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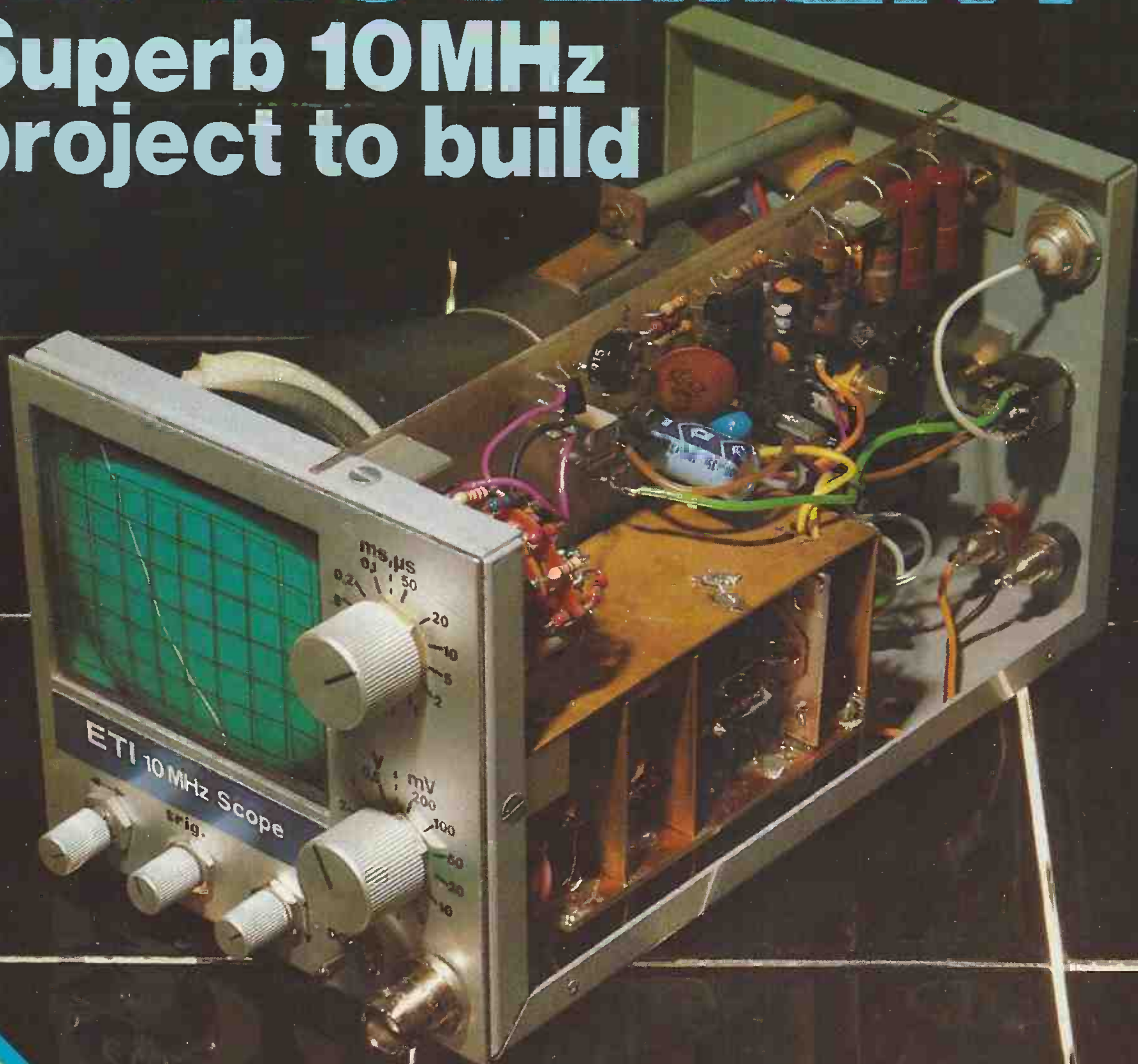
MAY 1982 75p

SCOPE FOR IMPROVEMENT?

Superb 10MHz project to build



- Insulation Tester: Makes rewiring quick, easy and safe!
- Slot-car controller: Novel design techniques
- Electro-music circuits to try from Tim Orr

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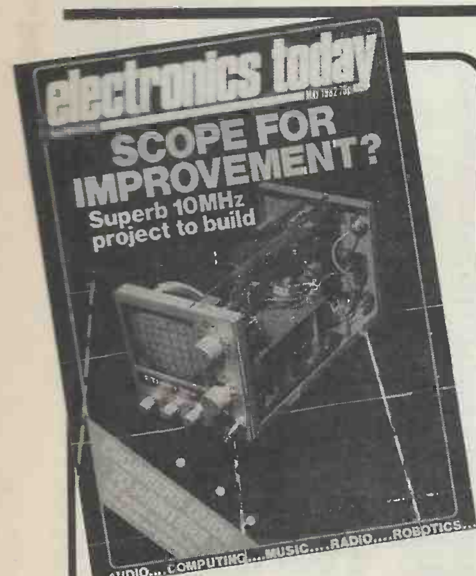

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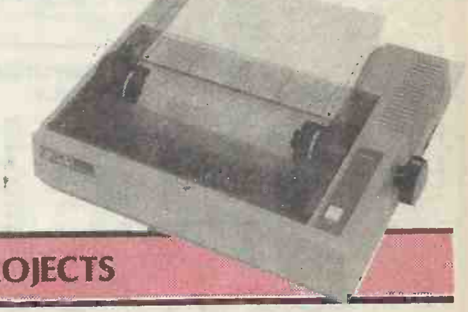
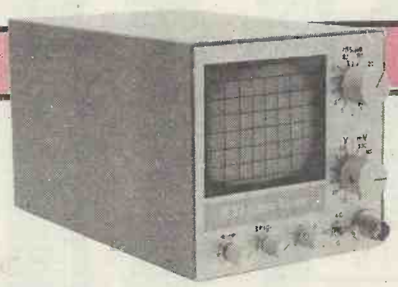


PROJECTS



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TAG-END TYPE: 450V: 100µF 65p; 70V: 4700, 245p; 64V: 3300 198p; 2200 139p; 50V: 3300 154p; 2200 110p; 40V: 4700 160p; 25V: 10,000 320p; 15,000 345p.

POLYESTER CAPACITORS: Axial Lead Type
400V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8 11p; 10n, 15n, 18n, 22n 12p; 33n, 47n, 68n 16p; 150n 20p; 220n 30p; 330n 42p; 470n 52p; 680n 1uF 68p; 2u2 82p.
160V: 10nF, 12n, 39n, 100n 11p; 150n, 220n 17p; 330n, 470n 30p; 680n, 38p; 1uF 42p; 1u5 45p; 2u2 48p; 4u7 58p.
1000V: 1nF 17p; 10nF 30p; 15n 40p; 22n 36p; 33n 42p; 47n, 100n 42p.

SIEMENS Pcb
Type Miniature poly. Capacitors
250V
1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 10n, 12n, 15n 7p
18n, 22n, 27n, 33n 8p
39n, 47n 8p
39n, 56n 12p
82n, 100n 11p
100V
100n, 120n 10p
150n, 180n 12p
220n, 270n 15p
330n, 390n 20p
470n, 560n 26p
680n 30p
1uF 34p
2u2 50p

POLYESTER RADIAL LEAD CAPACITORS: 250V
10n, 15n, 22n, 27n 6p; 33n, 47n, 68n, 100n 7p; 150n, 220n 10p; 330n, 470n 13p; 680n 19p; 1u 23p; 1u5 40p; 2u2 46p.

FEED-THROUGH CAPACITORS
1000pF/450V 8p

TANTALUM BEAD CAPACITORS
35V: 0.1µF, 0.22, 0.33 15p; 0.47, 0.68, 1.0, 1.5 16p; 2.2, 3.3 18p; 4.7, 6.8 22p; 10 28p; 16V: 2.2, 3.3 16p; 4.7, 6.8, 10 18p; 15, 36p; 22 30p; 33, 47 40p; 100 75p; 10V: 15, 22, 26p; 33, 47 35p; 100 55p; 6V: 100 42p.

POTENTIOMETERS: Rotary, Carbon, Track. 0.25W Log & Lin.
500Ω, 1KΩ & 2KΩ (Linear only) Single Gang 29p
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5KN-2MΩ Single Gang D/P Switch 78p
5KΩ-2MΩ Double Gang 89p

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10KΩ-500KΩ dual gang 110p
Self Stick Graduated Bezel 40p

CERAMIC CAPACITORS 50V:
Range: 0.5pF to 10nF 4p. 15nF; 22nF; 33nF; 47nF 5p. 100nF/30V 7p, 200nF/6V 8p

PRESET POTENTIOMETERS
0.1W 50Ω 5MΩ Miniature
Vertical & Horizontal 7p
0.25W 100Ω 3.3MΩ horiz. larger 10p
0.25W 200Ω 4.7MΩ vert. 10p
Cermet, Precision, multiturn, 0.75W 3/4in 100Ω-100KΩ 89p

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SILVER MICA (Values in pF) 2, 3.3, 4.7, 6.8, 8.2, 10, 12, 15, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180pF 15p each
z200, 220, 250, 270, 300, 330, 360, 390, 470, 800, 800, 820 21p each
1000, 1200, 1800, 2200 30p each
3300, 4700pF 60p each

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POLYSTYRENE CAPACITORS:
10pF to 1nF 8p; 1.5nF to 12nF 10p

MINIATURE TYPE TRIMMERS
2-6pF, 2-10pF 22p; 2-25pF, 5-56pF 30p; 10-88pF 35p

COMPRESSION TRIMMERS
3-40pF, 10-80pF 20p; 20-250pF 28p; 100-580pF 39p; 400-1250pF 48p

RESISTORS Carbon Film High Stability Low Noise Miniature Tolerance 5%.

	RANGE	VAL	1-99	100
¼W	2Ω2 4M7	E24	2p	1p
½W	2Ω2 4M7	E12	2p	1p
1W	2Ω2 1MΩ	E12	5p	4p
2% Metal Film 10Ω-1MΩ			6p	4p
1% Metal Film 0.5W 51Ω-1M			8p	6p

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TRANSISTORS

AC125	35	BC212	10	BF244B	29	MPSU02	58	ZTX301	16	2N3773	270	2SC2166	165
AC126/7	35	BC212L	10	BF245	30	MPSU05	55	ZTX302	16	2N3819	22	2SC2335	225
AC128	30	BC213	10	BF256A	35	MPSU06	55	ZTX303	25	2N3820	38	2SC2612	225
AC141/2	30	BC213L	10	BF256B	45	MPSU52	65	ZTX304	17	2N3822/3	50	2SD234	74
AC176	28	BC214	10	BF257/8	32	MPSU55	60	ZTX314	25	2N3824	65	2SK45	90
AC187	32	BC214L	10	BF259	35	MQSU56	60	ZTX326	30	2N3866	90	3N128	112
AC188	32	BC237/8	14	BF274	42	MPU131	52	ZTX341	30	2N3879	150	3N140	112
ACY17/18	70	BC307B	14	BF336/7	40	OC26	170	ZTX500	14	2N3903/4	15	40097	120
ACY19/20	75	BC308	16	BF451	35	OC28/35	130	ZTX501/2	15	2N3905/6	15	40250	95
ACY21/22	75	BC327/8	15	BF594/5	30	OC36/41	75	ZTX503	18	2N3906	17	40311	60
ACY28	75	BC337/8	15	BFR39/40	23	OC42/44	120	ZTX504	25	2N4037	46	40313	130
ACY39/41	85	BC441/61	34	BFR41/79	23	OC45/70	40	ZTX531	25	2N4041	40	40315	90
AD142	120	BC477	40	BFR80/81	25	OC71/72	40	ZTX550	25	2N4058	10	40316	95
AD149	79	BC516/7	40	BFR98	105	OC74/75	50	2N697	23	2N4061/2	10	40317/20	80
AD161	42	BC547/8	12	BFX29	28	OC76/77	50	2N698	40	2N4064	115	40323	60
AD162	42	BC549C	14	BFX81	45	OC81/82	40	2N699	48	2N4220	78	40324	100
AF115/6	60	BC556/7	15	BFX84	26	OC83/84	40	2N706A	19	2N4234/6	48	40326/7	70
AF117/8	90	BC558/9	15	BFX85/6	28	OC170/71	50	2N708	19	2N4264	24	40347	90
AF124/26	70	BCY30	68	BFX87/8	28	OC200	50	2N918	35	2N4286	15	40348	120
AF139	40	BCY31	85	BFY18	50	TIP29A	36	2N1131/2	24	2N4289	18	40360	60
AF178	75	BCY35	50	BFY50/1	23	TIP29B	56	2N1302	45	2N4314	68	40361/2	70
AF186	70	BCY39/40	85	BFY52	23	TIP29C	60	2N1303	60	2N4400	18	40407/8	75
AF239	78	BCY42/43	14	BFY53	32	TIP30A	48	2N1304/5	60	2N4427	80	40411	285
ASZ21	125	BCY45	50	BFY55/6	32	TIP30C	58	2N1306/7	65	2N4859	78	40412	90
BC107	10	BCY58/59	35	BFY64	35	TIP31A	45	2N1308	68	2N4871	68	40467A	130
BC107B	12	BCY70/71	16	BFY81	120	TIP31B	48	2N1613	30	2N4898	135	40468	85
BC108	10	BCY72	20	BFY90	90	TIP31C	55	2N1670	150	2N4901	175	40594	105
BC108B	12	BCY78	24	BRY39	40	TIP32A	48	2N1671B	160	2N4921	55	40603	110
BC108C	12	BD112	125	BSX20	20	TIP32C	60	2N2160	295	2N4922	60	40636	175
BC109	10	BD124	115	BSX26/29	34	TIP33A	65	2N2217	45	2N5135/6	20	40673	85
BC109B	12	BD131/32	43	BSX78	45	TIP33C	78	2N2218A	45	2N5138	18		
BC109C	12	BD133	60	BSY26	30	TIP34A	74	2N2219A	28	2N5172	13		
BC114/5	22	BD135	45	BSY95A	25	TIP34C	88	2N2220A	26	2N5179	45		
BC117/8	24	BD136/37	40	BU105	170	TIP35A	160	2N2221A	26	2N5180	45		
BC119	38	BD138/39	40	BU205	190	TIP35C	185	2N2222A	26	2N5190/1	75		
BC137/9	40	BD140	40	BU206	200	TIP36A	170	2N2297	45	2N5305/8	24		
BC140	30	BD144/45	198	BU208	209	TIP36C	199	2N2303	45	2N5457/8	30		
BC142/3	30	BD158	55	BUY69C	225	TIP41A	55	2N2368	25	2N5459	30		
BC147	9	BD205/6	110	E421	250	TIP41B	60	2N2369A	18	2N5485	36		
BC147B	10	BD222	85	MD8001	250	TIP42A	60	2N2476	50	2N5777	45		
BC148	9	BD245	45	MJ490	90	TIP42B	75	2N2483/4	27	2N5879	190		
BC148B	10	BD378	70	MJ491	175	TIP120	90	2N2904/5	28	2N6027	32		
BC149	9	BD434	55	MJ2955	90	TIP121/2	99	2N2906/7	26	2SA715	60		
BC149C	10	BD517	75	MJE170	150	TIP141/2	120	2N2907A	26	2SC495	70		
BC153/4	27	BD695A	85	MJE180	150	TIP147	120	2N2926G	10	2SC496	70		
BC157/8	10	BD696A	85	MJE340	54	TIP2955	60	2N3011	28	2SC1096	85		
BC159	11	BDY56	180	MJE370	100	TIP3055	60	2N3053	26	2SC1173	125		
BC160	45	BDY60	160	MJE371	100	TIS43	32	2N3054	58	2SC1306	100		
BC167A	10	BF115	35	MJE520	65	TIS44/5	45	2N3055	45	2SC1307	150		
BC168C	10	BF154/8	25	MJE521	95	TIS46	45	2N3108	45	2SC1449	85		
BC169C	10	BF167	29	MJE2955	99	TIS59/74	50	2N3252	46	2SC1678	140		
BC170	15	BF173	27	MJE3055	70	TIS90/91	30	2N3302	30	2SC1679	190		
BC171/2	11	BF177	25	MPF102	40	UC734	65	2N3441/2	140	2SC1923	50		
BC177/8	16	BF178	30	MPF103	30	VK1010	80	2N3663	15	2SC1945	225		
BC179	20	BF179	35	MPF104	30	VN10KM	50	2N3702/3	10	2SCz1963	90		
BC182/3	10	BF180/2	38	MPF105	30	VN46AF	78	2N3704/5	10	2SC1957	90		
BC184	10	BF184/5	38	MPF106	40	VN66AF	85	2N3706/7	10	2SC1969	140		
BC182L	10	BF194/5	12	MPSA05	22	VN88AF	94	2N3708/9	10	2SC2028	85		
BC183L	10	BF196/7	12	MPSA08	25	ZTX107/8	11	2N3710/11	10	2SC2029	210		
BC184L	10	BF198/9	16	MPSA12	32	ZTX109	12	2N3713	140	2SC2078	170		
BC186/7	30	BF200	30	MPSA55	30	ZTX212	28	2N3771	179	2SC2091	85		
		BF224A	25	MPSA56	30	ZTX300	13	2N3772	195	2SC2314	85		

