.99 £26.79
VOCODAVOX: Modular Vocoder	SET 152	£68.96 £72.76
VOOALEK: Robot type voice modulator	SET 155	£12.75 £14.75
VOICE FILTER: tunable for selected freq bandwidth & gain	SET 142	£10.21 £12.61
VOICE-OP-FAOER: for reduction of music level during talk-over	SET 30	£10.02 £12.42
VOICE-OP-SWITCH: with variable sensitivity & delay	SET 123-LS	£13.80 £15.80
WAH-WAH: with auto-trigger, manual & oscillator control	SET 140	£17.31 £20.21
WHEEBY—JEEBY: 2 intercoupled oscillators produce sirens	SET 151	£13.78 £15.58
WIND & RAIN: manual control of these two effects	SET 28	£11.39 £13.79
WOBLE-WAH: Oscillator controlled wah-wah	SET 161	£13.40 £15.40
KIMBER ALLEN KEYBOARDS (surely the best?!):	3-Oct £32.43, 4-Oct £40.68, 5-Oct £48.52	
KEYBOARD CONTACTS GJ (SPCO):	3-Oct £20.29, 4-Oct £26.50, 5-Oct £32.71	
KEYBOARD CONTACTS GB (DPST):	3-Oct £23.27, 4-Oct £30.45, 5-Oct £37.62	

NEW

DIGITAL 3 Oct Multiwaveform Synthesiser	P.O.A.
JUNIOR 2 Oct Push Switch Keyboard Synthesiser	P.O.A.
NOTE Frequency Changer and Waveform Modifier	£35.12 £38.02
NOTE Triggered Envelope Shaper	P.O.A.
SYNTHESISER Interfacer with Trig & Freq Control	P.O.A.
MUSIC RING Modulator	P.O.A.
DIGITAL to Analogue Converter (E.G. Synth Control)	P.O.A.
MULTI-WAVEFORM VCO (Log Control)	P.O.A.
VOLTAGE CONTROLLED FILTER	P.O.A.
POLYWAH - Automatic 3-band Frequency Wah Wah	£16.02 £17.82

P.O.A. PRICES & FURTHER DETAILS IN CATALOGUE

PHONOSONICS

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Please use full address. Payment CWO, CHQ, PD, Access, Barclay, or pre-arranged collection. Prices incl UK P&P & 15% VAT. E&OE. Despatch usually 10-14 days on most items. For full catalogue send S.A.E. (if you live overseas send £1.00). MORE KITS IN CATALOGUE.

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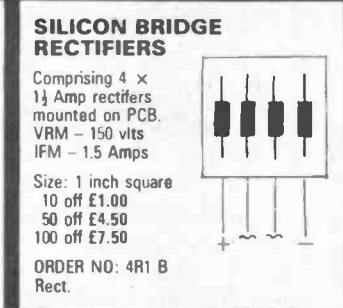
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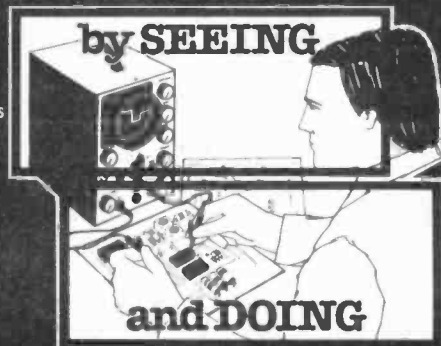
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NEW STYLE

FOR some time the editorial staff of *PE* have been discussing the pros and cons of our logic circuit symbols. The symbols were based on BS3939 of 1969 and were accepted practice for many years. While we are aware that for some time our symbols have not conformed to any of the various "standards" (BS having been revised many years ago), we have been reluctant to change until one system of identification became accepted. Our main problem being that we neither liked nor found many working examples of the later BS specification symbols.

Early this year when our *Introduction to Digital Electronics* series was being planned, it became obvious that if this series was to be readily accepted in education and of maximum benefit to hobbyists and students alike, the symbols used should conform to those generally accepted. Further investigation led to further confusion as the systems used in many schools and colleges and recommended by some examining boards do not conform to any other standard.

What we have found is virtual uni-

versal acceptance of the so called American Mil. Spec. for logic symbols in industry, and that this system is used in many educational establishments. This standard is also now used by virtually every other electronics publication.

It does seem rather silly that some UK educational establishments and examining boards use a system that is individual but then so did *PE* until now. No doubt they have suffered from the same problems as us.

From now on *PE* will use what is known as the Mil. Spec. standard for logic symbols. However, trying to get hold of a "Mil. Spec." proved difficult but, aided by the local library, we discovered the correct title is ANSI Y32 14-1973/IEEE Std 91-1973, the letters representing American National Standards Institute and The Institute of Electrical and Electronics Engineers. This standard is a revision of ANSI/IEEE of 1962 and MIL-STD-806B, MIL-STD-00806C (Ships) hence the Mil. Spec. title.

Both the ANSI/IEEE and BS documents refer to IEC (International Electrotechnical Commission) Publication 117-15, BS, claiming their symbols are

identical to IEC and ANSI saying theirs are "substantially compatible". Investigation reveals that the American Standard gives two alternative symbols, one is a box which is virtually the same as IEC and BS, while the other is called the Distinctive-Shape Symbol and this is the one that has become universally adopted. So what is in use is probably not what was intended by IEC but it does seem to be easier to follow on a circuit diagram and more logical!

The industry has shown that it will not adhere to a system just because it is set as a standard, it also has to be representative of the needs of the users. Perhaps IEC and BS should now amend their symbols and fall in line with the users!

Comparisons of the old and new *PE* styles are shown elsewhere in this issue and Part 2 of *Introduction to Digital Electronics* will show comparisons of the Mil. Spec. "distinctive shapes" with BS boxes.



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We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in *PE*. All letters requiring a reply should be accompanied by a stamped, self addressed envelope, or addressed envelope and international reply coupons, and each letter should relate to one published project only.

Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

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NEWS &

New Computer Range

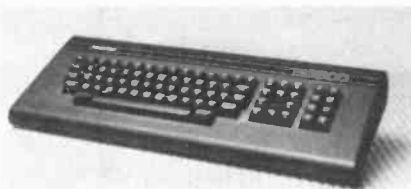
The latest home computer to enter the micro market is the MTX 500 from Memotech. The standard machine will have 32K of user RAM with a further 16K dedicated to video RAM. Also to be launched is a 64K user RAM version—the MTX 512. They will cost £275 and £315 respectively.

The 'all purpose computer' is the selling angle and indeed extra attention has been paid to the differing uses of the micro. As can be seen the keyboard is of the QWERTY type with a separate 12 key numeric cursor control and editing pad and an 8 key user definable function keypad. The unit is housed in an anodised aluminium case angled towards the user and is ergonomically high scoring.

Whether your needs are for personal programming, games playing, scientific or process control, educational or business use the machine is already capable or is easily adaptable to most applications boast the manufacturers. The 16K ROM contains several languages and routines. Standard languages being MTX BASIC, LOGO and NODDY, ROM routines include and ASSEMBLER/DISASSEMBLER with screen display of Z80 CPU registers, which can be manipulated from the keyboard. Other in-

teresting features include an Add-on 80 column video board as opposed to the 40 column norm, twin RS232 interface ports and ultimate expansion to 512K.

With a programming speed of 2400 baud the quality of the cassette player used in conjunction with this machine will play an important role in accurate data transferal. Games, Educational and Business software will also be available produced in the main by Continental Software Ltd.



The New Steam Age

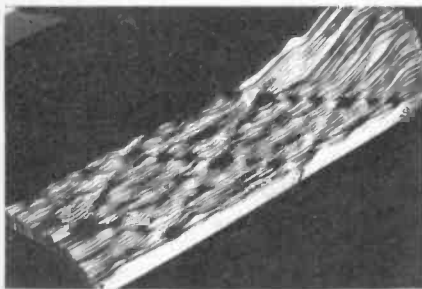
For those nostalgic of the ignifluous hearded, albescent breathed labourer of the permanent way, in short, the *steam locomotive* the news that living steam is to return to the railways of North America might come as a pleasant shock. But not the clanking, brass bell and smokestack machine. Instead, a loco' "heavily disguised" as a diesel unit with pistons on its wheels, manufactured by American Coal Enterprises, will beat through American suburbs where electrification infrastructure costs are prohibitive.

With a microprocessor for a firemen, efficiency of the locomotive is lifted from the 5 per cent of its ancestors, to 15 per cent. Whilst diesel may be 30 per cent efficient, this fuel costs four times as much as coal, and with a micro on the footplate to ensure minimum pollution in terms of gases and ash, the New Jersey company feels it has sparked off a good idea for the future. Production is expected to start soon.

IBM Breakthrough

IBM scientists have hit the news again; this time with a microscopy breakthrough at their Zurich Research Laboratory. An effect known as vacuum tunnelling has been successfully exploited to study surface topography down to atomic level — vertical differentiations of as little as 0.1 Angstroms, and horizontal differentiations of as little as 6 Angstroms (1 Angstrom unit equals 10^{-7} mm).

The tunnelling technique actually detects the electron clouds surrounding surface atoms, and as such, qualitatively reflects the atomic surface structure. In vacuum conditions a probe scans the specimen raster fashion, so that a 3-D facsimile is



gradually built up. An electric current between the probe and surface is used to detect surface deviations. So sensitive is this technique that a distance the diameter of *one atom* changes the tunnel current by a factor of 1000.

The photograph shows an enlarged model of a silicon surface constructed from STM data. Two rhomboid-shaped unit cells are clearly visible. The individual "bumps", which are as little as 6 Angstroms apart, have never before been observed.

Mic on a Chip

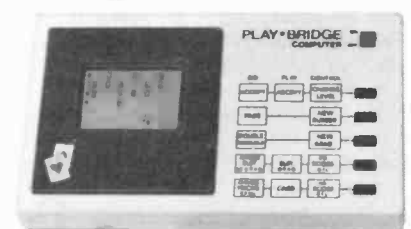
A new technology pioneered by Honeywell has led to the creation of the "mic on a chip"—a completely solid state microphone! Zinc oxide on a single silicon substrate offers a chip-sized microphone with significant advantages over the ceramic alternative; it responds to frequencies as low as 0.1Hz, as opposed to 20Hz. Honeywell's microphone is devoid of mechanically linked parts, and consequently far more reliable and robust. It is smaller and lighter too. The mic consumes a mere 40mW which makes it ideal for battery powered field work, and it is sensitive to as little as one microbar of pressure.

COMPUTER BRIDGE

The Systema BG1 Bridge Game is a simple computer, with control keys and display, designed so that one person can play Bridge, using the computer to play the roles of the other three persons.

The computer will deal new cards each time and you can choose between two levels of difficulty. It allows you to be dummy, declarer or defence. Between the hands, result of contract and vulnerability are displayed as well as below the line scores.

In each game you are able to bid and play your hand against the computer. During the auction, you make your own decisions as to what to bid, but the decisions of the other three players are made by the computer. The BG1 Bridge game is expected to retail at under £30.



MARKET PLACE

Briefly...

Five UK banks are to link together their 2,500 cash dispensers for shared customer use, by 1985. Bank of Scotland, Lloyds, Williams & Glyn's, Barclays and the Royal Bank of Scotland will be providing this common on-line facility to a total of 15 million customers.

• • • •

Researchers at Battelle-Columbus have developed a low-cost, energy efficient method for coating plastics with metal. The technique is known as "in-mould" plating because unlike conventional deposition, the plastic component emerges from the mould with its metal coating. Processing costs are cut by over 30%, and the technique may well herald an era of lightweight production parts for automobiles, business equipment and plumbing fixtures.

• • • •

W. H. Smith have opened three specialist computer shops at their branches in Birmingham, Bristol and Croydon. If these first efforts realise their predicted sales figures a national network will follow next year. The first special offer will be Mattel's new micro 'Aquarius' well before its official UK launch.

• • • •

Socialist France has installed data links between its treasury and its border posts. Electronic warrants enable emigration police to identify and jail immediately anyone who, upon trying to leave the country, owes money to the exchequer. Having fed the traveller's passport through a scanner terminal, the officer on duty is empowered to detain any offender until he/she pays up and wipes out the debt. In a matter of weeks of operation, hundreds of citizens had settled in cash rather than lose their connection.

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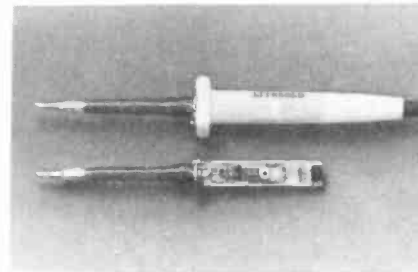
Maplin Electronics has introduced its Computer Aided SHOPping by TELEphone (CASHTEL) service, which allows owners of home computers with RS232 and modem facilities (CCITT 300 Baud) to link directly into its stock control computer. The user must have a customer number, and hold one of the major credit cards to be able to place an order, and may check that the components he/she requires are in stock. Maplin's computer is a DEC PDP11/70 with 2Mbytes of MOS memory and 200Mbytes of on-line disc. It is accessed by dialling 0702 552941.

LITESOLD

Litesold have just introduced a mains-voltage soldering iron.

The EC50 incorporates an electronic temperature control circuit mounted inside the handle, which operates in response to a thermistor fitted inside the bit-mount. Power to the 50 watt heating element is controlled by a triac operated by a zero-voltage switching i.c., to minimise spiking and RFI, and the iron is fully earthed so that it may safely be used on sensitive equipment and components.

A special feature of the design is that the low-voltage supply necessary for the control circuit is obtained by means (for which a patent is pending) which do not involve the fitting of a dropper resistor in or near the handle. This problem has previously prevented a



mains iron of this type being made to run with a sufficiently cool handle.

Access is provided to the temperature control potentiometer, and settings may be varied from approximately 280 to 400°C. Standard setting is 370°C. The iron costs £28 + VAT and postage from Light Soldering Developments Ltd, 97/99 Gloucester Road, Croydon, Surrey, CRO 2DN. (01-689 0574).

FLASHBACK

Would you give a week's pay for a calculator with only the most basic of functions? The answer is yes if you bought one ten years ago. Before such technology was available to the general public, those in the know could purchase the Sinclair Cambridge for a staggering £43.95. The average weekly wage at that time was around £36 and the electronics world was celebrating the Silver Jubilee of the transistor. Such was the state of technology in 1973.

Nowadays the purchasing power of our weekly pay packet could run to three computers, ZX81's of course. With the microprocessor bandwagon well and truly rolling who knows what goodies will be around for our 1993 pay days?

Silicon News Corner

Bulletins announcing new semiconductor devices arrive at PE daily, so it is possible only to describe them briefly. Details of how to obtain further information are included, however.

Mullard ♦ Electronic humidity sensor (type 2322 691 90001) that operates between 10-90% relative humidity. Is a metallised film, capacitive cell. Worst case accuracy is 5%.

♦ AM/FM receiver TEA5570. Suitable for hi-fi, car radio and portable. S.w. to 30MHz.

♦ 128 x 8 bit static low-power RAM (type PCD 8571) in 8-pin d.i.l. package. Designed for battery back-up using only one ni-cad cell. Data transferred serially via I²C bus.

♦ High speed 8K PROM, type 82S181B (1024 x 8) and 82S185B (2048 x 4). Both 45ns access. Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.

Siemens ♦ 10kV rms opto-isolator HIL10 in 16-pin d.i.l. package.

♦ Claimed to be the world's smallest (match head sized) reflective opto switch, type SFH900. Very high dark/light ratio sensor. Emitter capable of 1.5A, 10µs pulse.

♦ 35 dot intelligent display, DLO 7135 series. 96 chars, ASCII format, µP compatible. Red,

yellow, or green. Row/column addressing simplified by integral memory/decode/drive chip. Chars 0.68 in. high, with 75° viewing angle.

♦ Low power, 8-digit intelligent alphanumeric display, DL1814. 8 x 17 seg., 0-112 in. chars. Full ASCII/TTL compatibility through on-board memory/decode/drive. Synchro Services, High St., Harrold, Bedford.

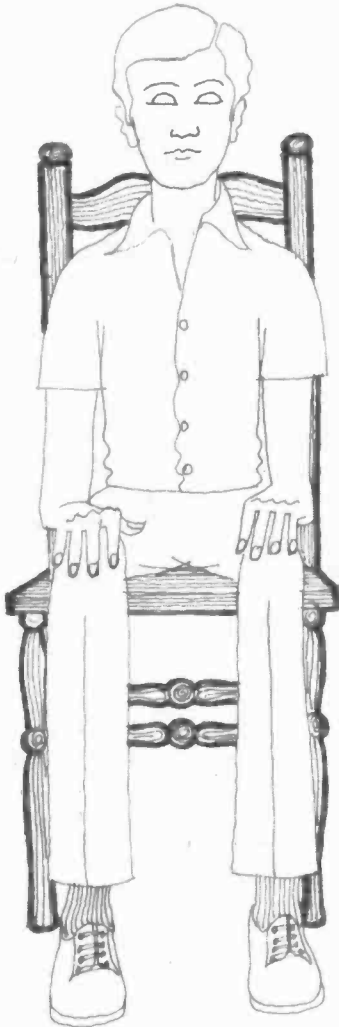
Pronto ♦ A CMOS 2 µP with enhanced/extended instruction set. The SY65C02 works to 4MHz at current of 8mA (10µA standby).

♦ New series of extremely low noise, wide band op amps, the OP-27 is intended for instrumentation. Slew rate 2.8V/µs and low frequency noise corner frequency of 2.7Hz.

Synertek ♦ Low cost CRT controller with wide range of display features. The SY68045 is designed to interface 6500/6800 micro's raster scan CRT units.

Mostek ♦ The MK3801 Z80 STI contains a USART for serial communication, and reduces Z80 system chip-count. This multifunction device contains two binary, two full function timers, and eight general purpose bi-directional lines. 16 out of 24 internal registers are directly addressable. Pronto Electronic Systems Ltd., 466 Cranbrook Road, Gants Hill, Ilford, Essex IG2 6LE.

A Safe Relaxometer...



RALPH LOVELOCK

ANYONE who has watched a very young baby acquiring manual skills such as reaching out and grasping a desired object, will have realised the complexity of the process. The hand first closes short of the object, then beyond it, then to one side of it, but once success has been attained, all further attempts are effortless and automatic. To the infant there is no comprehension of the physiological process, but the mind desires a certain end, the eyes feed back to it the results of trial and error, and the child 'learns' to use its body to perform the task.

Such knowledge continues with us into adult life, and without any conscious awareness of the individual electrical impulses which actuate the muscles, we can automatically learn, through feedback of the results of trials, from the five senses, from emotional reactions in the mind, and from the pleasure of attaining the desired end.

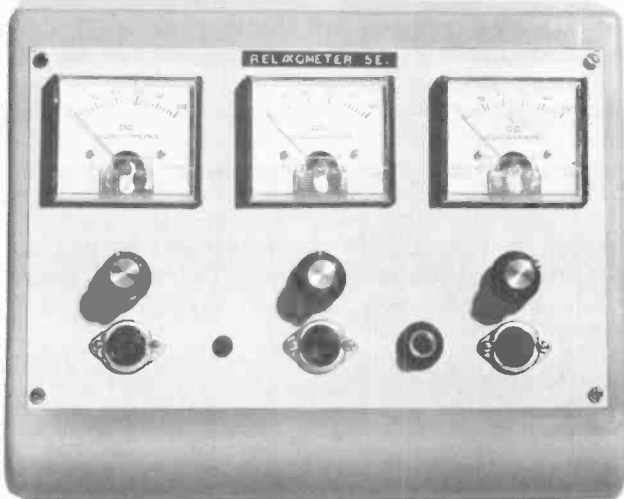
Much of the control and operation of bodily functions are exercised without conscious awareness. By fitting a suitable transducer to the body which will feed back to the mind through the senses an indication of state from moment to moment, the operation of such autonomic control is brought to the level of consciousness. This process has been named 'biofeedback', and through it it has been found possible to learn to raise or lower body temperature, blood pressure, rate of heart beat, and the operating mode of the mind itself.

One of the earliest applications of this process was in the American lie detector, which informed the questioner rather than the subject, of an emotional state. All well-equipped hospitals today employ many involved electronic machines to inform the doctor and nurses of the operational state of many bodily functions. This article is concerned with the development of the lie detector to respond to much more subtle states of mind, and feed back to the subject himself so that he may learn to control states beyond the level of consciousness. Such methods are being used currently in therapy of a number of psychosomatic conditions including cancer.

RELAXATION

It is common knowledge that worry, anxiety, sorrow, and emotional stress can all give rise to acute nervous tension. Some of our younger generation have sought relief from the pressures of Western civilisation by learning to relax under the guidance of Eastern religions. A regular entry into deep relaxation often accompanied by concentration on a fixed theme or phrase, as in transcendental meditation, can bring relief from such troubles, often allowing the operation of bodily functions below the level of consciousness to return to normal, and thus allow the natural responses of the body to meet and destroy any undesirable invasion.

Such relaxation is often accompanied by a brain wave known as 'alpha rhythm', and there has been an attempt in America to sell to the general public a cheap version of equipment to feed back to the patient the results of such electrical pulses by sound or sight, using biofeedback to learn control of the process. While such machines are in



Prototype which will accommodate three patients

large scale use by medical staff to measure brain conditions in patients, the output is fed to the doctor, and not to the patient. Because sharp cut-off band pass filters are used which can be excited by electrical noise, such anomalous response can be very dangerous if fed back to the individual himself, occasionally resulting in epileptic seizure.

The electrical conductivity of the outer layers of the human skin has been the subject of much valuable research which has allowed a refined version of the lie detector to be used as a biofeedback machine to monitor, and teach to the private individual, the ability to develop deep relaxation, and by a type of transcendental meditation to receive therapy for his condition. The use of the skin conductivity machine by private individuals is quite safe, and can frequently be advantageous in improving the quality of life, although any sufferer from serious illness is well advised to seek the assistance of a trained therapist so that the state of relaxation can be advantageously utilised in therapy.

SKIN CONDUCTIVITY

These machines are often misnamed 'skin resistance meters', but such a designation is not true, because the relationship between applied voltage and resulting current is not linear, nor does the nature of conductivity variation with emotion remain similar over a wide range of voltage applied. In the normal process of living, the skin is being constantly abraded and replaced by new growth; on the surface is the debris of wear, beneath this is a complex outer layer, and beneath that the inner materials associated with the electro-chemical organisation of life. It is in the outer layer of skin proper that the conductivity used occurs, while the surface debris offers an obstacle to measurement by injecting a high resistance limiting the effective area of electrode contact.

The conductance of the skin is not resistive because it is the result of electro-chemical transfer of charge through the walls of adjacent cells, and for the purpose of monitoring, relaxation research has indicated that potentials greater than 2V applied across electrodes will give anomalous results. The older method of obtaining a large effective area of conductance between electrodes and surface debris was to use a conducting jelly or fluid between electrode and skin (wet electrodes), but this introduces an uncontrollable variable into the system, which can mask some of the information desirable. With the wet electrodes, or with equally unsuitable metallic penetration of the debris by a layer of matted metallic fibres, effective resistance lay between five

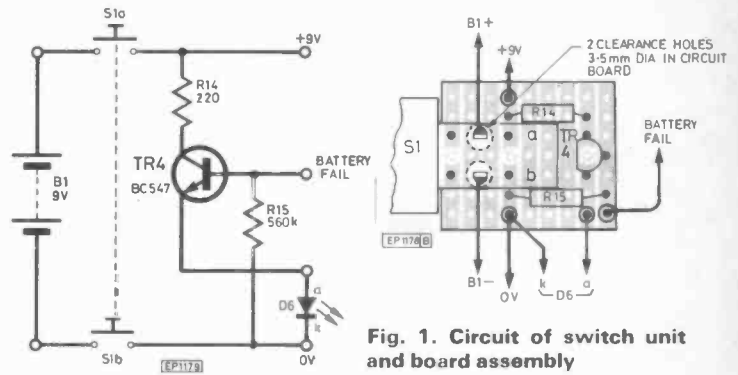


Fig. 1. Circuit of switch unit and board assembly

thousand and fifty thousand ohms, and such conductance was readily measured in a range of voltages below 2. With dry electrodes however, such as those described here, the effective resistance can rise to several megohms, and it was this limitation which was only overcome at a reasonable price when cheap versions of very high input resistance operational amplifiers became available. The instrument described here will allow an untrained person to adjust and monitor the conductance across the electrodes between five thousand ohms and fifty million ohms, a range of ten thousand to one, and involving the monitoring of changes in current of a few pica-amps.

In use, a needle moves across the scale of an instrument. With the electrodes applied to the skin, a knob is turned to increase the reading until it is approximately mid-scale. Any increase in nervous tension will cause the reading to increase, while a state of relaxation will cause it to fall back towards zero, the further the fall, the deeper the state. Apart from the difficulties of measurement in this range, a further difficulty was to use cheaply available components to obtain a smooth logarithmic variation of gain in the amplifier over such a wide range, without backlash or drift, such that an untrained person could easily operate it. Very early in the development it became obvious that the greatest operating cost was likely to be the destruction of sensitive meters through accidental overload, and in designing a meter protection circuit a means was found of obtaining a very desirable modification of input/output law over the working range.

CIRCUIT OPERATION

The meter protection circuit is shown in Fig. 2. The output of the amplifier is a voltage proportional to the current into the electrodes, and this is fed into the meter circuit. Since the purpose of the instrument is to 'teach' relaxation, there is no need for the reading to be a linear measure of conductance, but it is desirable that it shall have a large change of reading about the centre scale; this will enable a small start

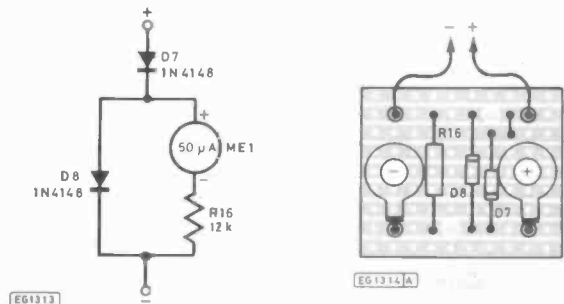
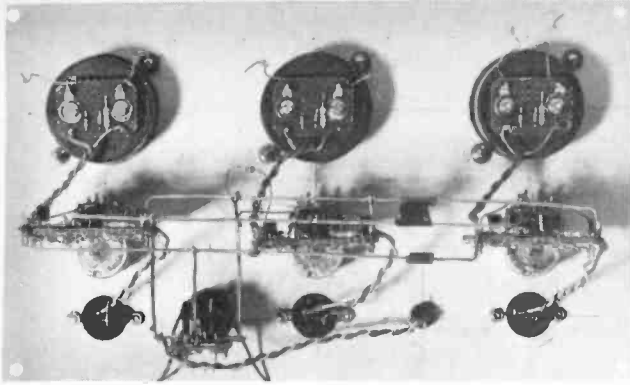


Fig. 2. Meter protection circuit and board assembly



towards relaxation to be clearly visible to the user, and thus encourage him to make further progress. The overall response of the circuit is shown in Fig. 5. D7 suppresses the zero, and D8 compresses the maximum reading, thus giving the expanded deflection around mid-scale which is desirable. In addition to this function, D7 masks the effects on meter reading of small offset voltage output from the amplifier, which varies from chip to chip, and also protects the meter from application of reverse polarity to the input. In addition to compressing scale reading, D8 protects the meter from damage due to too great an input of excessive voltage.

The switch unit circuit is shown in Fig. 1. Use of an indicator lamp to show that the instrument is switched on would be a waste of battery current, but lack of such an indication leads to run-down of batteries due to not switching off after use. To offset this problem a push switch is used which has an 'indicator' button; this button displays an indicating orange disk while on, which becomes invisible when off. It is very desirable however that when the battery has discharged to a voltage incapable of maintaining a constant voltage output from the regulator used in an amplifier, that a visible warning be given that performance is no longer reliable. When the switch unit is controlling a number of work units, such a failure must be detected from any one of the voltage controllers in that particular amplifier; this is accomplished by TR4, which in the absence of input to the battery fail line remains cut off due to R15, but when a failure drives the battery fail line positive, TR4 allows a limited current to flow, lighting D6 in the emitter circuit. There will still be enough output from the battery to continue lighting the lamp, and indicating that a new battery should be fitted.

The amplifier circuit is shown in Fig. 3. The voltage regulator section is designed to accept the output from the 9V battery at the collector of TR1 and deliver at the emitter a drive potential constant for varying load at a value between 5.5 and 6.5V. A value of 6V will cause a current of

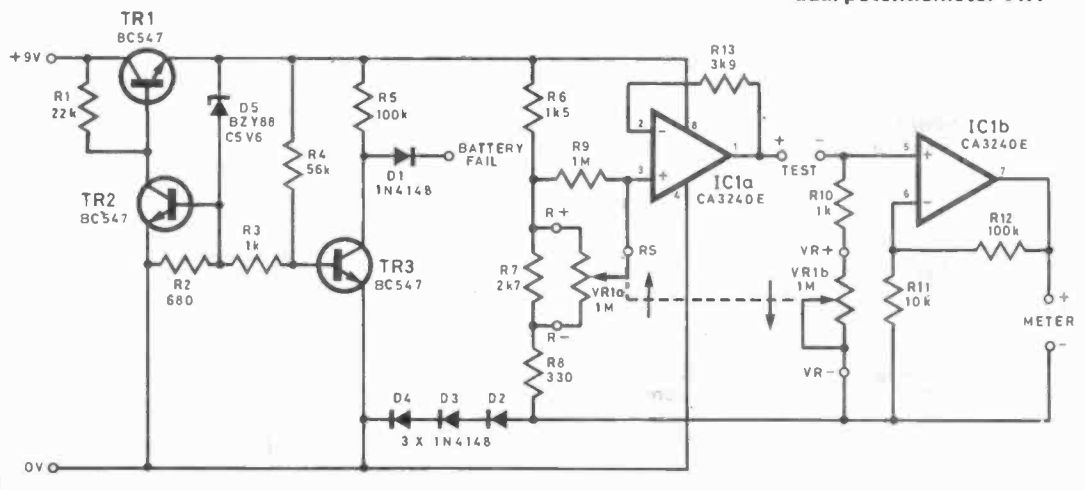


Fig. 3. Amplifier circuit

0.104mA to flow through R4, R3 and R2, raising the base of TR2 to 0.07V which will leave it cut off in the absence of additional current through D5. If the battery voltage falls to such a level that D5 ceases to conduct, the voltage on the base of TR3 will fall to 0.17, it will also be cut off, its collector will rise to 6V, applying 5.3V through D1 to the fail line; although there may be up to nine more amplifiers connected to this line, each will have a diode in the same location, which will prevent them from shunting this voltage to zero, and the switch unit will light the alarm lamp. Until the battery voltage fails to too low a value to cause current to flow through D5, that additional current through R2 will rise until TR2 conducts, when feedback from R1 to TR1 will maintain a voltage just sufficient to cause around 0.5mA to flow through D5, and TR3 will conduct.

The amplifier section of the unit consists of a dual operational amplifier having input impedances around 1500 megohms and designed for single ended operation from 4-36V. The dual logarithmic potentiometer of 1M resistance is loaded so that the overall response of the amplifier to rotation of the control is very nearly logarithmic, and the response of a typical machine is shown in Fig. 6. A current of 0.93mA flows through D2, D3, D4, giving a ground line to the amplifier of 1.8V above the zero voltage input to it. This same current through R6, R7, R8, places a voltage across the potentiometer between 0.3 and 2.8V above the ground line. This is the voltage which should be applied across the electrodes, but their impedance is so low that the desired logarithmic control would not occur, and the first of the two operational amplifiers is used as a unity gain buffer of high input and low output impedances so that the required voltage is applied to the test terminals.

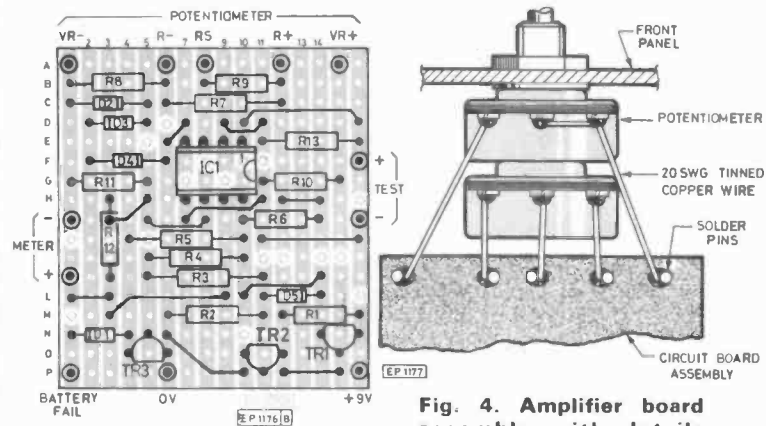


Fig. 4. Amplifier board assembly with details (right) for connecting the dual potentiometer VR1

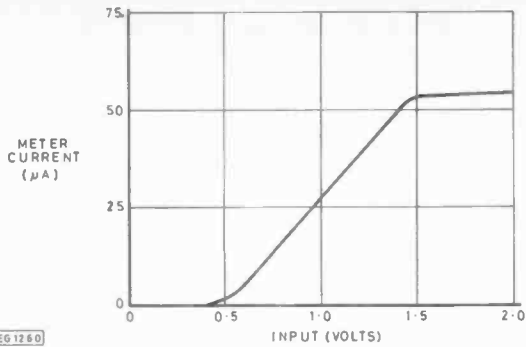


Fig. 5. Response graph of Relaxometer

The current flowing through the test terminals flows also through R10 and VR1b. The voltage developed across them is applied to the input of the second op amp. For very low values of skin resistance, not only is a lower voltage applied to limit current flow to the requisite low levels for significant response to tension, but the input resistance in the path of test negative to ground is also very low to prevent a masking of test variation by a significantly high resistance in series with the skin conductance. As the voltage is increased to give a test current which is low enough to register tension, but is also high enough to operate the amplifier above the 'noise' level when skin conductance is low, the value of the second potentiometer resistance is also increased for the same reason, and the combination of the two gives the overall logarithmic response which is shown in Fig. 6 and which also keeps the second op amp operating satisfactorily over the design range.

As far as the operator is concerned these various adjustments of condition are automatically performed and in turning the control knob from zero towards full scale, he sees a smooth increase of meter reading until it is half scale, at which point he leaves it there, and watches the needle for indication of relaxation or of tension.

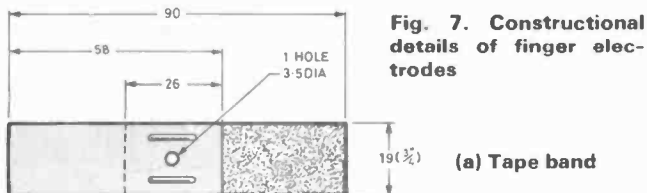


Fig. 7. Constructional details of finger electrodes

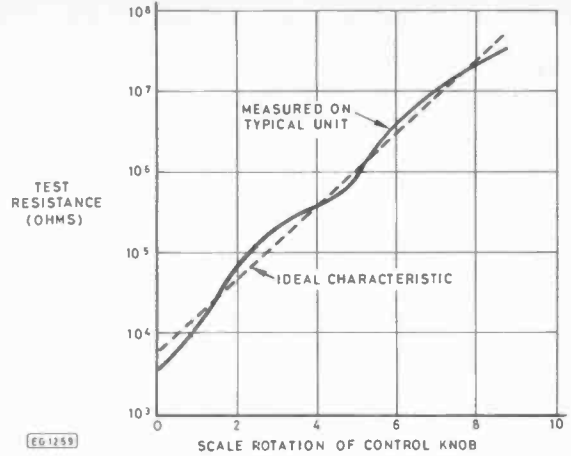
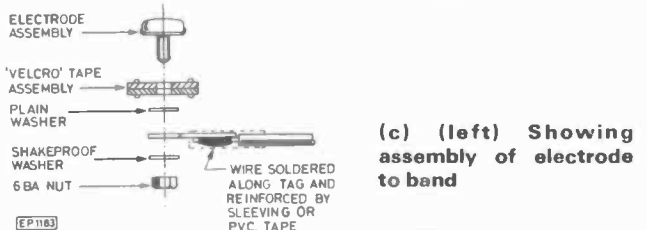
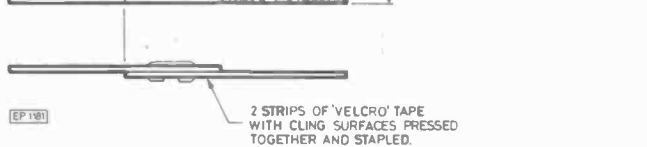


Fig. 6. Graph showing rotation of control knob to give mid-scale deflection of meter for resistance value across test terminals

PERSONAL USE

The instrument is basically of assistance in learning to relax. Most people think initially that if an effort of 'will' is made, and the mind concentrated on a firm intention of relaxing, that they succeed, and that the harder the mind is stressed in achieving the end, the deeper will be the relaxation. In practice, nothing could be more effective in preventing it; the very stress of concentration leads to tension, the very antithesis of the desired end.

COMPONENTS

Resistors

R1	22k
R2	680
R3	1k
R4	56k
R5	100k
R6	1k5
R7	2k7
R8	330
R9	1M
R10	1k
R11	10k
R12	100k
R13	3k9
R14	220
R15	560k
R16	12k

All resistors 0.4W metal film $\pm 1\%$ tolerance

Semiconductors

TR1-TR4	BC547 (4 off)
D1-D4	1N4148 (4 off)
D5	BZY88C5V6
IC1	CA3240E
D6	Red l.c.d.
D7-D8	1N4148 (2 off)

Potentiometer

VR1	1M log
-----	--------

Miscellaneous

B1	PP9
ME1	50 μ A meter
S1	Double pole indicating push button switch (RS 339-443)

Biofeedback is only one of many methods which have been used to train in relaxation, but it is probably the easiest, and certainly the most universally applicable, since it is the only one which is not tied to any one aim, but applicable alike to mystical, spiritual, religious, and medical assistance.

When commencing to use it, a number of sessions are normally needed before it becomes possible to rapidly relax. The difficulty or ease of learning depends in large measure on one's prior disposition and experience, and if one does not become discouraged, and gives the routine a fair trial, eventual success is certain. Many attitudes are currently adopted in relaxation, varying between standing on one's head, sitting cross-legged on the floor, lying on the floor, and sitting in a chair. A straight-backed chair is the easiest, and most effective to use, where the feet, when sitting upright, can rest comfortably on the floor.

The electrodes are attached to fingers or to the palm according to type, the unit switched on, and the meter adjusted to half-scale reading. The mind is gently diverted from surrounding objects and present interests, by slowly reviewing the bodily members, from feet, up legs, thighs, trunk, hands, arms, shoulders, gently relaxing all muscular tension in each in turn and leaving it in this state as attention is turned to the next. The breathing rate is dropped to about two-thirds of normal, but making each breath deep, slowly in, then *completely* expelling from the bowel upwards. Finally, the mind is detached from all the surroundings, and thought centred on a single matter (mental picture, or single syllable sound without rational meaning) and the needle idly watched with the full confidence that it is slowly going to drop towards zero.

The unit can be successfully used in private, in one's own home, but it is usually easier and more effective when done regularly in a group, from three up to six, all sitting around a table on which the machines rest. The location should be

BAZAAR

WANTED Kodak Carousel projector type SAV 2000. Mr. B. R. Smith, 128 Eastbourne Rd., Southport, Merseyside PR8 4EA. Tel: 66316.

OSCILLOSCOPE wanted. Small, single beam, for use as vector graphics display. Offers less than £70 only. Mr. P. G. W. Beart, 11 Apthorpe St., Fulbourn, Cambridge CB1 5EY.

UK101 8K, BASIC 5, Mon 2 inst. manual, cased few software tapes plus 12 inch b/w TV £140 o.n.o. G. J. Garrett, Phone Luton (0582) 422147 after 6p.m.

WANTED good condition oscilloscope single or double beam. Preferably in Cleveland area. J. A. Talbot, 7 Bamard Avenue, Fairfield, Stockton-on-Tees, Cleveland TS19 7AB.

PRACTICAL Electronics Volume 1, bound yearly from 1964-1977 plus approx. 2 years unbound. S.A.E. with offers please. Mr. F. Allen, 34 Charlton Close, Cheltenham, Glos. GL53 8DJ.

ELECTRONIC piano kit, Wireless World, 51 Note Keyboard etc. As purchased. Cost £108 any reasonable offer? R. A. McCall, 20 Empress Ave., West Mersea, Colchester CO5 8EX. Tel: 0206 38 3039.

APPLE II Europlus 48K, 9 inch monitor, 1 disk drive, Silentyper printer, private ownership hence v.g.c. £950. J. D. Dell, 'Cygnets', Norfolk Road, Buntingford, Herts SG9 9AN. Tel: 0763 72828.

TELEPRINTER Kode keyboard friction-feed paper punch + reader RS232-20mA good condition useful electric typewriter £75 o.n.o. H. H. Meinhardt, Morningside, Brereton, Heath Lane, Somerford, Congleton, Cheshire. Tel: 0477 35277 evenings.

MICROTAN with latest Tanbug and lower case chip. £60 bargain. Circuit diagram and manual included. M. Goonewardane, 241 Norbury Crescent, London SW16 4LF. Tel: 01 764 0839.

PRACTICAL TV 1958 June 1983. Electronics 1st issue to June 1983 £50. Tel: 01 874 6232. Mr. J. McGlynn.

DATA on cheap 1 to 2 second delayed flip flop from 12V d.c. wanted. M. Foster, 1 Buckles Way, Banstead, Surrey SM7 1HB.

EX COMPUTER power supplies -5 amp +5, +12, -12 £38. Gold edge connectors 2 x 36 £1.10 o.n.o. Tel: Cardiff (0222) 43015. Max Murison.

GUNSONS Sparktune Mk2 £5, 9 inch b/w monitor ITC-PM-910. Superb condition £55. B. M. Kermode, 56 Brantwood Road, Bradford 9, West Yorkshire.

PE VDU board £12 o.n.o. Elector 16K DRAM £15 o.n.o. Microtan 65 £25, SCMP/2 IN8154 £8 each d.i.l./plug in relays 75p/£1, MM5303 unused £5. G. Williams, 85 Salthouse Rd., Barrow-in-Furness, Cumbria LA13 9TN. Tel: 0229 29152.

FOR SALE, 7 TMS2516 EPROMS, 8 2114 RAM chips, 3 MPU's. Offers for lot. Will split. Tel: Chesterfield 825185.

QUANTITY magnetic tapes. Suitable computer programs. 30p each or £2.50 for 10 + postage. J. Harding, 30 Springhill, Upper Cam, Dursley, Glos GL11 5PF.

MONO DX-TV isolated chassis. All band tuner, audio/video in/out £25 o.n.o. or what have you! Mr. A. Bouskill, 129 Lymminster Rd., Sheffield, S. Yorks S6 1HY. Tel: 0742 311191 after 4.30p.m.

COSSOR monitor screen plus case £40. Some 74 series chips packed on p.c.b.'s offers. Mr. M. Faulks, 218 Watford Rd., Croxley Green, Rickmansworth, Hertfordshire WD3 3DD. Tel: (0923) 30584.

WILLIAM Stuart's "Big Ears" speech reconditioning system for UK101. Superboard, Nascom, Atom. £30. Call Chang. 041 332 7695 after 9p.m.

ATOM 13K+ 16K Utility 4A p.s.u. manuals leads etc., books, over £60 software Acorn tested £199. Mr. C. D. Bittlestone, 1 Beechcroft Ave., Dere Park, Brandon, Co. Durham DH7 8TF. Tel: Durham (0385) 780925.

RADIO controlled car cost £70 reluctant sale price £30. Tel: 01 504 0565. D. Snowdon, 124 Walpole Rd., South Woodford, London E18 2LL.

UK101 Cegmon 32 x 48 16K 1/2 300/600 green screen v.d.u. Manuals. Software various. £260 o.n.o. Tel: (07344) 501656, (07344) 22410. P. R. Border.

WANTED Everyday Electronics Feb 1979 or copy of correction to circuit for Solid State Roulette. D. S. Jackson, 13 Columbia St., Cheltenham, Glos GL52 2JR. Tel: (0242) 20770.

PRINZ Cruiser 8. Personal stereo radio cassette recorder, 1 month old, perfect in condition, with guarantee £60. Mr. Wing Lee, 5 Crown Street, Hebden Bridge, West Yorkshire HX7 8EH.

REALISTIC DX200 Receiver £70 and ZX81 Computer £30 o.n.o. Both in mint condition, possibly will deliver. Mr. S. Sagar, 293 Acrcrington Rd., Blackburn, Lancs. Tel: 65803.

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WANTED urgent help needed to make my P.E. analogue board work. All replies answered, 'phone Gloucester 730919. Andy Bradley.

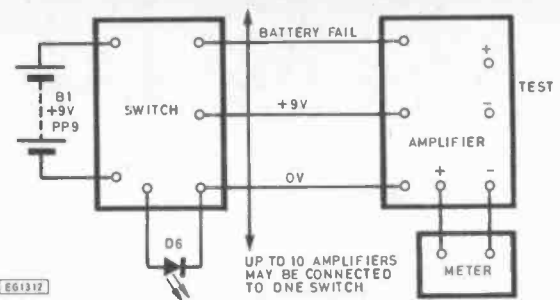


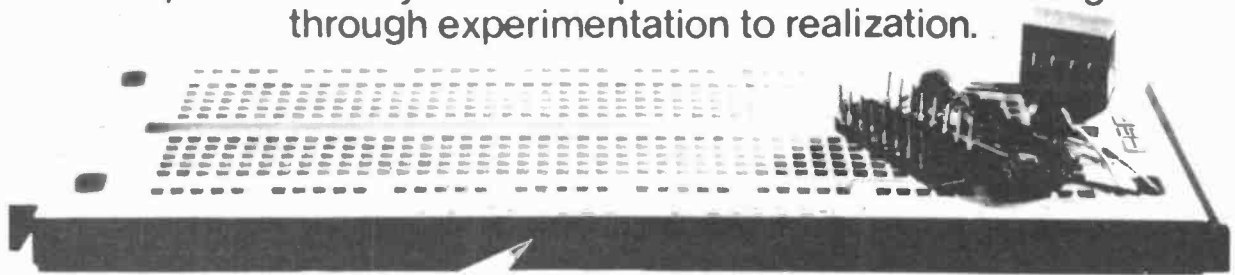
Fig. 8. Showing interconnection of board assemblies for complete Relaxometer

quiet, with no probability of external interruption, and duration from twenty to fifty minutes. It will be found that even if it takes a time to enter relaxation, to remain there for at least ten minutes will bring a feeling of great rest, and a peace which will remain for the remainder of the day. Even when able to relax with ease, it should be practised regularly, at least weekly, if possible more frequently, even perhaps daily. It will become possible with practice, to relax without a machine, but it is advisable to monitor occasionally with one to make certain that one is still relaxing; in any case the reassurance of seeing its existence will bolster confidence in its use.

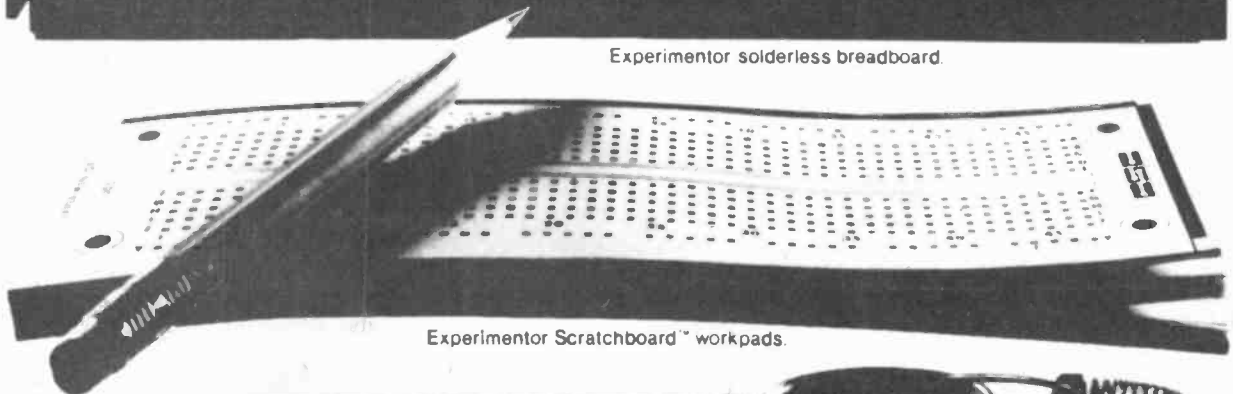
Finally, it should be noted that it is a complete mistake to think that sleep is a condition of deep relaxation. During a prolonged period of sleep, the brain experiences periods of intense activity in dreaming, with rapid eye-movements and other muscular activity. It is often found by patients that after a period of many minutes of noting the needle on zero, they have dropped off to sleep, and on waking have found the needle at full scale. ★

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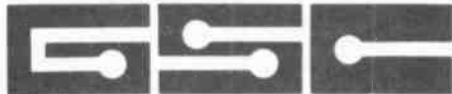
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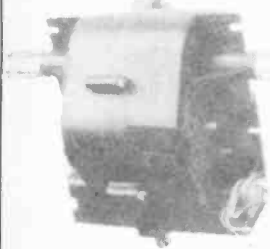
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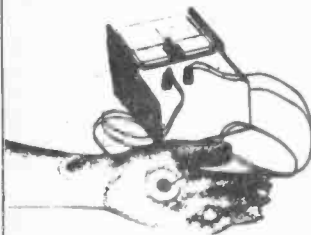
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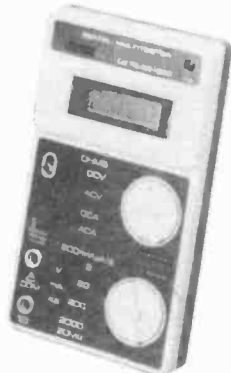
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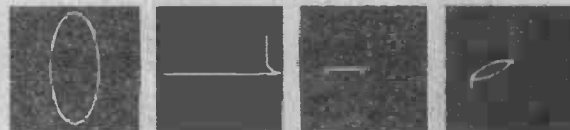
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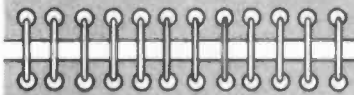
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INDUSTRY NOTEBOOK

By Nexus



Who Pays?

The General Election, barely three months in the past, already seems light-years away. The result will affect industry and commerce until 1987/88. The opposition parties remain in disarray, divided and powerless. With hindsight it is now clear that the Conservatives fought on the Labour Manifesto rather than their own.

Whatever sins of omission or commission can be laid at the feet of Mrs Thatcher during her first term, she cannot be faulted for proclaiming an elementary truth. This is that governments don't pay wages. Neither do local councils or chairmen or managing directors of companies. They can only channel the money paid by customers and taxpayers. It is the latter who pay and loss of custom means less pay, ultimate unemployment. Taxpayers, too, need and demand value for money. The message is now taking hold.

Results

Nobody understands the principle of customer satisfaction better than Lord Weinstock who took over ailing GEC twenty years ago. Today GEC is second only to British Petroleum in stock market capitalisation. Trading results issued mid-year showed a turnover of £5.5 billion with profits up to £670 million from last year's £584 million. Moreover, cash at the bank and short-term investments rose to £1.34 billion from £1.04 billion. Of the £670 million profit, £224 million came from electronics. Order books are nine per cent up on the previous year.

Despite such apparently good results during the recession there are still hard times ahead. A climb out to improved growth could be painful. As Lord Weinstock observes, it is a mistake to imagine that recession is a prelude to boom and although the business outlook is improving there will be no sharp recovery in employment. Increased activity in high-tech manufacture could also precipitate a shortage in some of the more exotic i.c.s.

This view adds weight to the rumour that Lord Weinstock has his eye on Inmos as a possible acquisition.

Another high-flyer is Sir Ernest Harrison heading up the Racal Group which, ten years ago, was not rated in the top 100 and is now in 19th spot. Racal boosted pre-tax profit to £114 million from £103 million last year but the City remains unimpressed, downgrading Racal from its former 'glamour' status. Those with the foresight to invest £1,000 in Racal shares when the company went public in 1961 and left them with dividends intact would find themselves today with a return of over £500,000. Well, you can't grow at that rate for ever and there are good reasons for the slow-down. Defence electronics in the Middle East is one of Racal's most profitable markets. The cut-back in oil prices in OPEC countries didn't help there. The data communications business in the USA ran into a price-cutting war and this didn't help, either. Then there was the problem of Decca, recently acquired, and needing turning round to profit. Borrowings soared to finance the Decca deal but these have now been paid off. So all-in-all the Racal Group looks set for further advances.

The three-year re-structuring of Decca and its integration into the Racal Group has now been virtually completed. Central to this task was David Elsbury, an old Racal hand and one of the earliest high flyers who has now returned to the centre as Deputy Chief Executive, second only to Sir Ernest in the hierarchy. Elsbury also has special responsibility for the Data Communications Group recently relinquished by D. Leighton Davies who has taken early retirement but remains a consultant to the company. A new promotion is that of Barton J. Clarke to chairman of Racal Radar Defence Systems Ltd. Clarke joined Decca in 1957 and in recent years succeeded in building up the company's electronics warfare business to world status. Now, within Racal, this EW group employs 1,800 people exporting to 30 countries.

The larger the company the harder it becomes to get dramatic growth in percentage terms. Thus Ferranti, almost a midget beside GEC, romped home with 31 percent increase in pre-tax profits to £31.5 million. Electronics again showed the sharpest advance, 49 percent up on the previous year. Order books for the current year are 20 percent up compared with a year ago.

STC, now British controlled (ITT retaining only a minority share), is also flying high as, indeed, are Plessey and Thorn-EMI.

Change

But to keep going means changing with the times, ditching old unprofitable lines, introducing new products at keener prices. So it was that GEC's telecommunications factory at Hartlepool which once employed 6,000 people is now reduced to a few hundred. Hardship for those displaced but it needn't be for ever. Remember Corby, 'crucified' by closure of British Steel with 6,000 people 'thrown on the scrap heap' three years ago? With government incentives, over 200 new firms have emerged

not counting the great Wonderworld leisure complex yet to come with £200 million pounds investment and another 3,000 jobs. Corby hasn't yet solved its unemployment problem but has accepted the challenge of writing off steel in favour of a diversity of new enterprises. What should have been a Labour stronghold, fuelled on discontent, Corby with a vision of a new future ahead voted Conservative. But change is not all for the good. RS Components, for example, relocating at Corby means a loss of jobs in London.

Fruit Machines

Small computers named after fruits continue to proliferate but I should imagine that Lemon or even worse, Raspberry, models will not appear. We all know that the cost of computing is on a downward curve but it is still a surprise to learn that if aircraft fares had fallen at the same rate as computing power over the last 40 years you could fly the Atlantic for a penny! The comparison is based on the original Eniac at a then estimated cost of £10 million. The humblest micro will do more or less the same job today for a handful of notes.

The hardware may fall in cost but the software may not. It is conceivable that, like the Gillette safety razor once given free with a packet of blades, so the computer will come free with the software. Not yet. ACT, unveiling its new Apricot model at a basic £1,500, is decidedly up-market compared with, say, Sinclair, but even in this bracket there is an active price war with Apricot claimed to have the price edge through lower overheads, and might comfortably drop further when production speeds up to 4,000 machines a month early next year.

It is bad enough with genuine competition. The real trouble comes with illegally produced look-alikes, the cheap copies made in Hong Kong, Taiwan, Singapore, even, it is said, in Japan itself. Apple is the principal target, one machine being labelled Apollo (near enough to confuse) with other look-alikes with different names but boldly sub-titled Apple-compatible. One such is reported as being marketed in North America as the 'Orange'.

And how about software? Will computer software go the same pirating way as video tapes? There seems no reason why not while there is tainted money to be made. No, I'm not advocating the practice, just observing what could go wrong. The very prospect is terrifying the whole legitimate industry.

A possible countermeasure is the recent adoption by Japanese manufacturers of a common standard for both hardware and software for personal computers. Thus, any low-priced home computer will take any software. This could reduce prices to a level where it is not worthwhile for the copycats. On the other hand it sharpens up the existing price war to the point where only the strongest can survive. Looks like a re-run of the pocket calculator struggle. Perhaps we should forget the agonies of the manufacturers and concentrate on the benefit to the consumer.

PE LOGIC TUTOR

MICHAEL TOOLEY BA
DAVID WHITFIELD
MA MSc CEng MIEE

THE PE Logic Tutor has been designed specifically for use with the series, 'Introduction to Digital Electronics' which commences in this issue of PE. The Logic Tutor provides the user with "hands-on" experience of digital circuits and numerous practical investigations have been included in the text. Furthermore, although primarily designed as a learning aid, the Logic Tutor can be used as a "breadboarding" system in its own right. It is thus eminently suitable for those readers engaged in the design and development of logic circuits. Indeed, it is envisaged that the newcomer will continue to find numerous applications for the Logic Tutor when the series has been completed.

LEARNING AIDS

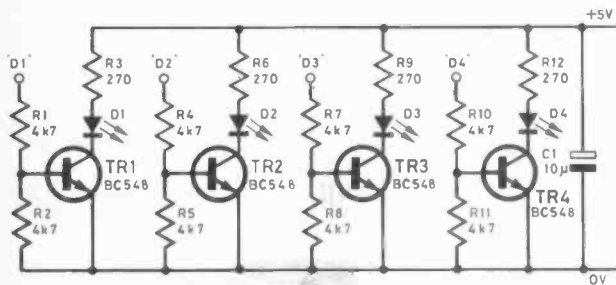
There are, essentially, two distinct approaches to the problem of providing an effective digital logic learning aid. The first involves a fixed arrangement of logic gates wired permanently to a board with terminals to facilitate links between gates. Such an arrangement is ideal for a beginner but tends to be somewhat inflexible and often fails to reflect the "real-life" characteristics of integrated logic devices. The second approach involves the use of a "breadboard" area into which a wide variety of TTL and CMOS logic integrated circuits may be inserted. Such an arrangement is usually based upon a proprietary breadboarding system and is often lacking in such additional facilities as logic level generators of various types, a means of logic state indication, clocks and a power supply. Some, or all, of these items have to be provided by the user at additional cost and inconvenience.

The PE Logic Tutor combines both approaches; retaining the simplicity of the first method with the flexibility of the second. It is, therefore, adaptable and versatile, and furthermore is completely self-contained, requiring only a power source to be fully operational.

CIRCUIT DESCRIPTION

Logic State Indicators

The circuit diagram of the four logic state indicators is shown in Fig. 1. Each logic state indicator consists of a single npn silicon transistor operated in common emitter



EG1231

Fig. 1. Circuit diagram of the four logic state indicators

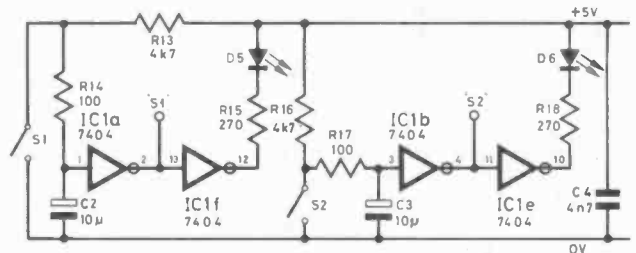
mode as a saturated switch. The l.e.d. connected in the collector of the transistor becomes illuminated whenever the transistor is in its conducting ('on') state. R1 and R2 set the input switching threshold and are arranged so that a logic '1' input state is recognised whenever the input voltage exceeds approximately 1.4V. The maximum input current drawn from the circuit under investigation is limited by R1 to below 1mA. Under the saturated condition in which TR1 is operated, R3 determines the 'on' state collector current and thus can be used to adjust the brightness of the l.e.d. Where desired, the value of R3 may be changed to increase or reduce the brightness of the l.e.d. The value specified should provide an adequately bright display under normal conditions of room illumination without excessive drain upon the supply. The minimum recommended value for R3 is 150ohm and, in this condition, the l.e.d.s will be operated with forward currents of approximately 20mA each. De-coupling of switching transients appearing upon the supply rail is provided by C1.

Logic Level Generators

Four switched logic level generators are provided. Two of these are momentary and two provide a latching action. Each switch is fully "debounced" (i.e. momentary switching transients due to contact bounce have been removed by means of appropriate circuitry). The output of each of the four logic level generators is fully TTL compatible in terms of the output voltage levels produced.

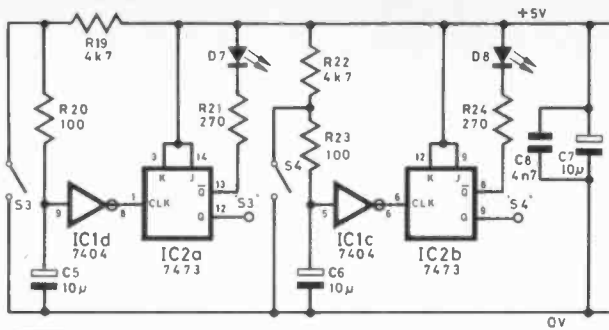
The circuit diagram of the two momentary switches, S1 and S2, is shown in Fig. 2. IC1 is a hex inverter (hex simply means that it incorporates six individual and identical logic gates).

Two inverters are used in each of the switch circuits; the first inverter provides the TTL compatible output whilst the second is used to complement the logic state and operate the l.e.d. R13, R14, and C2 perform the signal conditioning and de-bouncing necessary for S1. When S1 is closed, the input of IC1a (pin 1) will be at 0V (logic '0'). Due to the inverting action of IC1a, its output (at pin 2) will be at approximately +3.5V (logic '1'). TTL gates can usually sink very much more current than they can 'source' (this subject will be explained at greater depth in the Introduction to Digital



EG1232

Fig. 2. Circuit diagram of the two momentary action logic level generators



EG1233

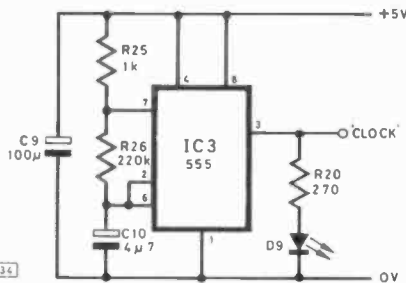
Fig. 3. Circuit diagram of the two latching action logic level generators

Electronics series). The second inverting stage, IC1b, is thus used to further invert the logic state such that the l.e.d. becomes illuminated when its output (at pin 12) is in the logic '0' condition.

The circuit diagram of the two latching action switches, S3 and S4, is shown in Fig. 3. The switch de-bouncing circuitry is the same as that used for the two momentary action switches. The output of the first inverting stage is, however, taken to a bistable stage which "remembers" the logic condition and remains in that condition until the switch is pressed a second time. The i.c. used is a dual J-K bistable (the significance of the term will again be explained in Introduction to Digital Electronics) and it offers two complementary (i.e. logically opposite) outputs which are labelled 'Q' and 'Q̄'. One of these, the Q output, is used as the TTL compatible output, whilst the second, Q̄, output is used to 'sink' current for the l.e.d. indicator for the same reason as before.

Clock

The clock produces a low frequency square wave output at approximately 1Hz. The voltage levels produced by the clock are, again, TTL compatible. The circuit diagram of the clock is shown in Fig. 4. IC3 is a 555 timer connected in astable mode with timing components (R25, R26 and C10) chosen such that the output duty cycle (i.e. ratio of 'on' to 'on' plus



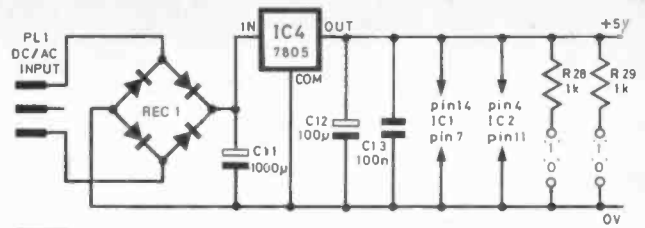
EG1234

Fig. 4. Circuit diagram of the clock

'off' times) is very nearly 50%. The clock frequency may be increased or decreased simply by changing the values of either R26 or C10. Note that, to preserve the 50% duty cycle, it is essential to use a value for R25 which is very much less than that used for R26. C9 provides supply de-coupling and D9 is used to indicate the logical state of the clock output.