RF CHOKES
Miniature PCB type
1uH, 2u2, 4u7, 10u, 22u, 33u, 47u, 100u, 220u, 330u, 470u 30p
1mH, 1m5, 2m2, 4m7, 10mH 35p
22m, 33m, 43m 60p
100m 75p

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2764	£19	MC14412	795
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709C 8 pin	35	CA3080E	70	M253AA	1150	TAA700	275
741 8 pin	14	CA3081	190	M51513L	230	TAA900	00
747C 14 pin	65	CA3085	95	M51515L	320	TAD100	159
748C 8 pin	36	CA3086	48	M51516L	475	TBA120S	70
753 8 pin	185	CA3089E	215	MB3756	440	TBA540Q	275
810	159	CA3090AQ	375	MC1204	250	TBA550Q	330
9400CJ	350	CA3123E	150	MC1301	79	TBA641 BX or BX11	350
AY-1-0212	675	CA3130	90	MC1303	88	TBA651	190
AY-1-1313A	660	CA3140	48	MC1304P	260	TBA800	80
AY-1-1320	225	CA3160	95	MC1310P	150	TBA810	95
AY-1-5050	99	CA3161	135	MC1445	150	TBA820	80
AY-1-5051	160	CA3162E	450	MC145106	695	TBA920Q	290
AY-3-1270	840	CA3189	295	MC1458	40	TBA950	300
AY-3-1350	350	HA1336W	240	MC1469	300	TBA990Q	350
AY-3-8500	390	ICL7106	750	MC1494	694	TBA540	275
AY-3-8910	600	ICL7107	975	MC1495	350	TCA220	350
AY-3-8912	625	ICL7611	00	MC1496L	70	TCA270Q	350
AY-5-1224A	235	ICL8038CC	300	MC1596	226	TCA940	175
AY-5-1230	450	ICL8211A	150	MC1648	290	TCA965	120
AY-5-1317A	630	ICM7204	550	MC1709G	90	TDA1004	290
AS-5-3500	350	ICM7205A	1150	MC3302	150	TDA1008	310
AY-5-4007D	520	ICM7207	475	MC3340P	120	TDA1022	525
AY-5-8100	775	ICM7215	1050	MC3360P	120	TDA1024	105
CA3011	130	ICM7216AJ	1950	MC3401	65	TDA1034	350
CA3012	175	ICM7216B	1950	MC3403	89	TDA1490	290
CA3014	275	ICM7216C	1950	MC3405	150	TDA2002	325
CA3018	86	ICM7217A	790	MC4016	00	TDA2020	320
CA3019	80	ICM7224	785	MFC6040	97	TDA2030	320
CA3020	210	ICM7555	80	MK50398	635	TDB0791	420
CA3023	210	ICM7556	150	ML924	275	TLO61CP	40
CA3028A	95	LA3350	250	MM5303	635	TLO62CP	60
CA3035	265	LA4031P	340	MM5307	1275	TLO64CN	98
CA3036	270	LA4032	295	MM5387A	475	TLO71CP	30
CA3043	275	LA4400	440	MSM5526	820	TLO72CP	50
CA3045	385	LC7130	340	NE515	275	TLO74CN	100
CA3046	70	LC7210	300	NE529	225	TLO81CP	25
		LF347	150	NE531	140	TLO82CP	45
		LF351	48	NE534	150	TLO83CP	75
		LF353	95	NE543K	225	TLO84CN	95
		LF355	85	NE544	210	TL170	50
		LF356	95	NE555	16	TLO91CP	55
		LF357	110	NE556	45	UA2240	120
		LM10	360	NE560	325	UAA170	170
		LM301AP	26	NE561	398	UAA180	170
		LM307	00	NE562B	410	UAA1003-3	935
		LM308T	95	NE564	420	ULN2003	85
		LM311	70	NE565A	120	ULN2004	90
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		LM339	54	NE5534A	125	UPC1156H	270
		LM348	64	RC4136D	69	XR2206	300
		LM349	115	S566B	245	XR2207	375
		LM358	65	SAB3209	425	XR2216	675
		LM377	155	SAB3210	295	XR2240	120
		LM379	480	SAB3271	485	XR2266	360
		LM380	75	SAB4209	595	ZN414	88
		LM381N	145	SG3402	295	ZN419E	190
		LM382	125	SL490	350	ZN423E	135
		LM384	140	SN76003N	350	ZN424E	130
		LM386	90	SN76013	350	ZN425E	345
		LM387	120	SN76018	148	ZN426E	300
		LM389	95	SN76023N	350	ZN427E	600
		LM393	100	SN76023ND	240	ZN428E	478
		LM394	290	SN76033N	350	ZN429E	210
		LM725CN	325	SN76115N	215	ZN1034E	200
		LM733	75	SN76131	125	ZN1040E	675
		LM1458	45	SN76227N	95		
		LM2917	195	SN76477	175		
		LM3302	95	SN76488	480		
		LM3900	50	SN76660	120		
		LM3909N	85	SP8629	299		
		LM3911	125t	TA7210	150		
		LM3911	126	TA7130	160		
		LM3914	210	TA7204	225		
		LM3915	220	TA7205	220		
		LM3916	220	TA7205A	225		
				TA7222	175		

TTL 74 (TEXAS)

7400	11	74112	170	74279	90
7401	11	74116	88	74283	90
7402	11	74118	80	74284	199
7403	14	74119	90	74285	199
7404	14	74120	75	74290	105
7405	18	74121	30	74293	125
7406	28	74122	45	74297	236
7407	28	74123	50	74298	100
7408	16	74125	42	74351	
7409	16	74126	40	74365	
7410	14	74128	42	74366	55
7411	20	74132	48	74367	55
7412	20	74136	35	74368	55
7413	24	74141	70	74390	99
7414	32	74142	190	74393	99
7416	25	74143	250	74490	120
7417	25	74144	250		
7420	16	74145	70		
7421	20	74147	99		
7422	20	74148	75		
7423	22	74150	80		
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7473	30	74181	140		
7474	25	74182	75		
7475	40	74184	99		
7476	30	74185	99		
7480	48	74186	470		
7481	120	74188	290		
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7484	80	74188	290		
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7496	45	74199	99		
7497	120	74221	80		
74100	85	74246	150		
74104	54	74247	150		
74105	55	74248	150		
74107	32	74249	150		
74109	35	74251	80		
74110	40	74259	195		
74111	55	74265	65		
		74273	195		
		74276	150		
		74278	160		

74L

74L00	68
74L04	85
74L30	50
74L47	380
74L75	145
74L85	349
74L121	165
74L123	325

74S

74S00	38
SO4	40
S132	110
S138	180
S158	195
S188	210
S189	158
S194	320
S195	795
S201	320
S225	510
S241	390
S262	850
S287	300
S288	210
S289	195
S301	00
S470	325
S471	620
S472	1150
S475	825
S571	620

74LS

LS00	12	LS22	15	LS195	40
LS01	13	LS26	18	LS197	85
LS02	14	LS27	15	LS200	345
LS03	14	LS28	20	LS202	345
LS04	15	LS30	18	LS221	60
LS05	15	LS32	15	LS240	96
LS06	15	LS33	16	LS241	96
LS08	15	LS37	16	LS242	85
LS09	15	LS38	16	LS243	85
LS10	15	LS40	16	LS244	80
LS11	15	LS42	35	LS245	60
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LS13	30	LS48	80	LS248	65
LS14	48	LS49	60	LS249	68
LS15	15	LS51	15	LS251	40
LS20	15	LS54	15	LS253	40
LS21	15	LS55	30	LS257	48
		LS63	150	LS258	40
		LS73	25	LS259	85
		LS74	25	LS260	21
		LS75	28	LS266	25
		LS76	20	LS273	90
		LS78	24	LS275	290
		LS83	50	LS279	88
		LS85	70	LS283	250
		LS86	38	LS285	45
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		LS91	80	LS293	46
		LS92	36	LS295	215
		LS93	36	LS298	130
		LS95	45	LS299	420
		LS96	120	LS300	175
		LS107	43	LS320	270
		LS109	30	LS323	270
		LS112	30	LS324	200
		LS113	40	LS325	320
		LS114	35	LS327	315
		LS122	44	LS347	150
		LS123	55	LS348	190
		LS124	105	LS352	185
		LS125	30	LS353	185
		LS126	30	LS362	750
		LS132	45	LS363	150
		LS133	35	LS364	150
		LS136	28	LS365	37
		LS138	35	LS366	37
		LS139	38	LS367	37
		LS145	75	LS368	90
		LS147	199	LS373	75
		LS148	99	LS374	75
		LS151	39	LS375	48
		LS153	39	LS377	90
		LS155	39	LS378	69
		LS156	39	LS379	65
		LS157	35	Ls384	395
		LS158	36	LS385	378
		LS160	41	LS390	62
		LS161	41	LS393	60
		LS162	41	LS395	199
		LS163	41	LS396	190
		LS164	48	LS398	275
		LS165	145	LS399	220
		LS166	85	LS445	140
		LS168	85	LS447	195
		LS170	170	LS471	620
		LS170	170	LS490	245
		LS173	72	LS541	135
		LS174	72	LS571	620
		LS175	58	LS640	225
		LS181	130	LS641	225
		LS183	275	LS645	210
		LS190	58	LS668	175
		LS191	58	LS669	150
		LS192	58	LS670	175
		LS193	65	LS673	550
		LS194	40	LS674	750

DIODES

AA119	15
BA100	15
BY100	24
BY126	12
BY127	12
CRO33	250
OA9	40
OA47	12
OA70	12
OA79	15
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	15
1N5404	16
1N5406	17
IN5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

BRIDGE RECTIFIERS

(plastic case)	p
1A/50V	20
1A/100V	22
1A/400V	29
1A/600V	34
2A/50V	35
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	350
25A/200V	240
25A/600V	395
BY164	56
VM18 DIL	50

75 SERIES

75107	125
75108	95
75110	90
75150	125
75154	150
75182/3	99
75188/9	55
75322	140
75324	00
75450	86
75451/2	52
75454	85
75491/2	65

ZENERS

Range: 2V7 to 39V 400mW 8p each
Range: 3V3 to 33V. 1.3W 15p each

SCR Thyristors

5A/40V	32
5A400V	40
5A600V	48
8A300V	60
8A600V	90
12A100V	78
12A400V	95
12A800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5062	32
2N5064	38
2N4444	130

TRIACS

3A200V	54
3A400V	56
8A100V	60
8A400V	69
8A800V	115
12A100V	78
12A400V	82
12A800V	135
16A100V	103
16A400V	105
16A800V	220
25A500V	220
25A800V	295
T2800D	120

NOISE

Z5J 195p

VARICAPS

BA102	50
BB105B	40
BB106	40
MVAM2	165
MVAM115	158

DIAC

ST2 25

Sinclair ZX81 Personal Comp
the heart of a system that grows with you.

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. Not surprisingly, over 50,000 were sold.

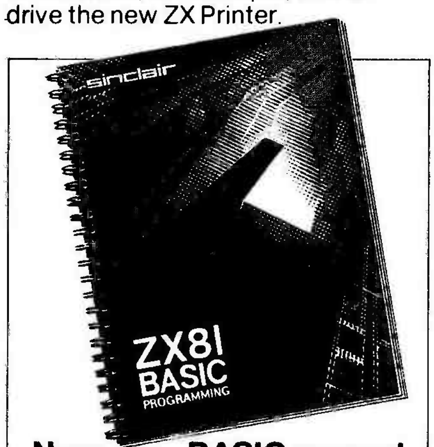
In March 1981, the Sinclair lead increased dramatically. For just £69.95 the Sinclair ZX81 offers even more advanced facilities at an even lower price. Initially, even we were surprised by the demand – over 50,000 in the first 3 months!

Today, the Sinclair ZX81 is the heart of a computer system. You can add 16-times more memory with the ZX RAM pack. The ZX Printer offers an unbeatable combination of performance and price. And the ZX Software library is growing every day.

Lower price: higher capability
With the ZX81, it's still very simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, *and* to drive the new ZX Printer.



New BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BAS... first principles to complex prog...

Kit: £49.95

Higher specification, lower price – how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80'

New, improved specification
- Z80A micro-processor – new faster version of the famous Z80 chip, widely recognised as the best ever made.
- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numerical arrays.
- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer.
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

Built: £69.95

Kit or built – it's up to you!
You'll be surprised how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.

uter-

Available now- the ZX Printer for only £49.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alpha-numerics *and* highly sophisticated graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further intructions.

At last you can have a hard copy of your program listings – particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your computer – using a stackable connector so you *can* plug in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions.

16K-byte RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

With the RAM pack, you can also run some of the more sophisticated ZX Software – the Business & Household management systems for example.

How to order your ZX81

BY PHONE – Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day.

BY FREEPOST – use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST, Camberley, Surrey, GU15 3BR. **Order**

Qty	Item	Code	Item price £	Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack.	18	49.95	
	Sinclair ZX Printer.	27	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

☐ Please tick if you require a VAT receipt TOTAL £______

*I enclose a cheque/postal order payable to Sinclair Research Ltd, for £______

*Please charge to my Access/Barclaycard/Trustcard account no.

*Please delete/complete as applicable ______

Please print.

Name: Mr/Mrs/Miss ______

Address: ______

______

FREEPOST – no stamp needed. Offer applies to UK only. ETI 05

sinclair
ZX81

6 Kings Parade, Cambridge, Cambs., CB2 1SN.
Tel: (0276) 66104 & 21282.

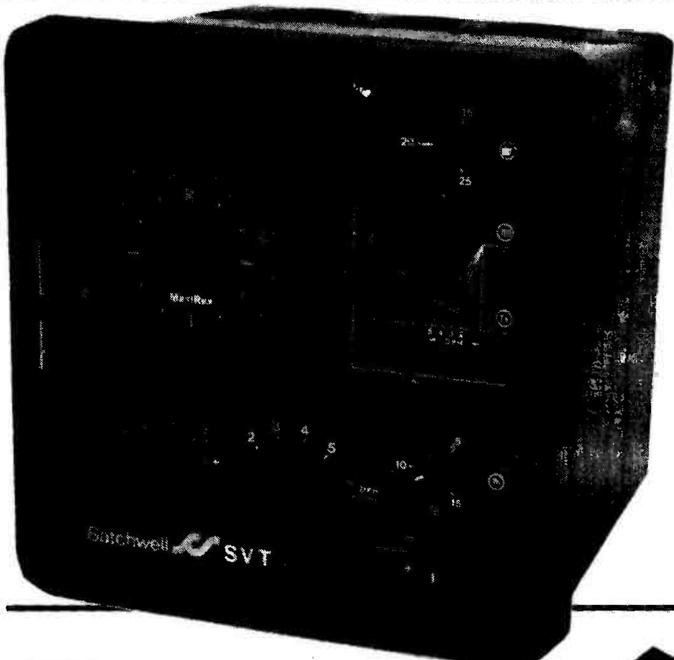
DIGEST

'Ears A Novelty

This new calculator has been specifically designed for Arab oil producers who wish to calculate up-to-the-minute profit figures while driving between oil wells. The device may be unobtrusively powered from the car battery via the discreet power lead, and for road safety one hand can always remain on the steering wheel since the buttons are operated by ear.

Well, that's what we first thought when this photograph fell out of our mail, but a glance at the accompanying press release revealed a more mundane explanation. Philips have received a share of an order from the Kingdom of Saudi Arabia for the delivery and installation of a national automatic mobile telephone network. Covering 32 cities and several of the nation's traffic corridors, the network involves 18,000 mobile telephones and 48 base-station sites, half of which are to be supplied by Philips. The full duplex system operates in the 420-470 MHz band and provides 866 channels nationwide. The mobile telephone network can be automatically connected into the 'fixed' telephone system, allowing any number in the world to be called. Facilities include a push-button dialling, dialled-number LCD display, automatic display/keyboard illumination to suit the lighting conditions, last-number recall and malicious-call tracing (wonder what the Saudi penalty for *that* is?). Naturally, the whole kaboodle is built round a microprocessor, and will give Saudi Arabia one of the most modern systems in the world.

Somehow our explanation seemed so much more *fun*. . .



Satch A Good Idea

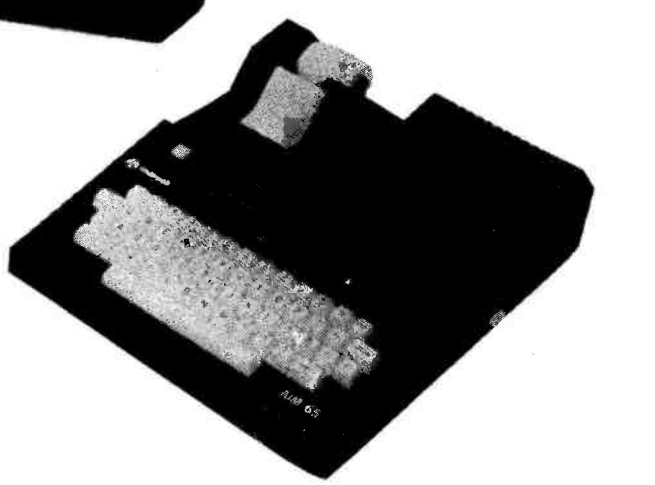
If you don't fancy a trip to London for the energy control seminar (see Save It!), for about the same money (£100) you can purchase a simple optimiser from the bottom end of the Satchwell control system range. This gadget, called the SVT, optimises the heating system in smaller commercial buildings and can allow companies whose fuel bills are only a few thousand pounds to recover the cost very quickly. Payback periods range from six months, to as little as 12 weeks in exceptional circumstances. The device is aimed at shops, small offices, clubs and so on who are presently unaware of the benefits of optimum start control. For more details contact Michael Edwards, Satchwell Control Systems Ltd, PO Box 57, Farnham Road, Slough, Berks SL1 4UH.