Power Supply

The circuit diagram of the power supply is shown in Fig. 5. The power supply comprises a bridge rectifier, REC1, and a monolithic integrated circuit voltage regulator, IC4. The



EG1235

Fig. 5. Circuit diagram of the power supply

bridge rectifier has a dual function. When the Logic Tutor derives its power supply from a d.c. source (such as a 9V battery) the rectifier ensures that the supply polarity is always correct regardless of the actual polarity of the battery connections. When the Logic Tutor is to be operated from an a.c. mains adaptor (consisting of a 240V/6V step-down transformer) the bridge rectifier provides its normal function

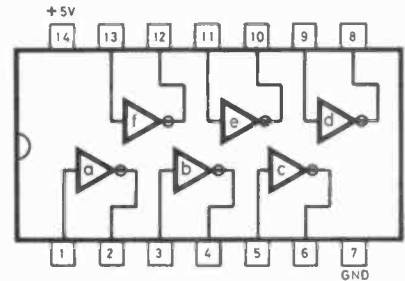
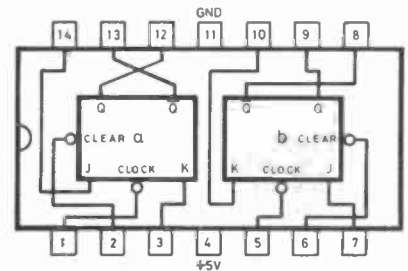
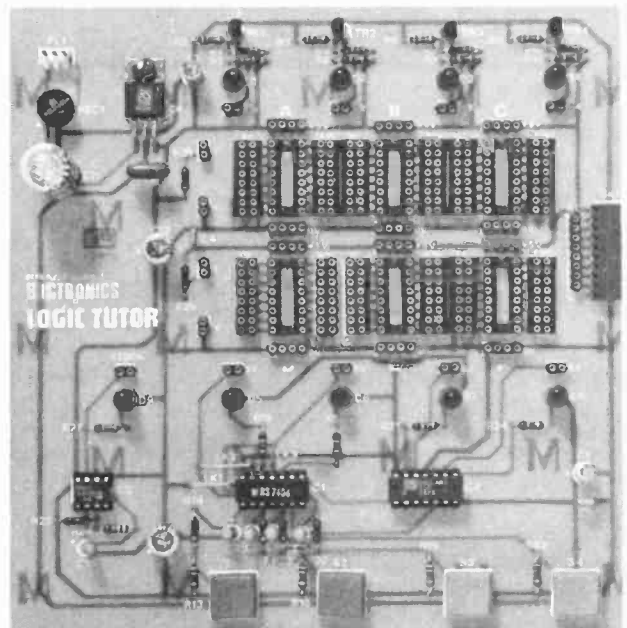


Fig. 6a. Pin configuration for the 7404



EG1236

Fig. 6b. Pin configuration for the 7473



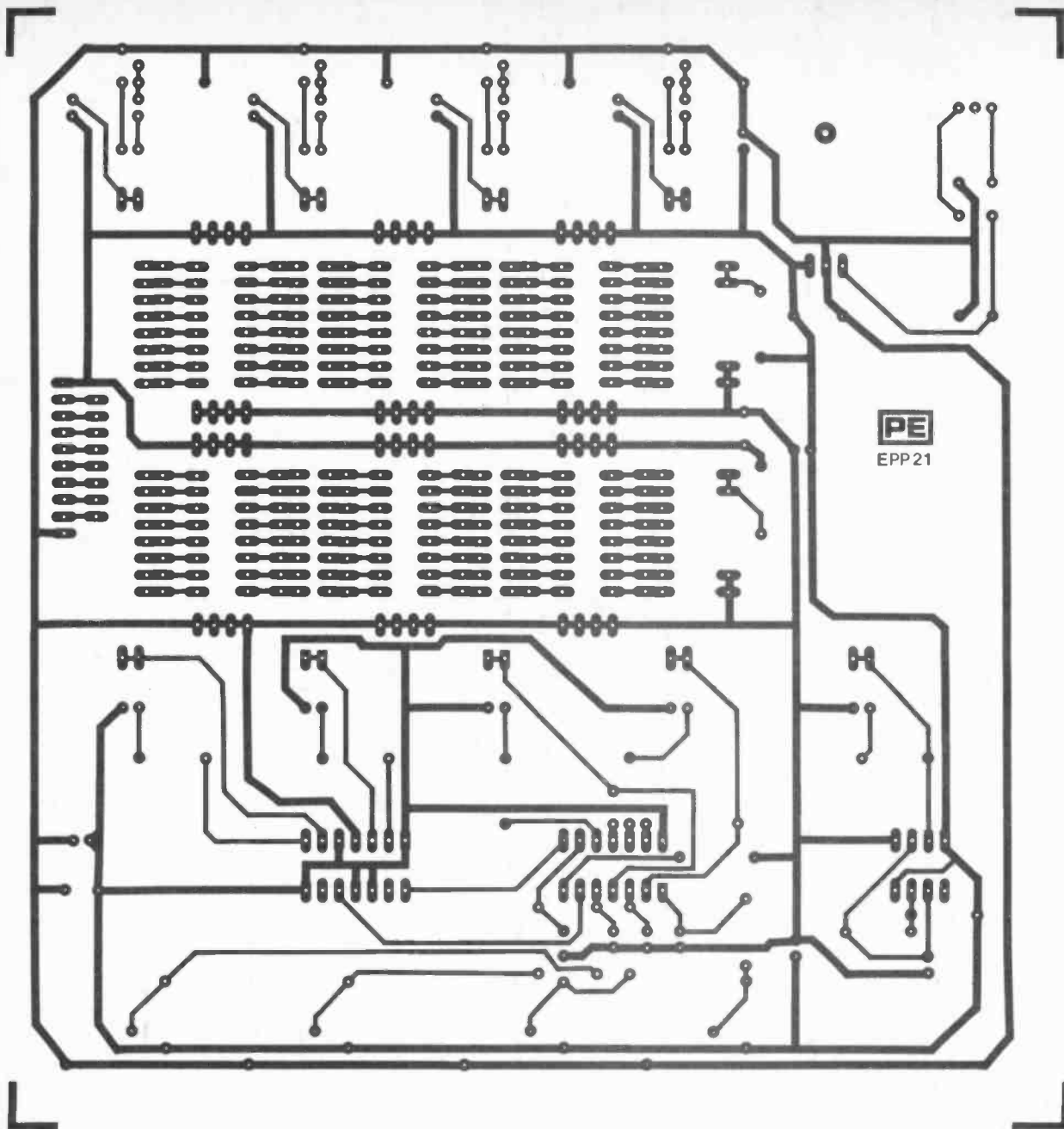


Fig. 7. P.c.b. design for the Logic Tutor board

of rectification and produces a 'raw' d.c. output which is developed across C11. A highly accurate and stable 5V output is produced by IC4. This supply is provided at various points throughout the breadboard area and is also taken to the other integrated circuits, IC1, IC2 and IC3. Two separate contact points are used to provide a logic '1' level. Resistors, R28 and R29, are connected in series with these points in order to limit the available current in the event of an inadvertent short circuit. The maximum current which can be sourced from either of the two logic '1' points being a modest 5mA. Further de-coupling is provided by C12 and C13. It is, incidentally, good practice to include a number of supply rail de-coupling capacitors in a digital logic system. These capacitors can often be instrumental in reducing the unwanted effects of supply borne transients and should always be distributed throughout the area occupied by the digital i.c.s.

CONSTRUCTION

The PE Logic Tutor is built on a single sided printed circuit board measuring approximately 163x172mm. The foil layout for the p.c.b. is shown actual size in Fig. 7 and the corresponding component layout on the top side of the p.c.b. is given in Fig. 8. The p.c.b. is available screen printed such that all components and connecting points are readily identifiable. Components should be fitted to the p.c.b. in the following order; i.c. sockets, connecting strip, connectors, resistors, capacitors, bridge rectifier, i.e.d.s, transistors and regulator. Care should be taken to correctly locate components prior to soldering them into place. Furthermore, it is particularly important to check the polarised components such as electrolytic capacitors, i.e.d.s and transistors.

The long term success of the Logic Tutor depends largely upon the ease with which reliable links can be made within

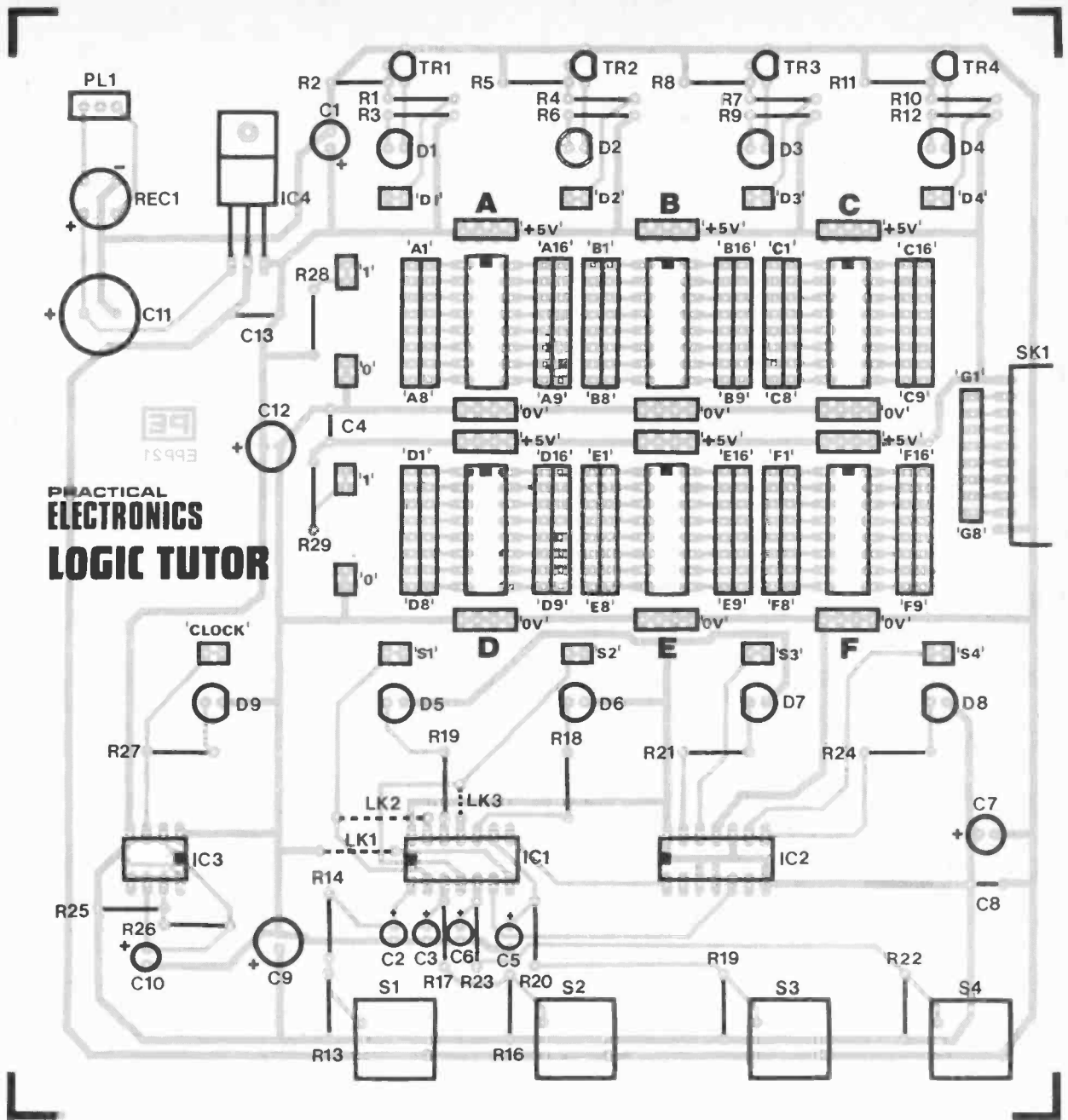


Fig. 8. Component layout

the breadboard area. It is, therefore, essential to use high quality connecting strip and i.c. sockets. The socket strip is supplied in 20-way lengths. These may be easily cut to produce any desired number of ways. The sockets themselves will accept connecting wires, or component leads, having diameters in the range 0.4 to 0.6mm. The sockets are of two-part machined construction with a four finger contact arrangement made from beryllium copper, gold plated over nickel. Such a high quality of construction does, unfortunately, carry a penalty! The i.c. sockets, and connecting strip, are relatively expensive, however it is felt that this is not too high a price to pay for reliability and ease of use.

When construction has been completed, carefully check the underside of the p.c.b. for dry joints and solder splashes between adjacent tracks. Finally, insert the integrated cir-

cuits into their respective holders taking care to observe the correct orientation of each device. Assembly is now complete and the Logic Tutor is ready for initial testing.

INITIAL TESTS

The following items of equipment are required in order to confirm that the Logic Tutor is fully functional:—

- (1) d.c. multi-range meter of 10kohm/volt minimum
- (2) regulated d.c. power supply

The power supply should preferably incorporate some form of short-circuit protection. If such a supply is not available, then a fuse of 500mA rating should be incorporated in the positive supply lead to offer a measure of protection in the event of an inadvertent short-circuit across the supply rails. Similarly, if a d.c. supply is unobtainable, then either a 9V dry battery (such as a PP9 or similar capable of delivering a

COMPONENTS . . .

Resistors

R1, R2, R4, R5, R7, R8, R10, R11, R13, R16, R19, R22	4k7 (12 off)
R3, R6, R9, R12, R15, R18, R21, R24, R27	270 (9 off)
R14, R17, R20, R23	100 (4 off)
R25, R28, R29	1k (3 off)
R26	220k

All resistors $\frac{1}{4}$ W 5% carbon

Capacitors

C1, C2, C3, C5, C6, C7	10 μ 16V p.c. elect. (6 off)
C4, C8	4n7 ceramic (2 off)
C9, C12	100 μ 16V p.c. elect. (2 off)
C10	4 μ 7 35V tant
C11	1000 μ 16V p.c. elect.
C13	100n polyester

Semiconductors

D1 to D9	red 0.2in l.e.d. (9 off)
TR1, TR2, TR3, TR4	BC548 (4 off)
IC1	7404
IC2	7473
IC3	555
IC4	7805
REC 1	50V 1A bridge rectifier

Miscellaneous

1x8-pin, 2x14-pin low profile d.i.l. sockets
6x16-pin high quality d.i.l. sockets (see text)
0.1" connector strip (appx. 15x20-way strips)
1x3-way 0.1" connector, 1x10-way 0.1" 90-degree connector
4xminiature s.p.s.t. p.c.b. switches
Printed circuit board
Mains adaptor incorporating 6V 3VA transformer
Five stick-on rubber feet (for the rear of the p.c.b.)

load current of up to 100mA) or the recommended mains adaptor may be brought into service. In either case, however, it is essential to check for short circuits and correct orientation of the bridge rectifier *before* connecting the supply.

Set the d.c. supply to give an input of 12V d.c. and connect the meter in series with the positive supply lead in order to measure the supply current. Switch the supply 'on' and check that the supply current is in the range 30mA to 90mA. If the supply current is greatly in excess of 90mA, or the overload protection in the power supply operates, or the in-line fuse blows, then check for incorrectly located components and short circuits on the underside of the p.c.b. If the supply current is very much less than 30mA, or zero, then similarly check for incorrectly located components, open circuit connectors and dry joints. Assuming that the supply current is in the correct range, the next stage is to check the output voltage from the regulator. This is easily done by connecting the meter, on the 10V d.c. range, across the rails marked '+5V' and '0V'. The reading should be in the range 4.5V to 5.5V. If this is not the case, check the regulator and associated components.

Having established that the nominal 5V supply rail is correct, the next step is to check the low frequency clock. D5 should be flashing 'on' and 'off' at a rate of approximately one flash per second. If this is not the case then check IC3 and associated components. The logic level generators, S1 to S4, should now be checked. D6 and D7 should become illuminated when S1 and S2 respectively are depressed. The l.e.d.s should become extinguished when the switches are

released, thus demonstrating the 'momentary' action of these switches. Depending upon the initial conditions, D8 and/or D9 may be illuminated. Depressing S3 and S4 should, however, change the state of D8 and D9 respectively. These l.e.d.s will remain in the illuminated or extinguished state until the appropriate switch is depressed again, thus demonstrating the 'latching' action of these switches. If the action of any of the switches is suspect, check IC1, IC2, and associated components. It is also worth checking that the l.e.d.s have been fitted with the correct polarity!

Finally, the logic state indicators should be tested. This is very simply accomplished by feeding a logic '1' (obtainable from the appropriate connecting point marked on the p.c.b.) to the input of each indicator, D1 to D4, in turn. In each case, the appropriate l.e.d. should become illuminated. If this is not the case check the polarity of the l.e.d., transistor, and associated components. This completes the construction and testing of the Logic Tutor. If desired, the protected d.c. power supply may be replaced with the recommended 6V/3VA a.c. mains adaptor. Details of the first practical investigation using the Logic Tutor will be found in Introduction to Digital Electronics elsewhere in this issue of PE. ★

LOGIC TUTOR BOARD KITS

Complete kits for the Logic Tutor are available from the following suppliers:

Howard Associates, 59 Oatlands Avenue, Weybridge, Surrey KT13 9SU (0932 42376)

Riscomp Limited, Electronic Component Distributors, 21 Duke Street, Princes Risborough, Bucks HP17 0AT (084 44 6326)

TK Electronics, 11 Boston Road, London W7 3SJ (01-579 2842)

Magenta Electronics Ltd., 135 Hunter St., Burton-on-Trent, Staffs DE14 2ST (0283 65435)

G. D. & P. Cowan Services, 9 Harcourt Terrace, Headington, Oxford (0865 60741)

Electronics World, 1C Dews Road, Salisbury SP2 7SN

Microstate Ltd., 5 Northfield Close, Fernhill Heath, Worcester WR3 7XB (0905 56322)

Bi-Pak, PO Box 6, Ware, Herts (0920 3182)

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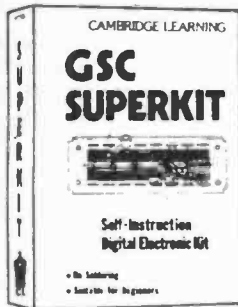
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V.T.'s views and opinions are entirely his own and not necessarily those of PE

LET it be known that there's nothing wrong with the Church's eyesight. Hot on the heels of my plea in an earlier issue of PE for our spiritual leaders to employ the bountiful blessings of electronic technology, comes news of a positive and encouraging response.

A church computer-users' group, with no less than 200 ministers of all denominations on its membership roll, is using computers to manage parish accounts and, among other functions, maintain records of its church's members. The Rev. Peter Goodlad, minister of the United Free Church at Seven Kings, Essex, is even harnessing video games to teach the old Bible stories. He's kicked off by reconstructing the rebuilding of the walls of Jerusalem by that pioneer of property development, Nehemiah. Mr. Goodlad is obviously a canny cleric, for he's fixed it so that Nehemiah always wins.

The idea is an inspired one. The colourful and enduring Bible tales lend themselves admirably to modern technological interpretation. But where does the good Mr. G. go from here?

May I suggest he casts a computerised eye at that notable encounter between David and Goliath. All kinds of angles could be brought in: weather, wind velocity, the weight and trajectory of David's projectile and so on. All good stuff.

The opening of the Red Sea would make another excellent subject. Among the various considerations here would be the likely effect of tidal variations and the danger of the odd bore (the kind they get down on the Severn, not the type you so often find getting into Parliament) turning up and altering the whole course of Hebrew history.

And what about the feeding of the 5,000? Leave the compilation of this game to a mixed bag of statisticians and bright young management trainees from Trust House Forte, and they'd probably be able to show, computer-wise, they could have met double the catering requirement with half the materials, but plus VAT. The same may go for the changing of water into wine in Canaan.

Mr. Goodlad, you're still on the fringe.

★ ★ ★

We kids used to think my gran's doctor was about 100 years old. Gran herself used to reckon that he qualified around the time that Lord Lister—father of antiseptics—was sloshing the old carbolic around and turning major surgery from a likely death sentence into a sporting chance.

Dr. B. (I never found out his real name) wore a top hat and frock coat and carried a Gladstone bag. We firmly believed it contained babies. He was a traditionalist and even if electrical and electronic devices had

been available then, he would have scorned them. Instead he stuck to standard remedies like purgatives, gaily-coloured tonics (which did wonders for the mind if nothing for the body) and evil-tasting expectorants. Ugly rumour had it that he even bred his own leeches in the scullery. When he died, a golden age died with him.

Mum's doctor was a different draught of syrup of figs. He was young and therefore, in the eyes of senior patients, not be trusted. He was also daft enough to adopt the scientific approach. Putting on his best bedside face, he'd first observe, then question and finally examine. This was foreign to the old hands. Dr. B. just used to look. He *knew* what was wrong with you. But my mother's doctor was a real progressive. He favoured X-rays both for diagnosis and therapy, infrared radiation for muscular ailments, ultraviolet for skin conditions and—though it was mentioned only in hushed whispers—electric shock treatment for mental disorders.

My doctor is a man of compromise. He is always prepared to prescribe ready-made medicines—selecting the latest from the manufacturers' catalogues like a gourmet choosing a celebration dinner. At the same time he's ever eager, indeed rabid, to call in such high-tech facilities as body-scanning, electrocardiography, encephalography, deep X-ray therapy, electron microscopy, laser techniques . . . the lot. Indeed, his attachment to these things is such that he didn't speak to his wife for a week when she presented him with a birthday gift of a knitted jumper instead of the electronic stethoscope he'd set his heart on.

But whatever their failings and foibles, these three brothers of the Hippocratic order were at least tangible. You could communicate with them on human terms. They had a ready supply of sympathy, understanding and reassurance. And they offered it in the kind of language you could understand. They were *people*.

This is why I get a touch of wind round the heart when I read the forecasts, by those who profess to know, about the way medicine is likely to go in the not-so-far-off future.

We all know today's pattern. You phone for an appointment, toddle along to the surgery, thumb through a vintage copy of Woman's Own or Menswear, enter the Presence when the buzzer buzzes, pour your heart out and then leave, bearing a slip of paper which is your passport to a return to health and vigour.

All that's going to change, say the pundits.

True, you'll still have to phone for an appointment, the date and time being determined by an electronically-controlled availability schedule. There will be no jolly

mags to read while you're waiting (although, thanks to automated patient-traffic control, you won't have to). All you're going to have are uplifting works like Nature and New Scientist. And you can bet your last barbiturate they'll be current issues.

The most horrific change will be apparent when you sit before he who used to assure you that cremation wasn't around the corner and a couple of these three times a day would soon put you right. There will be no light preliminary chat about Arsenal's chances for the Cup or the price of fish. It will be straight down to business if your GP is to complete his quota as laid down by Those Above.

Fingers poised above his terminal keyboard, he will request you (in clipped Daleksque tones, I wouldn't wonder) to recite your symptoms, which will be fed into a computer standing where the examination couch used to be. A short pause, and an allegedly infallible diagnosis will appear on the read-out (with increasing sophistication you might get the treatment as well). Mind you, things won't always be as straightforward. If the system's down you could sit there all night.

Apart from its total lack of soul, this frightening way of life—or, if the computer happens to be in a bad mood of unreliability—death, the system is highly-prone to the consequences of human error. Both on your part and that of the medico.

You may go along to your doctor feeling a bit under the weather, but perhaps unsure and not too explicit about the actual symptoms. Here lurks horror. One inaccuracy, one slip of the tongue, one ambiguity might spell the difference between a course of pep pills and a frontal lobotomy.

On the other hand your GP (who underneath is as mortal as you) may have been celebrating his latest pay rise the night before and be experiencing inescapable remorse in the form of the unsteady hand. Terminal buttons aren't all that big. Even total abstainers have been known to stab the wrong one. You know what I mean.

There is but one way to avoid this impending Armageddon. It can be expressed in seven simple words.

Come back Dr. B. We need you.

★ ★ ★

A few years back, until the cold wind of austerity began to blow up the commercial trouser leg, Mullard, the UK's biggest electronic components company, provided a unique educational service. It offered, sometimes free, sometimes at nominal cost, a vast range of aids for the teaching of electronics in schools, colleges and technical training centres. Its passing was universally mourned, though those who never heard the sad news still write in asking for help.

It was therefore heartening when in 1982 Mullard made a modest return to the educational field by sponsoring—jointly with PE's sister-journal Everyday Electronics—a Schools Electronic Design Award Competition (SEDAC). It was a huge success and was repeated this year. The standard of entries—and the level of knowledge and innovation displayed—surpassed even that of 1982. In fact two of the judging panel, Andy Beer and Terry Giles, both top Mullard IC men, are said to be fearing for the future of their jobs!

4½ DIGIT PANEL METER

USING THE INTERSIL 7129 CHIP

BRIAN CURRIE

THE Intersil ICL7129 is a full specification, 4½ digit A to D converter, that drives directly a three way multiplexed liquid crystal display. Drawing only 1mA from a 9 volt battery, it requires only a voltage reference and a handful of passive components to make a complete working DVM. To achieve this, the device uses successive integration, an elegant extension of the proven dual slope conversion technique.

DUAL SLOPE CONVERSION

Fig. 2 shows a successive integration waveform. To understand this it is first necessary to appreciate how a normal dual slope converter works. The simplest form consists only of an integrator, into which either the unknown input voltage or a known reference voltage can be switched, a comparator, a continuously running counter, and some simple logic. Starting with the integrator output at zero, the unknown signal is applied to the integrator for a fixed number of clock periods (determined by the counter). The integrator output will ramp away from zero at a rate directly proportional to the input voltage, and at the end of the integrate period will have reached a voltage directly proportional to the input voltage and the integration period, but inversely proportional to the integrator R-C time constant. Next, the reference voltage (which must be of opposite polarity to the unknown) is applied, causing the integrator to ramp linearly back towards zero. The time taken to reach zero will be directly proportional to the starting voltage, but inversely proportional to the reference voltage and the R-C time constant. The point at which the ramp returns to zero is detected by the comparator, and the logic registers the number of counts (i.e. the time) taken. It should by now be clear that this is proportional to the ratio of unknown and reference voltages, and is independent of the R-C time constant and of the frequency at which the counter is clocked. This digital count is the required output.

SUCCESSIVE INTEGRATION

The integrate and DE1 phases shown in Fig. 2 are therefore the classical dual slope waveform. In practice, however, it is necessary in all dual slope converters to detect the zero crossing synchronously with the clock, to overcome the effects of clock noise on the integrator output. Zero crossing is therefore not actually detected until the next clock edge after zero crossing occurs, and by this time the integrator will have overshoot zero by an amount proportional to the fraction of a count by which the input value exceeds the registered result. The ICL7129 cunningly uses this fact to increase its accuracy. The DE1 phase gives a digital result essentially accurate to 3½ digits, then the residual integrator

SPECIFICATION

Input Impedance	>100M
Full Scale Reading	199.99mV
Accuracy	0.01% of reading ± 1 digit.
Power Supply	6-14 V dc
Power Supply Current	2mA max.
Sample Rate	1.6 reading per sec.
Over Range Warning	M.S.B.=1 other digits blank
Temperature Range	0-35°C
Temperature Stability	50ppm/°C typical
Digit Height	10mm
Low Battery Warning	6.3 to 7.7 volts
Continuity Detector threshold	100 to 400mV
Overall Dimensions	72 x 36 x 27mm
Panel Cut Out	68 x 33mm

voltage is multiplied by -10 , and de-integrated a second time. Now the accuracy has increased to 4½ digits. The residual is once again multiplied and de-integrated to yield a final resolution of 5½ digits.

To make a complete conversion, the ICL7129 repeats this cycle twice—once using the unknown input voltage and once with zero input. The difference of these results then gives a final result free of any zero errors, so the offset voltages of amplifiers and comparators on the chip don't matter. Because the internal resolution is ten times the displayed resolution, auto zeroing is good to one tenth of a displayed increment. A further refinement is that, by increasing the integrate period by a factor of ten, the chip can switch from 2 volts full scale to 200mV full scale (corresponding to 10 microvolts resolution) with no other circuit changes. A digital range input controls this facility.

Another novel feature of the ICL7129 is its direct drive to a three way multiplexed LCD. Multiplexing is necessary to keep a reasonable pin count. Because of the unusual drive waveforms, it is difficult to use external drivers for extra annunciators and decimal points. The ICL7129 therefore provides on chip decimal point drivers for four decimal points and two annunciators. The continuity annunciator indicates when the input voltage falls below approximately 0.6 volts and is useful for quick continuity checking, while the low battery annunciator warns that the battery voltage has fallen to approximately 7.2 volts. Continuity can be user disabled. Finally, an annunciator drive waveform is provided which is guaranteed to turn on any annunciator connected to it regardless of its backplane. This will most commonly be used for range or function flags.

The analogue part of the chip also features fully differential input and reference, allowing easy implementation of

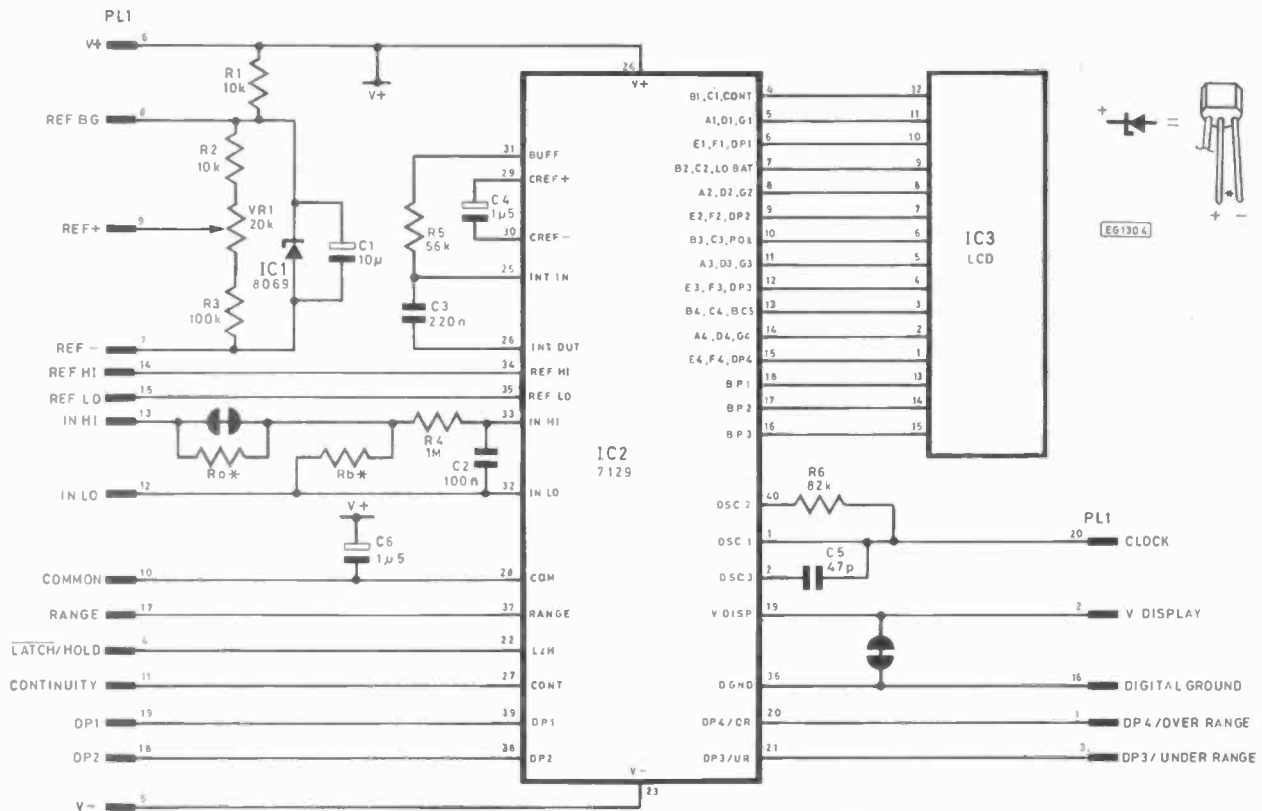


Fig. 1. Circuit of Panel Meter. The pin-out of IC1 is shown top right

LINK (EASILY CUT FOR ALTERNATIVE DESIGN OPTIONS)
* OPTIONAL INPUT SCALING COMPONENTS

ratio-metric resistance measurement and simplicity of use with bridge connected sensors or transducers. Input noise voltage is only 7 microvolts peak to peak, giving steady displays even at 10 microvolts resolution, while input bias current is 10 picoamps maximum at 25°C. On the digital side, control inputs include range change and run/hold control. Digital output signals indicate continuity, over-range, and under-range (i.e. less than 5% of full scale), allowing easy integration into autoranging DVMs.