Long Live Batteries

And now, the battery that goes on working after the battery that goes on working, stops. Israel's Tel Aviv University has developed a unique lithium-sulpher battery which yields one of the highest energy densities available. The cell can be used for a period of up to 10 years, yet is more compact and cheaper to construct than conventional long-term batteries. Existing in prototype form only at present, projected uses include microcomputer power failure back-up, calculators and watches, inaccessible instrumentation (eg military equipment) and pacemakers, where you don't really want to stick new batteries in every couple of months.

AIM To Please

If you're a fan of the AIM 65 'bareboard' microcomputer you will doubtless be glad to know that you can now cover up its naked little body with an accessory enclosure from Rockwell. The ABS enclosure has a brown non-reflective crinkle finish, on-off and reset switches and internal AC lines. An optional power supply providing +5 V at 3 A and +24 V at 500 mA is also available with the enclosure. Available from all AIM 65 distributors as well as many computer store dealers, the enclosure has a retail price of about £90 with the PSU and £50 without.



Save It!

Are you stuck in a mental rut as regards traditional mechanical and electrical devices? Do you worry about the energy costs of your company? Kill two birds with one stone and visit a one day seminar on microcomputers and energy conservation. The seminar, to be held on Tuesday 20th April at the CEGB in London EC1, will explore what computers can and cannot do to save energy, from controlling electricity demand to optimising combustion in boilers. The seminar fee is £100 plus VAT per delegate and further details can be obtained from Miss Mallory Barker, Scientific and Technical Studies, Norwich House, 11-13 Norwich Street, London EC4A 1AB (Tel. 01-242 2481).

TTLs

7400	11p
7401	11p
7402	12p
7403	12p
7404	12p
7405	18p
7406	25p
7407	25p
7408	14p
7409	15p
7410	15p
7411	20p
7412	20p
7413	22p
7414	35p
7416	25p
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7420	17p
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7427	25p
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74156	50p
74157	55p
74159	100p
74160	60p
74161	60p
74162	60p
74163	60p
74164	50p
74165	55p
74166	70p
74170	140p
74172	300p
74173	65p
74174	60p
74175	60p
74176	50p
74177	70p
74178	100p
74180	50p
74181	160p
74182	90p
74184A	90p
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74293	100p
74298	100p
74365	55p
74366	55p
74368	55p
74390	100p
74393	100p
74490	120p

74LS SERIES

74LS00	12p
74LS01	14p
74LS02	14p
74LS03	14p
74LS04	15p
74LS05	15p
74LS08	16p
74LS09	15p
74LS10	15p
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74LS109	30p
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74LS114	30p
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74LS251	40p
74LS253	40p
74LS257	45p
74LS258	40p
74LS259	90p
74LS260	24p
74LS266	25p
74LS273	70p
74LS279	45p
74LS283	45p
74LS298	160p
74LS323	250p
74LS324	150p
74LS348	150p
74LS352	100p
74LS353	100p
74LS363	160p
74LS364	160p
74LS365	36p
74LS367	36p
74LS268	36p
74LS373	70p
74LS374	70p
74LS375	50p
74LS377	70p
74LS378	60p
74LS390	55p
74LS393	50p
74LS399	200p
74LS540	135p
74LS541	135p
74LS670	170p

4000 SERIES

4000	12p
4001	14p
4002	15p
4006	65p
4007	16p
4008	60p
4009	35p
4010	40p
4011	14p
4012	16p
4013	35p
4014	60p
4015	60p
4016	30p
4017	45p
4018	60p
4019	32p
4020	60p
4021	65p
4022	70p
4023	20p
4024	40p
4025	20p
4026	130p
4027	32p
4028	60p
4029	75p
4030	40p
4031	170p
4034	160p
4035	80p
4036	295p
4039	295p
4040	55p
4041	70p
4042	55p
4043	60p
4044	70p
4046	70p
4047	75p
4048	55p
4049	27p
4050	27p
4051	60p
4052	80p
4053	60p
4054	130p
4055	125p
4056	120p
4059	500p
4060	90p
4063	100p
4066	35p
4067	400p
4068	18p
4069	18p
4070	18p
4071	18p
4072	18p
4073	20p
4075	20p
4076	60p
4081	16p
4082	20p
4086	72p
4089	150p
4093	40p
4094	150p
4095	95p
4096	95p
4097	340p
4098	90p
4099	120p
40085	90p
40097	£120p
40098	120p
40102	180p
40103	180p
40106	45p
40109	100p
40163	100p
40173	120p
40174	90p
40175	100p
40193	90p
40257	160p
4502	70p
4503	50p
4507	40p
4508	200p
4510	65p
4511	50p
4512	65p
4514	150p
4515	150p
4516	75p
4518	45p
4520	70p
4521	150p
4526	75p
4527	90p
4528	75p
4532	90p
4534	500p
4536	300p
4538	120p
4539	110p
4543	100p
4553	290p
4555	50p
4556	60p
4560	180p
4568	300p
4569	180p
4572	30p
4583	90p
4584	45p
4585	100p
14495	400p

74S SERIES

74S00	60p
74S04	60p
74S08	75p
74S30	60p
74S32	90p
74S74	90p
74S85	300p
74S86	180p
74S124	300p
74S132	160p
74S133	75p
74S138	225p
74S139	225p
74S157	250p
74S163	300p
74S174	250p
74S175	320p
74S194	350p
74S241	400p

LINEAR I.Cs

AN103	200p	MB3712	225p
AY1-0212	600p	MC1310P	150p
AY1-1313	668p	MC1458	40p
AY1-1320	320p	MC1495L	350p
AY1-5050	140p	MC1496	70p
AY3-8910	600p	MC3340P	120p
AY3-8912	650p	MC3401	90p
AY5-1224A	240p	MC3403	120p
AY5-1315	600p	MK50398	750p
AY5-4007D	520p	ML920	800p
CA3028A	120p	MM57160	620p
CA3019	80p	MN6221A	£6
CA3046	70p	NE531	150p
CA3048	225p	NE555	20p
CA3059	300p	NE556	50p
CA3080E	72p	NE564	420p
CA3086	48p	NE565	130p
CA3089	225p	NE566	155p
CA3090AQ	375p	NE567	140p
CA3130E	90p	NE570	425p
CA3140	50p	NE571	425p
CA3160E	100p	NE5534A	150p
CA3161E	190p	PLL02A	500p
CA3162	450p	RC4136	70p
CA3189E	300p	RC4151	200p
CA3240	120p	RC4558	60p
CA3280G	200p	S566B	260p
DAC1408-8	200p	SAD1024A	1250p
HA1366	195p	SFF96364	800p
HA1388	270p	SL490	350p
ICL7106	850p	SN76477	175p
ICL8038	300p	SP8515	750p
ICM7555	80p	TA7120	165p
LC7120	325p	TA7204	195p
LC7130	325p	TA7205	125p
LF347	160p	TA7222	160p
LF351	48p	TA7310	160p
LF353	100p	TBA651	200p
LF356P	95p	TBA800	90p
LF357	120p	TBA810	100p
LM10C	425p	TBA820	90p
LM301A	27p	TBA950	300p
LM310	120p	TCA220	350p
LM318	200p	TCA940	200p
LM319	225p	TDA1004A	300p
LM324	45p	TDA1008	320p
LM335Z	140p	TDA1010	225p
LM339	65p	TDA1022	550p
LM348	75p	TDA1024	125p
LM358P	50p	TDA1034B	250p
LM377	175p	TDA1170	300p
LM380	75p	TDA2002V	325p
LM381AN	180p	TDA2020	320p
LM382	120p	TL071/81	40p
LM386	95p	TL072/82	75p
LM387	120p	TL074	130p
LM389	95p	TL084	110p
LM393	100p	TL094	200p
LM394	350p	TL170	50p
LM709	36p	TL430C	70p
LM710	50p	UAA170	170p
LM711	70p	UA2240	300p
LM733	100p	UDN6118	320p
LM741	18p	UDN6184	320p
LM747	70p	ULN2003	100p
LM748	35p	UPC575	275p
LM2917	200p	UPC592H	200p
LM3302	140p	UPC1156H	275p
LM3900	55p	XR2206	300p
LM3909	95p	ZN414	90p
LM3911	130p	ZN419C	225p
LM3914	210p	ZN423E	150p
LM3915	225p	ZN424E	135p
LM3916	225p	ZN425E	350p
LM13600	125p	ZN427E	625p
M51513L	300p	ZN1034E	200p
M51516L	500p	ZN1040E	700p

VOLTAGE REGULATORS

FIXED PLASTIC

1A	+ ve		− ve	
5V 1A	7805	50p	7905	55p
12V 1A	7812	50p	7912	55p
15V 1A	7815	55p	7915	60p
18V 1A	7818	55p	7918	60p
24V 1A	7824	55p	7924	60p
5V 100mA	78L05	30p	79L05	60p
12V 100mA	78L12	30p	79L12	70p
15V 100mA	78L15	30p	79L15	70p

OTHER REGULATORS

LM309K 1A 5V	135p	78HGKC	600p
LM317K	325p	78H05KC	550p
LM317T 1A Adj	200p	78MGT2C	140p
LM337T	225p	78GUIC	200p
LM323K 3A 5V	500p	79GUIC	225p
LM723 150mA Adj	37p	79HGKC	700p
TL494	300p	TL497	300p
78S40	300p	LM305AH	250p

OPTO-ELECTRONICS

2N5777	45p	ORP60	120p
OCP71	180p	ORP61	120p
ORP12	120p	TIL78	55p

OPTO-ISOLATORS

ILD74	130p	TIL111	90p
MCT26	100p	TIL112	90p
MCS2400	190p	TIL113	90p
ILQ74	240p	TIL116	90p

LEDS

0.125"		0.2"	
TIL32	55p	TIL220 Red	12p
TIL209 Red	11p	TIL222 Gr	15p
TIL211 Gr	16p	TIL228 Yel	22p
TIL212 Ye	18p	Rectangular LEDs (R, G, Y)	30p
TIL216 Red	18	NSB5881	570p
		TIL311	600p

DISPLAYS			
		TIL312/3	110
3015F	200p	TIL321/2	130p
DL704	140p	TIL330	140p
DL707 Red	140p	7750/60	200p
FND357	120p	DRIVERS	
FND500	90p	9368	250p
FND507	90p	9370	300p
MAN3640	175p	UDN6118	320p
MAN4640	200p	UDN6184	320p

* SPECIAL OFFER *

	1-24	25-99
2114L-2	90p	85p
2716	210p	200p
2532	400p	375p
4116-200nS	70p	65p

COMPUTER COMPONENTS

CPUs

1802CE	700p
2650A	£12
6502	450p
6502A	600p
6800	370p
6802	425p
6809	£10
6809E	£15
8035	750p
8039	850p
8080A	350p
8085A	550p
INS8060	£11
TMS9980	£20
Z80	370p
Z80A	450p
Z80B	£16
8088	£19

SUPPORT DEVICES

3242	800p
3245	450p
6522	500p
6532	775p
6821	160p
6551	650p
6821	160p
6845	£10
6847	£10
6850	160p
6852	250p
6875	600p
8154	950p
8155	800p
8205	220p
8212	160p
8216	160p
8224	250p
8226	250p
8228	250p
8243	450p
8250	850p
8251	350p
8253	800p
8255	350p
8257	800p
8259	800p
8279	950p
Z80PIO	300p
Z80APIO	350p
Z80CTC	300p
Z80ACTC	350p
Z80ADART	800p
Z80ADMA	£12
Z80S101	£12

CRT CONTROLLER

COM5037	£18
SF96364	£8
TMS9927	£18
6845	£10
6847	£10
9365	£60

MEMORIES

2101A	400p
2102-3L	120p
2107B	500p
2111A	300p
2112-A	300p
2114-2L	95p
2114-4L	90p
2147	450p
4027	300p
4044-45	450p
4116-15	90p
4116-20	75p
4118-3	500p
4118-4	450p
4164-2	600p
4816AP-3	500p
5101	300p
6116P-3	530p
6514-45	300p
6810	200p
7489	210p
74S189	325p
74S201	350p
74S289	325p

ROMs/PROMs

74S188	325p
74S287	308p
74S288	226p
74S387	325p
74S471	650p
74S473	850p
74S474	650p
74S570	650p
74S571	650p
74S573	950p

EPROMs

1702A	500p
2708	300p
2716 (+5V)	300p
2564	£25
2516 (+5V)	300p
2532	400p
2732	400p
2716-300nS	500p
2732-300nS	750p

UARTSs

AY-3-1015P	300p
AY-5-1013P	300p
IM6402	450p
TR1602	300p
COM8017	300p

CHARACTER GENERATORS

RO-3-2513UC	750p
RO-3-2513LC	700p
SN74S262AN	£10

INTERFACE ICs

AD558CJ	775p
AD561J	£14
AM25S10	350p
AM26LS31	160p
AM26LS32	190p
DAC80	£20
DM8131	375p
DP8304	450p
DS8832	250p
DS8833	225p
DS8836	150p
DS8838	225p
LF13201	450p
MC1488	55p
MC1489	55p
MC3418	950p
MC3446	300p
MC3480	850p
MC3486	500p
MC4024	325p
MC4044	325p
MC14411	700p
MC14412	900p
MC4044	325p
MM58174	£12
ULN2003A	100p
ULN2004A	100p
75017	160p
75110	160p
75112	160p
75114	160p
75115	160p
75150P	140p
75154	140p
75182	230p
75324	375p
75361	150p
75363	150p
75365	150p
75451/2	72p
75453/4	72p
75491/2	70p
8T26	120p
8T28	120p
8T95	120p
8T97	120p
81LS95	90p
81LS96	120p
81LS97	90p
81LS98	120p
9602	220p
9637AP	160p
ZN425E-8	350p
ZN426E-8	350p
ZN427E-8	650p
ZN428E-8	500p

DISC CONTROL

FD1771	£20
FD1791	£30
FD1793	£32
FD1795	£35
FD1797	£37
WD1691	£15
WD2143	550p

CRYSTALS

32.768KHz	180p
100KHz	300p
200KHz	300p
1.0MHz	320p
1.008MHz	350p
1.5MHz	450p
1.8432MHz	250p
2.00MHz	250p
2.45760MHz	250p
2.5MHz	250p
3.276MHz	150p
3.5795MHz	100p
3.686MHz	300p
4.00MHz	150p
4.194MHz	200p
4.43MHz	150p
5.00MHz	175p
4.43MHz	150p
5.00MHz	175p
6.0MHz	150p
6.144MHz	250p
7.0MHz	150p
7.168MHz	175p
8.00MHz	175p
8.86MHz	175p
10.00MHz	250p
10.7MHz	150p
12MHz	250p
13MHz	350p
14.318MHz	175p
15MHz	200p
16.00MHz	250p
18.00MHz	200p
18.432	150p
19.968MHz	150p
24MHz	175p
26.690MHz	150p
27.145MHz	200p
38.6667MHz	175p
48.0MHz	175p
55.5MHz	400p
116.0MHz	300p

KEYBOARD ENCODER

AY-6-2376	700p
74C922	500p

MODULATORS

6MHz UHF	375p
8MHz UHF	450p

BAUD RATE GENERATOR

COM 8116	£8
MC 14411	£7

TELETEXT ICs

SAA5020	£6
SAA5030	£9
SAA504	£16
SAA5050	£9

CONNECTION SYSTEMS

JUMPER LEADS

24" Cable with Headers

	14pin	16pin	24pin	40pin
Single end	145p	165p	240p	380p
Double end	210p	230p	345p	540p

Cable with Sockets

	20pin	26pin	34pin	40pin
Single end (24")	160p	210p	270p	300p
Double end (18")	290p	385p	490p	540p

34 Way Edge Conn (36") One End £5.50
D. Conn 25W 24" M: £5. F: £5.50

ID CONNECTORS

(Speed block) Type	10 Way	26 Way	34 Way	40 Way
Header plug	90p	200p	240p	270p
Receptacle	90p	200p	240p	270p

EUROCONNECTORS

	Plug	Skt
DIN 41612 2 × 32 Way	300p	350p
Angled 2 × 32 Way	350p	400p
3 × 32 Way	370p	430p
Angled 3 × 32 Way		450p
DIN 41617 31 Way	200p	200p

(for 2 × 32 Way please specify A + B or A + C type)

DIL HEADER PLUGS

	14pin	16pin	24pin	40pin
Solder type	50p	60p	100p	275p
IDC type	130p	140p	200p	285p

MIN D CONNECTORS

	9	15	25	37
MALE				
solder	95p	135p	200p	280p
angled	160p	230p	265p	425p
FEMALE				
solder	125p	190p	345p	375p
angled	175p	240p	310p	500p
Hoods	100p	100p	100	150p

DIL SWITCHES

4 way	110p
8 way	140p
6 way	125p
10 way	160p

ZIF SKTS

24 pin £6
28 pin £8
40 pin £10

EDGE CONNECTORS

	0.1	0.156
2 × 18 Way		150p
2 × 22 Way	310p	170p
2 × 23 Way	335p	–
2 × 25 Way	210p	200p
1 × 43 Way	260p	–
2 × 43 Way	350p	–
1 × 77 Way	700p	–

ACORN ATOM

Basic Kit £120 Built £135
Fully Expanded 12K + 12K £188
p&p £2.50/unit
SEE APRIL PE FOR
ATOM VISION
Phone for details on Atom Accessories

LOW PROFILE DIL SOCKETS BY TEXAS

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

WIRE WRAP SOCKETS BY TEXAS

8 pin	25p	18 pin	50p	24 pin	70p
14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

TRANSISTORS

AD161/2	45p
BC107/8	13p
BC109C	14p
BC117	20p
BC147/8	9p
BC149	10p
BC157/8	10p
BC159	11p
BC169C	12p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC337	16p
BC338	16p
BC461	25p
BC477/8	30p
BC516/7	40p
BC547B	14p
BC548C	12p
BC549C	16p
BC557KB	14p
BC559C	16p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BD135/6	40p
BD139	40p
BD140	40p
BD189	60p
BD232	60p
BD233	75p
BD235	85p
BD241	60p
BD242	60p
BD677	40p
BF244B	35p
BF256B	50p
BF257/8	32p
BF337	30p
BFR39	25p
BFR40/1	25p
BFR79	25p
BFR80/1	25p
BFR96	180p
BFX29	40p
BFX30	27p
BFX84/5	40p
BFX86/7	27p
BFX88	27p
BFX89	180p
BFY50	24p
BFY51/2	24p
BFY56	33p
BFY90	80p
BRY39	45p
BSX19/20	24p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
BUX80	£6
BUY69C	350p
E310	50p
MJ802	£4
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJ4502	£4
MJE340	60p
MJE2955	100p
MJE3055	70p
MPF102	40p
MPF103/4	30p
MPF105	30p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSA93	40p
MSPU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
TIP29A	35p
TIP29C	40p
TIP30A	35p
TIP30C	40p
TIP31A	40p
TIP31C	45p
TIP32A	46p
TIP32C	40p
TIP33A	70p
TIP33C	80p
TIP34A	90p
TIP34C	120p
TIP35A	120p
TIP35C	140p
TIP36A	140p
TIP36C	150p
TIP41A	50p
TIP41C	55p
TIP42A	60p
TIP42C	65p
TIP54	160p
TIP120	75p
TIP121	75p
TIP122	80p
TIP142	130p
TIP147	130p
TIP2955	78p
TIP4055	70p
TIS93	30p
ZTX108	12p
ZTX300	13p
ZTX452	45p
ZTX500	15p
ZTX502	16p
ZTX504	18p
ZTX552	55p
ZTX652	60p
ZTX752	70p
VN66AF	72p
VN10KM	60p
VN66	80p
2N697	25p
2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	36p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	25p
2N2222A	25p
2N2369A	25p
2N2484	30p
2N2646	45p
2N2904/5	25p
2N2906A	25p
2N2907A	25p
2N2926	9p
2N3053	30p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3584	250p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	300p
2N3819	25p
2N3820	40p
2N3823	50p
2N3866	90p
2N3902	700p
2N3903/4	16p
2N3905/6	16p
2N4037	65p
2N4123/4	27p
2N4125/6	27p
2N4401/3	27p
2N4427	90p
2N4871	60p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5194	90p
2N5245	40p
2N5298	65p
2N5401	60p
2N5457/8	40p
2N5459	40p
2N5460	60p
2N5485	44p
2N5875	250p
2N6027	48p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1172	150p
2SC1306	100p
2SC1307	150p
2SC1957	90p
2SC1969	150p
2SC2028	95p
2SC2029	250p
2SC2078	200p
2SC2335	250p
2SC2612	250p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	120p
40290	260p
40361/2	75p
40408	90p
40409	100p
40410	100p
40411	300p
40594	120p
40595	120p
40673	75p
40871/2	100p

DIODES

BY127	12p
BYX36.300	20p
OA47	8p
OA90/91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
1S920	9p

BRIDGE RECTIFIERS

1A 50V	19p
1A 100V	20p
1A 400V	25p
1A 600V	30p
2A 50V	30p
2A 100V	35p
2A 400V	45p
3A 200V	60p
3A 600V	72p
4A 100V	95p
4A 400V	100p
6A 50V	80p
6A 100V	100p
6A 400V	120p
10A 400V	200p
25A 400V	400p

ZENERS

2.7V-33V

400mW	9p
1W	15p

TRIACS PLASTIC

3A 400V	60p
6A 400V	70p
6A 500V	88p
8A 400V	75p
8A 500V	95p
12A 400V	85p
12A 500V	105p
16A 400V	110p
16A 500V	130p
T2800D	130p

THYRISTORS

3A 400V	100p
8A 600V	140p
12A 400V	160p
16A 100V	180p
16A 400V	180p
C106D	45p
MCR101	36p
TIC44	27p
2N3525	130p
2N4444	180p
2N5060	30p
2N5064	35p

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* MICROPROCESSOR TRAINER *

(As published in Wireless World Jan 81)

This micro computer based on 6802 processor and only 8 other ICs, provides up to 4K EPROM, 1K RAM, PIA, 6 digit display and up to 8 monitor commands. Though designed as a trainer Nandcomp can be used as desktop computer and a software development tool. The spare EPROM space allows modification for dedicated control or calculator application.

Kit (incl. all comps for computer, psu, & cassette interface, 2K monitor EPROM & all PCBs) **£72** P&P £1

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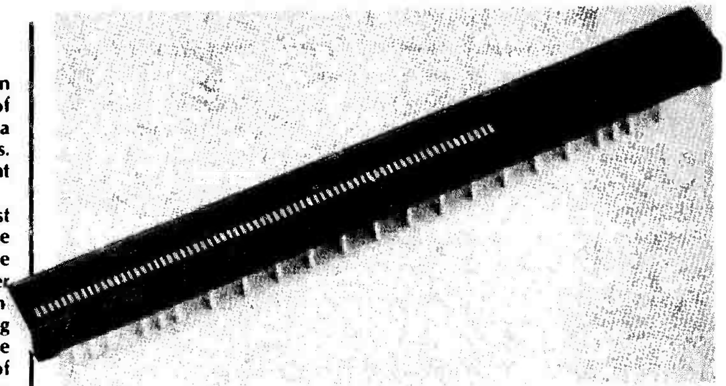
Improving Memories

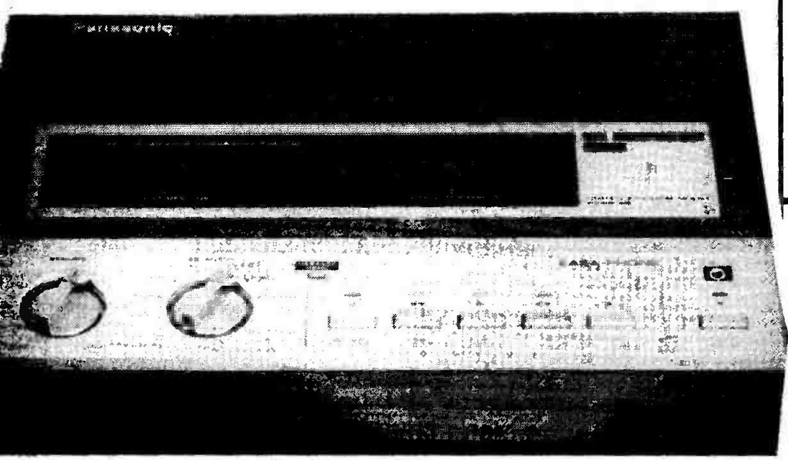
Not many people know this, but computer RAM chips have a built-in mechanism for producing errors — the casing of the IC. Trace elements of radioactive isotopes found in the device packaging materials give off alpha particle radiation, causing soft errors in both static and dynamic RAM chips. Two companies have tackled this problem using two very different approaches.

Dow Corning decided that shielding the silicon surface seemed the most logical approach, and developed a silicone rubber which is applied to the memory chips in the last step before hermetic sealing. One syringeful of the liquid silicone (30 cc) can coat 2400 static 4K RAMs and give at least one order of magnitude failure rate reduction. Hitachi, on the other hand, have improved the reliability of their new plastic-packaged 64K dynamic RAMs using a combination of design features. These include higher cell charge storage capacities and higher signal read-out levels, resulting in a two orders of magnitude improvement over non-coated devices. Hitachi expect these chips to replace conventional ceramic 64K dynamic RAMs in the majority of applications.



Big, Big, Bar

LED bargraphs are considerably more robust and visually attractive than mechanical meters, but suffer from poor resolution due to the limited number of LEDs available. Until now, that is. This massive beast from the Hewlett-Packard stable contains 101 — count them — LED elements in a 10.58 cm long package; the wide elements (1.52 mm) and 1% resolution result in accurate and reliable meter indication. The LEDs are red and configured as a common cathode arrangement to simplify interfacing; HP say the HDSP-8820 is particularly well-suited to industrial process control systems. In one off quantities the device costs £35.10 from HP authorised distributors — for more information contact Enquiries Section, Hewlett-Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks RG11 5AR.



This Is A Recording

A telephone answering machine which uses a microprocessor to combine simplicity of operation with versatility of use has been launched by Panasonic. The KX-T1524BE (who the hell dreams up these names?) is a twin cassette system using standard cassette tapes for both incoming and outgoing messages, eliminating the need for 'endless loop' or other specialist tapes. A variety of operating modes are available to cater for most user requirements and by using an individually coded pocket bleeper, you can retrieve messages by calling your own number from anywhere in the world. Skip and repeat functions are speeded up by using a message search system; a tone is added to the beginning and end of each message which is easily identified by the search system. The unit is available from dealers of Panasonic Business Equipment. Now if only British Telecom could do something about wrong numbers . . .

OOPS

A couple of boobs to comment on this month. First, the Music Processor (November '81). There are two R38s on the overlay; the one connected to pin 7 of IC5 is an error, but makes little difference as pin 7 is not connected internally. The published PCB has IC6 pins 5 and 6 connected together; pin 6 should only connect to C15 so cut the extra track. Boards supplied by our PCB Service do not have this error. The lead from R51 is marked LED1 anode on the overlay; it should be LED3 anode. The point marked LED3 cathode should also go to LED1 cathode.

Second, two errors appeared in the Guitar Tuner circuit diagram (January '82). The supply pin numbering for IC3 is reversed; (+ ve is pin 4, — ve is pin 11), and IC3c is drawn incorrectly. Pin 5 goes to the V/2 rail only; R12 and C10 should go to pin 6. The overlay is correct. Incidentally, it appears that some people have been buying TMS 1000 ICs from sources other than Magenta and finding that the project doesn't work. This is because the IC is a mask-programmable chip and different versions do different things (some of them are doorbell chips, for example). Only chips described as TMS 1000 — MP0121 will work in this circuit and only Magenta sells them.

This is the last time that OOPS will appear in the Digest pages. From now on amendments and improvements to our projects will appear in the READ/WRITE pages.

Just Dropped In

New equipment approved by the Electricity Council for high voltage live-line testing of overhead power cables and switchgear busbars will incorporate taut-band meter movements from Sifam Ltd of Torquay. One of the tests involved dropping the meters five times from a height of two metres onto a concrete floor; since Sifam won the contract we assume the photograph shows the meters being assembled prior to testing, and not repaired afterwards.

Mao-Tse Tongue

Chinese publishers and businesses can now handle text with the same electronic ease as their Western counterparts; Ferranti Computer Systems have just developed a unique Chinese word processing system. Text is input onto disc using Chinese phonetics, the computer's software helping the operator to select the correct character from a dictionary of over 8,000. Text can then be edited, formatted into tables or forms, coded for telex transmission or printed on paper. Incoming telex messages can also be decoded. No technical knowledge is required to run the processor, just the ability to speak and read Chinese. Bet Mao would have liked one for his little red book!

Is VIC There?

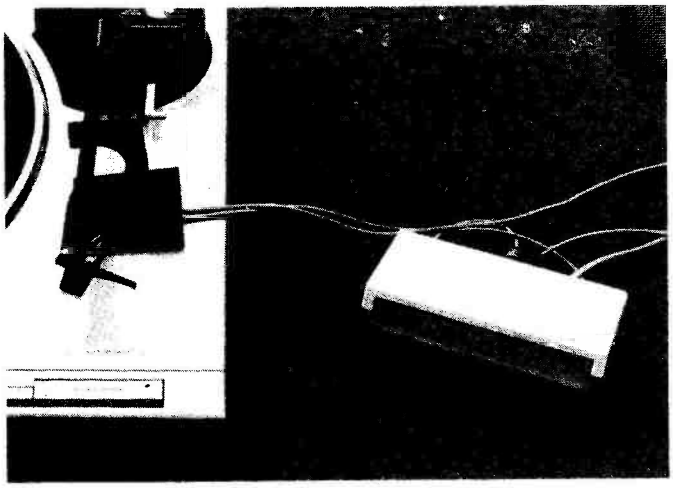
Whenever a major company launches a peculiarly limited computer, someone somewhere will start to design improvements for it. It happened to the ZX81 and now B & B Computers of Bolton have produced an add-on unit for Commodore's VIC-20. The 'black box' will increase the 22 column display to 40 columns and expand the memory from the meagre 3K to 35K; all connecting cables and an additional PSU are included. The expansion unit costs £220 plus VAT by mail order from Beelines Ltd, Freepost, Bolton BL3 6YS; the comparable CBM system would cost £337.81 plus VAT.

Tangerine Toolkit

Hard on the heels of their high definition Programmable Graphic Module, the Tangerine User Group are now offering a powerful Toolkit for comprehensive control of both PGM and chunky graphics on the Microtan 65. As well as fast plotting from both machine code and BASIC instructions, a number of extras such as BASIC line renumbering are offered. The PGM Toolkit is supplied in a 2716 EPROM with a comprehensive user manual and costs £26.69 for non-members.

NEXT MONTH

electronics today INTERNATIONAL



STYLUS TIMER

Diamond is pretty tough stuff but eventually all that bumping and grinding through the dusty grooves of your records takes its toll. To prevent damage to your precious discs the stylus should be changed at the end of its recommended life but how do you know when that is? Simple — you build the ETI Stylus Timer which ticks away as long as your stylus is in use and remembers the accumulated time period even when the hi-fi is powered down. At the end of the recommended lifetime the unit indicates that it's time for a change. The sensor has been designed so that no electrical connection whatsoever is required to the hi-fi, and the whole thing is neat and compact. For audiophiles everywhere.

ETI MOBILE

With the publication next month of the digital PWM board (held over for lack of space) and the infra-red proximity detector, our mobile robot is starting to take shape. Even if you're not a robot freak, the designs are versatile enough to be used in a whole range of other applications. Something for everyone — that's the June ETI.

BREADBOARDING SYSTEMS

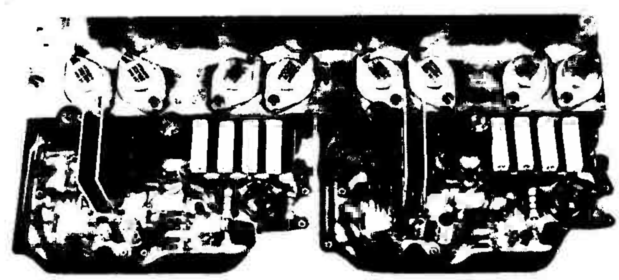
As we pointed out last month, there are many new breadboarding systems being released. Unfortunately most of them are so new that they didn't arrive in time for us to write the feature this month. Never mind, though — it's all here now and ready for our in-depth testing and review. If you're not keen on etching PCBs, wait with bated breath for the revelations that will unfold before your very eyes in next month's issue.

NEGATIVE ION GENERATOR

One or two letters have come flooding in, demanding an ion generator design. Ever eager to please, we'll be publishing a simple experimental device next month so that you can see for yourself whether the claims are justified. Cleaner air, fewer headaches, allergies alleviated, a happy disposition even while reading your morning paper; all this can be yours at no risk of electrocution (we've been quite careful about that). Delve into bioelectronics with ETI next month.

SERIES 5000 MOSFET AMP

We broke new ground with our System A Class A power amps and now we've a superb project for people who like MOSFETs and masses of power. By 'masses' we mean 150 good old-fashioned root-mean-square watts per channel, with extremely low harmonic, transient and intermodulation distortion. The output stage employs recently released Hitachi MOSFETs and is a real 'no-compromise' design (but then you've come to expect that from ETI, haven't you?). Naturally something that sounds as good as this should look good, too, and the project will be built into a very cheap, standard 19" rack using the somewhat substantial heatsinks as a design feature. If you like it LOUD, get the June issue of ETI.



LOOK OUT FOR THE JUNE ISSUE ON SALE 7th MAY

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

COLUMN LOUDSPEAKER DESIGN

The column loudspeaker is an example of a directional sound source which is of special use if acoustic feedback is a problem; it is most commonly found in sound reinforcement or public address applications. David Hornsby describes a novel design that can be made at a fraction of the cost of its commercial equivalent.