Because of its combination of facilities, the ICL7129 is therefore equally at home as a stand alone DVM chip or as the heart of a sophisticated, auto ranging multimeter.

CIRCUIT

The ICL7129 has the unique feature of a range input. This is a digital input which if left unconnected, or held to DGND, will give a 200mV full scale meter. By taking the input high (to V+) the time for which the capacitor is charged will be reduced by a factor of 10 and thus give a 2V full scale meter.

Referring to Fig. 1, C3 is the integrator capacitor and R5 the integrator resistor. It should be noted that C3 is polypropylene as it must have a very low dielectric loss in order not to give the meter poor linearity. C4 is used to hold the reference voltage during the de-integrate phase of the converter cycle.

IC1 is a bandgap voltage reference which has a low temperature coefficient. The voltage is divided by R2-3 to form the required 1V reference voltage. The equation for a reading is given as:

$$200\text{mV f.s.d.} \quad \text{Reading} = 10^5 \frac{V_{in}}{V_{ref}}$$

$$2\text{V f.s.d.} \quad \text{Reading} = 10^4 \frac{V_{in}}{V_{ref}}$$

COMPONENTS

Resistors

R1	10k	5%
R2	10k	1%
R3	100k	1%
R4	1M	5%
R5	56k	5%
R6	82k	5%

All 1/8W metal film

Potentiometers

VR1	20k	multiturn
-----	-----	-----------

Capacitors

C1	10μ	elect 16V
C2	100n	polycarbonate 63V
C3	220n	polypropylene 160V
C4	1.5μ	tantalum 35V
C5	47p	polystyrene
C6	1.5μ	tantalum 35V

Integrated Circuits

IC1	ICL 8069	DCA
IC2	ICL 7129	CPL
IC3	Lucid LU.1 1179/121F	(4 1/2 digit triplex)

Miscellaneous

PCB—Display edge connector (2 off), plug—(2 off) socket—(2 off), bezel, bezel mounting clips—(2 off), bezel mounting screws—(6 off)

A kit of parts is available from **Lascar Electronics Ltd., Module House, Whiteparish, Salisbury, Wilts, SP5 2SJ.** (Tel. 07948 567) at a price of £29.95 including p&p and VAT.

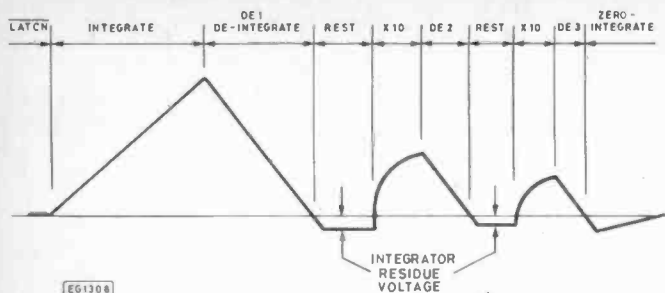


Fig. 2. Integrator waveform for negative input voltage showing successive integration phases and residue voltages

Ra and Rb are optional extra resistors which can form a potential divider if greater than 2V f.s.d.s are required.

Rb should be added on its own if the instrument is required to measure current.

Required F.S.D.	Range input	Ra	Rb
2V	HI	—	—
20V	HI	9M1*	1M
200V	HI	10M*	100k
2kV	HI	10M*	10k
200µA	LO (o/c)	—	1k
2mA	LO (o/c)	—	100R
20mA	LO (o/c)	—	10R
200mA	LO (o/c)	—	1R

*Ensure PCB link across Ra is cut

R4 and C2 form an input smoothing filter and R6 and C5 form the oscillator time constant. The oscillator runs at about 100kHz.

ANALOGUE INPUTS

IN HI, IN LO, REF HI and REF LO (pins 13, 12, 14, 15) are true differential inputs. That is to say that they respond to the voltage across them and not their voltage with respect to the power supply. There is a limit to this however, known as the common mode range. Any input can be no greater than (V+) - 0.5V and no less than (V-) + 1.5V. It is recommended, however, that for best performance the inputs are kept well within the common mode range. The ideal situation is to connect both IN LO and REF LO to COM (pin 10). Common is actively held at approximately 3.2V below V+. The COM pin can sink up to 2mA but can only source 20µA.

By far the biggest problem encountered by users is failing to appreciate the limitation imposed by the common mode range. A typical example is a user connecting IN LO to V-. Doing that will give very odd results!

DIGITAL SECTION

Digital ground (DGND) is held at between 4.5 and 6 volts below V+. This is the supply voltage for the digital section including the display drivers. If CMOS logic is used to provide or decode DPM60 digital signals, then it can be powered from V+ and DGND up to a maximum of 1mA. For greater power it will need to be buffered.

DISPLAY FORMAT

The ICL7129 is designed to drive a triplexed liquid crystal display. This type of display has three backplanes and is driven in a multiplexed format. The actual display is shown in Fig. 3. Notice that the polarity sign, decimal points, low battery and continuity annunciators are directly driven by the i.c. The individual segments and annunciators are addressed in a manner similar to row-column addressing. Each backplane

(row) is connected to one-third of the total number of segments. BP1 has all F, A and B segments of the four least significant digits. BP2 has all the C, E and G segments. BP3 has all D segments, decimal points and annunciators. The segment lines (columns) are connected in groups of three, bringing all segments of the display out on just 12 lines.

MODULE FEATURES

The ICL7129 has a large number of features which make it very useful in such applications as auto-ranging digital multimeters. Note that 'Hi' means V+(6) and 'Lo' means DGND(16). Four of the pins are input/outputs featuring 'weak' outputs. Referring to Fig. 4, the output is connected to the input internally via a resistor. Thus to use it as an input, the 'output' is easily and safely overridden. In order to obtain the output data, the pin must be connected to a high impedance input.

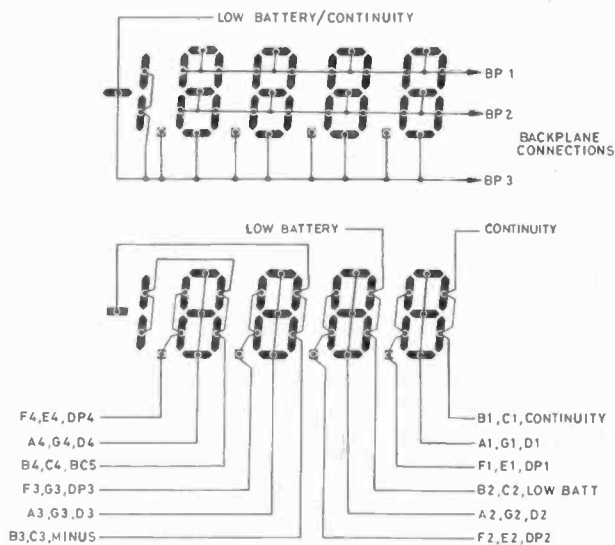


Fig. 3. Triplexed liquid crystal display layout for ICL7129

CONTINUITY (11)

If the converter input voltage drops below a nominal 230mV, then the continuity annunciator will be shown and the output will be high. This feature is very useful because it is much faster than the converter and can give an instant continuity signal in meters requiring this feature. The output can be used to trigger an audible continuity alarm. To disable the continuity indicator, pin 11 should be held Lo.

LATCH/HOLD (4)

Input: When floating, the converter operates in the free-run (normal) mode. When pulled Hi, the last displayed reading is held. When held Lo, the result of the counter contents are shown incrementing during the de-integrate phase of the cycle.

Output: A negative pulse occurs when the data in the display latches is updated. It can be used as a convertor status signal.

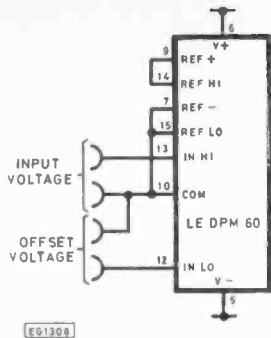
DP4/OVER RANGE (1)

Input: When pulled Hi the left-hand decimal point will be shown. If DP4 is not to be used, connect it Lo.

Output: The output will go Hi if the result exceeds ±19999. This can be used to initiate an autoranging facility.

Note: If DP4 is to be shown and the O/R signal is to be sensed at the same time, then Pin (1) should be used as an input under normal conditions except during latch/hold output when the O/R flag should be sensed.

Fig. 11. If a zero display is required when the applied input is not zero volts the offset voltage should be connected between IN LO and COM, while the input voltage is connected between COM and IN HI



edge connector for extra anchorage. The fitting of the edge connector is shown in Fig. 8. The lower edge of the display is identified by the fact that it has metallised glass connectors. The upper edge has no connection.

Carefully place the LCD on the board over IC2. Ensure that it is level and in contact with IC2 but not pressed hard against it then solder in place.

The board is now complete but before applying power, ensure that all solder connections have been made and that all component leads are cropped close to the board.

To calibrate wire up the two sockets to give the module connections shown in Fig. 9. Apply a known voltage to the input (e.g. 100mV) and adjust R3 to give a reading of 10000.

BAZAAR

MON 02 for UK101 computer wanted. Good price, as new. Hans-Petter Naas, 2450 Rena, Norway.

KAY 6 string guitar built-in effects. Include fuzz, echo, tremolo etc. £150 unwanted present. Neil Taylor, 4 Berekeley Close, Hyde, Cheshire. Tel: 368 2168.

UK101 8K, Cegmon, cased, 300/600 Baud, lots of software and information £90 o.n.o. D. Callender, 17 Badger Way, Banbury, Oxon OX16 9UD. Tel: Banbury 53475.

DYNAMCO manual etc. needed for 'scope units 7103 (sweep), 7130 (display), 7118 (input). Borrow or buy. K. J. Preston, 10 Stream Farm Close, Lower Bourne, Farnham, Surrey GU10 3PD. Tel: Farnham 725764.

WANTED Mullard f.m. tuner module LP 1186 in good working condition. Mr. L.J. Channing, 8 Brymore Close, Bridgwater, Somerset TA6 7PL.

TANNEX bare board brand new with circuit diagram £15.00. P. Martin, 17 High St., Wyke Regis, Weymouth DT4 9NZ. Tel: 03057 71917.

OVER fifty electronic mags. including many PE and EE good condition £5.00. Buyer collects. Paul Williams, 31 Gainsborough Rd, Warrington, Cheshire WA4 6DA. Phone: 0925/36018.

MARCONI TF1389 nanosecond pulse generator, repetition: 35-350pps and external drive, variable output voltage, amplitude, offers. Nick Powell, 66 Lock St., Abercynon, Mountain Ash, Mid Glam.

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BELLS 24V 6inch ideal for burglar or fire alarms brand new only 10 available £3 each. Mr. D. Harries, 12 Penk Rise, Tettenhall Wood,

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KSR teletype with paper tape punch and reader working order with manual £65 o.n.o. Dave Davis, 13 Maple Rd, Surbiton, Surrey KT6 4AA. Tel: 01-399 5487.

WANTED manual and circuit diagram for Heath-Kit Laboratory Oscilloscope Model 10 12 U to copy. Good price paid. W.H. Davis, Gate House, Little Barford, St. Neots, Cambs. PE19 4YB. Tel: (0480) 72480.

COMMODORE PR100 Programmable £12. Casic FX31 £8. Holdway, No. 20 Studland Close, Millbrook, Southampton, Hants.

ELECTRONICS nut. Clearing out bedroom. All new, bargain packs value approx. £80 only £10, p.o., cheque. Mr. Driver, 27 Haverhill Rd, Steeple Bumpstead, Haverhill, Suffolk CB9 7DN.

ZX81, leads, manual, 16K, printer, I/O port and software all hardly used £100 o.n.o. Paul Harris, Yew Tree Farm, Pencroesoped, Llanover, Nr Abergavenny, Gwent NP7 9EW. Tel: Nantyderry 880213.

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DP3/UNDER RANGE (3)

Input: When pulled Hi the next most left decimal point will be shown. If DP3 is not to be used, connect it Lo.

Output: The output will go Hi if the result is less than ± 1000 .

Note: If DP3 is to be shown and the U/R signal is to be sensed at the same time, then Pin (3) should be gated with latch/hold as described above.

DP2(18), DP1(19)

These pins have an internal $3\mu\text{A}$ pull down and need not be connected if the decimal points are not to be shown. To show the point, connect Hi.

RANGE (17)

This pin has an internal $3\mu\text{A}$ pull down and need not be connected for a 200mV full scale. For 2V full scale connect Hi.

LOW BATTERY (NO PIN)

If the power supply voltage between V+ and V- is less than 7.3V (nominal) then the low battery annunciator will be shown. The feature cannot be overridden.

CONSTRUCTION

The p.c.b. supplied is of the double-sided plated through hole type and if a mistake is made in soldering the components in (especially the ICL7129 or the LCD), it can be very

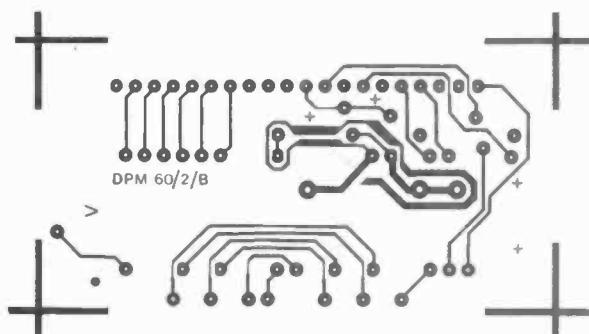


Fig. 5. Topside etching detail

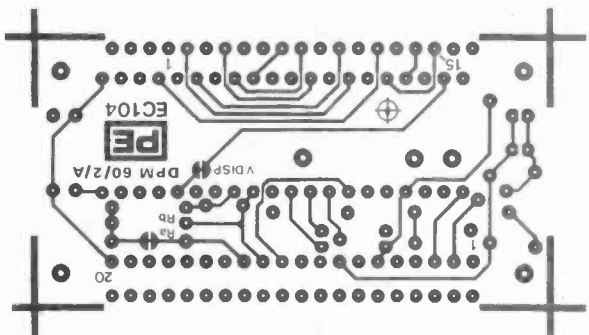


Fig. 6. Underside detail

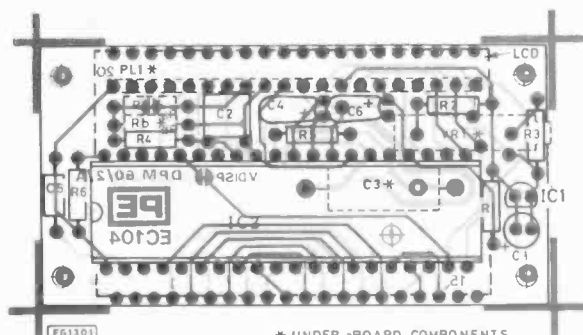
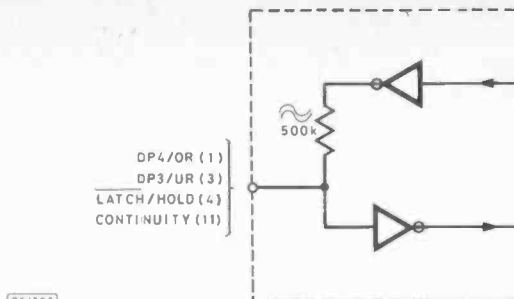


Fig. 7. Track and component layout

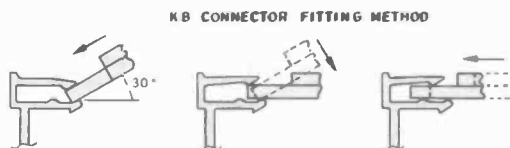


EG1303

Fig. 4. 'Weak' output

difficult to rectify the fault. Avoid using excessive solder and hold the iron on the component for no longer than is necessary. The ICL7129 is a MOS device and although its inputs are protected, antistatic precautions should be taken. The order in which the components are soldered onto the board is important, so do follow the instructions.

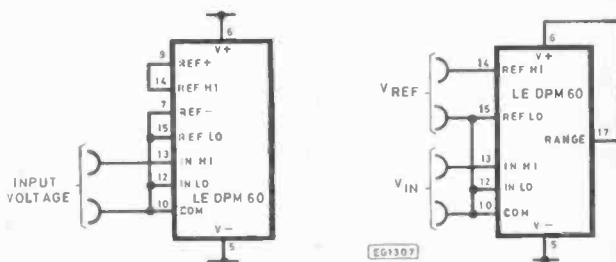
All components except C3, VR1 and the plug are inserted on the top of the board. The top is the side marked DPM60/2/B. Because the LCD has to straddle the components on the board, they should be mounted as close as possible to it. Although the board is solder-masked, ensure no solder bridges are allowed to occur.



EG1305

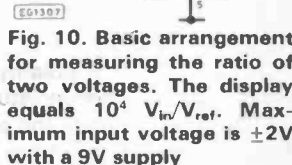
Fig. 8. Display edge connector fitting

1. Assemble all the resistors (except VR1) onto the board and solder in place.
2. Bend and cut the leads of C3 to size, ensuring that when fitted underneath the board, the leads will not protrude more than 0.5mm above the top. Solder C3 in and the other capacitors. Ensure that C1, 4 and 6 are fitted with the correct polarity and that C2, 4 and 6 are fitted flat to the board (see Fig. 7).
3. Fit IC1 ensuring that the correct lead is removed (see Fig. 1). Fit close to the board ensuring correct polarity and solder.
4. Next fit IC2. Ensure that all the leads are correctly spaced and it is correctly orientated before soldering close to the board.
5. Now fit VR1 from underneath the board and solder in place from top of the board.
6. Repeat 5 for the two-part plug, PL1.
7. If you intend to use the DPM60 inside the case then only fit the lower edge connector to the display. For general purpose panel meter applications fit the upper



EG1315

Fig. 9. Module connections for measuring a floating voltage source with 200mV full scale



EG1307

Fig. 10. Basic arrangement for measuring the ratio of two voltages. The display equals $10^4 V_{in}/V_{ref}$. Maximum input voltage is $\pm 2V$ with a 9V supply

SEMICONDUCTOR CIRCUITS

TOM GASKELL B.A. (Hons)

OVERVOLTAGE PROTECTOR (MC 3423)

MOST semiconductor circuitry is very sensitive to excessively high supply voltages. A supply voltage below the rated minimum can cause incorrect functioning of the circuit, but voltages above the rated maximum, whether continuous or transient in nature, will often result in both malfunction and permanent damage. Such an 'overvoltage' condition is usually caused by either a short circuit between one supply rail and another of higher voltage, or by the failure of a voltage regulator, which could then pass high level unregulated voltages directly to the rest of the circuitry. The problem is made especially serious when the main circuit components are particularly expensive. This can cause difficulties for many designers, who as a result may be unwilling to use a power supply of their own design with complex or costly circuitry.

The MC 3423 is an 8 pin i.c. which can give a considerable measure of protection against overvoltage conditions. It monitors the voltage of the power supply continuously, and as soon as the voltage rises above a predetermined level it trips, turning on an external thyristor and causing the supply to current limit, shut down, or blow a fuse, as appropriate. This arrangement of shorting out the power supply is often called crowbar protection. Naturally, it assumes that the supply itself is capable of withstanding such a short circuit.

The pinout and specifications of the device are shown in Fig. 1, and the basic protection circuit is shown in Fig. 2. Note that D1, C1, and R4 are only needed if the positive supply is greater than 36V; they ensure that the positive supply to the i.c. is kept well below its maximum, while still allowing voltages of up to 45V to be used for the main supply. Normally, D1, C1 and R4 are omitted, and pin 1 connects directly to the positive supply. If these components are being used, R4 should be arranged to allow 25mA to flow through it:

$$R4 \text{ (in kilohms)} = \frac{\text{(positive supply voltage)} - 10}{25}$$

Pins 2 and 3 are the sense pins, with the potential divider formed by R1 and R2 determining the proportion of the power supply voltage fed to them. This sense voltage is compared with a fixed internal voltage reference of nominally 2.6V. The result of the comparison is used to determine whether or not to fire the thyristor. Hence, the voltage at which the MC 3423 trips is given by:

$$\text{Trip voltage} = 2.6 \left(\frac{R1 + R2}{R2} \right)$$

For best results, R2 should be kept below 10k. Note that both pin 2 and pin 3 must have reached 2.6V before the thyristor is turned on.

DRIVING THE THYRISTOR

Pin 8 of the i.c. is the output for driving the external thyristor. R3 should be provided to limit the drive current from the i.c.; Fig. 4 shows the minimum value to use, and normally it is wise to stick with the smallest value permissible to ensure fastest turn on of the thyristor. (For supplies in excess of 36V, make R3 a short circuit.) With a low value of R3 the

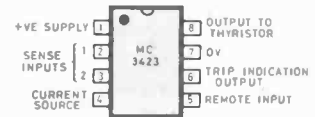


Fig. 1. Overvoltage protector integrated circuit pin-out with its specification below

Characteristic	Notes	Minimum	Typically	Maximum	Units
Supply voltage	All specs measured at +5V supply	4.5		36	V
Monitored voltage	Supply to pin 1 \leq 36V			45	V
Temperature range		0		70	$^{\circ}$ C
Quiescent current			5		mA
Sense input voltage	Both sense input 1 and 2			6.8	V
Remote input voltage				7.0	V
Output current	Pin 8 (to thyristor)			300	mA
Output voltage	Pin 8		3		V
Internal reference voltage	V_{ref}		2.6		V
Temp. variation of V_{ref}			0.08		$\%$ / $^{\circ}$ C
Current from pin 4	Constant current source		220		μ A
Trip indication current			10		mA
Remote input current			100		μ A
Time delay	Minimum time, from overvoltage, to driving of thyristor		0.5		μ s
Output current rise time			0.4		A/ μ s

response time of the circuit will be very fast indeed: 0.5 μ s for the i.c., plus approximately 1 μ s for the thyristor, and a little for the rise time of the i.c. output current. The total is between 1.5 and 2 μ s.

The thyristor itself should be chosen with reference to the power supply voltage and current capabilities. Bear in mind not just the

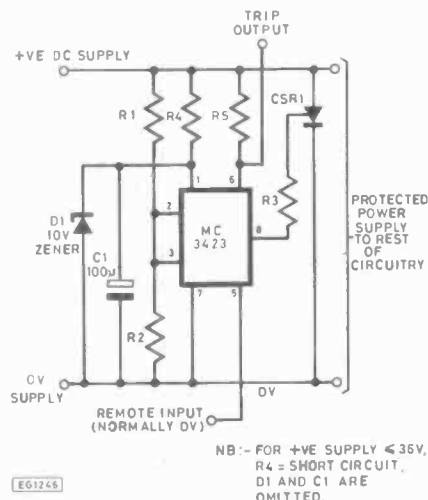


Fig. 2. Basic overvoltage protection circuit

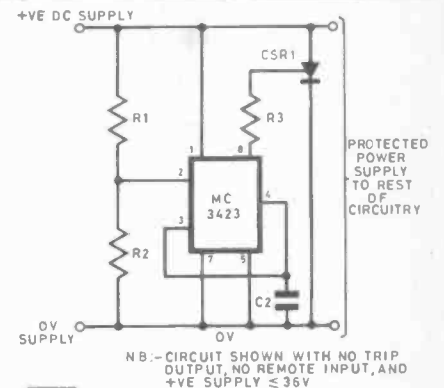
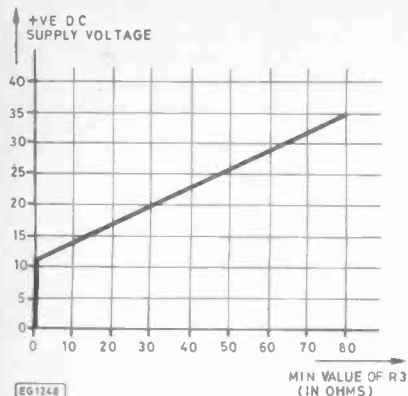


Fig. 3. Circuit to give delay before tripping

regulated supply, but the unregulated supply from which it is derived, since this will be presented to the circuit if the regulator goes short circuit. An unregulated d.c. supply may be capable of supplying a short circuit current of many amps for a few seconds, whereas the regulator may pass only 500mA or 1A typically. The usual arrangement is to provide a suitable fuse prior to the regulator i.c. or circuitry, to reduce the current carrying requirements of the thyristor. The continuous current rating of the thyristor should in any case be



EG1248
Fig. 4. Graph of minimum value of R3 versus positive supply voltage

considerably higher than the fuse rating and the maximum regulated current. Too low a current capability can result in the thyristor breaking down, overheating, or sometimes even causing false tripping of the overvoltage protection i.c. Adequate heatsinking, of course, should be provided. The whole circuit is reset by turning off the supply for a few seconds, then turning it back on again.

OTHER FACILITIES

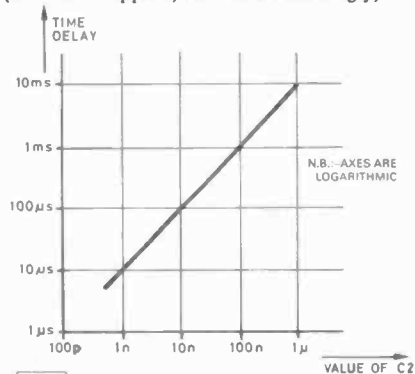
Pin 6 provides a trip indication output. This is an open collector output from a transistor, so it needs a load resistor (R5 in Fig. 2) taken up to a positive supply rail to give an output voltage swing. The transistor turns on inside the i.c. (i.e. pin 6 is switched to 0V) when the i.c. detects an overvoltage condition, and turns off again when the thyristor shorts out the supply rail. Hence, under most circumstances, this output is only a pulse of approximately 1µs which will need suitable extra circuitry to indicate the condition or act on it. (Note that it is pointless feeding it into circuitry which is powered from the same protected supply rail). Pin 5 is a remote input which can be used to activate the i.c. and shut down the power supply. Normally this should be held at 0V, but if raised to above 2V or thereabouts it causes the i.c. to trip, even if there is no actual overvoltage condition present.

Pin 4 is a constant current source which can be used in conjunction with an external capacitor (C2) to provide a time delay facility; see Fig. 3 and Fig. 5. In some applications, short duration spikes or noise on the power supply could cause the protection system to operate, yet may not pose any threat of damage to the particular circuitry used in the rest of the system. A suitable time delay can be provided to ensure that the overvoltage condition must last for a fixed period before being acted upon. The constant current source charges up C2 when pin 2 detects an overvoltage condition. If the voltage on C2 reaches 2.6V, the thyristor is turned on, but if the overvoltage condition is removed before the C2 voltage reaches 2.6V, C2 is discharged (at 10 times the charging rate) and the system carries on as normal.

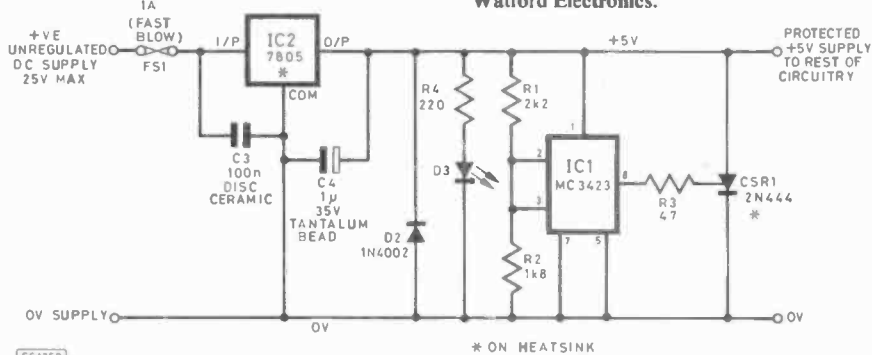
APPLICATIONS CIRCUIT

Fig. 6 shows the circuit diagram of a 5V protected regulator, designed to take an unregulated d.c. supply, and provide a 5V output

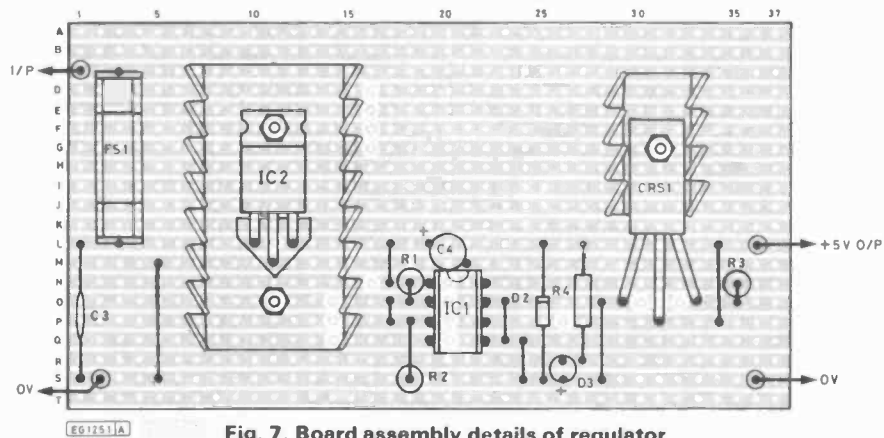
with overvoltage protection, with a current capability of up to 1A depending on the heat-sink provided and the unregulated supply used. The basic regulator circuit is formed by IC2, with C3 and C4 providing decoupling (essential to prevent oscillations) and D2 providing a measure of protection against temporary shorts to negative supply rails. R4 and D3 (which can be any type of l.e.d.) merely give an indication that the supply is operational. R1 and R2 set the trip voltage at approximately 5.8V. (It is wise to leave a few hundred millivolts at least above the nominal regulator voltage to allow for device and component tolerances, noise, etc). R3 is set to 47 ohms, not a short circuit as one may have chosen from Fig. 4, because if IC2 were to go short circuit a much higher voltage could be fed to IC1. With R3 equal to 47 ohms, this unregulated supply can safely be up to 25V d.c. (For other supplies, scale this accordingly).



EG1249
Fig. 5. Graph of value of C2 versus time delay (see Fig. 3)



EG1250
Fig. 6. Circuit of 5 volt protected regulator (D1 and C1 of Fig. 2 are omitted)



EG1251A
Fig. 7. Board assembly details of regulator

The thyristor chosen is a 5A type, which in conjunction with a 1A regulator i.c. and a 1A fast blow fuse gives more than enough protection capability. Large, finned heatsinks should be provided, the largest being for IC2 since that might have to pass short circuit currents for quite long periods with high power dissipation, and silicon grease should be used between the semiconductor device and the heat-sink surface. Beware of letting the heatsinks or their fixing screws short against anything; IC2's heatsink is connected to 0V via IC2 itself, but TR1's connects to its anode (the positive supply rail) so take care. It may be necessary to open up the Veroboard holes a little with a fine drill to take the large leads of TR1; take care not to cut away all the copper track, and make a good solder joint to these leads.

The unregulated supply used should be chosen to suit IC2, i.e. a minimum voltage under load of 8.5V d.c., at 1A or more, but not too large a voltage or IC2 will dissipate too much power, and the amount of regulated supply current available will be small. (The voltage should, in any case, be kept under 25V off load). The final circuit can be tested by shorting IC2's input to its output, which should shut down the supply and blow the fuse, or by connecting a 9V battery across the 5V supply, which will shut down the supply but probably not blow the fuse. (Connect the battery only momentarily, or via a ½A fuse itself). Try not to let the circuit stay shut down for too long as IC2 will get rather hot. Naturally, all voltages given in this circuit can be scaled to suit different supply voltages as required.

The MC 3423 can be obtained from Watford Electronics.

INTRODUCTION TO DIGITAL ELECTRONICS

MICHAEL TOOLEY BA DAVID WHITFIELD MA MSc CEng MIEE

O & A Level Part One

TWENTY-FIVE YEARS ago the use of digital electronics was almost solely confined to computers. At that time only about one thousand machines were completed in the whole year. Since that time, however, the growth of digital electronics has been both continuous and spectacular. Today, one manufacturer alone can produce more hand calculators in one hour than the total number of computers then produced worldwide in a whole year. To underline the rate of advance which has occurred, some of these new calculators now have more computational ability than any of those 1958 computers.