A standard loudspeaker tends to radiate sound in all directions, both forwards and backwards. It is helpful to look at this sort of response on a polar diagram (Fig. 1); the circle round the sound source shows that the sound loudness is about the same in all directions. If the loudspeaker is now placed in an enclosure then sound is allowed to radiate forwards only and we have a 'unidirectional' source. The polar diagram for it in Fig. 2 shows a balloon-like shape for the sound radiation pattern, which now covers an angle of slightly less than 180°. The dotted line shows the response if the enclosure lets a little sound out backwards.

If polar diagrams are new to you, these two diagrams will probably have given you a fairly good feel for what they are all about. They are similar to the contour lines on a map, but instead of showing height they show the sound intensity or loudness. The further the line on the polar diagram is from the sound source at the centre then the louder the sound is in that direction.

One-Way Sound

The unidirectional sound source is the one most of us use in our homes and cars but it's not very good for live performances where the microphone(s) is in the same area. Diffraction effects, echoes and reverberations all help to spread the sound back from the loudspeaker to the microphone so that as soon as the sound is turned up, positive feedback makes the system oscillate and howl.

There are one or two different solutions to this problem but the most common and probably the best is to use a highly directional sound source. This tends to concentrate the sound into the area where it is needed, the audience, but well away from the microphone.

One type is the horn loudspeaker which has good directional properties and is also very efficient electrically. Unfortunately it has to be physically large to be effective at low frequencies. The fog horn at your local lighthouse (you do have one, don't you) and the PA in a cinema have space for large horn

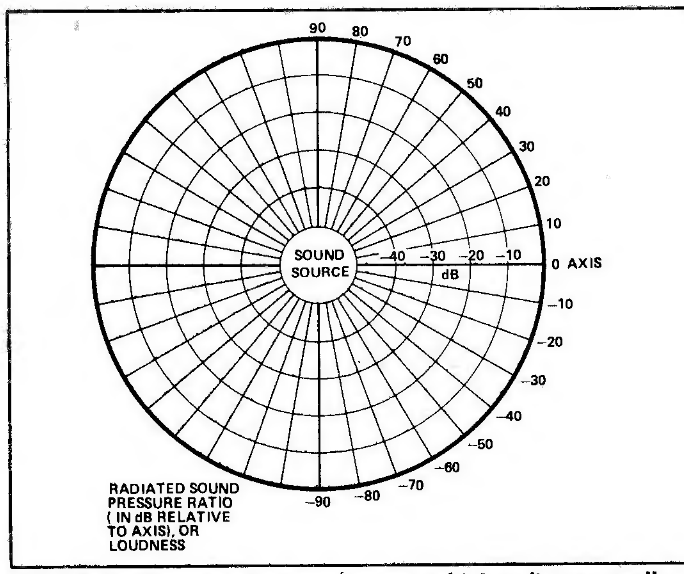


Fig. 1 Polar diagram of a sound source which radiates equally in all directions (approximated by an unmounted loudspeaker). The sound source is at the centre of the diagram.

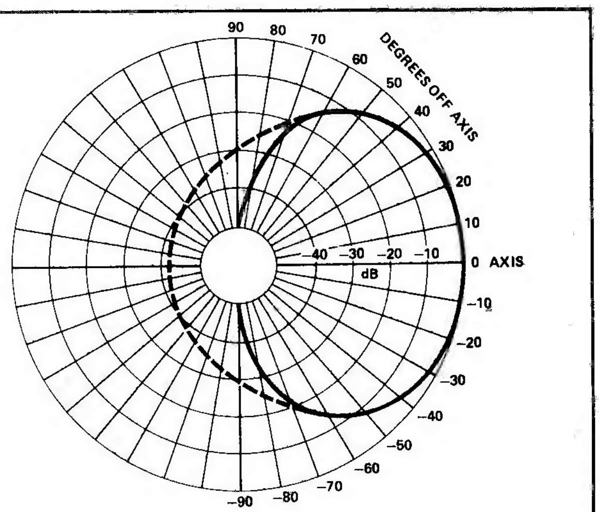


Fig. 2 Polar diagram of a sound source which radiates mostly forwards (approximated by a loudspeaker mounted on an infinite baffle enclosure). If a little sound is allowed out backwards the dotted line applies.

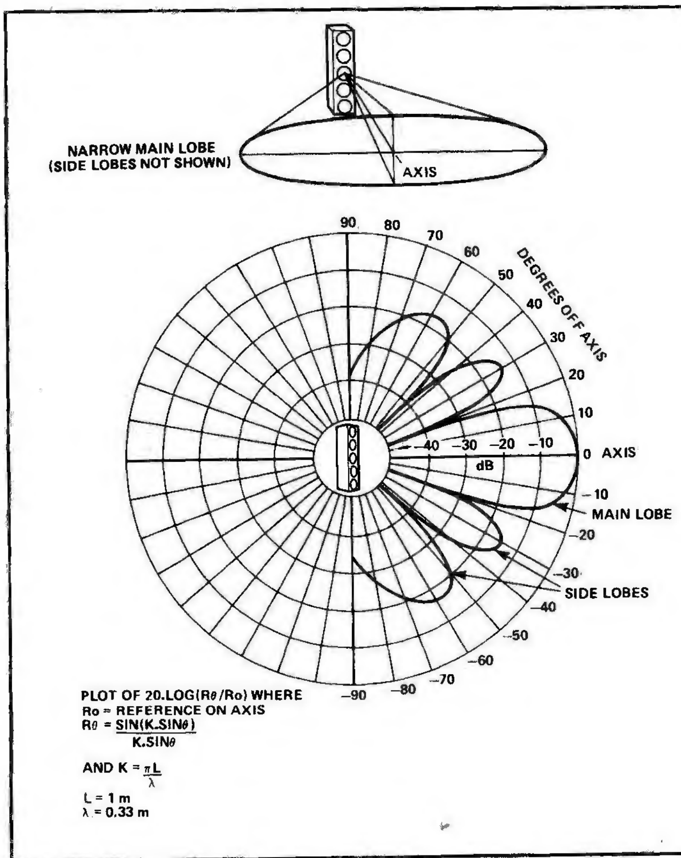


Fig. 3 Polar diagram of a column loudspeaker at 1 kHz.

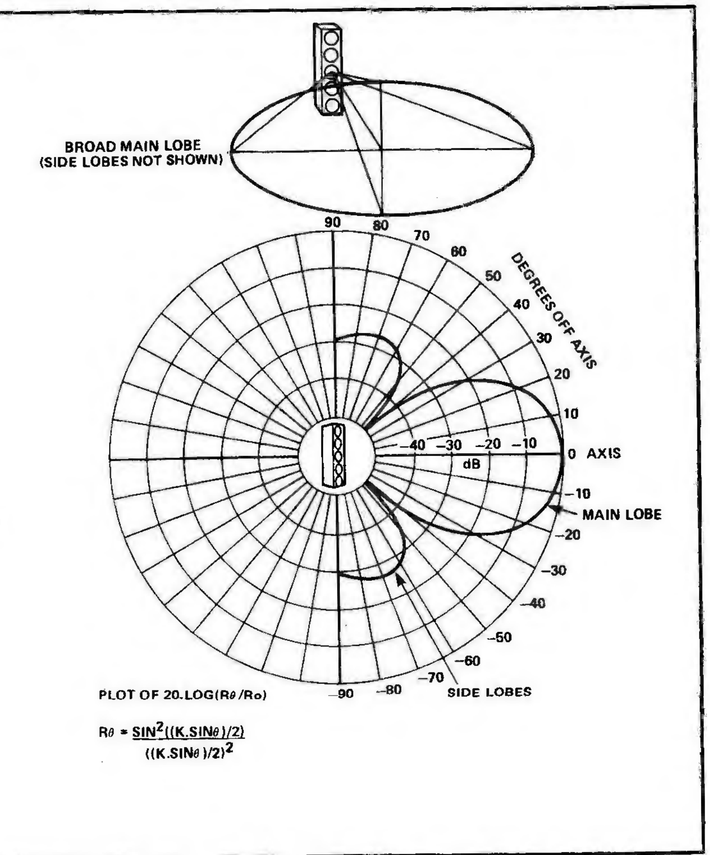


Fig. 4 Polar diagram of a column loudspeaker at 1 kHz with graded aperture.

units, but in the domestic scene we either have to use a folded horn design or just use tiny horns for high frequency tweeter applications.

The other directional type of loudspeaker in common use is the 'line source' or column loudspeaker, and that's the one we're going for here. The theory tells us that all we need is a loudspeaker with a cone which is long and narrow, rather like an elliptical loudspeaker taken to the extreme. Put that in a similarly long and narrow enclosure and that should be it! We do still have the problem that unless we allow the length to be at least a few feet then we will lose the beaming effect on the low frequencies, but there's a far worse problem — how do we actually get hold of our crazily-shaped loudspeaker? Does such a beast even exist? Actually it probably could be made with an electrostatic speaker but that's not for us. Instead we can approximate a line source with several conventional round speakers stacked in a line. Commercial designs use three or more, often quite a few more, and this works well. Our design uses five speakers spaced evenly along an enclosure of one metre length.

Directional Characteristics

It is at this stage that we must look again at a polar diagram for our design, Fig. 3, and this is where this diagram begins to give us some useful information. The first thing to note is how the shape is drastically changed from a balloon to a series of fingers of various sizes. The largest finger is the main beam or lobe of our column loudspeaker while the smaller fingers are unwanted side lobes. If you have seen interference patterns on a ripple tank then you will probably understand the reason for this sort of pattern. To improve the directional properties of the speaker system still further, we want to reduce the side lobes and enlarge the main lobe. It would probably also be useful to have a slightly broader main lobe, since it is unlikely that we can arrange for the audience to be confined into too narrow a region.

Without going into all the maths of the solution, both these aims may be reached by a process known as 'grading' or 'tapering' the aperture. This is a little trick that is used in all sorts of situations, not just column loudspeakers. Microwave dish aerial systems often do just the same, for example. In our case, tapering the aperture simply means that we must arrange to evenly decrease the power fed to each of the individual loudspeakers as we move away from the central one on the column. The effect of this is shown in Fig. 4. Note that these diagrams both apply only at one frequency, 1000 Hz. At higher frequencies the lobes are narrower and more numerous, but they become wider and less numerous at lower frequencies until below about 500 Hz, the wavelength of sound is comparable with the length of the column and the beaming effect begins to fail. Fortunately acoustic feedback is likely to be worst at frequencies well above 500 Hz so one metre is as long as we need to make the column.

You may occasionally come across giant column loudspeakers which are also curved so that they look concave from the listener's vantage point. This produces the same effect as tapering but is not necessary except for systems much longer than one metre.

Electrical Design

So now a way of arranging the power feed to each speaker has to be devised. If series resistors of appropriate values are wired in with the speakers, then, although things work well enough acoustically and electrically, we will have an inefficient design which wastes much of the power of the amplifier as heat in these resistors. The common commercial solution is to forget about tapering altogether, or for expensive units to use a special matching transformer with tappings for each individual speaker. This not only adds to the cost but also to the weight of the final product. Don't forget that no transformer has yet been designed which gives zero distortion, so that's yet another problem. While pondering this (in the bath — where else!) the author devised what seems to be a splendid engineering solution; that is, one that cheats the situation by winning several points at one go but without making any serious concessions. The key is to use identical speaker units but with different coil impedances. After many calculations with a range of different combinations, one design stood out as being almost ideal. It produces an effective impedance of 6.15 ohms, gives an even tapering and uses just 8 ohm and 15 ohm speaker units which are readily available.

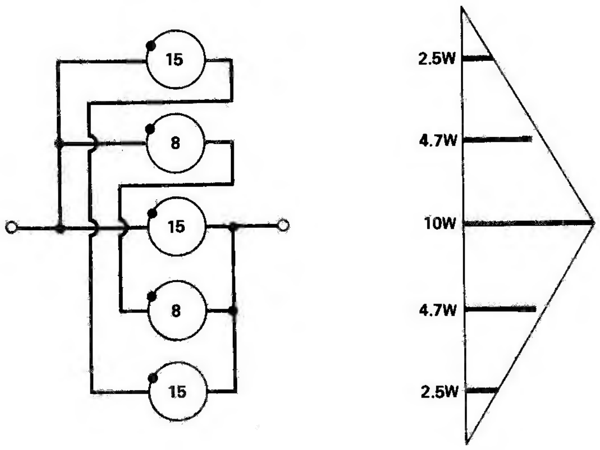


Fig. 5 The wiring diagram for the 8 and 15 ohm speakers. Note how each speaker is wired in phase. For 10 W speaker units the power handling is about 25 W (actually 24.375 W). At right is shown the profile of the graded aperture.

The electrical set-up is given in Fig. 5 and for nominal 10 W units produces a speaker system of 25 W capability. The actual make of loudspeaker unit doesn't really matter provided you can get both 8 and 15 ohm units in the same style. The original design used R.S. Component's wide-range six-and-a-half inch loudspeakers which have given reliable service for over four years now. Some may object that five 10 W speakers ought to give a system capable of more than 25 W. It is, of course, the tapering of the system which causes this reduced power rating,

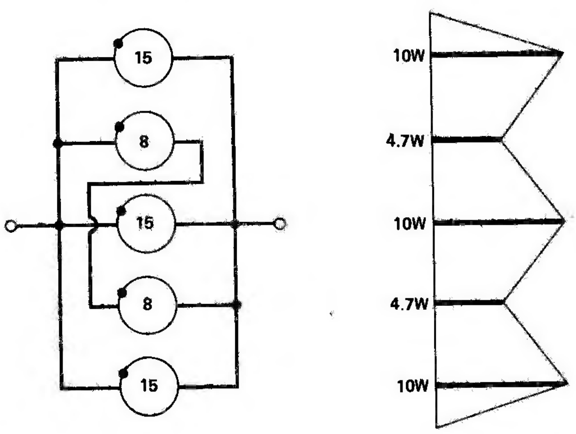


Fig. 6 An alternative way to wire the speakers. This gives a power handling of nearly 40 W but is not recommended as the aperture is not correctly graded. The profile of the aperture is irregular, as shown.

but its electrical efficiency is fair and there is no real problem. It is in fact possible to rewire the individual units so as to increase the power rating to 40 W, as shown in Fig. 6, but the tapering goes out of the window with this arrangement and it is not recommended.

Calculations show that the series/parallel combination of speaker units in our design gives an effective impedance of 6.15 ohms. This is just about ideal and suits the 4 to 8 ohm range that most power amplifiers are designed to feed. If you happen to have one which cannot drive impedances less than 8 ohms then you will need to add a 2 ohm series resistor to get things right. However, most column loudspeakers are necessarily mounted some distance from the amplifiers and the leads' resistance may provide some or all of this extra 2 ohms if you are lucky.

A Case In Point

The cabinet for the design may be made from chipboard. Three-quarter-inch thick is about the right grade for this job. If you are going to use the R.S. speaker units then, provided your woodworking skills are fair, it is only necessary to refer to Fig. 7 for all the details. If you have or can gain access to a circular saw (what about woodwork evening classes?) the task is that much easier. None of the dimensions are that critical, but the overall volume has been designed to match the suspension characteristics of the speakers themselves and should be kept the same. The unusual cross-sectional shape is not an essential

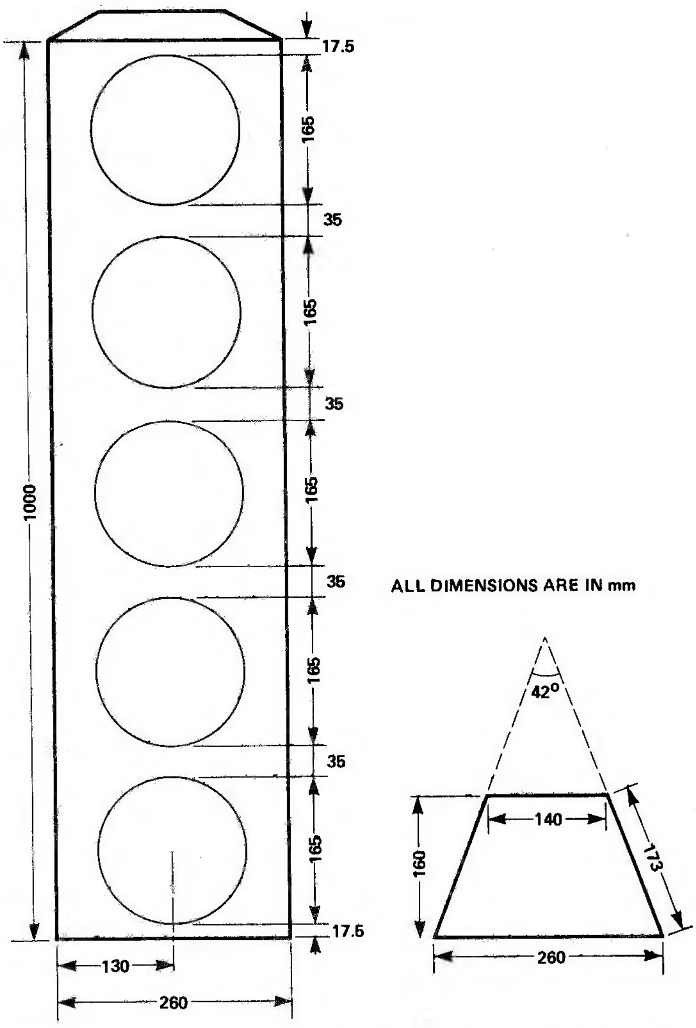


Fig. 7 Cabinet details — all dimensions are in millimetres. The total cabinet volume is 0.324 cubic metres. A suitable material to use is ¾" chipboard and this thickness needs to be added to the dimensions shown where appropriate.

part of the design either but was chosen so that the column could be neatly and permanently mounted on a wall and still point in the right direction. If your intended use is stage work then a square or rectangular cross-section giving the same volume would be easier to make.