This series aims to provide a practical introduction to the subject of digital electronics. The material that we shall be covering is suitable for students in education, electronics hobbyists, and newcomers with an interest in digital electronics. All that we assume is that the reader has some elementary knowledge of basic electricity (a familiarity with voltage, current and resistance), and an understanding of simple wiring. No mathematical knowledge is required other than the ability to count up to two! Indeed, the most important requirements are a curiosity about the way in which things work, and an interest in building real circuits to solve practical problems.

The series will appear in eight monthly parts, and is supported by practical work on a Logic Tutor to simplify the construction and investigation of digital circuits. Each part of the series will build on the preceding parts, and the pages will be laid out in a constant format to allow them to be collected into a complete reference. Regular data sheets will be used to summarise useful practical information separately to avoid interrupting the flow of material. The basic approach that we will adopt is to introduce each logic element in terms of a small number of basic 'building blocks'. It should be possible to explain each new circuit in terms of these basic elements.

The most important point to make, however, is that this series is all about 'real' digital electronics. The idea is to use logic in practice, and to this end the examples given will involve using real integrated circuits to bridge the gap between theory and practice. It is otherwise all too easy to overlook the differences between 'perfect' paper devices, and the ones that can actually be bought in the shops. This problem usually only shows itself as a circuit which 'should' work, but doesn't.

ELECTRICAL SIGNALS AND INFORMATION

One effect of the continuous advance of semiconductor technology is that electronics are being used in an ever increasing variety of everyday applications. The complex functions of these electronic circuits can, however, easily obscure some of their basic characteristics. As a result, it is not always obvious at first sight that everything which is done in an electrical system involves either manipulating information or doing work, or sometimes a mixture of both. The 'information' in an electronic circuit is in the form of an

electrical signal, while the 'work' done is often some type of mechanical movement. A radio receiver, for example, manipulates information in the broadcast programme which starts as a modulated radio carrier, and ends up as an audio signal; the work done is in making the loudspeaker cone vibrate to transfer the final sound to the listener.

The aim of this series is to investigate a branch of electronics which is devoted to manipulating electrical signals which are being used to represent information. We will start, therefore, by looking at the ways in which electrical signals can be used

to represent information in practical circuits and systems.

ANALOGUE SIGNALS

We usually think of an electrical signal as a voltage which varies in level as time passes, but it can just as easily be a varying current. When this voltage is plotted against time on a graph, the result is known as the waveform of the signal during the time shown by the graph. A waveform which is often encountered in electronics is the sinewave, shown in Fig. 1.1. Examples of signals which have a sinewave shape include the mains electricity, and

the output signal from a microphone being used to record a tuning fork.

A sinewave has a simple and regular waveform which has two peaks at different voltage levels, and which

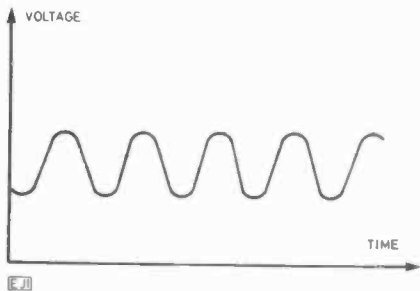


Fig. 1.1. Waveform for a sinewave signal

repeats every cycle. The signal changes smoothly from one peak of voltage to the other peak, and then back again. Other signals, such as those shown in Fig. 1.2, are not as smooth as a sinewave, but they are still of a regular nature. Returning to the tuning fork for a moment, we can see that if we watch

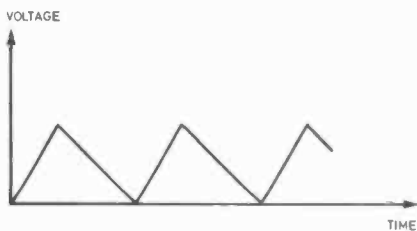


Fig. 1.2. Regular waveforms which are not smooth

the microphone output for a longer time after it is struck, the shape of the signal remains the same but the peaks gradually die away as the sound gets quieter. This is an example of the way in which one waveform may be added to another. There is, however, no reason why the waveform of a signal needs to be regular at all, and Fig. 1.3 shows what the microphone signal might look like if used to record a singing voice, rather than a tuning fork.

Signals with waveforms of the type described above fall into a general category known as analogue signals. The voltage level of an analogue signal typically varies smoothly between two

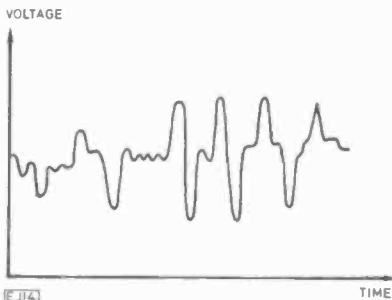


Fig. 1.3. Waveform for a singing voice

extreme limits, though not necessarily always reaching these limits. The variations will not always be regular, however, nor will the changes always be smooth. Circuits which use these types of signals are called analogue circuits, and are widely used in radio, television and audio, as well as in many types of measuring equipment.

DIGITAL SIGNALS

Digital signals are very different in nature to the analogue signals described above. A digital signal does not change its level smoothly, nor does it vary freely over a range of levels. When the voltage level of a digital signal is not rapidly changing, it remains steady at one of only two possible levels, called states. Any changes between these two states occur very rapidly (typically requiring only a small fraction of a microsecond), and are so fast that for practical purposes they occupy an almost negligible time. The two possible states for digital signals are commonly referred to variously as 'low'/'high', 'off'/'on', 'false'/'true' or, most often, simply as '0'/'1'. Conventionally, the two (binary) states in a digital system are defined so that the low/off/false/0 state refers to the lower voltage level, while the high/on/true/1 state refers to the higher voltage level. In this series we will adopt 0 and 1 to refer to the binary logic states since this is the most common and useful definition. The majority of practical digital applications are designed so that 0 is usually represented by a level near zero volts, and 1 by a level slightly below the supply voltage.

A transfer characteristic for a circuit

shows graphically how the output responds to an input signal. The characteristic for a typical digital circuit is shown in Fig. 1.4. The output remains at the 0 level until the input exceeds a

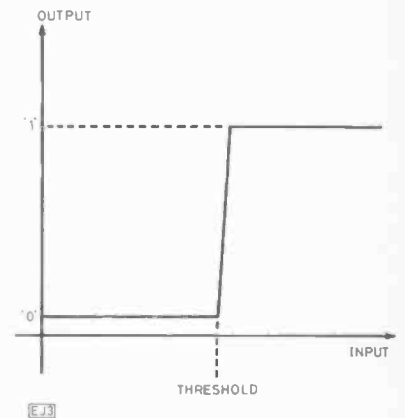


Fig. 1.4. Digital transfer characteristic

certain (threshold) value, at which point the output rapidly changes state from 0 to 1.

ADVANTAGES OF DIGITAL SYSTEMS

One of the attractions of digital systems is that they offer a number of significant advantages over their analogue counterparts. In an analogue system, changes in component values (due to ageing and temperature effects) can have a marked effect on circuit performance, and considerable care must be taken to combat such changes. Applications requiring high precision are particularly troublesome in this respect. Digital systems, however, use switching techniques and are much less susceptible to individual component changes, and they are thus not as prone to the effects of ageing and drift.

Noise and interfering signals can be a significant problem in some analogue circuits, particularly those handling small signals. Digital circuits, on the other hand, can be almost impervious to the effects of noise or interference. This is because, if it is to have any effect, the unwanted signal must have an amplitude which is comparable to the switching threshold of the circuit.

THE PE LOGIC TUTOR

The PE Logic Tutor is introduced on page 26 and a full description of the system, together with constructional details is given there.

The purpose of the PE Logic Tutor is

to allow us to investigate the behaviour of a wide range of practical logic circuits. We will be reviewing the range of facilities provided by the Logic Tutor a little later. For the moment, however, we will direct our attention towards some practical ways of indicating and generating the logic levels to be found in practical digital circuits.

INDICATING LOGIC STATES

We have seen that digital circuits transfer information by using signals which represent the binary states of 0 and 1. The designers of such circuits, while free to choose the actual voltages used to represent these two states, usually choose to keep to the convention of representing 0 by the lower voltage, and 1 by the higher voltage. The majority of today's digital circuits in fact use the same voltage levels for 0 and 1 as those used in the PE Logic Tutor. These levels are such that any voltage below 1 volt is a logic 0, and any voltage above 2.5 volts is a logic 1.

When we investigate how a digital circuit works, it is useful to be able to look at the logic state (0 or 1) at any point. We could use a conventional voltmeter for this purpose, but it becomes rather tedious each time to have to measure the voltage, and then decide whether this represents 0 or 1. A much easier, and quite widely used, alternative is to use some sort of indicator which shows the logic state at a glance. Light emitting diodes (l.e.d.s) are ideally suited to this purpose, and are used extensively in the PE Logic Tutor. The normal convention adopted is that when an l.e.d. is on, this indicates that a logic 1 is present, otherwise the state is a logic 0. The PE Logic Tutor follows this convention for displaying logic states.

Indicators D1 to D4 are each available to show the logic state at any point in a digital circuit. They are used by simply linking a wire between the point under investigation and the appropriate indicator's connector; D1, D2, D3, or D4. A simple demonstration of this technique can be given by using the power supply rails as sources of logic signals. According to our definition above, +5 volts should indicate as a 1, and 0 volts as a 0 when connected to the input of D1 in turn. Therefore when +5 volts (logic 1) is connected, the l.e.d. should be illuminated, whereas when 0 volts (logic 0) is connected, D1 should be extinguished. Repeating this demonstration using the

signals from the sockets labelled 'logic 0' and 'logic 1' (adjacent to i.c. socket A) should produce similar results.

GENERATING LOGIC LEVELS

When investigating the behaviour of a digital circuit, it is useful to be able to produce a known logic level (0 or 1) to apply to the circuit in question. This allows us to see how the circuit responds to different combinations of inputs. As we have seen, the PE Logic Tutor provides us with indicators to show logic states at any point in the circuit. In addition, therefore, four logic level generators, S1 to S4, are provided to complement the indicators. These generators are operated by push-button switches, and allow us to produce logic 0's and 1's as required. Built in to each generator is an l.e.d. to indicate the instantaneous logic state of its output. Operating these switches in turn will show that two of them (S1 and S2) produce a 1 for only as long as the switch is pressed, whereas the other two (S3 and S4), change the output state each time the switch is pressed. These two different types of logic generator will be useful in differing applications, as will be seen in due course.

FIXED LOGIC LEVEL

Sometimes, instead of a variable level, a circuit requires a fixed logic level at one of its inputs. This may possibly be routed via a switch or other external electromechanical device, before being input to a logic circuit. To cater for such requirements, the Logic Tutor provides fixed logic 0 and logic 1 sources. These have no indicator l.e.d.s associated with them since they are each capable of driving over twenty logic inputs. As before, however, indicators D1 to D4 may be used to verify their correct operation in case of any doubt. Wherever possible, it is preferable to use the logic 1 source rather than the +5 volt supply rail since this will minimise the effects of accidentally shorting the supply to the 0 volt rail. Even though the power supply is protected, a short circuit could still upset the logic states established in a circuit.

I.C. LOGIC FAMILIES

As we have mentioned, computers were the majority users of digital circuits during the 1950's. Since then, however, digital techniques have been applied to the solution of an ever wider

range of problems. One of the major reasons for this expansion has undoubtedly been the rapid advances in semiconductor manufacturing technology during the same period. Indeed, we are now seeing the introduction of some advanced circuits which manipulate analogue signals by first converting them into equivalent digital signals, processing them using digital techniques, and then converting back to an analogue signal at the output. This, however, is running ahead of the present series, in which we aim to provide an introduction to the underlying principles of digital logic circuits.

The computers of the 1950's used assemblies of discrete semiconductor devices (transistors and diodes) and passive components. Often the basic circuits were repeated many times over in a single unit, and as a result, the development of the integrated circuit (i.c.) in the late 1950's led quickly to the introduction of digital i.c.s. Initially, these i.c.s were simply subcircuits (known as 'gates'), comprising a few transistors, diodes and resistors in a single semiconductor 'chip'; capacitors were (and still are) rarely included due to the difficulty of fabrication. As the technique developed, a number of 'standard' gates came into common use, and these were subsequently interconnected in a single chip to produce more complex digital circuits. This increase in complexity has continued to the present day, to the point where a modern microprocessor i.c. may have the equivalent of over 20,000 basic gates in a single chip.

STANDARD LOGIC FAMILIES

As part of the development of digital i.c.s, a number of standard ranges have been introduced. The importance of the concept of standard logic families cannot be over-stated. The basic gate in each range gives the name to the complete family of devices, and determines the operational characteristics of all devices in the family. In this way, the designer is freed from the problem of checking that the logic levels between gates are compatible; the logic levels, power supply requirements, and general rules are common to all i.c.s in a logic family. This then allows the designer to concentrate on the design of the function of his circuit, and greatly simplifies his overall task once the basic 'rules' for that family are understood.

Over the years a number of different

logic i.c. families have been available, but many have now virtually dropped out of use. The main families to have emerged are as follow:—

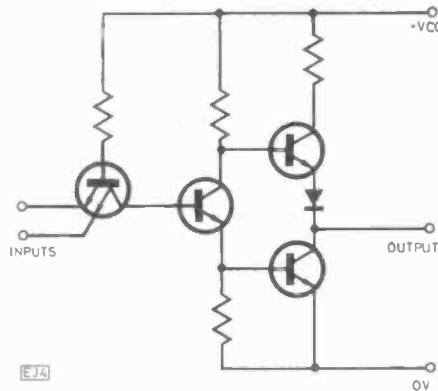
- (a) DTL = Diode-Transistor Logic
- (b) TRL = Transistor-Resistor Logic
- (c) RTL = Resistor-Transistor Logic
- (d) DCTL = Direct-Coupled-Transistor Logic
- (e) RCTL = Resistor-Capacitor-Transistor Logic
- (f) TTL = Transistor-Transistor Logic
- (g) TSL = Tri-State Logic (a type of TTL)
- (h) ECL = Emitter-Coupled Logic
- (i) CMOS = Complementary MOS logic
- (j) PMOS = P-channel MOS logic
- (k) NMOS = N-channel MOS logic

Each logic family listed above has its own special characteristics which may make it more appropriate for particular applications, e.g. ECL is very fast, but requires considerable power. In current practice, however, the families which are most commonly used are TTL, TSL and CMOS; ECL is also frequently used where the highest speed is required. Without doubt, however, it is the TTL family in its various forms which is the logic family in widest use, and we have therefore restricted practical discussions in the majority of this series (parts one to seven) to TTL, with part eight providing coverage of CMOS.

At this point we should, however, stress that the theory of digital logic is the same for all logic families. The differences between the various families are confined to the practical aspects of building circuits, e.g. the power supplies required, the logic levels, etc. A clear understanding of the theory of logic circuits, therefore, can rapidly be applied to any logic family by simple reference to the electrical specifications and the operating 'rules'.

THE 7400 TTL SERIES

TTL is a form of logic which has gained a very high degree of acceptance. The internal circuit for a basic TTL gate is shown in Fig. 1.5: note the distinctive multi-emitter transistor associated with the input stage of the gate. We do not actually need to un-



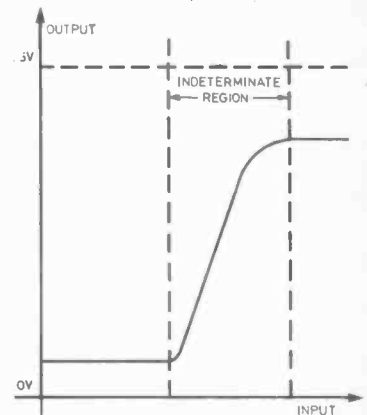
EJ4

Fig. 1.5. Internal circuit for a basic TTL gate

derstand the details of this circuit in order to be able to use it, but it is an indication of the size of circuit which would be involved if i.c.s were not available. The commonest TTL family is known as the '7400 Series'. Each i.c. in the 7400 series has a type number of 4 or 5 digits, always starting with '74', e.g. 7404, 74123. Different manufacturers add various letters before and after the basic number, e.g. SN7400N, but i.c.s of the same number will always have the same function, whoever the manufacturer. The range of TTL i.c.s which is available is considerable, with many manufacturers offering hundreds of different types.

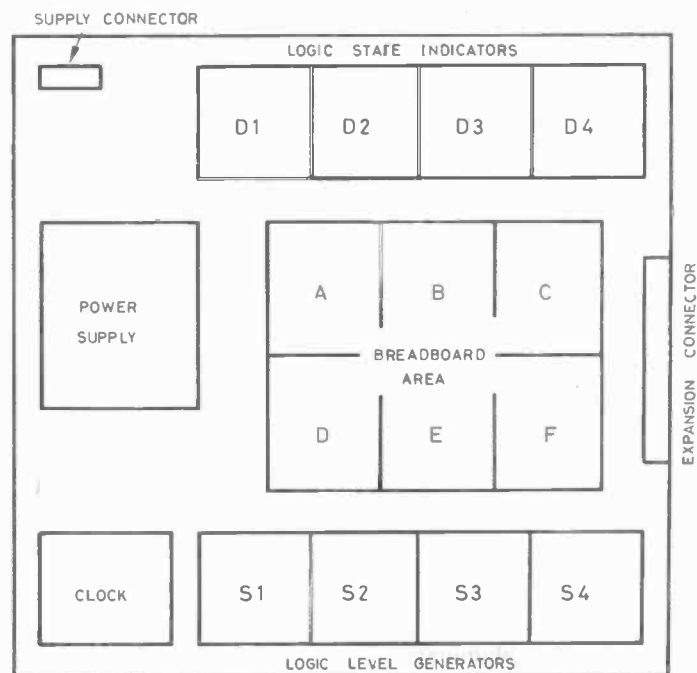
The basic transfer characteristic for

TTL is shown in Fig. 1.6. As we can see, there is a range of input voltage which will produce an indeterminate output level. This means that the output for an input in this range cannot be predicted in terms of logic level. Although possibly surprising, this is quite common in digital logic circuits, and does not destroy the theory. A logic 0 is defined in TTL as a level of less than 0.8 volts, while a logic 1 is a level greater than 2.4 volts. The indeterminate outputs therefore correspond to illegal input levels! We shall return to consider the other characteristics of TTL at a later stage, but for the moment the only other information



EJ5

Fig. 1.6 Transfer characteristic for TTL



EJ6

Fig. 1.7. Main features of the PE Logic Tutor

we require is that the supply voltage for TTL is +5 volts.

The basic characteristics of the TTL 7400 Series are summarised in the data sheets which accompany this series. Further details are available from manufacturers' data books.

PE LOGIC TUTOR SUMMARY

The aim of the PE Logic Tutor is to allow the user to construct and investigate the behaviour of a wide range of i.c. logic circuits. The main elements of the Logic Tutor, are summarised in Fig. 1.7. The items of significant interest are as follows:—

- (a) A regulated and protected power supply which provides supply rails at +5 volts and 0 volts
- (b) A breadboarding area which can accommodate up to six 14-pin or 16-pin dual-in-line i.c.s
- (c) Four logic state indicators incorporating i.e.d.s
- (d) Four switch-controlled logic level generators; two of these have a momentary action, while the other two have a latching action
- (e) A low frequency square wave signal generator which provides a logic-compatible clock at approximately 1Hz

In order to cater for developing and investigating the behaviour of more complex circuits than can be built in the existing breadboarding area, a 10-way expansion connector is also provided. This allows the connection of external circuitry and, with the aid of a supplementary circuit board, also provides a way of increasing the breadboarding area.

The power supply to drive the board may be either an a.c. or d.c. source of between 8 and 12 volts, with a typical supply current of around 150 to 200mA. This type of supply is usually readily available in most laboratories and workshops. Just as suitable, however, is a simple a.c. mains 9V adaptor of the type used with many calculators and cassette recorders.

The use of the Logic Tutor provides a means of reinforcing the subjects covered in this series. The object is to supply examples every month which allow practical investigations to be undertaken, in order to provide the essential 'hands-on' experience. The examples have been carefully designed to complement the subjects discussed, and to develop a familiarity with the use of digital logic techniques. Even

when the series has been followed through, the Logic Tutor will still be useful as a development tool in its own right.

THE BUFFER

We have already mentioned the fact that there is an almost bewildering array of digital 'building blocks' available to today's logic designer. The simplest of all active logic elements is without doubt the logic buffer. This has only one input and one output, and the logical state of its output is a direct copy of the logic state at its input. Hence an output of 0 is produced whenever the input is 0, and a 1 is produced for an input of 1. Since no apparent logical operation has been performed by the buffer, it may at first sight seem to be a rather strange element to want to include in any logic circuit. There are, however, a number of situations in which a buffer can be quite invaluable.

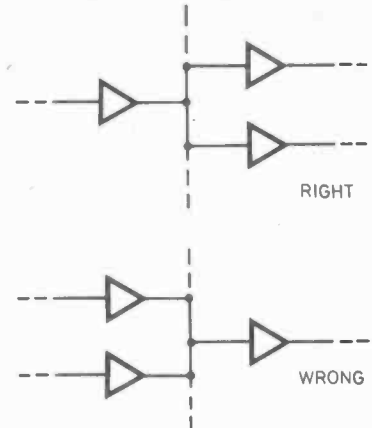
The first point to note is that the description given above refers only to the voltage levels at the input and output of the buffer. The current flowing at the output of a buffer, however, can be much greater than the current at its input, even though the logic levels (in terms of the input and output voltages) remain essentially the same. Hence a buffer is said to exhibit 'current gain', which is a consequence of its internal circuitry. In this way, buffers can be used to interface a logic system to circuitry which demands so much current that the logic levels could not be maintained within their limits if other types of logic elements were used instead. Similarly, it is often possible to connect more logic elements to the output of a buffer than is possible with other types; the buffer preserves the logic state of the signal, but increases the current 'drive' which is available.

Finally, buffers may be used to regularise and standardise the input signals, in terms of logic levels, that are presented to, or taken from, a logic circuit.

When drawing logic circuits, the symbol used to represent a buffer is shown in Fig. 1.8. In logic diagrams it is normal to show the input on the left hand side, and the output on the right. Thus, in most logic circuits, the 'progress' of a logic signal is usually



Fig 1.8. Logic symbol for a buffer



EJ7

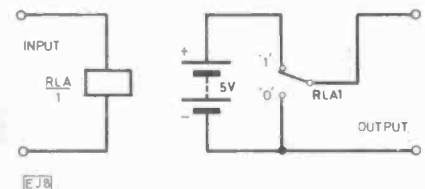
Fig. 1.9. Connecting buffers together

from left to right across the page. At this juncture, it is worth illustrating these points by introducing the first of the rules which must be observed when connecting logic elements together. A single output may be connected to a number of different inputs, but each may normally only be taken from one output (i.e. you may not connect several outputs together and expect the circuit to behave properly!). We shall return to discuss this point in greater detail later on, but for the moment this important rule is summarised in Fig. 1.9.

THE INVERTER

An inverter, or inverting buffer as it is sometimes known, is a logic element which is like a buffer in that it has only one input and one output. Inverters are used to generate the logical opposite, or complement, of a logic signal. In order to understand this definition, however, we must first explain that the complement (or inverse) of 1 is 0, and the complement of 0 is 1. Hence, when the input of an inverter is 0, its output will be 1; similarly, when the input is 1, the output will be 0.

The action of an inverter can be illustrated by looking at the simple relay circuit shown in Fig. 1.10. When the



EJ8

Fig. 1.10. Relay analogy for inverter operation

logical input is at a 0 level, no current flows in the relay coil and the contacts remain in the state shown, producing an output level of 1. When the logical input is a 1, current flows in the relay coil, the contacts change over, and a 0 is produced at the output. The relay thus inverts the logical signal so that an input of 0 becomes an output of 1, and vice versa. The relay in this example is in effect acting as an electromechanical inverter.



Fig. 1.11a. Symbol for an inverter

The symbol for an inverter is shown in Fig. 1.11a. Note that this is almost the same symbol as we used earlier for the buffer; the small circle on the output, however, shows that the signal has been complemented. In effect, the circle indicates that the output of the logic element to which it is attached is inverted. Thus the symbol for the inverter is made up of that for a buffer, with the addition of a circle to show that the buffer output is inverted. Hence the inverter is sometimes referred to as an inverting buffer.

Inverters can, if required, be made to function as buffers, and because of this flexibility they are often used in preference to simple buffers. Connecting two inverters in series will produce an output from the second which is at the same logic level as the input to the first. The first inverter complements the input (e.g. changes 1 to 0), while the second complements it back again (e.g. 0 back to 1). The overall effect, illustrated in Fig. 1.11, is



Fig. 1.11b. Action of two series connected inverters

that of a buffer. We shall return to this point again later, but for now we shall proceed with a practical investigation of the behaviour of the inverter. As this is the 'first use' of the PE Logic Tutor, the example will be covered in somewhat greater detail than will be given in subsequent practical exercises.

7404 INVERTER CIRCUITS

The 7404 consists of six individual inverters in a single 14-pin dual-in-line

package. The pin connections and internal logic arrangement for the i.c. are shown in Fig. 1.12. When identifying

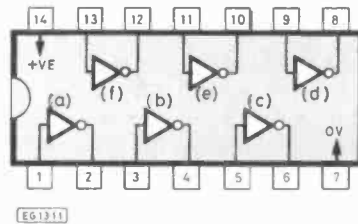


Fig. 1.12. Pin connections and internal logic for the 7404

the pins, view the i.c. from above (i.e. with the pins pointing downwards). The notch on the package is then between pins 1 and 14, and with the notch on the left, the pins are numbered anti-clockwise starting with 1 in the bottom left corner. In a few cases there will be no notch on the i.c. package, but instead there will be a round indentation on the top of the package next to pin 1. The power supply connections for 0 volts and +5 volts are at pins 7 and 14, respectively. It is worth pointing out that the six inverters in a 7404 are all electrically identical, although they are usually labelled (a) to (f) for convenience of identification in circuit diagrams.

A 7404 should be carefully inserted into the dual-in-line socket marked 'A' on the Logic Tutor. It may be necessary to pre-form the i.c. leads so that both rows of pins will fit into the socket, or an i.c. insertion tool may be used instead. Care should, in any event, be taken to ensure that the chip is orientated with pin 1 in position A1; this will then mean that pin 14 will be in position A16; the notch should be between A1 and A16. As a final check before proceeding, it is worth verifying that all of the i.c. pins are correctly inserted in the socket, and that none have been bent under during the installation.

The first test circuit to be set up is shown schematically in Fig. 1.13, and uses the (a) inverter. The diagram here includes the connections to the power supply, as well as the logic intercon-

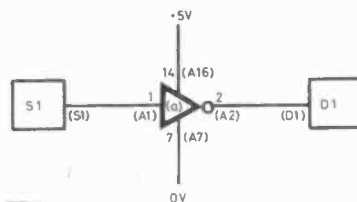


Fig. 1.13. Single inverter test circuit

nections. In normal practice, however, these power supply links are omitted from circuit diagrams since it is assumed that every i.c. will be connected to the +5 volt and 0 volt rails at the appropriate pins. The resulting diagram otherwise becomes very confusing. It is recommended that the circuit is wired up with the power supply to the Logic Tutor switched off. Link the positive supply to pin 14 of the i.c. by connecting a wire from any +5V point to A16. Similarly the 0V rail is connected to i.c. pin 7 by a wire between any 0V point and A7. The input to the inverter (at i.c. pin 1) is connected to the logic level generator by a wire between S1 and A1. The output from the inverter (at i.c. pin 2) is connected to the logic state indicator using a link between A2 and D1. To re-cap, there should be a total of four links on the board, connected as follows:—

- S1 to A1 (input to inverter)
- A2 to D1 (output from inverter)
- A7 to 0V (ground)
- A16 to +5V (positive supply)

When the power supply to the Logic Tutor is connected, the output of S1 will be a 0 (shown by the associated l.e.d.), and the output of the inverter (shown by D1) should represent a 1. Pressing S1 will cause it to generate an output of 1, and the output of the inverter should now change to a 0, i.e. D1 should now be extinguished. Releasing S1 should cause the output of the inverter to resume its original state, i.e. 0.

Readers may wish to verify that the same behaviour is obtained from the other inverters in the 7404; the necessary pin connections may be taken from Fig. 1.12.

Keeping the circuit already set up, we can now extend it to demonstrate the result of cascading two inverters to produce the buffer action mentioned earlier. The two inverter circuit shown

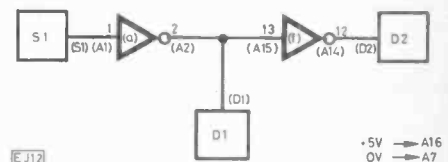


Fig. 1.14. Double inverter test circuit

in Fig. 1.14 uses the (a) and (f) inverters from our 7404, though any pair may be used. This circuit is set up on the Logic Tutor using the following links:—

S1 to A1
A2 to D1
A7 to 0V
A16 to +5V

As for previous circuit

A2 to A15 (connect O/P of (a) to I/P of (f))

A14 to D2 (O/P of (f) to D2)

When this circuit has been set up, D1 should normally be on and D2 off. Pressing S1 should cause this to swap over so that D1 is off and D2 is on; D2

should always be in the same state as the l.e.d. associated with S1.

The final circuit is left as an exercise for the readers, and uses all six inverters in the 7404. The idea is to prove that replacing EACH inverter in the circuit above with THREE inverters in series (i.e. output of first to input of second, and output of second to input of third), and using the input of the first and the output of the third, will give a circuit which behaves in the same way

as the one last investigated. Thus if we have connected up the inverters in the sequence a-b-c-d-e-f, then connecting S1 to A1, D1 to A6/A11, and D2 to A14 will produce an equivalent circuit from a logical point of view. In effect, the whole i.c. has been set up to behave as a single buffer made up of six inverters!

NEXT MONTH: Logic gates, truth tables and fan-outs.

INTRODUCTION TO DIGITAL ELECTRONICS FURTHER READING

The following books are available from the Modern Book Company, 15-21 Praed Street, London W2 1NP. The complete set, excluding Volume 2 of the TTL Data Book, is priced at £32.50 post free. Please note however p&p is an extra 15% if individual books are ordered.

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This is one of the TEC series, and is aimed at the half-unit in Digital Techniques. It aims to develop an understanding of binary arithmetic, Boolean Algebra, and logic circuits. The book follows a nicely logical sequence covering digital signals, binary counting, gates, truth tables, and Boolean Algebra. The treatment of logic goes as far as discussing sequential circuits, and Boolean Algebra is introduced, without being greatly developed. Each chapter starts with a brief outline of its objectives, and includes useful (but unobtrusive) summaries and exercises. A final test is included to revise the main chapter topics. The subjects are covered without reference to any particular logic devices.

Ian Sinclair
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UNDERSTANDING DIGITAL ELECTRONICS

This is another in the excellent TI 'Understanding Series'. This one provides a self-teaching course on digital circuits, arranged in the form of a question and answer text. It covers digital components, logic systems, memories, and even looks briefly at computer hardware and software. The book is copiously illustrated, and as with the other books in the series, adopts an informal and essentially non-mathematical approach. Each of the ten chapters concludes with a quiz (answers provided), and the book contains a comprehensive glossary of terms.

Gene McWhorter
Texas Instruments
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Ian Sinclair
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THE TTL DATA BOOK

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Space Watch...

A COMPANION FOR UKIRT

The soil of Mauna Kea, on Hawaii, has been disturbed again. The work was begun at an official ceremony on the 14,000 ft high mountain early in June. A budget of 1.5 million pounds per annum is to be shared between the Science and Engineering Research Council (SERC) and the Nederlandse Organisatie voor Zuiver-Wetenschappelijk Onderzoek (ZWO). The capital cost of the project will be £7M, in the ratio of 80% from the United Kingdom and 20% from Holland. The telescope should be completed by 1986. It will be remotely controlled like UKIRT but cover a different part of the spectrum.