Take care to close all joints with enough glue to make the unit reasonably airtight since this is a requirement of this type of speaker unit's cone suspension. The inside of the cabinet is filled with acoustic wool or similar sound-absorbing material so as to reduce internal sound reflections which otherwise give an unnatural colouration to the performance. I once knew a musician who insisted that internal lining of an enclosure reduced the high frequency response, but he had simply come to enjoy a particular type of distortion — don't leave it out! The best way to fix it is to tack it on lightly before the front is put on the enclosure. If it is not fixed it will soon fall to the bottom and lose most of its effect; if it is glued it tends to become compressed on to the glue which again cuts down on its absorption properties. Similarly, use a proprietary make of grille material for the front rather than any old material or again you will distort the sound. Most probably it will be the high frequencies that you lose this time if you are tempted to use the spare curtains because they are the right colour!

If the final unit is to be attached to a wall, a small screw recess can be provided near the top of one side for this. Most ironmongers stock screw-on brass plates that are ideal as a reinforcement for this. Don't forget to provide electrical connections on the back before the unit is assembled. Suitable types are available from the same sources as supply the acoustic wool and grille material (and the speakers themselves for that matter). The finish on the outside of the cabinet is obviously a matter of personal choice. If you wish to make a feature of it you can use a wood veneer or vinyl covering to achieve a smart appearance. The original design was made to appear unobtrusive (if that's not a contradiction in terms) by simply painting it the same colour as the wall it was to hang on, and this worked very well.

Performance

In assessing how well the design works we must first decide what it is we are looking for. With a speaker system intended for hi-fi applications we might look at the frequency response and phase linearity, for instance, but this design is for sound reinforcement purposes. The chief needs are to reduce acoustic feedback by efficient beaming of the sound and to improve the audibility of whatever is behind the microphone. The design was originally made to meet the needs of a church of moderate size (about 50 by 30 feet) for both music and singing from the music group at the front, and for speech from the pulpit (but not both at the same time!).

Judged by these standards the final product is totally effective; the beaming effect is very noticeable. When it was tested in the living room at home before installation the sound appeared to be thrown forwards towards the listener in a way that the conventional speaker cannot achieve. With a pair of speakers now hanging on side walls each side at the front of the church, their base being six feet from the floor and the axis of each speaker pointing towards the floor at the mid point of the back wall, the comparison with the old temporary single speaker units is really quite spectacular. At the front of the church the sound is beamed high over people's heads and so is not deafeningly loud. At the back, however, the beams reach down to ear level and the sound seems every bit as loud as at the front even though you are further from the speakers. What is more, the sound, particularly speech, is strangely clearer. The effect is perhaps not unlike that in the Whispering Gallery in St. Paul's Cathedral, where you might be surrounded by background noise yet can hear a whisper with startling clarity from a spot exactly opposite. The speakers do not whisper but the sound seems to surround you in the same way.

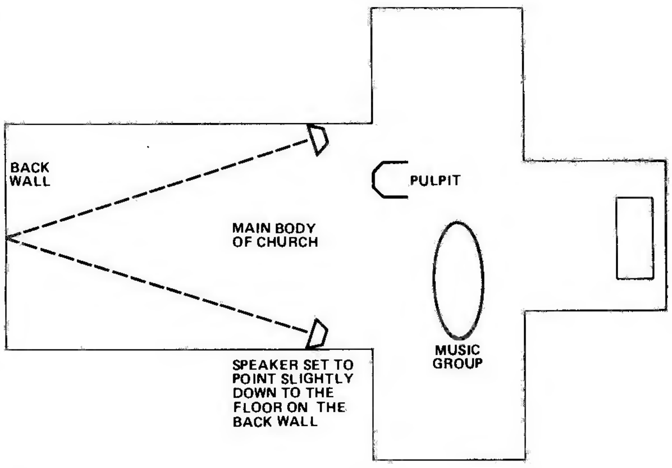


Fig. 8 The working layout of the speakers in the church.

The power handling of the column loudspeaker, 25 W, is more than adequate. The two units are driven by mere 15 W amplifiers but even these are never turned up anywhere near full volume. Acoustic feedback is no longer a critical problem, no mean achievement in a stone church building. The improvement is so pronounced that the music group now need to be provided with extra speakers to provide foldback.

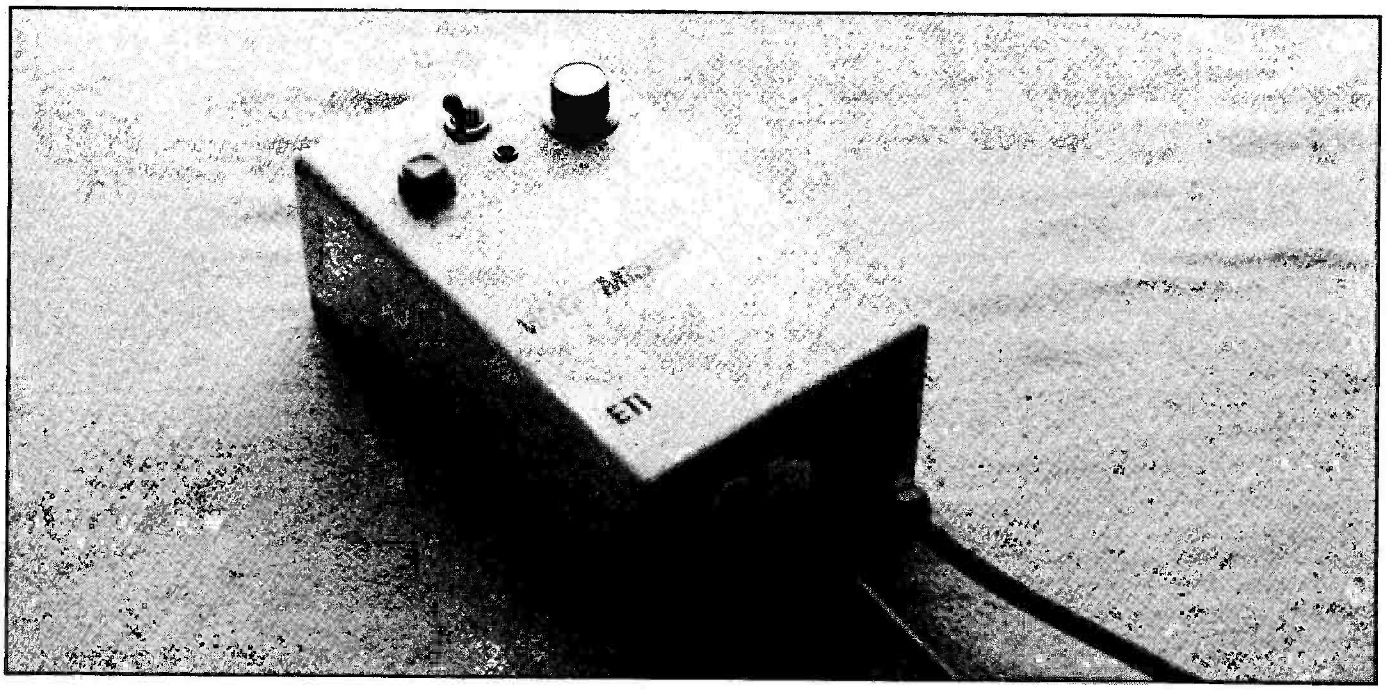
The frequency response of the units is essentially that of the individual loudspeakers — about 70 to 16 kHz for the R.S. units in an enclosure of this volume. Purists will notice and object to the lack of the extreme high frequency element, but this is unimportant in this application. In fact a design of this type will have rather better characteristics than the straight theory predicts since the matching of the system to the air is improved with the larger surface area of many loudspeaker cones. At low frequencies in particular it appears the response goes down well below 70 Hz although no measuring equipment was available to make quantitive measurements. If operation above 16 kHz is important for you don't despair: add a horn tweeter and mount it on top of the cabinet.

The overall impression of the speakers is of clean effortless performance, lacking only in that extreme high frequency content. They have been used regularly for four years now with 100% reliability. Applications have included not only the live sound sources mentioned earlier but also the playing of taped music and use for film shows. Once when playing back a tape-recorded voluntary from the pipe organ, several members of the congregation admitted to me afterwards that they had to look at the organ to check that it was not live playing — quite remarkable really when you think that the organ is at the back of the church and the column speakers at the front! This is the result obtained with directional sound: it seems to come directly to you. If you want to test for yourself and are in range of North Buckinghamshire, why not pop into Holy Trinity Church, Deanshanger and make up your own mind?

One last note of caution for you: do position your column speaker the right way round, that is vertically. You will have seen from Figs. 3 and 4 how the sound beam spreads out from the system. Possibly because this spreading is the opposite of what might at first be expected or perhaps because of plain ignorance, column loudspeakers are occasionally positioned the wrong way round! In fact I know of one not many miles from my home, where, in a specially converted stable, a column speaker is attached horizontally to an old oak ceiling beam. Wild horses wouldn't drag the exact location of the stable from me (pun intended — groan); I enjoy the little theatre too much to want to upset them. **ETI**

ECONOMICAL HEATER CONTROLLER

Save energy and master the meter; control your power consumption with the ETI Wattmiser. Design and development by Phil Walker.



After this winter's snow, frost and electricity bills we are probably looking for ways to save a little money without losing comfort or convenience. This project is designed so that appliances such as electric fires or water heaters can be set to turn on a little before they are needed. This will ensure that the room or tank of water, etc is comfortable or ready for immediate use when required, but has not been consuming those precious units all the time.

The device could also be used to control other things such as tape recorders, radios and so on where the precise timing is not too critical.

Operation

The device operates by dividing the mains frequency (50 Hz) by 180, 224 to get a signal with a period of about 1 hour. The actual division required was 180,000 but the 180,224 was more easily achieved and the error involved was less than 1 part in 500, or about 40 seconds in the maximum period of 9 hours delay.

This 1 cycle per hour signal advances a divide-by-10 counter which has 10 separate outputs. Each output is active for 1 hour and only one is active at a time. One of the outputs is selected to drive the mains power switching triac — thus giving an 'on' period of 1 hour after a selectable off period. Also it is possible (if SW4 is on) to have the output come on permanently after its set delay (this is always the case on the 9 hour delay setting).

To use the device, set the number of hours delay with SW3, select whether '1 hour only' or 'permanently on' operation is required with SW4 and press SW2 to start the device working.

Installation

When using the device, the mains supply must be fed from a plug or switched fuse outlet containing a fuse rated for the appliance used. Also the wire used should be suitably rated — round flex rated at about 15 A usually sold for electric fires or similar applications could be used in most cases.

Construction

The construction of the PCB should present no great difficulties. The first thing to do is to ensure that the mounting holes are of a suitable size and that the correct ones are being used if the specified box is utilised. Next put some M3 x 12 mm bolts through the mains power connection pads, heads on the copper side. Run some solder around these heads to secure them and improve the contact.

Now fit the wire links and the other components with the exception of the switches, LED1 and SCR1. Make sure that D1 and D2 are the right way round. Also note that IC1 is the opposite way round to IC2, 3 and 4.

Next fit SCR1 and its heatsink to the board, using an M3 x 6 mm bolt. Use heatsink compound under SCR1 to improve thermal conductivity. Bend the leads out from SCR1 to go through the proper holes. Note that if the lower rating triac is used, the fixing hole nearer the contact pads should be used and vice versa. SW3 should now be fitted. If the contacts are on a 22 mm diameter circle they may be connected straight to the board, otherwise short lengths of stiff wire should be used. (If all else fails you could fix the switch to the cover of the box and connect to the board using thin flexible wire — leave enough to remove the lid when fitted).

Attach some lengths of flex (6") to the PCB at the remaining switch positions (SW2 and SW4), LED1 position and transformer connections. Fit the transformer diagonally into the corner of the box (the end with the wider spaced fixing bosses) and then the cable glands, neon, mains switch

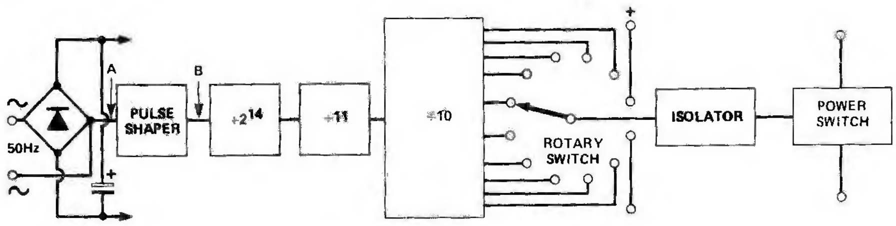


Fig. 1 Block diagram of the unit.

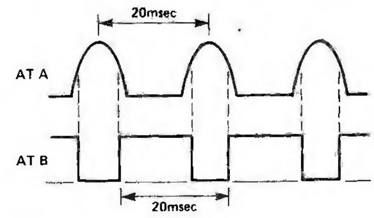


Fig. 2 Pulse shaper action.

PARTS LIST

Resistors (all ¼ W, 5%)

R1	15k
R2	220k
R3,4	100k
R5	27k
R6	1k2
R7	820R
R8	56R
R9	100R

Capacitors

C1	1000u 40 V axial electrolytic
C2	1n0 ceramic
C3	1u0 63 V axial electrolytic

Semiconductors

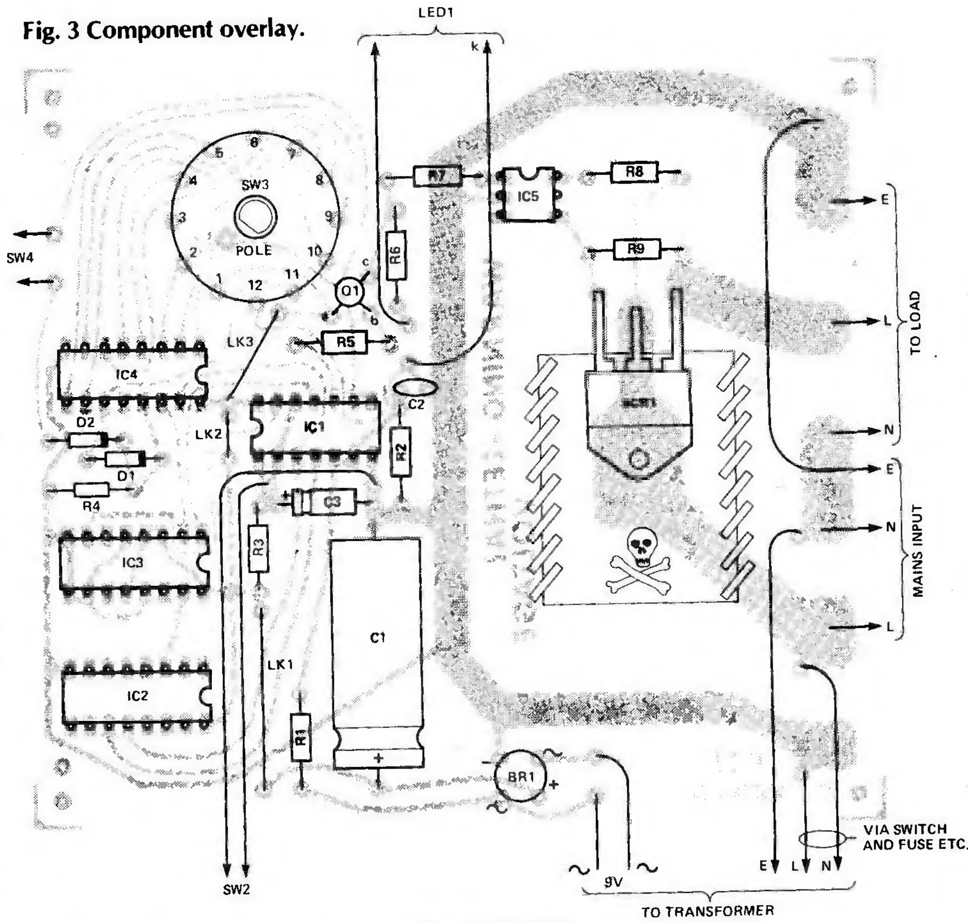
IC1	4093
IC2	4060
IC3	4516
IC4	4017
IC5	MOC3020
Q1	BC477
D1,2	1N4148
BR1	W01 bridge rectifier (100 V, 1 A)
SCR1	TIC263D (400 V, 25 A) or TIC246D (400 V, 16 A)
LED1	3 mm red LED

Miscellaneous

SW1	DPDT mains on/off rocker switch (miniature)
SW2	1 pole push-to-make switch, momentary action
SW3	1 pole 12 way rotary wafer switch, contacts on 22 mm diameter circle
SW4	SPST toggle switch
FS1	1A anti-surge fuse and panel fuse holder (20 mm)
LP1	Mains neon indicator with integral resistor (panel mounting)
T1	6 VA mains transformer (9 V secondary, 240 V primary)

PCB (see Buylines); case (see Buylines); 2 off cable glands (8-10 mm — see Buylines); 3 off 16 pin and one off 14 pin IC sockets (if used); heatsink (TO-220 style) knob; M3 nuts and bolts, spacers, etc.