The view on the Universe is to some extent dependent on the atmosphere. There are as it were various windows through which the astronomer may examine the surrounding scene. Thus at certain frequencies there must be a window which is transparent to those frequencies. Also the clouds of gas and dust that lie between the stars and the Earth are the source of most of the radiation which is under study in this area. The frequency is between a few millimetres and a third of a millimetre.

There were a number of reasons why this area was relatively poorly developed by astronomers. The three main ones were—the lack of receivers which were sensitive enough, the signals being absorbed by water-vapour before reaching the telescopes and the problem of making large instruments with sufficiently accurate reflecting surfaces.

Detectors using elements as small as one micron square and cooled to a few degrees above absolute zero have been developed now to satisfy the first difficulty. The second problem has also been overcome to a large extent now that the University of Hawaii has an observatory at such high altitude. The new telescope will be 15 metres in diameter and will overcome the third problem. To be capable of efficient operation the reflecting telescope used must have a surface accuracy of a small fraction of the wavelength of the radiation to be received. The surface of the 15 metre bowl must not deviate from paraboloid by more than 50 microns, including the effects of gravitation when the bowl is tilted or as the temperature changes. To protect it from the weather and from Solar Radiation it will have a co-rotating enclosure which will turn with the telescope. This will have a window covered

with a special membrane which is transparent to the wavelengths required but which will reflect much of the sunlight which falls upon it. This also helps to control the temperature gradients that will be encountered in the environment.

The paraboloid surface of the telescope will be made up of 276 panels mounted on a steel frame designed for the minimal and also predictable distortion under gravity as the elevation angle is changed. The panels are of lightweight construction consisting of an aluminium honeycomb covered with thin skins of aluminium sheet. Each is supported on three mounts which can be adjusted remotely. The measurement of this surface is very difficult and a sophisticated machine which incorporates a laser interferometer is being developed to deal with this problem. The mount of the telescope is of the Alt-Azimuth type with motor drives and friction contact with the tracks.

The optical design is that of the folded Cassegrain type with a 75cm diameter secondary mirror to focus the radiation on to one of a number of receivers via a third mirror mounted behind the primary. By mounting a number of receivers simultaneously, each set at a particular frequency or range of frequencies, it will be possible to optimise the use of the telescope and observe at the highest frequencies when the transparency of the atmosphere permits.

Although the telescope has been sited at the highest major observatory in the world, thus providing outstanding conditions for sub-millimetre wavelength observations, the conditions do vary both seasonally and on a much shorter time-scale. Substantial testing of the site has been carried out and the atmospheric conditions are being continuously monitored to assist in the planning of future programmes.

THE ECLIPSE FROM JAVA

As is usual at the time of an eclipse the most suitable observation point is the subject of an invasion of scientists both professional and amateur to catch the very fleeting moments of this event. This time the site was at Surabaya, East Java. It is a remarkable thing that observing such occurrences in various parts of the world reveals details of the diversity of mankind in its daily life and worship. In Surabaya the populace remained indoors so that they could pray to be free of blindness from the visitation of a power to black out the Sun.

There is quite an amount of lore in Java connected with the eclipse. Though there are some eighteen eclipses each year they occur mainly in inaccessible places or at sea. It is therefore not possible to do much more than just watch the eclipse itself. On this occasion it was possible to measure the shadow of the eclipse. A very accurate measure of this was the task of a team from New Scientist and University College, London. The standard semi-diameter of the sun is 959.63 arc-seconds.

Normally to check this figure it is necessary to ensure that there is a facility for doing this. Observers were stationed at suitable positions and the measurements averaged. From this the team were able to say that for 1983 the diameter of the Sun was smaller than the stan-

dard figure. Their measurements gave a figure for the polar radius as 0.34 arc-seconds less than the standard figure.

SATELLITE TDRSS-A

It took 39 steps to put this satellite into correct orbit. From this experience a ten years functioning period of thruster operation was accomplished. Thus necessity provided a bonus while doing an essential task. This satellite was the first of four in the planned Tracking and Data Relaying Satellite System. Stabilisation was obtained for a very elongated elliptical orbit after the upper stage failed following deployment by the Shuttle. For a time it was thought that it would have to be abandoned. But the ground controllers decided on rescue. They were eventually faced with the onerous task of getting it into the correct orbit. This task was completed after several weeks of painstaking effort. They used the attitude thrusters to slowly put the satellite into orbit. The thrusters finally succeeded at the 39th burn which itself took 5 min. 48 sec.

During this positioning some 817 lb of Hydrazine was sacrificed to the repositioning. For its original task it is now left with only 500 lb of fuel. However it has been worked out that to do its normal task the thrusters would need only 200 lb. This would leave enough for emergencies. It was fortunate as it turned out that a cancelled experiment allowed an excess of Hydrazine to accrue. It is expected that TDRSS will be ready for testing on the 8th shuttle mission and for operational purposes on the 9th mission.

The special bonus of this emergency operation was the fact that the thrusters had some 817 lb of fuel through them during the period of orbit correction. These thrusters are about the size of a thimble and have had what is the equivalent to ten years of working life during the sixty days of this emergency use.

EUROPEAN SPACE AGENCY

EXOSAT, the X-ray Observatory Satellite, has already sent detailed information on the location, spectral and temporal characteristics of cosmic X-ray emission sources. The satellite was launched from the Vandenberg site in May last.

On-board experiments include two imaging telescopes to collect information on cosmic X-ray sources in the 0.04–2 keV electron volts range. X-rays in this part of the electromagnetic spectrum have a wavelength 1,000 times shorter than the eyes are able to see. Imaging telescopes for low energy sources such as remnants from supernova stars are also included. A colour catalogue of extra galactic X-ray sources and studies of the time variations associated with X-ray sources which vary between milliseconds and days will be made. It would in fact take a complete *Spacewatch* to cover the tasks which are set. This is really an extension of the work of new discoveries made by the Cos-B satellite of the European Space Agency.

Frank W. Hyde

LOGIC ANALYSER

Part Three
D. MANDELZWEIG MSc Eng

LAST MONTH, construction of the basic unit was described. This month the circuit description and construction details of both the display options are given. At least one option must be fitted to the basic unit; however, fitting both options vastly increases the versatility of the instrument.

SCOPE OPTION

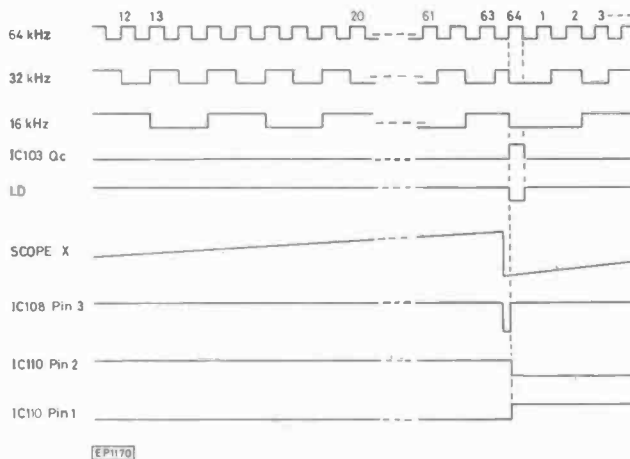
This option allows stored data to be displayed as timing diagrams on an ordinary dual trace oscilloscope. The oscilloscope must have X—Y capability. The option displays eight traces, one trace per data line, and each trace displays 16, 32 or 64 bits, depending on the EXPAND function. The circuit has been designed for oscilloscope displays with a minimum of 1cm square graticule markings. Smaller sized displays may impair readability of the displayed data.

THEORY

Eight traces are displayed on the oscilloscope in the following manner. A repetitive ramp waveform is applied to the X input of the oscilloscope, causing the beam to move across the display. Eight d.c. levels, equally spaced and in decreasing value, are in turn applied to the d.c.-coupled Y input of the oscilloscope, each for the duration of a single sweep. If the sweep repetition rate is fast enough, then the eye will see eight traces on the screen. When an analogue (or digital) signal is superimposed on the d.c. level, then eight traces of data can be seen. Remember though, that each trace follows sequentially the one preceding it and therefore eight real-time data signals cannot be displayed in parallel. Since the analyser is displaying stored data, this is of no concern to us. What happens is that a multiplexer applies a d.c. shifted signal with the D \emptyset bus one superimposed on it to the oscilloscope. The RAM is clocked for 16, 32 or 64 clock cycles, during which the trace is moving across the screen. This causes the D \emptyset contents of 16, 32 or 64 memory locations to be displayed as a waveform of ones and zeros. At the end of the trace, D1 is connected through, and the memory is again cycled through the same locations. Thus the data bits of D1 are displayed directly under the corresponding bits of D \emptyset . All eight data lines are therefore displayed and then the whole sequence repeats itself. In this manner a display of 16, 32 or 64 bytes of 8-bit data is built up. A timing diagram is shown in Fig. 3.1.

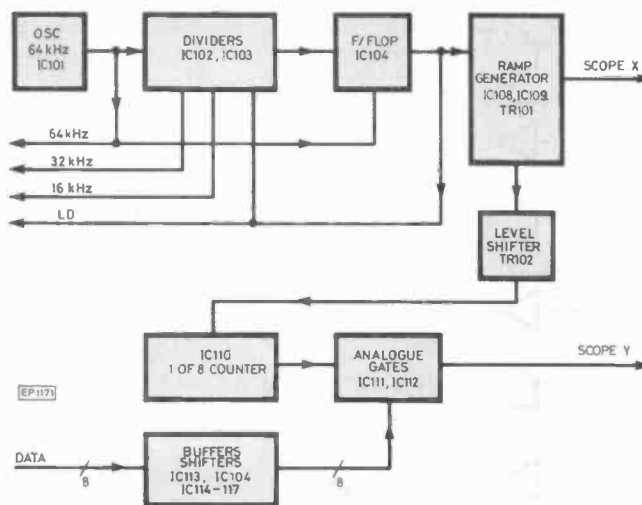
CIRCUIT DESCRIPTION

Refer to the block diagram and circuit diagram, Figs. 3.2 and 3.3 respectively. IC101 is configured as an oscillator running at 64kHz. The output is fed to IC102, IC105b and S20c via buffers IC105a & d. IC102 and IC103 are binary counters, used as dividers. The frequency at QA of IC102 is 32kHz and QB is 16kHz. These outputs are also taken to S20 and depending on the switch position, one is applied to the RAM counter circuitry on the main p.c.b. Output QC of



EP1170

Fig. 3.1. Oscilloscope option timing diagram



EP1171

Fig. 3.2. Scope option block diagram

IC103 is 1/64th of the input frequency, i.e. 1kHz. When QC goes high, IC104d goes low, albeit for a very short time, as the 64kHz clock resets the flip flop via IC105b. This short duration negative going pulse reloads the counters so that they count from zero again, triggers IC108 and provides the LD pulse used on the main p.c.b. for reloading the RAM base address (refer to part 1) and for the HEX display option (see below). Because these pulses are 1ms apart and are derived

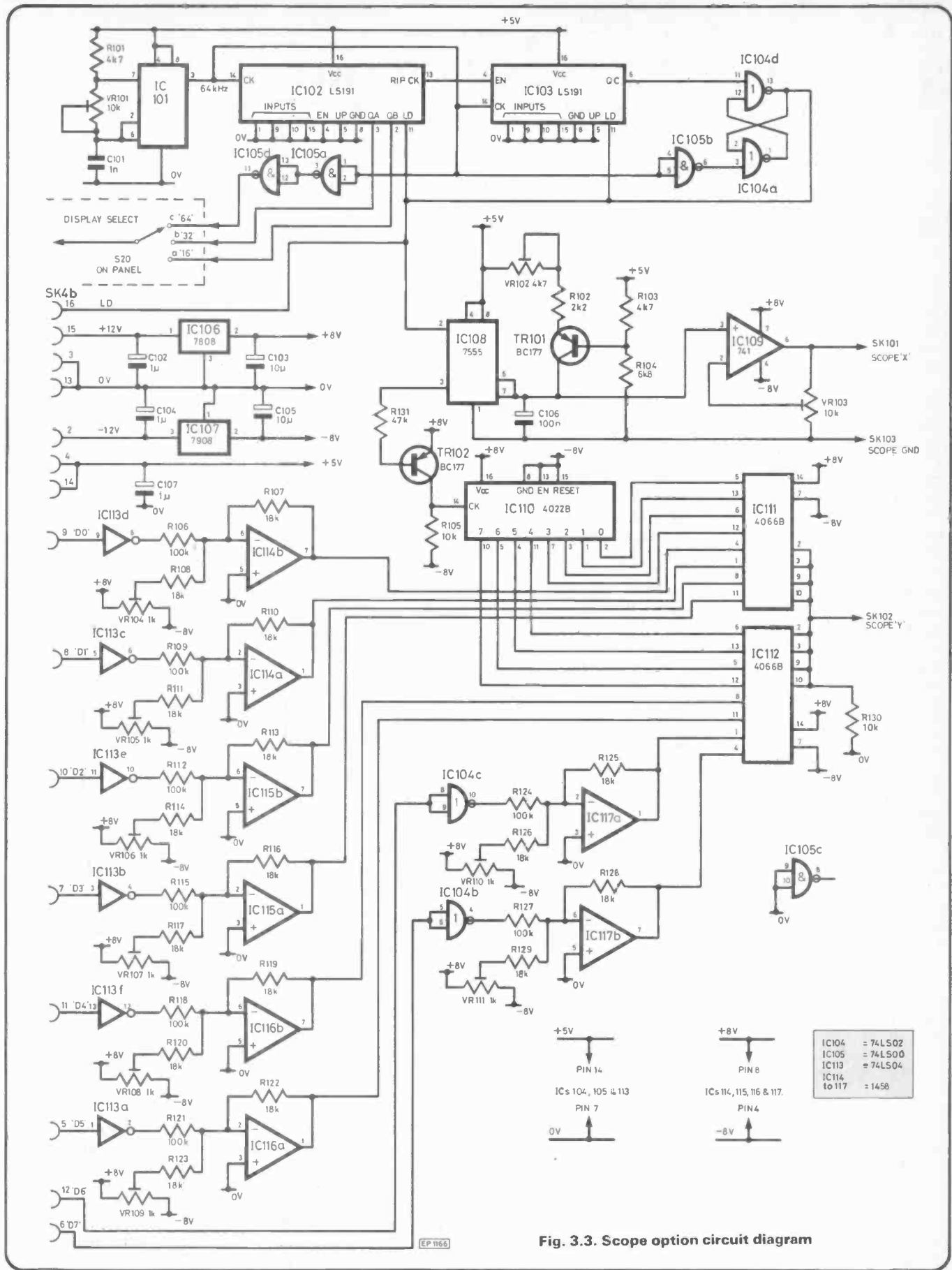


Fig. 3.3. Scope option circuit diagram

from the 64kHz clock, the RAM address counters increment 64, 32 or 16 times between the pulses, corresponding to the expand function allowing 64, 32 or 16 bytes to be displayed. IC108 is configured as a monostable, with its timing capacitor being charged via a constant current generator formed by TR101, VR102 and R102-R104. When IC108 is triggered, a ramp waveform is generated at the junction of TR101 and C106. The timing components have been chosen (and can be adjusted with VR102) such that the period of the ramp is just less than 1ms. The ramp is buffered and amplified by IC109, the output of which drives the X channel of the oscilloscope. VR103 is used to adjust the ramp amplitude and thus the width of the sweep on the display. With the ramp period slightly under 1ms and the ramp start tied to the 64kHz clock, the ramp is just long enough for the 64, 32 or 16 clock pulses to be completed before the next LD pulse is generated. TR102 level-shifts the square wave output of IC108 (period 1ms) to a level compatible with the dual supply rails used on the CMOS i.c.'s. IC110 is a 1-of-8 counter, each output goes sequentially high with every clock pulse. The outputs of IC110 control the analogue gates in IC's 111 and 112 with the result that every 1ms (equivalent to the ramp length, or a set of 64, 32 or 16 clock pulses) the outputs of IC's 114 to 117 are gated sequentially for 1ms to R130. R130 is in turn connected to the Y input of the oscilloscope. In other words, the 8 outputs are switched in turn for 1ms to the Y oscilloscope input. The data bus is buffered by IC113 and IC104b & c and applied to the op-amp IC's 114-117. The associated resistors (for example R106 and R107) are chosen such that the gain of the op-amp is 0.18. Multiplied by 5V, the output is 0.9V and with the oscilloscope Y input set to 1V/div, the waveform sits nicely within the graticule squares. Summed with the input signals are d.c. levels, adjusted by VR104-VR111. The gain of the d.c. level is 1 and therefore the signals fed to IC111 and IC112 consist of 0.9V amplitude waveforms superim-

posed on d.c. levels which can be adjusted from approximately -7V to +7V. These presets enable the traces to be correctly spaced on the oscilloscope screen.

CONSTRUCTION

Construction procedures follow closely those of the main p.c.b.—Soldercon sockets, followed by components and then the through-hole connections. Refer to Fig. 3.6. Fit the i.c.'s in place, then check for solder splashes and correct component orientation. Use Veropins for the connections to S20 and SK101, SK102 and SK103. If you intend fitting the HEX display option at this stage, complete it first, as it is fitted below the oscilloscope option. (If the HEX option is only to be fitted at a later stage, it will be no problem to lift the oscilloscope option board and place the new option board in between. It is therefore not essential to fit both options now.) The display option board(s) are mounted on stand-offs, between SK6 and SK8 on the main p.c.b. Wire the board to the front panel (i.e. S20 and SK101-103).

SETTING UP

With a frequency counter or an oscilloscope connected to pin 3 of IC101, adjust VR101 for an output of approximately 64kHz. Then connect up the oscilloscope with X input set to 0.5V/div. and the Y input to 1V/div. Apply a clock to the analyser, let the data inputs float high, ARM the analyser and store the high inputs. Adjust VR104-VR111 so that the traces are in order from the top of the screen downwards and that the traces are just under their respective upper graticule lines (i.e. indicating a high). Note that the presets are *not* in order on the p.c.b. (the author wasted an hour trying to figure out why the scope data did not agree with the HEX data, and all because the traces were adjusted in the wrong order!). Adjust VR103 so that the length of the traces just fit in the graticule area. Connect up (on protoboard or vero-board) the test circuit in Fig. 3.7 and store the data.

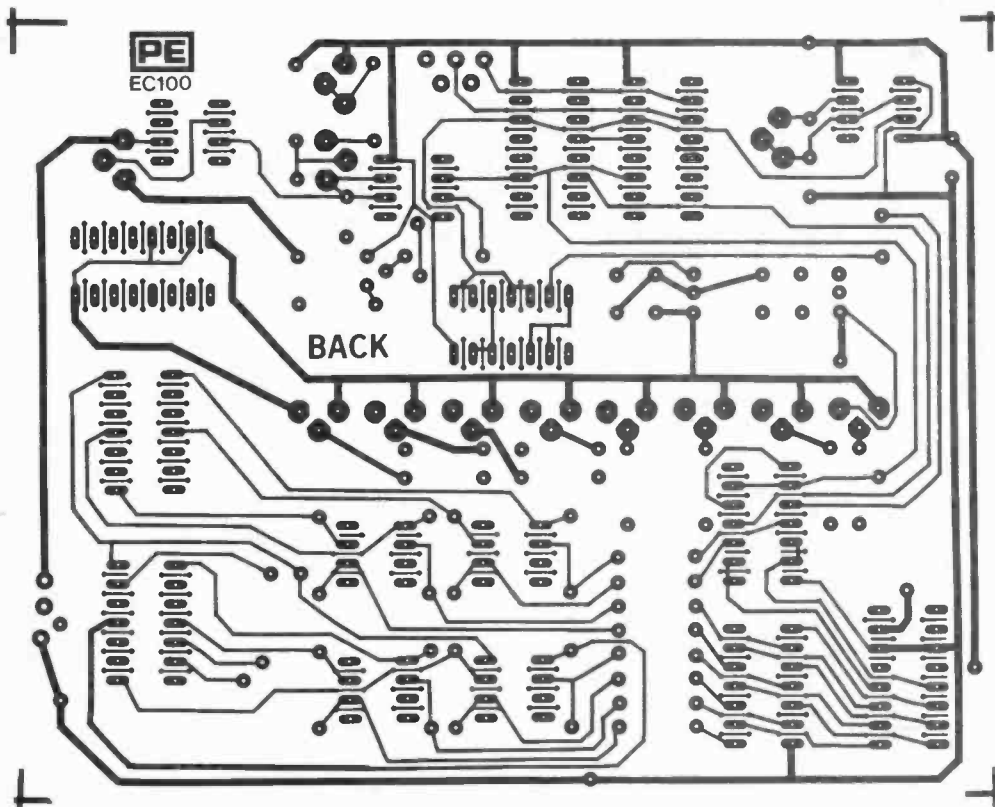
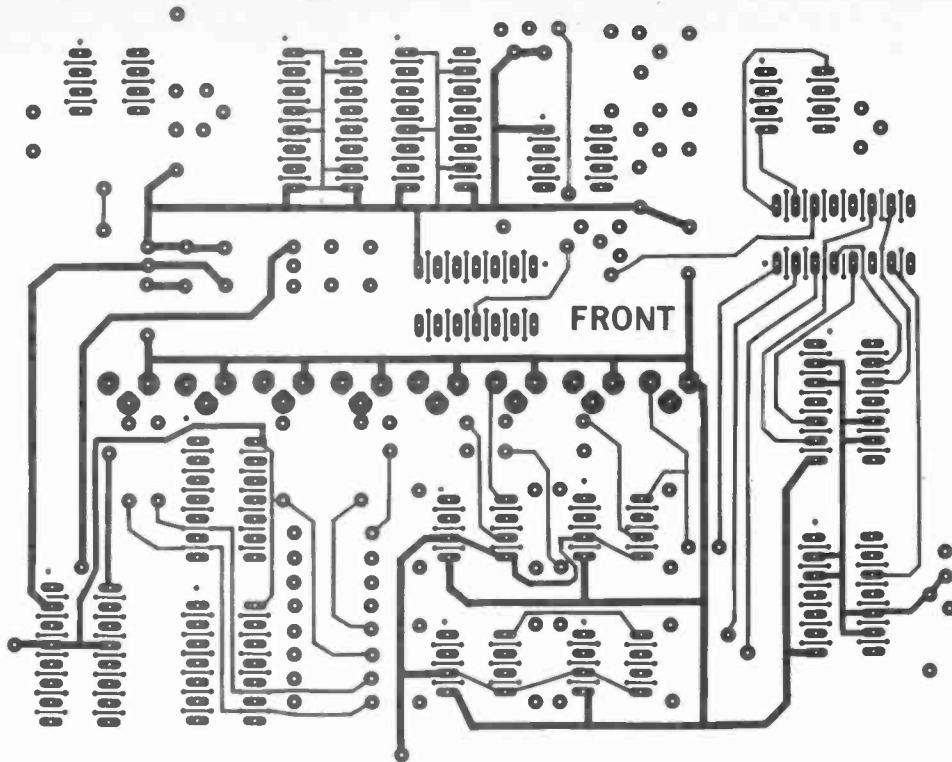
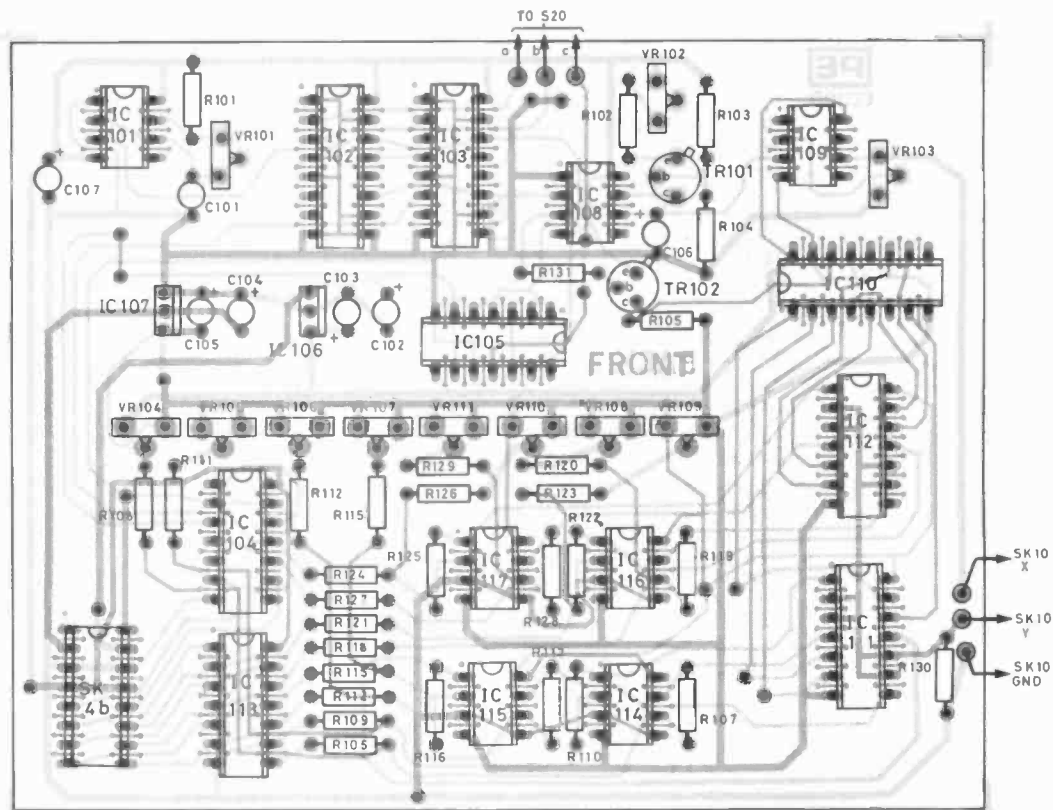


Fig. 3.4. Scope option p.c.b. track (track-side)



EC101

Fig. 3.5. Scope option p.c.b. track (component-side)



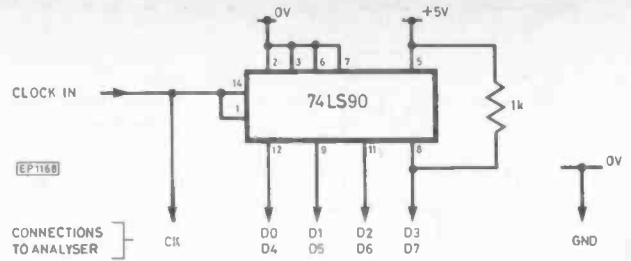
EG1267

EC101

Fig. 3.6. Scope option component layout (actual size)

With the EXPAND switch set to 16, adjust VR102 so that the top trace (D0) has 16 cycles on the screen. It may be necessary to readjust VR103 while the adjustment of VR102 is being done. Changing the position of the EXPAND switch will cause more bytes to be displayed. Final testing of the unit will be described at the end of the article, as the procedure is common to both display options.

Fig. 3.7. Analyser test circuit



COMPONENTS . . .

SCOPE DISPLAY OPTION

Resistors

R101,R103	4k7 (2 off)
R102	2k2
R104	6k8
R105,R130	10k (2 off)
R106,R109,R112,R115, R118,R121,R124,R127	100k (8 off)
R107,R108,R110,R111, R113,R114,R116,R117, R119,R120,R122,R123, R125,R126,R128,R129	18k (16 off)
R131	47k

All resistors 1/4W 5%

Potentiometers

VR101,VR103	10k vert min. preset (2 off)
VR102	4k7 " " "
VR104-111	1k " " " (8 off)

Capacitors

C101	1n
C102,C104,C107	1µ/35V tant. (3 off)
C103,C105	10µ/35V tant. (2 off)
C106	100n/16V tant.

Transistors

TR101,TR102	BC177 (2 off)
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Integrated Circuits

IC101,IC108	7555 (2 off)
IC102,IC103	74LS191 (2 off)
IC104	74LS02
IC105	74LS00
IC106	7808CT
IC107	7908CT
IC109	741
IC110	4022B
IC111,IC112	4066B (2 off)
IC113	74LS04
IC114-117	1458 dual 741 (4 off) (1558 may be used)

HEX DISPLAY OPTION

This option displays the HEX value of the data byte corresponding to the base memory address selected on the ADDRESS display, on two 7-segment displays. The HEX characters are displayed as shown in Fig. 3.8. The 7-segment displays should have already been fitted to the front panel p.c.b.

HOW IT WORKS

Fig. 3.9 shows the circuit. Incoming data is latched in IC201 by the LD input from the oscilloscope option via IC205C. If the oscilloscope option is not fitted, then as explained in Part 1, the latch is always disabled (i.e. unlatched). The output of the latch is connected to IC202 which is a quad 2-line-to-1-line multiplexer. The output lines A, B, C or D are either connected to D0-D3 or D4-D7, depending on the S input. This input is derived from IC205d and IC207, which is configured as a 100Hz oscillator. The oscillator allows the multiplexing of the data to the displays, minimising the HEX decoding circuitry and the connections between the option board and the front panel p.c.b. Multiplexing is achieved by TR201 and TR202 switching on alternately and hence enabling each display in turn. The selected 4 bits are decoded into 7-segment format by IC203. This i.c. decodes the values 0-9. IC204c and IC205b detect when the value is greater than 9 and when this is the case, enables IC203's lamp test facility and enables IC206. IC203 was chosen because it displays a complete "6", compared to the more common 7447 which has the tail missing. It is therefore easy to differentiate between a "6" and a "b" corresponding to the HEX "B". To explain how the display works, we will consider an example, say a "1". To display a "1", outputs b

and c of IC203 will be high (off), allowing current to flow via R208 and R207 through the b and c segments to the common cathode. All other outputs will be low (on), shorting out the segments, so they do not light. When the lamp test facility is enabled, all outputs are off, allowing all segments to light. However, IC206 decodes the 3 bit binary input to 1-of-6 lines and the selected line, buffered by IC208, blanks the not-required segments via the diode matrix, leaving the corresponding HEX character lit.

CONSTRUCTION

Once again, construction follows the previous procedures. Refer to Fig. 3.12 for the component overlay. The board is fitted to the main p.c.b. with stand-off pillars and is connected to the front panel p.c.b. via a 14 way ribbon cable, with headers connected such that the pin numbers correspond 1 to 1. There is no setting up required and testing is done as described below.

FINAL TESTING

Set up a word on the word recogniser switches and select WORD trigger, POST trigger and SYNCH clock. Select CQ1 and CQ2 to "dont care" and CQ3 to 0. Connect up the test circuit in Fig. 3.7, leaving the qualifiers open. ARM the unit and switch the CQ3 switch to "dont care". The analyser will



Fig. 3.8. Hex character display

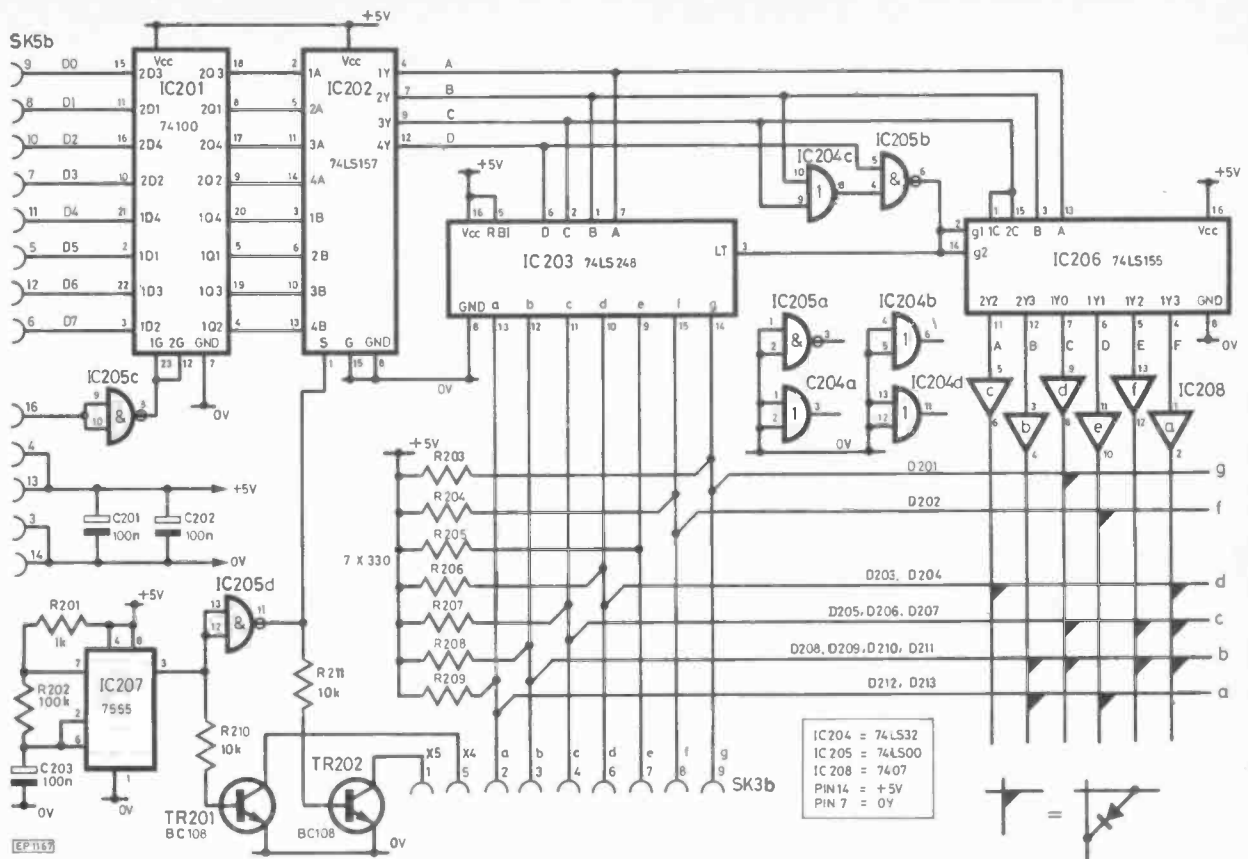


Fig. 3.9. Hex option circuit diagram

COMPONENTS . . .

HEX DISPLAY OPTION

Resistors

R201	1k
R202	100k
R203-209	330 (7 off)
R210, R211	10k (2 off)

Capacitors

C201-203	100n/16V tant. (3 off)
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Transistors & Diodes

D201-213	1N4148 (13 off)
TR201, TR202	BC108 (2 off)

Integrated Circuits

IC201	74100
IC202	74LS157
IC203	74LS248
IC204	74LS32
IC205	74LS00
IC206	74LS155
IC207	7555
IC208	7407

Miscellaneous

Soldercon i.c. socket strips
 SK3b can be a 14-pin i.c. socket

capture the counter's output. Now check that the HEX display corresponds to the chosen trigger word (on the switches) and that the left hand byte displayed on the oscilloscope also corresponds. (If only one of the options is fitted, then obviously it is only necessary to check that option.) Repeat the procedure with PRE and CENTRE triggering. Activating the UP/DOWN switch should cause the HEX display to increment or decrement between 00 and 99. (The 7490 is a decimal counter, therefore no HEX characters will be displayed.) The waveforms on the scope display should also move to the left or right. Switch off the analyser and switch on again. The memory will contain random data. Scan up the memory and check that the HEX characters are correctly displayed. Finally, check that MANUAL and EXT trigger (by applying an external signal, positive and negative edge selected) work and that the clock qualifiers work. If the option(s) and the unit work satisfactorily, the power supply wiring can be neatly finished off. The fuse is mounted on the back panel and remember to twist the mains wire going to the ON/OFF switch to reduce noise radiation. The analyser is now ready.

NEXT MONTH: Z-Mod and Internal Clock Options.

NOTE . . .

Fig. 1.6, the Main p.c.b. circuit schematic (August issue) should be corrected to show a link between pins 3 and 4 of IC32 and pin 5 of IC30.

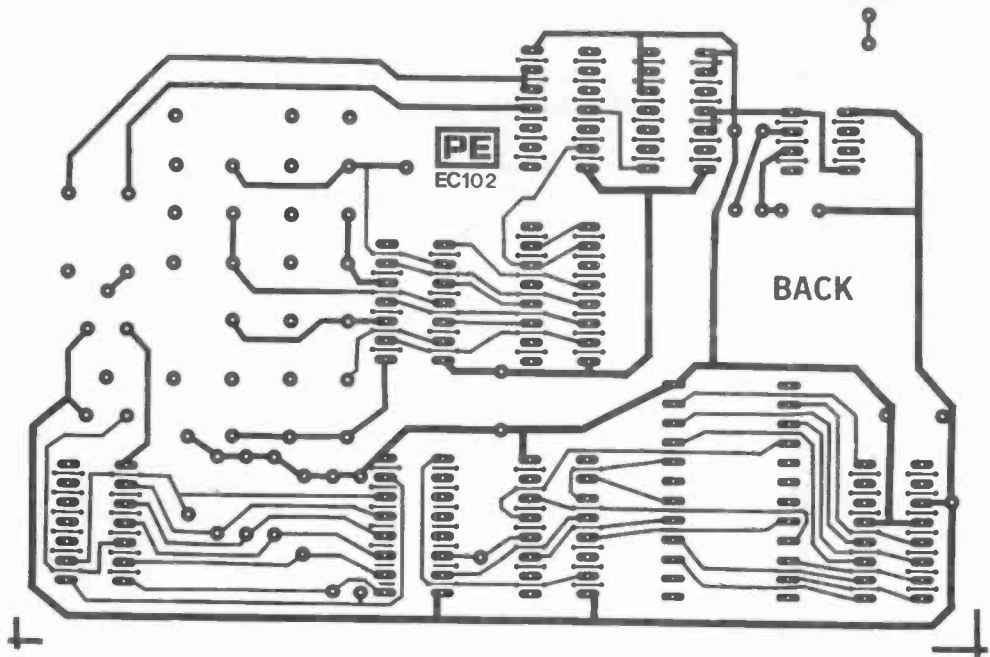


Fig. 3.10. Hex option p.c.b. track (track-side)

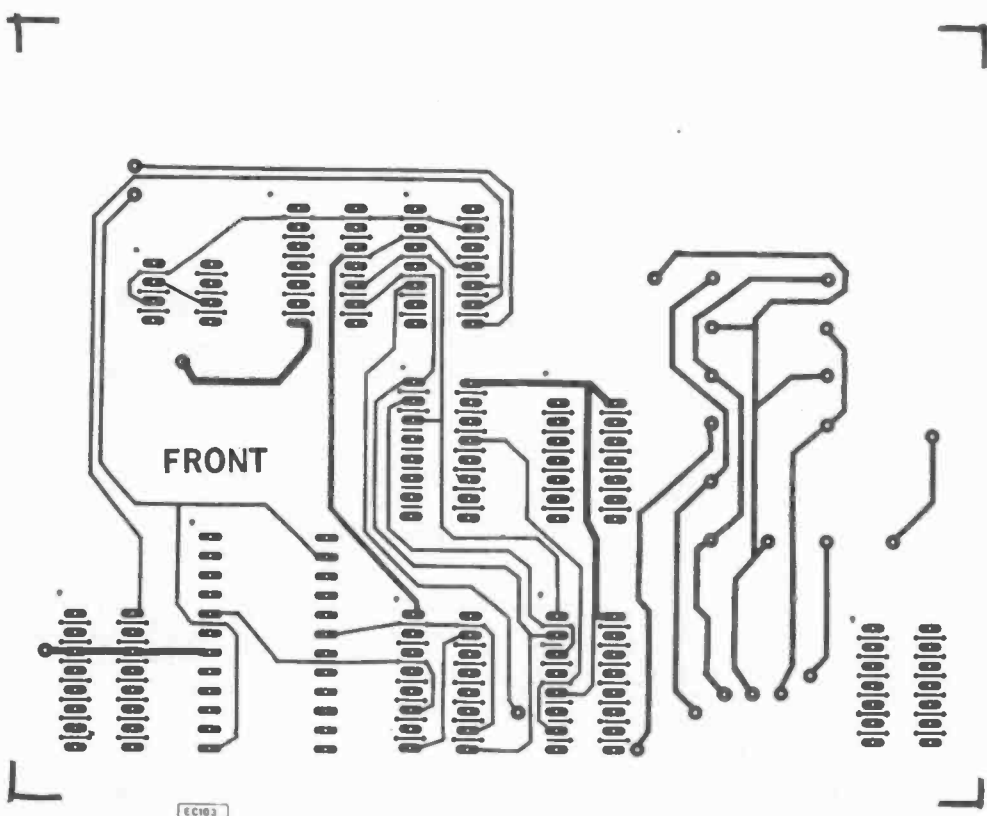


Fig. 3.11. Hex option p.c.b. track (component-side)

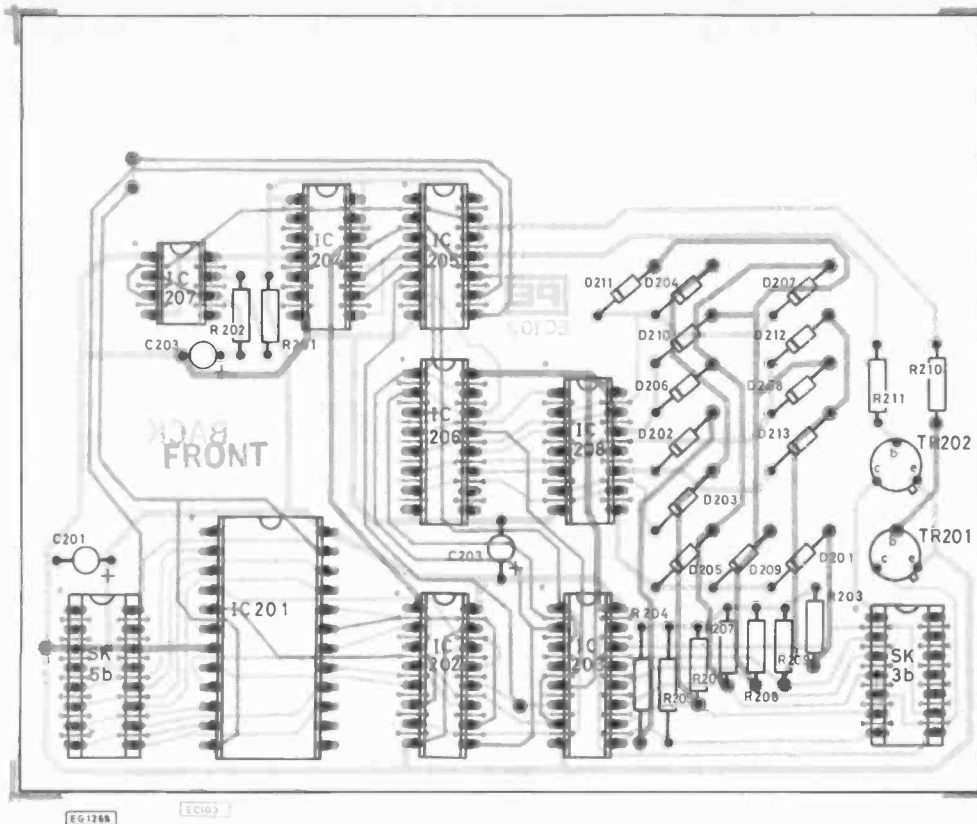


Fig. 3.12. Hex option component layout (actual size)

ELECTRONIC HOBBIES FAIR

Alexandra Palace, London – October 27-30, 1983

We are sorry to announce the cancellation of this year's Electronic Hobbies Fair, planned for 27th-30th October.

In spite of a significant success last year, the continuing recession is hitting the electronics hobby industry pretty hard. This has meant that many companies feel that this year they cannot sensibly allocate the resources of time, money and manpower involved in participation in exhibitions.

We feel that any exhibition sponsored by PE must offer the visitor a full range of components, equip-

ment, projects and demonstrations from a wide selection of companies across the industry. As we cannot be absolutely sure of doing just this, we have decided, with regret, that we must disappoint our readers now rather than in October. Practical Electronics would like to thank those companies who had undertaken to support the Electronic Hobbies Fair this year. With our apologies for the disruption of their plans we combine our hopes for a future event in a more buoyant business climate.

ELECTRONICS in PHOTOGRAPHY

Clifford Stokes
AIPP ARPS FRSA

SINCE the invention of a means of permanently recording an image made by "painting with light", photography still requires the same techniques as it did 150 years ago. There has always been a light tight box or camera and there has always been a pinhole or optical lens to form an image.

At first the image was copied by hand, a small portable camera being a popular means of sketching tourist views for the non-artistic traveller. When light sensitive emulsions were discovered, photography as we know it was made possible. Over the years the sensitivity of film emulsion has been improved, the optical performance of lenses and the method of varying and controlling the amount of light reaching the film, with some form of aperture and shutter arrangement, has been the subject of continual invention.

The actual method of exposing the film for a particular length of time has always been mechanical, clockwork gear trains or pneumatic systems, subject to variation and failure and requiring expensive and precision maintenance. When electronic control of these functions was introduced, it was without doubt one of the most important fundamental developments in the techniques of practical photography.

ELECTRONIC CONTROL

The huge "snap-shot" market was the first to benefit from electronic control, not only in the camera at the taking stage (which shall be dealt with later) but in the developing and printing of vast quantities of amateur colour negative films in 35mm, 126, 110 and Disc formats.

Meticulous attention to processing standards at the laboratory is required, to ensure acceptable quality prints at economical prices. To try to achieve adequate control by

manual means is impossible due to time/cost considerations in a mass market.

The films are developed in automatic sequence where time, temperature and replenishment of used chemicals is strictly monitored. After development, the films, either in individual, short lengths or joined together on a continuous spool, are printed on to roll paper which is processed and cut into single prints.

The laboratory printers used for this work can be either:

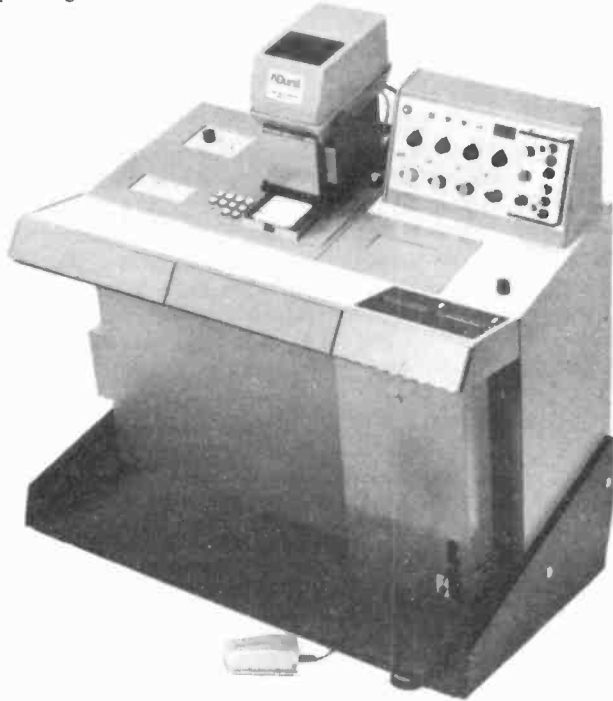
- A. Fully automatic,
- B. Partly automatic, where the operator can override or modify the function.
- C. Manual.

Amateur developing and printing is always automatically printed. A typical standard subject, based on the holiday view or group picture on a particular type of mass sale film, like Kodacolor II with C41 process, is programmed into the printer, which adjusts the function to compensate for any variables in the subject lighting and exposure.

OPERATING THEORY

The operating theory, established by Kodak in 1946, depends on the premise that most colour photographs can be integrated or scrambled to a standard grey. If a full colour image is projected onto a screen through a diffuser, the mixture of coloured light will produce the same effect on the screen irrespective of the content of the picture, assuming that the picture is a typical standard subject. If the picture is untypical, i.e. a white seagull against a blue sky, or a white cat on a red rug, the printer must have manual correction or sophisticated programme memory systems to estimate the required compensation.

Laboratory printers for the more exacting market of professional photographers are usually automatic with manual operator override. The film is handled in short strips, say three $2\frac{1}{4}$ " square negatives; these are numbered and test printed, checked and printed again with any required correction. These printers are capable of handling roll paper in a range of widths and format, the size being selected and set up prior to batch printing.



High-speed laboratory printer

The working principle of all printers for colour negative and reversal film material, is based on the theory that white light is composed of Blue, Green and Red light in equal amounts.

PRINTING

All colour film and paper has three layers of emulsion sensitive to Blue, Green and Red light respectively and can record any colour in the original subject by mixing different proportions of any two.

A colour printer, therefore, must have the facility to adjust the colour of light used to project the image onto the paper.

There are two basic printing methods,

Additive Printing where three consecutive exposures are made first through a Blue filter then through a Green filter then through a Red filter, different times of exposure through each will give in total an infinitely adjustable colour result.

Subtractive Printing (or white light) where one exposure is made through a pack of filters of complementary colours. Yellow filters to absorb Blue light
Magenta filters to absorb Green light
Cyan filters to absorb Red light
varying the densities of any two of these filter colours will again give an infinitely adjustable result.

All printers and enlargers for colour, either negative or reversal, operate on variants of the two basic systems.

As distinct from laboratory printers operating in a mass quantity market, enlargers are used for the independent printing of negative and slide originals onto sheets of paper in a wide range of sizes and surface finishes. Individual treatment, shading, masking and local correction and optical distortion control, to correct for camera angle errors, can be done during the printing process.

PRINT ANALYSIS

The correct combination of exposure times through the BGR filters in the case of additive enlargers and the exposure and filter densities in the case of subtractive, can be arrived at by a series of test prints, which can be wasteful of time and materials. To overcome these problems analysers are used, programmed to a standard subject. To illustrate the operation of an analyser we will look at the Durst CM300, a sophisticated home darkroom electronic analyser and timer. When used in conjunction with a colour head enlarger fitted with "dial in" dichroic filters the printing filter settings and exposure are quickly established, to a set programme.

To calibrate the unit, a negative is selected having a good distribution of colour, a market place or fairground shot is usually ideal, the negative should be of normal density and correctly processed.

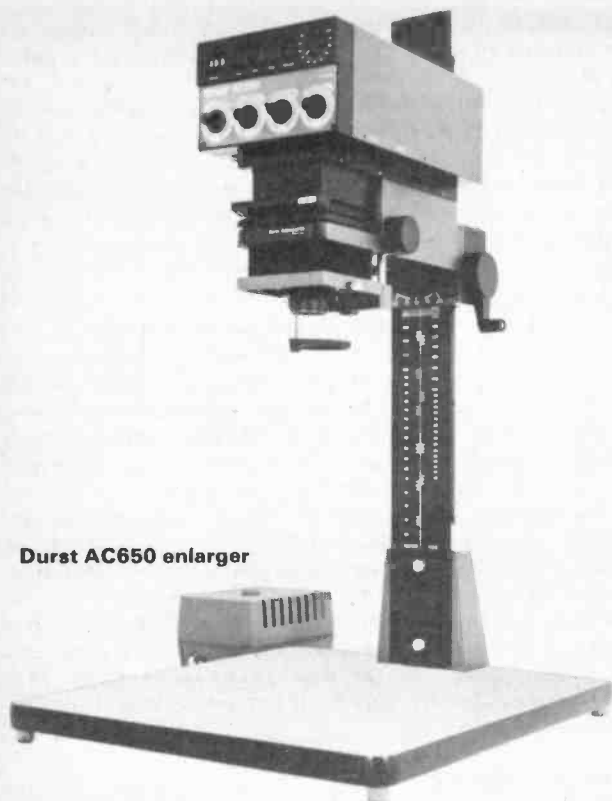
The negative is test printed until a satisfactory result is obtained.

The analyser is then programmed. With the enlarger set exactly as for the test print, filters, lens aperture and magnification, the analyser probe is placed on the baseboard under the lens. The slide on the probe is moved until the l.e.d. on the cyan channel lights and the calibration knob is adjusted until the two l.e.d.s come on together. The process is then repeated for magenta and yellow.

Any other negative of a similar type can be focused to a particular size, the probe placed on the baseboard and the filters adjusted in turn to light the two l.e.d.s together on each channel.



The Durst CM300 analyser measures the colour and density of colour negatives and directly controls the exposure procedure of the enlarger



Durst AC650 enlarger

For a portrait negative a print can be made by test and the analyser can be programmed by placing the probe (without the diffuser) on part of the face projected on the baseboard and calibrated as before. This will be for a typical skin tone and will yield an identical colour and tone in future prints irrespective of the background colour. The unit can be used for exposure determination for slides and black and white printing and as a basic exposure timer.

All analysers and computers for colour printing, work on the same principle irrespective of the manufacturers' operating sequence and attempt to provide guidance on optimum printing conditions for any negative, but the successful interpretation and use still depends to a large extent on the skill of the operator. To cater for different combinations of film and paper batch, some analysers have switchable memory banks or plug in modules for any number of calibration programmes,

STAGE TIMING

The accuracy and repeatability of electronic control has enabled a number of darkroom aids to be designed, one of which is the Nocon timer, an interesting electronic timer with programmable memory.

When making a test strip for exposure determination either in black and white or colour, it is necessary to make a series of time stages, maybe 2,4,6,8,10,12, seconds or a doubling up range like 2,4,8,16,32, seconds. A laborious technique subject to errors of repetition. The final print as a result of information obtained from the test, may require a different exposure in certain areas and it is usual to make a careful note of these times and aim to work to them for the finished print. With the Nocon timer, the basic exposure, say 10 seconds, can be entered on the display panel, five keys can select 0-59 minutes, 0-59 seconds and 0-9 seconds. A panel of 20 keys each with its own l.e.d., can be selected to give under or over the basic 10 seconds in terms of aperture f stops and $\frac{1}{2}f$ stops to give a range of up to 21 evenly spaced exposures. The correct exposures for different

areas of the print can be entered into the memory and can be repeated any number of times, exactly the same.

LEVEL PEGGING

The relative merits of additive versus subtractive colour printing systems have been expounded for a number of years without any real evidence of either's superiority. Most enlarger manufacturers use the subtractive system for manual enlargers, where the colour of the light projecting the negative, or positive image, is adjusted by means of a complementary filter pack, of gelatine or resin filters, or dial in fade free dichroic filters, using one exposure.

The Philips Tri-one colour enlarger uses a system which is a single exposure, as in the subtractive method, but a single exposure from three separate bulbs, one with a blue filter, one with green and one with red. The colour of the resulting mixture of light is varied by adjusting the intensity of each bulb, infinite control is thus obtained. The Durst AC650 is intended to give the advanced amateur and professional photographer an enlarger with the characteristics of a laboratory printer, with the ability to constantly vary the size of print and selectively compose the final result. A tungsten halogen bulb provides the illumination for 35mm and 6 x 6cm negatives and slides. Exposure is made by three consecutive exposures, each one timed automatically.

All the necessary colour and density measurements are carried out automatically once the photocells have recorded the correct amount of light for each colour.

However, the unit carries four control knobs for calibration to the standard negative and for personal manual override.

All automatic printing systems are subject to failure due to the inconsistency of the negative. Where there is a variation in density either through a negative process fault or wide change in the magnification, a reciprocity fault can occur. Each batch of paper has its own characteristics and the three layers of emulsion can be different in their response to over and under exposure, ideally, the photocell and filter response would match the sensitivity of the three emulsion layers, but in practice a shift occurs in both colour and density because of variations in the three characteristic curves. Special provision must be made in automatic printers to allow for this error and the adjustment is known as the slope control.

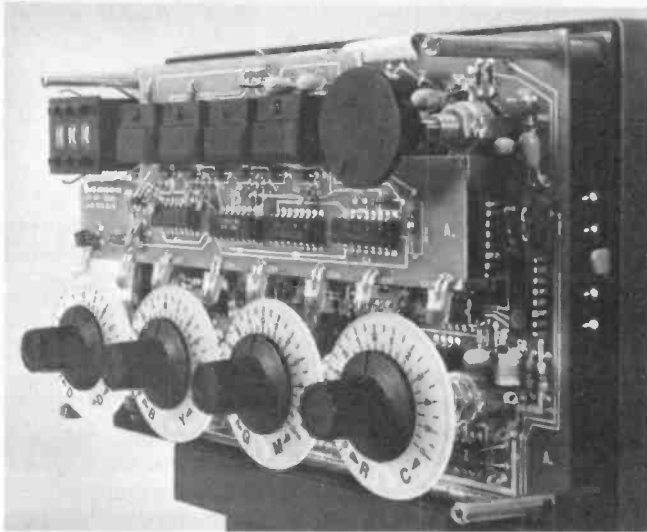
SLOPE CONTROL

For the mass market printer the slope control must be automatic without operator intervention. If it is found that the shift is toward green from an over exposed negative and toward its complementary, magenta, with an under exposed negative, a proportional reduction in the green exposure is required for under exposed negatives and an increase in the green exposure for over exposed negatives. In each channel adjustable response is provided, in series with the integrating condenser the photocell will read a "thinner than normal" negative and proportionately vary the green exposure.

An analyser used with an enlarger is subject to user override and the operator will make an allowance for thin or very heavy negatives and for larger or smaller degrees of magnification after normal analysis.

EQUIPMENT OPTIONS

Laboratory printers are now available in a wide range of specifications in both additive and subtractive variants. Mainly to cater for the professional photographer, there are package printers which analyse and simultaneously, through a cluster of lenses, produce a set of prints of different sizes, perhaps 1 @ 8x6, 2 @ 5x4, 4 @ 3x2, all exactly matched for colour. Also in the laboratories catering for the professional photographer, particularly in wedding and portrait work where a consistently high



With the cover removed the extensive use of electronic control in the AC650 can be seen

standard of printing is required at reasonable prices, methods to avoid the reprint of unsatisfactory prints are in demand.

Video systems enable the operator to view the negative reversed in values to a correct colour image on the screen, the image is compared to a correct standard alongside, the colour balance is automatically assessed and fine tuned manually. The printing values are entered and produce a readout on punched tape or magnetic retrieval systems, this data with the negative is passed to the printer and high quality "one off" prints are produced. This method with moderate quantity production is not suitable for the mass market.

In general the printing of slides usually involves the making of an "interneg", so that the prints can then be made on automatic printers with other negatives. Slides can be printed on enlargers, with selective control and composition and many laboratories offer this service, which is well within the scope also of the home

darkroom. In the home the colour can be balanced visually and the exposure established by a meter or the exposure channel of an analyser.

Successful photography depends to a large extent on accurate standardisation. Exposure of the film in the camera is critical if a high quality negative or transparency is to be produced. A professional photographer should have the skill to measure and judge the infinite variety of the effects of light and get his exposures correct; an amateur, who may only use his camera on holidays and occasionally at special events, will not have the experience and get very uneven results so it is in this area where automatic camera exposure control is very beneficial.

A simple meter system measuring the whole of the image area can produce very good results and more sophisticated camera exposure controls, measuring the centre of the image, an area around the centre and the outside edges and calculating the overall average. As the main subject is probably around the centre of the frame the method can hardly be faulted.

Standardisation in processing the film and printing the resulting negative is absolutely vital. Electronic control of process temperature and time and control of chemical replenishment, together with the programmed analysis of printers and enlargers, has revolutionised the practice of photography as it has been known since its invention, replacing years of experience and trial and error, with accurate, predictable and repeatable results, leaving the photographer free to concentrate on the picture composition.

LOOKING AHEAD

The future of silver based photography is now challenged by electronic image recording. Video has largely replaced home cine and an increasing amount of professional work and will undoubtedly produce an alternative means of recording family events, holidays and the snap shot.

The attraction of taking pictures, either still or cine, and then seeing the results on the domestic television must be obvious. There is still, however, the problem of producing a high quality print from a video image comparable to that obtained from the traditional silver base film. ★

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VIC 20

EXPANDING THE

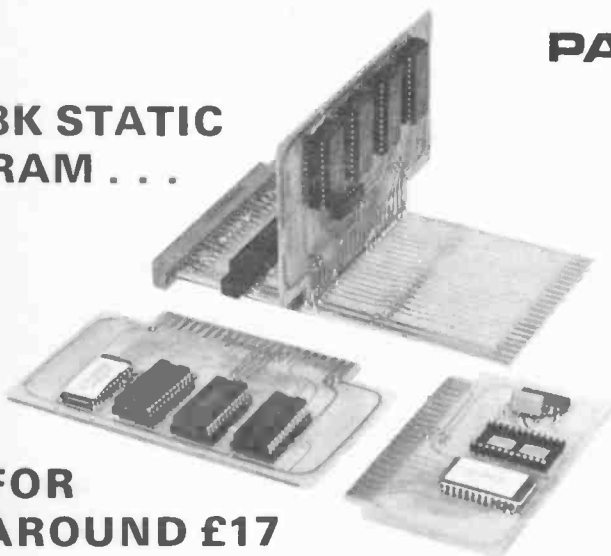
PART ONE

SAM WITHEY



8K STATIC RAM . . .

FOR AROUND £17



FALLING prices of the Commodore VIC 20 home computer have outpaced the prices of expansion packs, which, perhaps due to the high price of 2K RAMs, remain beyond the pocket of many home programmers. However, for the hobbyist constructor, an 8K static RAM card can be made for around £17, a considerable saving over the normal price of approximately £45.

Included in this series of articles is an 8K RAM pack, which uses 4x6116 2K CMOS static RAM, an 8K ROM board, which can accommodate a single 2716 EPROM, a single 2532 EPROM, 2x2532 EPROMS, or one 2532 and one 2716 EPROM. A simple modification to the 8K RAM board enables it to be converted into a 3K RAM card with provision for 4K of RAM. Finally, there is a mother board capable of holding 3 cards vertically plus a horizontal socket for further extension. An independent power supply can be added to the mother board at any time.

All boards are constructed on double sided fibreglass laminate and are designed so that a minimum of lines on the top (component) side of the board make through plating unnecessary.

An EPROM programmer and other interfaces designed specially for the VIC 20 are being prepared in this series. (We expect these to include a stepper motor controller for robotics, DAC/ADC board, and an I.e.d./switches simulator I/O control port for designers.)

ADAPTABILITY TO OTHER SYSTEMS

Since decoding is carried out on the individual cards, the only problem in direct interfacing with other systems is the arrangement of Data, Address, R/W, Enable and power lines on the edge connector, and the physical spacing of the segments. This can be easily overcome, by preparing a suitable connector on a ribbon cable harness.

THE 8K RAM BOARD

The 8K RAM board (Fig. 1.1) has provision for 4x24 pin devices laid side by side to facilitate paralleling of Data and Address lines. All of this is carried out on the under side of the board. Address lines A0 to A10 are taken directly to the edge connectors, whilst A11 and A12 are taken from the upper surface of the board using through-the-board link pins. Similarly, the +5V rail is distributed to all devices after transfer from the upper surface via a link pin. The ground rail appears on both sides of the board, interconnected by the -ve leads of decoupling capacitors C1 and C2.

Data lines D0 to D7 are taken directly to the edge connectors on the upper surface of the board from the adjacent 2K RAM IC4. The R/W is taken from pin 21 (WE) of IC1 to edge connector 17 and Pin 20 (OE) of IC1 is taken to ground. As stated earlier, these lines are paralleled on the under side of the board.

Pin 18 (CE) of IC1 to IC4 are decoded by one half of IC5, a 74LS139, 1 of 4 decoder. Data Select A and B from this device are taken to A11 and A12 respectively on the lower side of the board with link pins. Pin 13 (EN) of this device is taken to RAM blocks 1, 2 or 3, selected by a suitably placed blob of solder on the pads provided.

C1 and C2 are 330nF tantalum bead capacitors used for decoupling. The values are not critical, physical size being the more important. 10nF ceramic discs would probably provide sufficient noise suppression.

The 6116 CMOS RAM has the advantage of a very low operating current, avoiding the need for an additional power supply. Also, if 100k pull down resistors are soldered between the address lines and ground, the quiescent current is as low as 2µA, enabling a 2.4V back-up battery pack (2x1.2V nicads or 2x1.5V penlight) to be installed between the +5V rail and ground, to maintain programs during switch-off time.

CONSTRUCTION

4x6116, 150ns CMOS 2K Static RAMs are used for I.C.s 1 to 4 and it is therefore advisable to use sockets. Unless the constructor is a real novice IC5, being TTL, can be safely soldered directly on the board, Pins 8 to 15 on the upper surface and Pins 8 and 16 on the under side. See Fig. 1.4.