Fig. 3 Component overlay.



BUYLINES

Most of the components used in this project are standard off-the-shelf items. The MOC3020, TIC263D and TIC246D may be a little harder to track down and can be obtained from TK Electronics. The case we used was a BOC 450 from West Hyde Developments; the same company can provide the cable glands we specify. The PCB can be obtained from our PCB Service using the advert/order form on page 45.

and fuseholder into the end-plate. Wire up as shown on the circuit diagram.

Finally fit SW2, SW4 and LED1 to the lid of the box and cut a hole through to take SW3 spindle. Wire up as per the circuit diagram. Mount the PCB on pillars using M3 bolts at such a height that the SW3 spindle protrudes far enough to take the knob when the case top is in place.

In use it is advisable to solder eyelets to the mains wires to fit on to the PCB bolts; alternatively the ends of the wires should be soldered to stiffen them.

NOTE: As mains voltages are present, care must be taken that no unearthed metal parts are accessible from the outside and that clearances between live and earthed parts are maintained under all circumstances.

HOW IT WORKS

IC1a takes the raw AC 50 Hz signal applied to the bridge rectifier and converts it to a train of pulses at the same frequency. This is divided by 2^{14} (16,384) by IC2. Further division is done by IC3 which is connected with IC1c to divide by $11_{(10)}$.

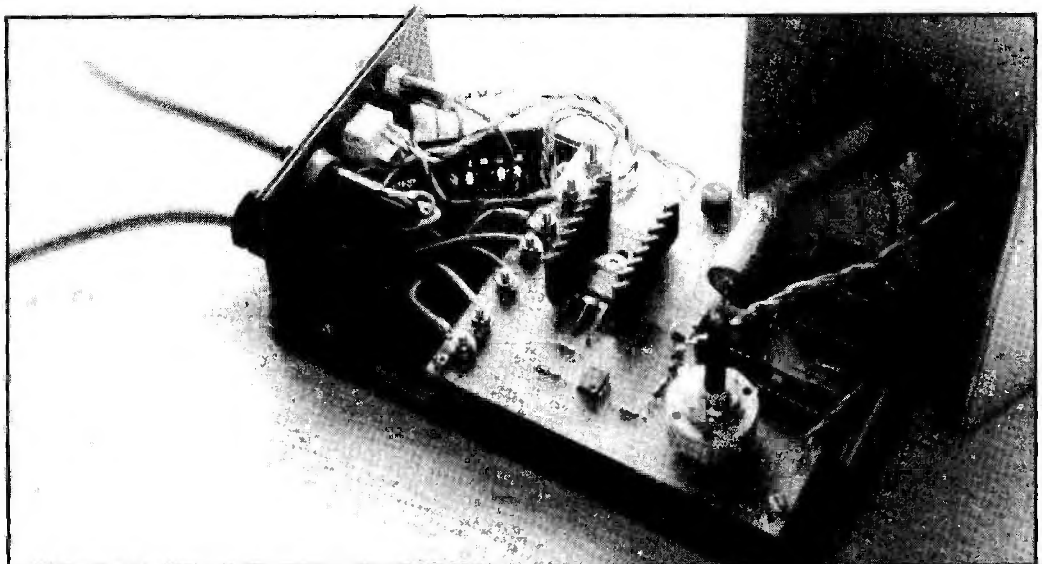
This is accomplished by loading 1011_2 into IC3 each time it counts down to $0000_{(2)}$. At the Q_4 output of IC3 there is a signal which has a period of 20 mS x 16,384 x 11 = 3,604,480 mS = 3,604.48 seconds. This signal is applied to the clock input of IC4, a divide-by-10 device with 10 decoded outputs. The output of IC4 selected will change every 3,604.48 seconds (about 1 hour) until the '9' output (pin 11) is high. At this time further clocking of IC4 is prevented by a signal at pin 13 via D1.

SW3 selects which output of IC4 drives the output power switch. This varies from permanently on (position 1), through zero delay (position 2), up to 9 hours delay (position 11), to permanently off (position 12).

If SW4 is open then in the 0 to 8 hour delay positions the output will be on for 1 hour after the set delay only, whereas if SW4 is closed or a 9 hour delay is selected the output will stay permanently on after the delay period.

IC1c takes the output signal from SW3 and drives Q1 and thus IC5. IC5 is an optically isolated triac which enables us to have the logic circuitry safely at earth potential while switching the mains power with SCR1.

The last part of the circuit is that around IC1a and IC1d. This is the reset circuitry which ensures that the time period will be consistent and start when SW2 is released. IC2 and IC4 are reset to 0 by IC1a, while IC3 is set to 1011 (decimal 11) by IC1d.



With the lid off, the general layout of the project should be clear. With the large currents involved, the mains wiring is secured to the PCB with nuts and bolts.

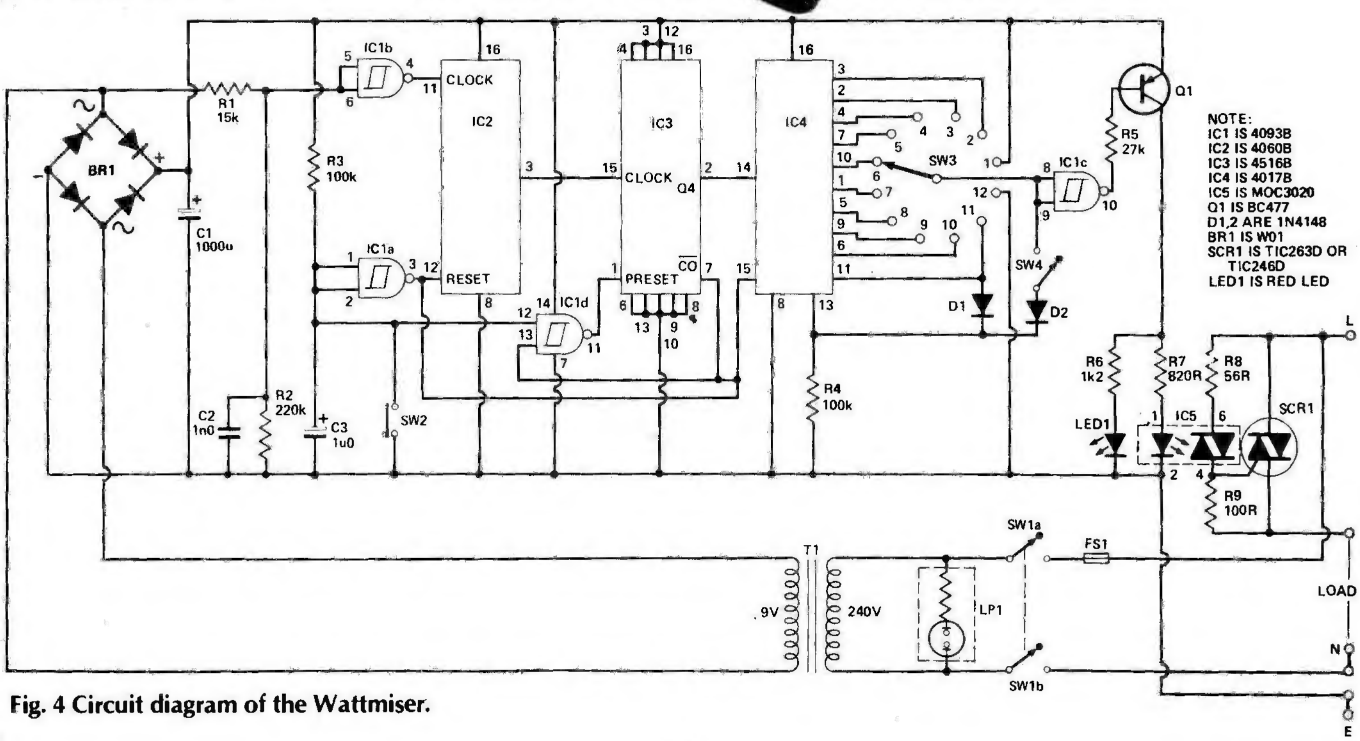


Fig. 4 Circuit diagram of the Wattmiser.

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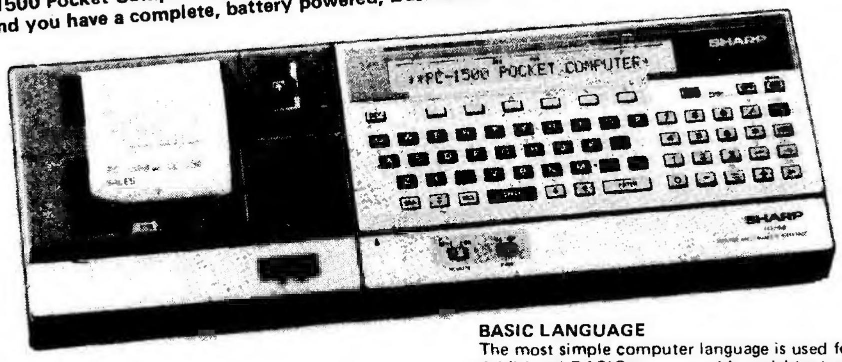

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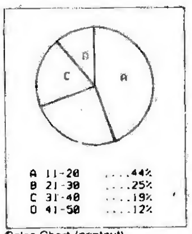

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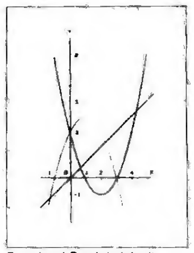
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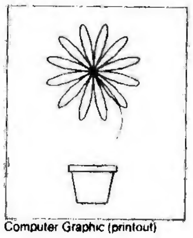
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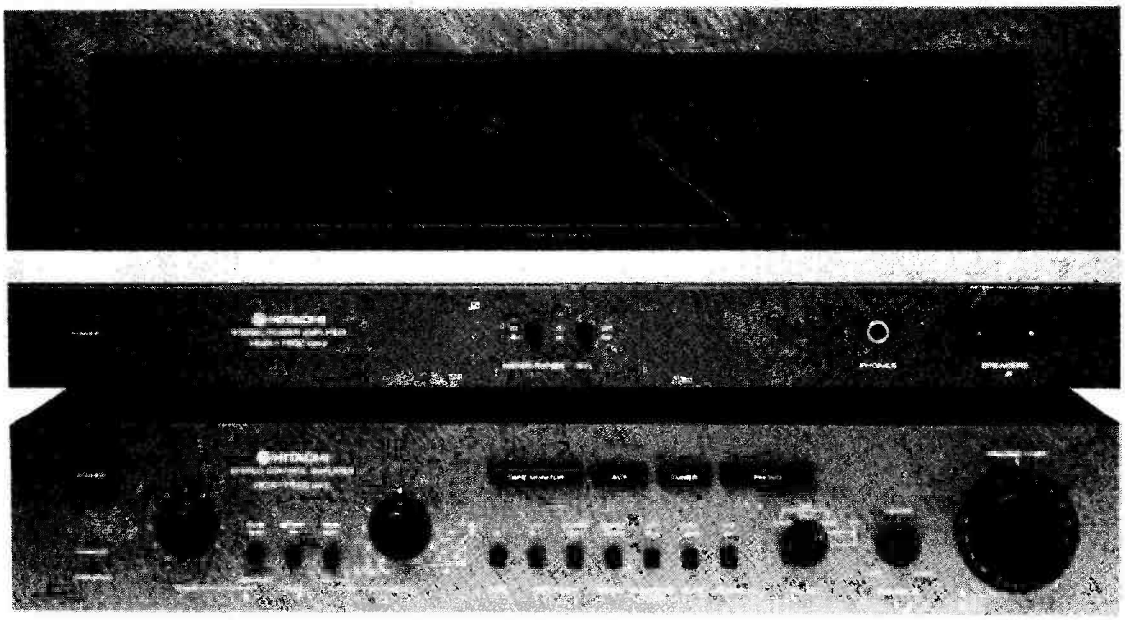
AUDIOPHILE

It's dents-in-the-desk time, as Ron Harris listens to some hernia-inducing Hitachi hi-fi. This MOSFET combo is mighty in more ways than one.



This month an excursion into MOSFET territory, made in the sure company of Hitachi — who can be regarded as something of pioneers in the field. Actually, this review comes about, in its present form, by the strangest of circumstances. Firstly, I was assembling a 'group-test' of four or five high-quality amplifier combinations of various technical bents. I *know* that sounds like an orgy in an all-male laboratory, but I can assure you my motives were pure.

As with all things in life, some arrive ahead of others, and the Hitachi came weeks ahead of the rest. (The Bishop's actress would have been proud of them. . .) In between times, there was a press launch from a major manufacturer for one of those few new models which can raise the eyebrows and clean out the ears in anticipation.

More detail than that I *dare* not reveal — the BOYS are leaning over my shoulder, hands on violin cases, even as I write this — death comes but once and that painfully. Embargo dates shalt thou keep, lest thy tender bits be removed and cast upon the waters. Watch next month's Audiophile. If I'm still in possession of my facilities, all questions will be answered. (I'm too young to die, I *still* haven't had that romantic dinner with Felicity Kendal. . .)

Anyway, returning to the track upon which we embarked, the fact that I *had* to tie up large chunks of next month, allied to the somewhat tardy arrival of all the other amplifiers, left Hitachi home-free this month with their HMA-7500 II power-amp and HCA-7500 preamp combination — unusual for its employment of MOSFETs.

This is a subject upon which we have received much correspondence — mainly requests to produce a project. Well we did — two years ago. Ahead of our time again, you see. Designs age, however, and that Ambit unit is somewhat irrelevant by today's standards of quality. If we were going to retain *our* reputation for state-of-the-art electronics, a complete re-design was called for. Next month you will be presented with the results of our efforts. A hundred and odd watts of pure magic. MOSFET magic.

Hitachi 7500 IIs

The 7500 IIs are actually cheaper than the Mark Is, but offer more facilities for lesser amounts of green stuff. The preamp is well-decked out with variable turnover tone controls, two tape inputs, moving-coil pre-preamp and variable input parameters on moving magnet. In addition the volume control is bedecked with little decibel numbers and there is a loudness control, a mute switch and a subsonic filter.

The power amp is bloody huge. It would be polite to call it 'large', but polite here is insufficient. Bloody huge somehow captures the spirit of the thing in a way that 'large' simply fails to do. The front panel sports huge meters, too — carefully graduated in watts RMS into four and eight ohms. In addition there is a 'BTL' facility which allows the 80 W stereo to be transformed into 150 W mono at no sacrifice in quality. Two pairs of speakers are catered for, although some care in choice is required.

All inputs and outputs on the preamp are phono — the dreaded DIN is nowhere in sight. Three cheers for Oriental partisanship. Sometimes anyway.

HCA-7500 II Preamp

At £139 this design represents a large number of buttons per pound. There are a restricted number of separate preamps available on the shop-shelves today and most cost considerably in excess of £139. Strange as it may seem to those descendents of Ebenezer Scrooge reading this, the Hitachi can be safely regarded as a BUDGET unit.

These days I am becoming increasingly suspicious of the disc-amplifier stages in all designs, especially if they are intended to cope with the moving-coil variety of groove followers.

Accordingly all preamps get somewhat of a beating about the equalisation if they pass this way. Well, it makes a starting point and we all need one of those, do we not? In addition the continual march of digital and high-quality 'super-discs' places ever increasing demands upon these stages. They are thus increasingly under the microscope.

Regrettably the 7500 did not pass this particular line unscathed. Technically it fared well under test. You can read the results for yourselves. However, in use, the pickup stage sounded below par — especially when compared to the rest of the 7500 set-up.

The moving-magnet amp added a certain warmth to the sound, which spoke of low-frequency colouration and clouded detail right up into the mid-range. The moving-coil option added some noise but did nothing to cleanup the sound.

These are absolute judgements you realise, relative to a reference far more expensive than the 7500. Taking price into consideration alters the balance to the extent that the Hitachi is a good value performer for its cost and one which does not seem ill-mannered in all but the most exalted company.

Pickup Downs

Apart from this, the HCA is a fine unit indeed. It is quiet and efficient and does its job with a minimum of fuss. Pulse testing the unit reveals a good handling of transients, a function of the unit's wide bandwidth and fast slewing, and conventional tests point to low-noise and flat frequency response.

Mechanically the controls operate smoothly and give the impression of having been well engineered. The volume control is a 'click-stop' type of high quality. Somehow, though, I found it awkward to use. It seemed to be wired the wrong way around! An odd observation I know, but if you tried it I think you would see what I mean. The dB graduations, which get lower in value as the volume goes up, don't help either, correct though they may be!

Cartridges tried with the HCA-7500 included the Dynavector Ruby and the DV20AII, the Goldring G900IGC and the Shure MV30H reported upon last month. Tuner source was the trusty (and unsurpassed?) Pioneer TX9500.

Tape facilities allow for two decks, with monitor on either and dubbing between the two in either direction. There is an unobtrusive little push-button labelled "Source Copy" which enables the outputs to tape. Forget to push this and you can have all sorts of fun trying to find out "where has all the signal gone. . ."

Three impedances are available for moving magnets (22k, 47k and 100k) and two input levels for moving-coil, (0.1 mV and 2.5 mV) at 100R input impedance. More useful perhaps would be capacitance switching for the MM units, to better control high frequency behaviour.

Loudness Played Softly

I've never understood why a button which corrects for hearing losses at *low* levels is called loudness. Still I suppose 'softness' conjures up images of fabric conditioners and woolly sounds.