The socket of IC4 should be mounted first, because it has pins to be soldered on both edges. Do not insert the sockets fully, but leave sufficient clearance to enable a fine soldering tip to touch the pins from the upper surface of the board. Having done this, tack the socket in position by soldering the corner pins on the lower side of the board. After soldering

COMPUTING PROJECT

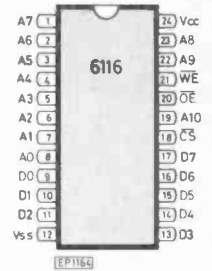
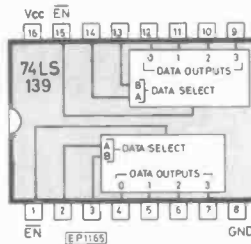
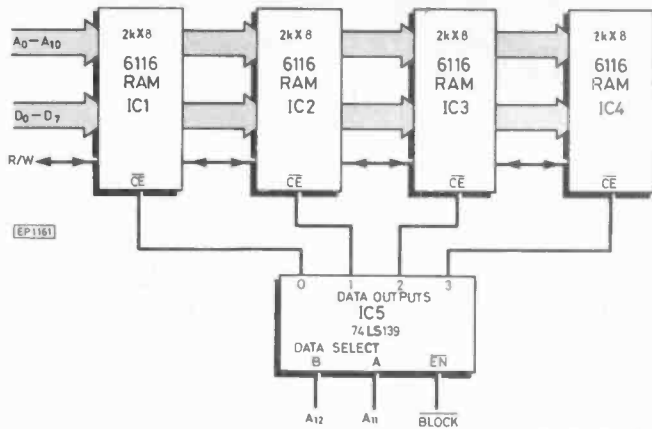


Fig. 1.1. 8K RAM card

Fig. 1.2 (below). RAM board track layout (track-side)

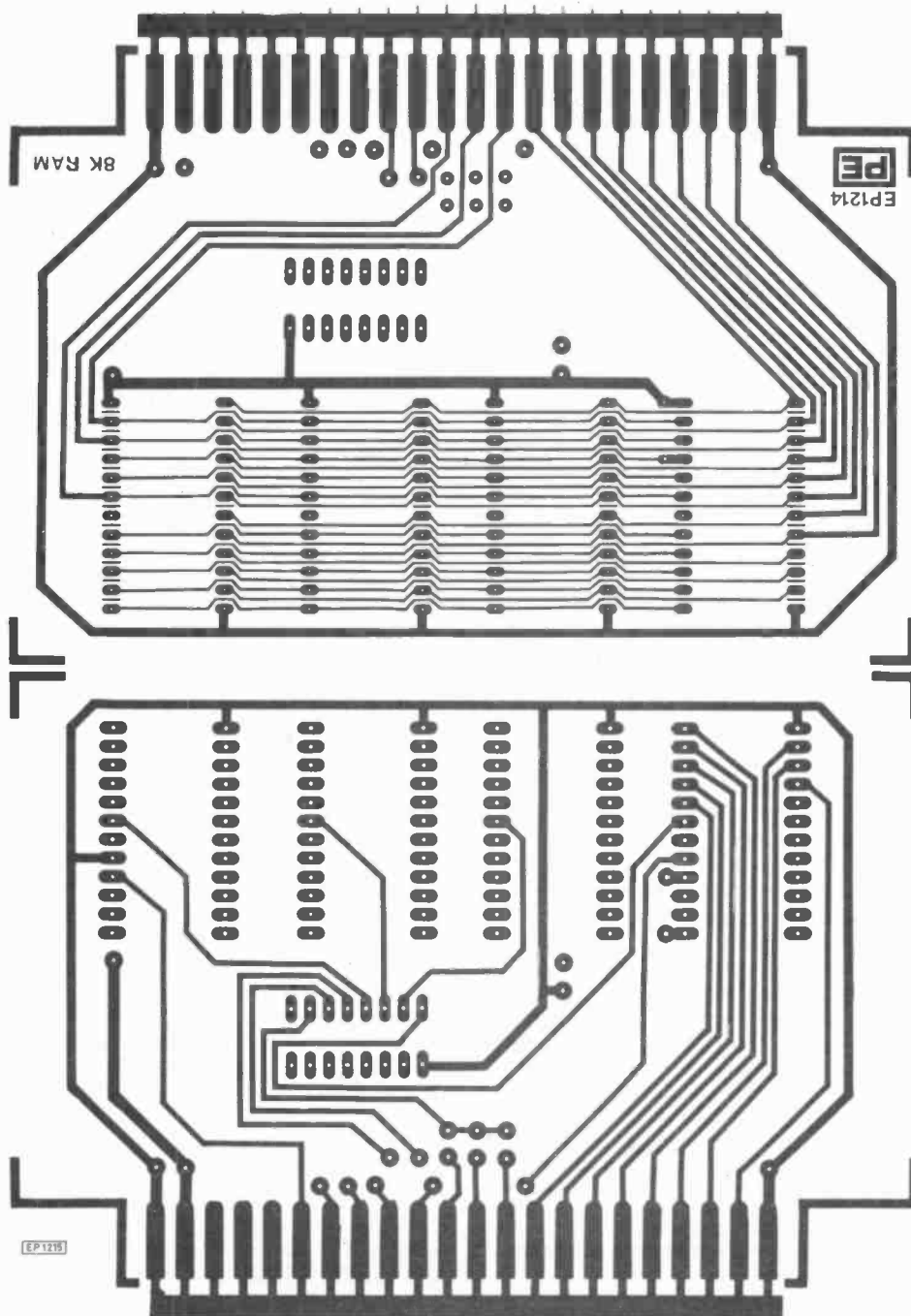


Fig. 1.3. RAM board track layout (component-side)

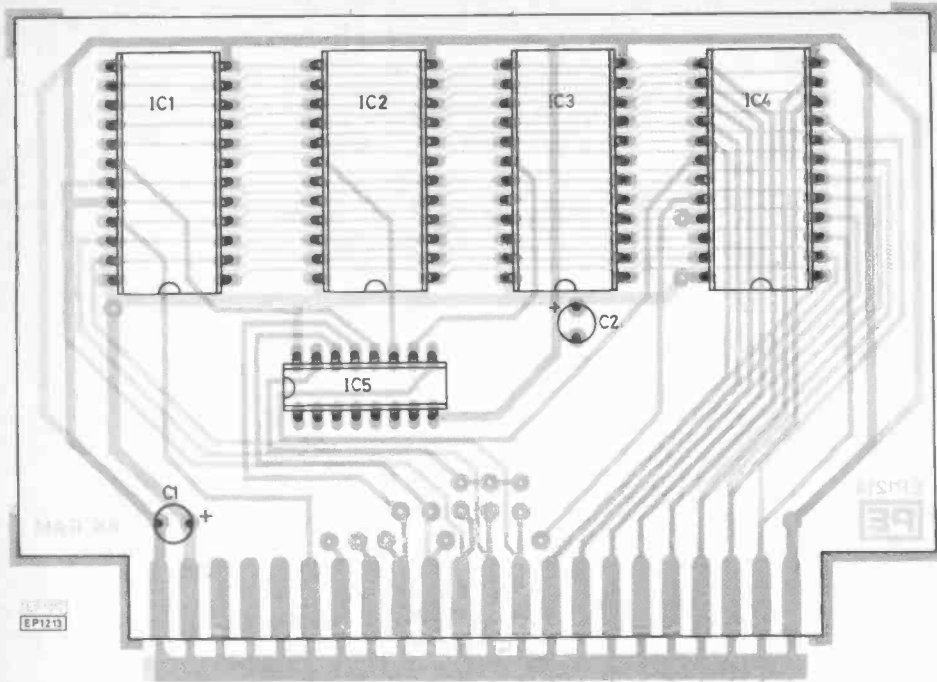


Fig. 1.4. RAM board component layout (actual size). It is suggested that solder-con pins (or RS socket strips) be used as i.c. holders, to simplify component-side soldering. Not all constructors will share the author's skill at soldering near the "underbelly" of plastic i.c. sockets—Ed.

NOTE: Whilst using the "Super-Expander" alone, VIC 20 BASIC ignores it when extra RAM blocks are added. It may, however, be used for m/c routines.

COMPONENTS . . .

8K RAM BOARD

Capacitors

C1, C2 330n tant. bead (2 off)

Integrated Circuits

IC1-4 6116 CMOS 2K Static RAM (4 off)
IC5 74LS139 1-of-4 decoder

Miscellaneous

Integrated circuit sockets
Printed circuit board*

Pins 9 to 18 (inclusive) on the upper surface of the board check that there are no bad joints before proceeding to IC3. This is best done by inserting an old 24 pin device in the socket and checking continuity with a multimeter.

Next insert IC3 socket where only Pins 12 and 18 have to be soldered on the upper surface. IC2 socket is the same. IC1 socket has to be soldered on Pins 12, 18, 20 and 21. As these are all clear of the previously mounted sockets this presents no difficulty. If the pins on the underside of the board were not soldered previously, solder them now.

The CMOS RAMs should be handled with care and it is worthwhile inserting an old 24 pin device into the sockets, not only for continuity checking, but also to "break-in" the socket and avoid risking bending the pins of the RAMs.

C1 and C2, together with the through-the-board links, are soldered in place before inserting the RAMs.

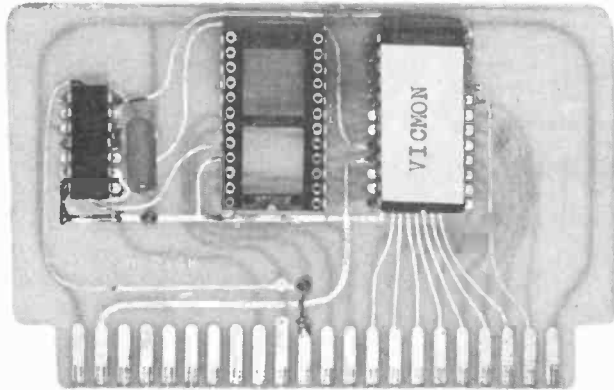
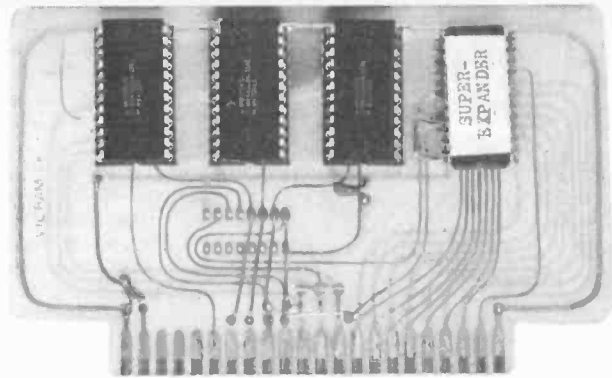
It is time well spent to check all solder joints before using the board on the computer. In particular, check that there is no short between +5V and ground.

CONVERTING THE 8K RAM BOARD TO 3K RAM PLUS 4K ROM (SUPER-EXPANDER)

Having designed an 8K RAM board it became obvious that at some time it would be desirable to fill in the 3K memory gap at location 0400Hex. Because of its pin compatibility with the 6118 first consideration was given to the use of the 4118A static RAM. At first it was decided to modify the 8K RAM board by eliminating one socket and the decoder. Then the possibility of using the 4th socket as a 4K ROM socket was considered. Since all Data and Address lines are shared and the 4118A and 2532 are also compatible a further look was taken at the 8K RAM board to realise that very few modifications were necessary in order to use the same board for both purposes.

The only pin connections which differ are 18, 19, 20 and 21. For the 3x4118 RAMs Pin 21 (WE) remain in parallel and connected to edge connector 17, whilst the track was cut under the board at IC4 and a small link made between Pin 21 and Pin 24 on the upper surface to tie Vpp to +5V. Pin 20 (OE) on the 3x4118A RAMs remain in parallel and tied to ground, Pin 20 on IC4 once more being isolated by cutting the track under the board. Pin 20 of the 2532 is the CE and a short insulated lead is taken from this pin to Block select 3 or 5. As there is no internal connection at Pin 19 of the 4118A it was decided to leave the existing line connected in parallel as A10 is required by the 2532. Pins 18 (CE) of the 4118A RAMs are taken individually to RAM 1, 2, and 3 at edge connectors 16, 15 and 14. Use is made of the pads of the decoder i.c. to keep leads short and neat. Pin 18 of IC4, 2532 ROM is also taken from the pad of the decoder i.c. and the link pad formerly used as a through-the-board link to A11 on the lower side of the board.

For the hobbyist who produces his own printed circuit boards this eliminates a considerable amount of work required in producing a new set of double sided board masks. It is suggested that provision should be made for this modification when preparing the 8K RAM board mask, i.e. provide pads over edge connectors 13 to 16 and a provisional line from Pin 20 of IC4 terminating in a pad by the side of Data 7.



8K ROM BOARD

The ROM board (Figs. 1.5 and 1.8) is arranged in a similar manner to the 8K RAM board, having 2 x 24 pin devices laid side by side. All pins are paralleled on the under side with the exception of Pins 24 (+5V) and Pins 21 (A11), which are tied to +5V on the upper side and Pins 20 (OE), which are decoded by IC3, a 74LS00 Quad 2 Input NAND Gate. As with the RAM board, all Data and Address lines are taken directly to the edge connectors, A12 being taken to Pins 1, 2, and 13 of IC3.

The ground rail is on the lower side of the board, but is taken from Pin 12 of IC1 on the upper side of the board to supply ground for IC3. The +5V rail is on the upper side of the board. C1, a 100nF ceramic disc, supplies sufficient noise suppression and is connected to the +5V rail via a through the board link pin.

If sockets are to be used, it is advisable to insert and solder Socket 1 first, leaving sufficient clearance for a fine soldering iron tip as with the RAM board. An insulated wire link selects ROM Block 3 or 5.

ROM is normally located in memory at A000Hex for ROM Block 5, or 6000Hex for RAM/ROM Block 3. If the latter arrangement is chosen, IC1 is located at 6000Hex and IC2 at 7000Hex. Referring again to the schematic diagram it will be seen that when A12 is low OE of ROM 1 is low and therefore active. OE of ROM 2 would be high and would not be selected. Inversely, when A12 is high, OE of ROM 2 is low and would be active, whilst OE of ROM 1 would be high and not selected. Blocks are always active low. Unlike the RAM used by BASIC, the ROM memory locations do not have to be one continuous program, but can be 2 or more separate functional routines that can be called from BASIC or machine code. Whilst a 2532 would normally occupy each socket, there is nothing to prevent a 2716 being used to provide programs from 6000Hex to 67FFHex or 7000Hex to 77FFHex.

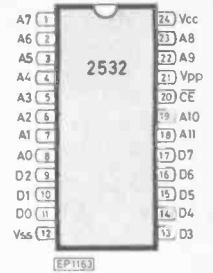
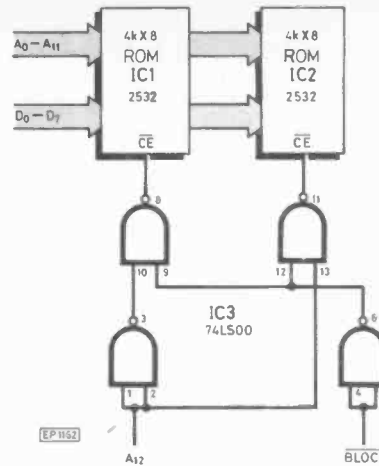


Fig. 1.5. ROM board

COMPONENTS . . .

8K ROM BOARD

Capacitors

C1 100n disc cer.

Integrated Circuits

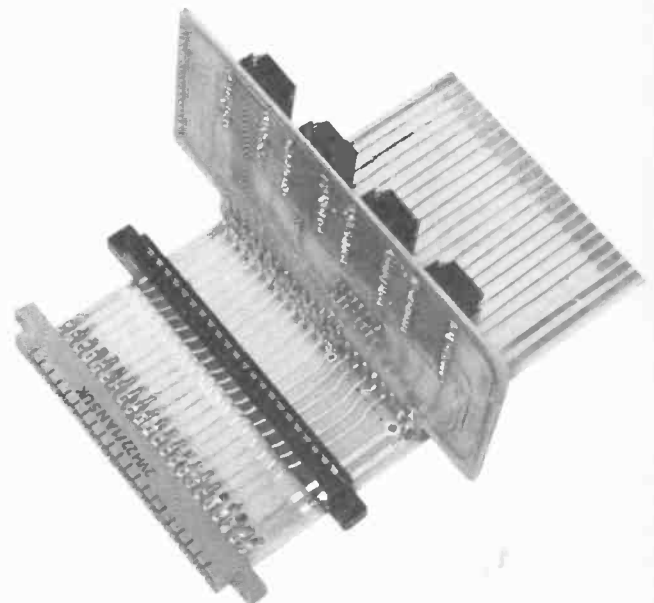
IC1, IC2 2532 4K x 8 ROM (2 off)

IC3 74LS00

Miscellaneous

Integrated circuit sockets

Printed circuit board*



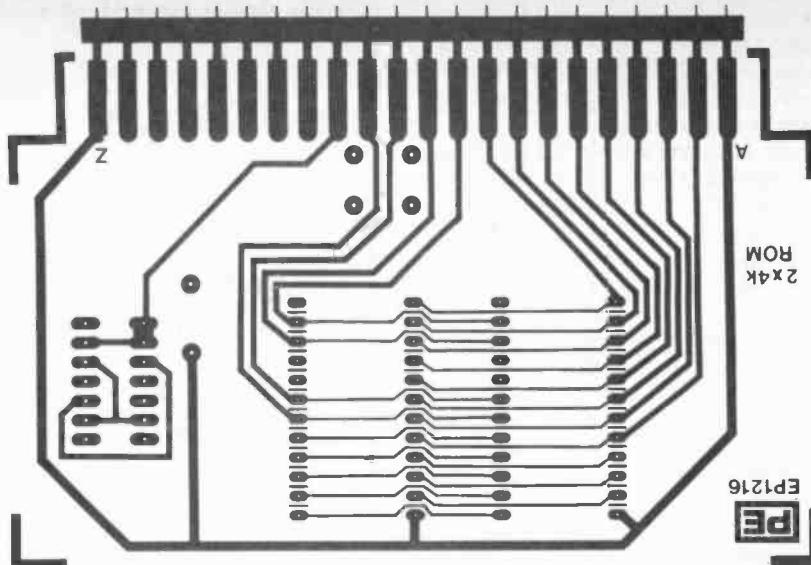


Fig. 1.6. ROM board p.c.b. (track-side)

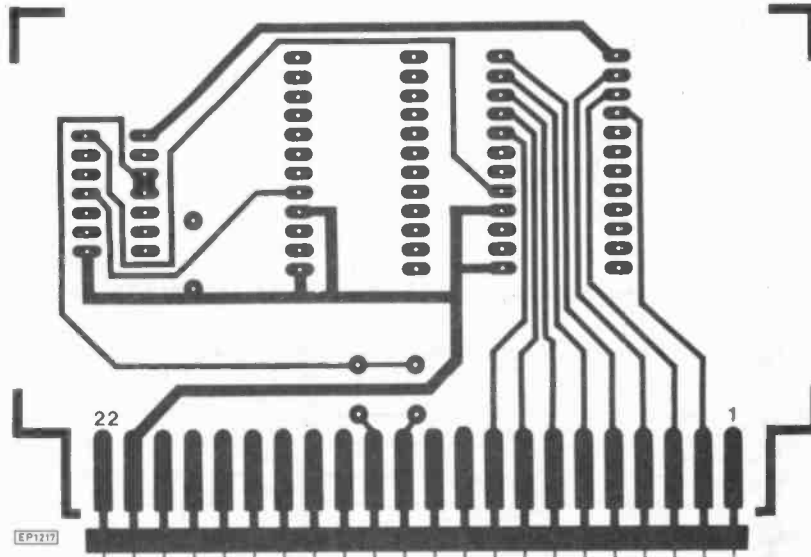


Fig. 1.7. ROM board p.c.b. (component-side)

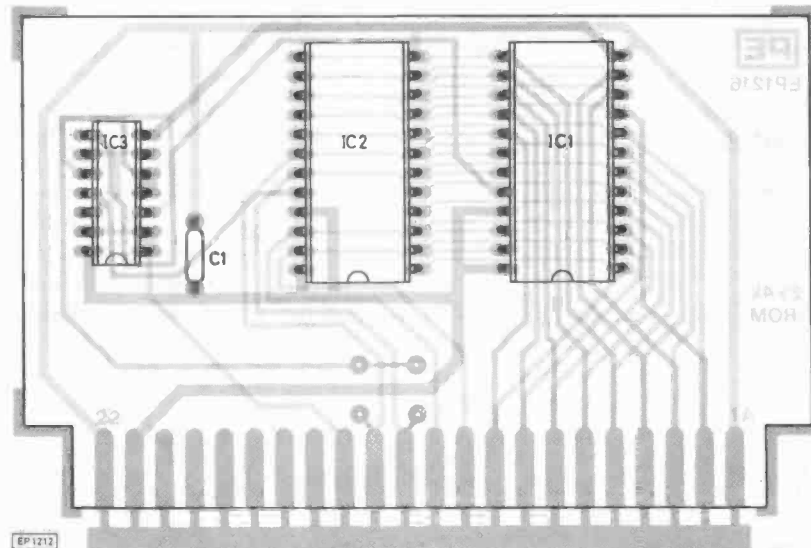


Fig. 1.8. ROM board component layout (actual size)

THE MOTHER BOARD

The Mother Board (Fig. 1.11) described here holds 3 boards vertically and a socket is provided for further horizontal expansion. Unused lines have been omitted, but it will be necessary to drill holes if sockets are to be used.

On the prototype, the first positions were used for RAM Blocks 1 and 2, memory locations 2000Hex and 4000Hex. The third position was taken by a 2 x 4K ROM Board, covering memory location 6000Hex at RAM/ROM Block 3. The lower 4K of the latter was used for the VICROM Machine Code Monitor, leaving the section 7000Hex to 77FFHex free for user Machine Code programs.

Since these boards were intended for regular use they were soldered directly to the Mother Board, with wires, saving the cost of sockets and leaving the rear horizontal socket for such applications as games cartridges.

Construction presented no difficulties, but it should be observed that boards or sockets should be mounted starting from the rear position first. This is because the mounting pads for the top lines are towards the front and should not be obstructed. Additional pads are provided on the lower surface for extra support for these pins. Sockets should, of course, be mounted slightly proud of the board to permit application of solder on the top pads.

The sockets required are 0.156 inch, or 4mm spacing and are 2 x 22.

COMPONENTS . . .

MOTHER BOARD

Miscellaneous

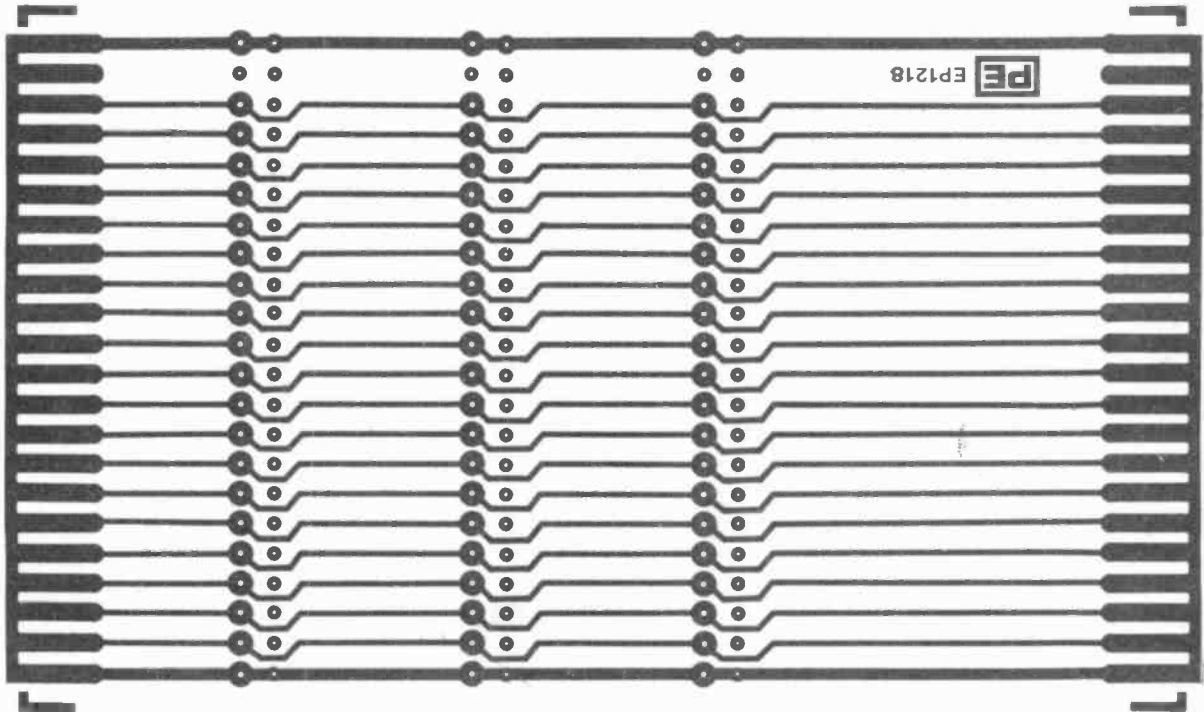
Edge connectors: 0.156in. (4mm) 2 x 22 contact
Printed circuit board

Constructors' Note

Edge connectors to suit (and most components) are available from **Watford Electronics**.

* If p.c.b.s are found to be unavailable from PE's usual suppliers, they may be obtained from Meridan Ltd., ☎ 0639 898277.

Fig. 1.9. Mother Board p.c.b. (track-side)

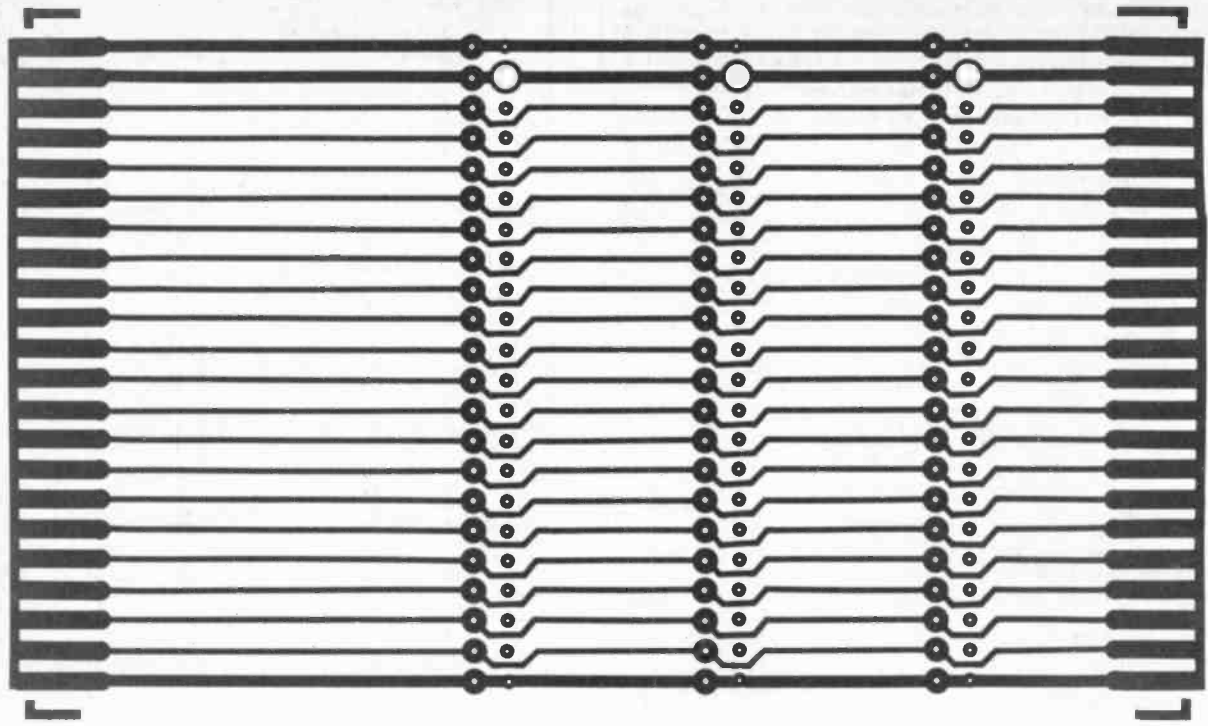


EXPANDING

THE

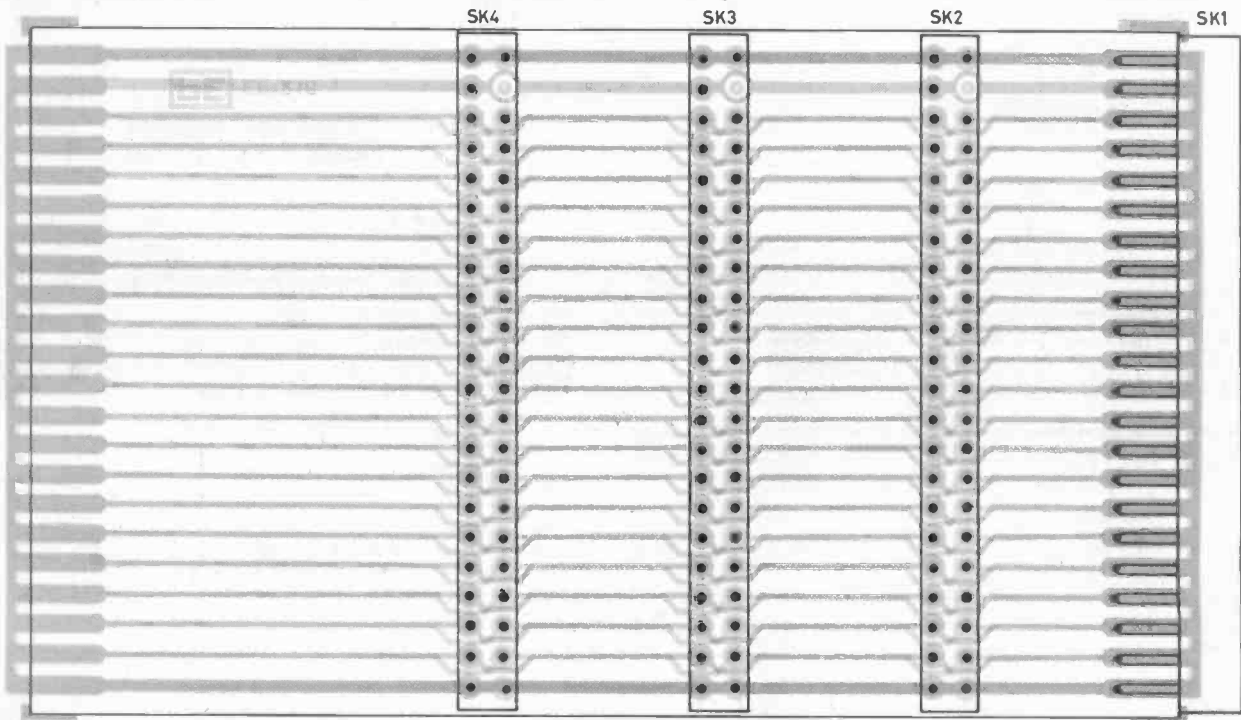
VIC 20

X



EP1219

Fig. 1.10. Mother Board p.c.b. (component-side)



EP1219
EP1211

Fig. 1.11. Mother Board component layout (actual size)

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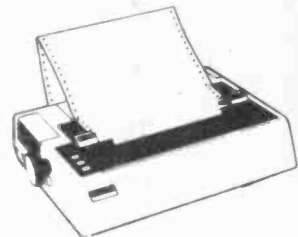
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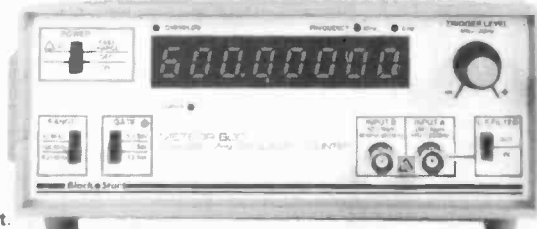
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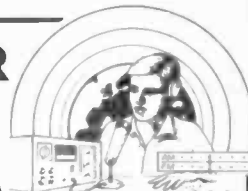
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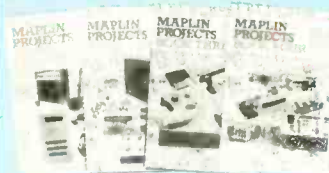
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