If you must have one of these ill-named tone controls, then this is about the best you'll find! Most tend to wildly overdo things in the bass with an excess of 10 dB boost at 100 Hz and below — and no top-end correction at all. Figure 1 shows the Fletcher-Munson curves upon which all such correction is based and you can see the required top-end lift quite clearly.

Because human hearing is less sensitive to extremes in the audio range, at low listening levels your perception of bass and treble is severely limited. Loudness controls are intended to compensate by shaping the frequency response into an inverse plot of the hearing sensitivity curve you see in the diagram.

At high levels, where frequency has far less effect upon perceived level, they should be inoperative.

As I said, the Hitachi HCA 7500 II boasts a somewhat more believable compromise than most.

Powerful Amps

The HMA-7500 II is a hefty piece of work, sporting two well-endowed power supplies and those massive meters. It is possible to switch the machine into bridged mode, doubling the power available into eight ohms. Those PSUs boded well for the burst power capability of the amp, an idea which seemed to be borne out by early listening tests — only to cause confusion in the lab!

The rated 75 W was delivered uncomplainingly from 5 Hz to 70 kHz (RMS) and at 1 kHz 90 W was available. This with less than 0.01% total distortions (THD and IM). Burst power delivery proved to be a disappointing 104 W into 8R — I would have expected greater things in view of the sheer size of the power supplies. Into 4R, delivery was, as near as dammit, the same — 100 W. Into 2R strange things began to happen, courtesy of the protection, and no readings were feasible.

Lesson? Be careful with speaker choice if you intend to push the 7500 II near its limits.

Burst Testing

I've had some puzzled letters — and one very aggrieved epistle for which 'tirade' is a good word — enquiring as to how I

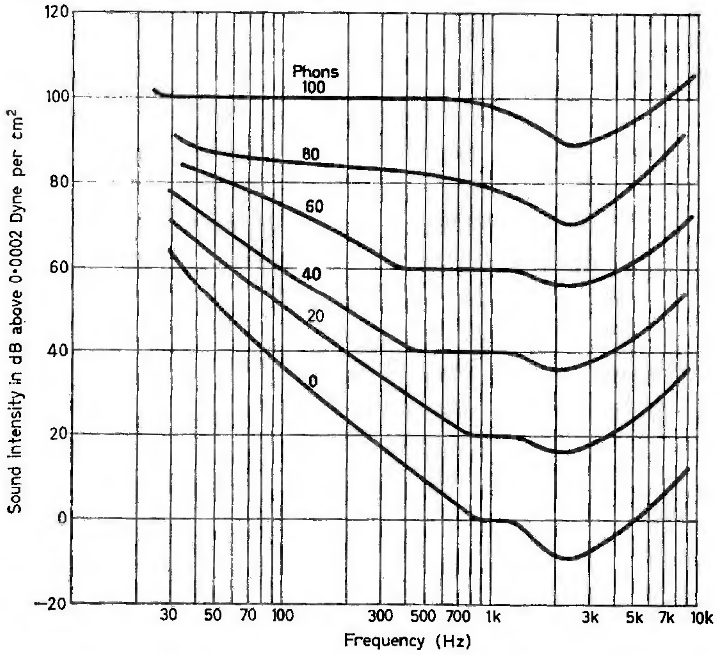
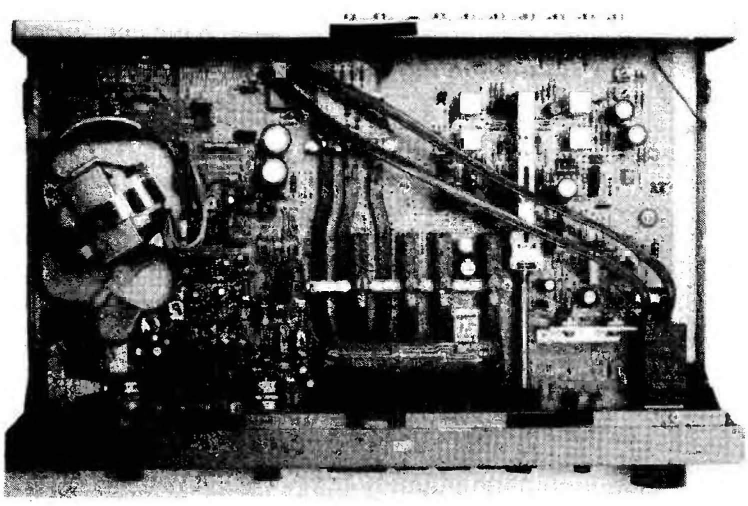


Fig. 1 Above: the Fletcher-Munson graphs of equal loudness. The curves plot the amount of energy required to produce a sound of equal intensity at the ear, for varying frequencies.



Left: the inside story on the 7500 preamp. Note the use of mechanical couplers to the input switching, which is PCB — mounted near the input sockets. Just about everything that can be done to reduce noise, has been done.

obtain my oft-quoted burst delivery power measurements.

The basic idea is to better simulate what the amp is capable of doing with music, as opposed to sine or square waves, thus correlating more closely lab test results with listening tests. As a music signal is composed of a whole spectrum of short-duration tone-bursts scattered from 20 Hz-20 kHz fairly randomly (!?), I don't think that a sine wave at 1 kHz is a close enough approximation, even in short pulses.

My own way of obtaining a number is to gate a 1 mS-10 mS burst of white noise, modulated by a sine wave, into the unit under test and read the resulting power delivery into an eight-ohm load. At present I'm working on improving the load, so that it will better approximate a speaker.

The variable length of the input pulse is required to discover when and where the protection, or limiting, operates in the amplifier circuitry. A perfect amplifier would delivery X watts into 8R, 2X watts in 4R, 4X watts into 2R and ∞ watts into a short-circuit! All without blowing fuses of course.

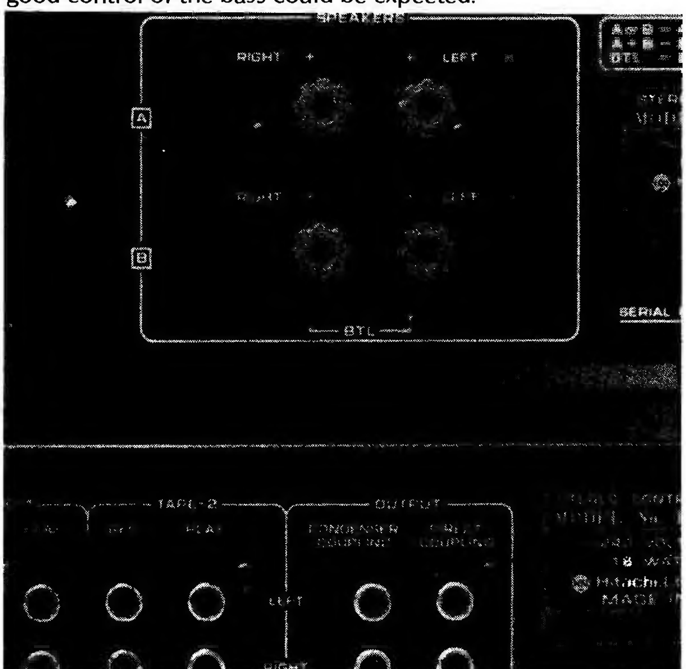
Allied to the good and true RMS readings, for long term delivery, I think these burst measurements paint a fairly good picture of the capabilities of a particular unit with regard to actually playing records.

I would welcome readers' comments on the method outlined so far, or any suggestions as to how it could be improved. (Physically possible suggestions only please, it's a big test-bench.)

Hitachi Hi-Power

In the bridged mode the 7500 II delivered 150 W into 8R all the way from 20 Hz-20 kHz. Burst power was a very healthy 201 W into 8R and 189 W into 4R. It is somewhat more choosy about impedance in this mode, so I did not attempt a 2R reading. Test loads are expensive and I'm running out of fuses.

Signal-to-noise was an impressive 94 dB down, unweighted and damping factor held above 50 down to 40 Hz. Provided the speaker doesn't take a downward leap in impedance, therefore, good control of the bass could be expected.



Bridging the 7500 II means connecting across the 'lives' of the two sets of speaker terminals. This is denoted by the obscure legend BTL. It actually stands for "Bridge Transformer Less"! I kid you not.

Testing Conclusions

Overall then, the combination gave a good technical performance, with the power amp appearing to be of a higher standard than the preamp, with only a very few reservations.

In order to test both, the combination was first tried together and then independent of each other, with known preamp and power units standing in for the missing partner where necessary. In this way a clearer idea of the sound behaviour of each unit could be obtained.

TEST RESULTS

HCA - 7500 II

Signal To Noise Ratios (to output, weighted)
Moving magnet : 85dB
Moving coil : 74dB
Tuner/aux : 88dB
Tape : 88dB

Frequency Response (to output)
Disc input : 20Hz - 20kHz ± 1.5dB
Tuner/aux : DC - 100kHz ± 1dB

Total Distortions (at output)
Moving magnet :
Moving coil : Less than 0.01% from 20Hz - 20kHz
Tuner/aux :

Overload/Max output
Moving magnet : 300mV (for 0.01% THD)
Moving coil : 21mV (for 0.01% THD)

Sensitivity (for 1V output)
Moving magnet : 3mV
Moving coil : 0.1mV
Tuner/aux : 180mV
Tape : 180mV

HMA - 7500 II

Power Output (into 8R/4R)
RMS (both channels) : 94W (20Hz - 20kHz) 91W (4R)
Burst Power (see text) : 104W (8R) 100W (4R)

Bandwidth : DC - 180kHz
Frequency Response : DC - 20kHz ± 0.5dB

Harmonic Distortion : 0.01%
TIM Distortion : zero
IM Distortion : 0.01%

Signal - to - Noise (incl. hum, weighted) 120dB
Damping Factor (100Hz) : 60 (110 at 1kHz)

Price for pre/power : approx. £400

Making MOSFET Music

As a pair the 7500s performed well — with the previously stated reservation on pickup input — sounding clear and powerful. Mid-range rendition was good and bass transients well handled. The treble tended to be a little 'soft', if the unit is driven hard — an effect which is infinitely preferable to the biting edge some designs reveal under these conditions.

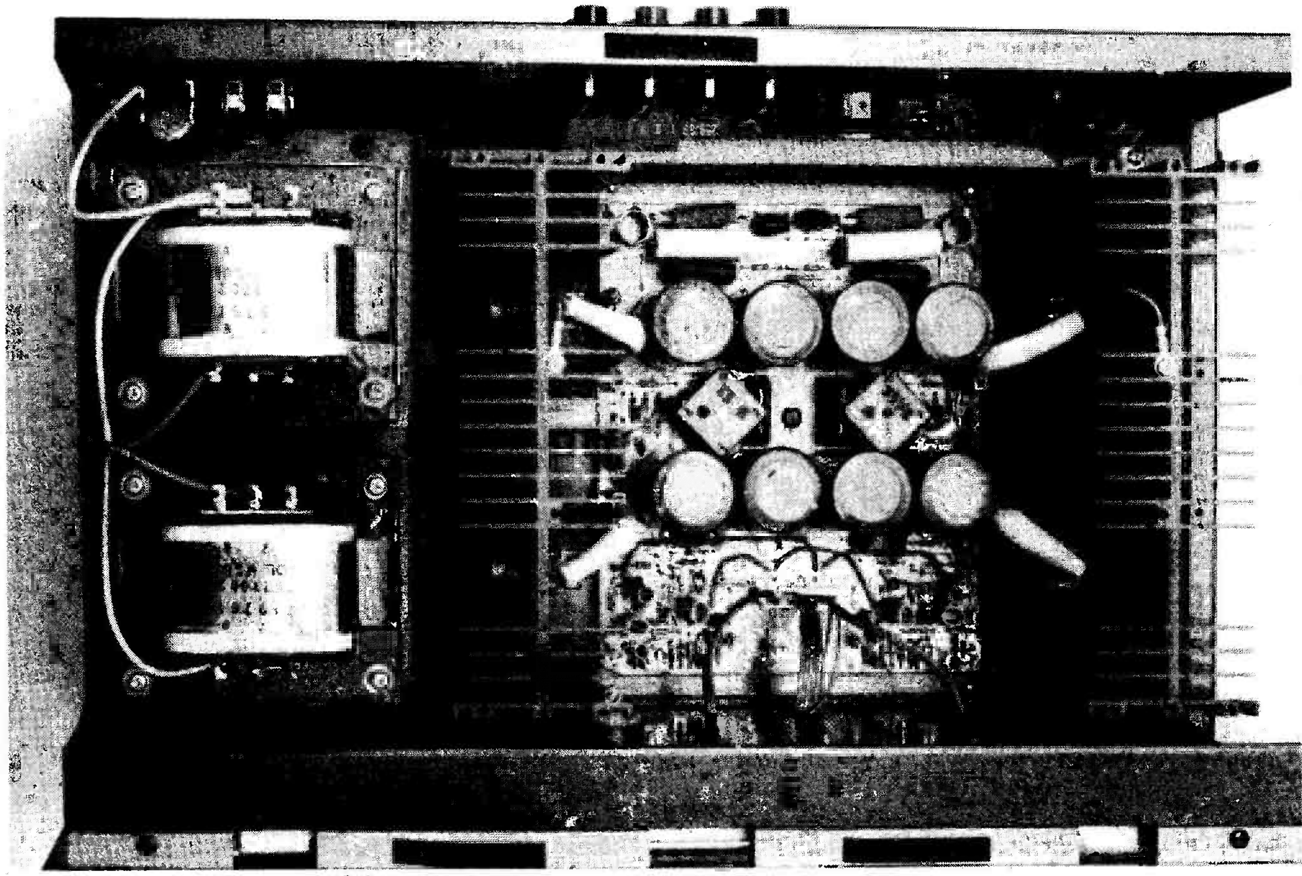
The preamp has a good performance for the price, which is low enough that, should you upgrade your cartridge beyond its capabilities, you could afford a specialist pickup amplifier to overcome the differences.

The power amp is very good indeed. It separates out the components of a complex piece very well, and portrays a convincing stereo image. The wildly dancing meters are impossible to ignore — what that means to you, be it good or bad, is a personal decision.

In bridged mode — which I have only been able to try in mono as yet — I felt the amp was even better, more open and with a more confident bass. I have contacted Hitachi and hope to be able to include a bridged pair of 7500s in the forthcoming comparison.

Final Notes

Final comments? Very good power amp by any standards. The preamp is good value for money, but the pickup input lets it down slightly. Overall a worthy production and one that cannot be considered expensive at £400.



Above: the mighty internals of the 7500 II power amp. Those huge transformers endow the machine with excellent separation and good power delivery.

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2.2	25	8p
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2.2	100	11p
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3.3	25	10p
3.3	40	11p
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4.7	16	8p
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4.7	40	11p
4.7	63	12p
4.7	100	14p
10	25	8p
10	40	12p
10	63	14p
10	100	16p
22	25	11p
22	40	14p
22	63	16p
22	100	21p
47	25	14p
47	40	17p
47	63	26p
47	100	28p
68	25	18p
68	63	25p
100	16	14p
100	25	16p
100	40	22p
100	63	25p
100	100	30p
220	10	16p
220	16	17p
220	25	22p
220	40	25p
220	63	30p
220	100	40p
330	16	19p
330	25	22p
330	63	38p
470	16	22p
470	25	28p
470	40	33p
470	63	43p
470	100	60p
1000	16	30p
1000	25	38p
1000	40	46p
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22	10	6p
22	16	7p
47	10	7p
47	16	8p
100	10	9p
100	16	10p
220	10	11p
220	16	12p
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470	16	18p
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2n2/2KV	30p
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2N2924	15p
2N2925	15p
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2N3403	50p
2N3404	50p
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2N3439	98p
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2N3468	1.00
2N3512	1.06
2N3553	1.15
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2N3564	25p
2N3565	20p
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2N3567	55p
2N3568	50p
2N3569	50p
2N3570	2.54
2N3571	2.19
2N3572	2.06
2N3584	2.76
2N3585	2.99
2N3605	36p
2N3606	28p
2N3607	28p
2N3632	9.88
2N3638	35p
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2N3639	36p
2N3641	39p
2N3642	25p
2N3643	15p
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2N3704	10p
2N3705	10p
2N3706	10p
2N3707	10p
2N3708	10p
2N3709	10p
2N3710	10p
2N3711	10p
2N3712	2.00
2N3713	2.86
2N3714	2.98
2N3715	3.31
2N3716	3.65
2N3724	75p
2N3725	85p
2N3730	4.65
2N3732	2.88
2'N3734	1.30
2N3725	2.45
2N3738	2.00
2N3739	2.38
2N3740	2.38
2N3741	2.76
2N3766	3.19
2N3767	3.43
2N3771	1.75
2N3772	1.83
2N3773	2.55
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2N3789	3.27
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2N3791	2.47
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2N3794	25p
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2N3854	44p
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2N3900	25p
2N3901	30p
2N3902	6.65
2N3903	15p
2N3904	15p
2N3905	15p
2N3906	15p
2N3945	85p
2N3962	30p
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2N4032	65p
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2N4058	10p
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2N4060	12p
2N4061	10p
2N4062	15p
2N4064	1.50
2N4069	1.00
2N4074	75p
2N4092	98p
2N4093	1.20
2N4121	45p
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2N4123	21p
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2N4126	27p
2N4220	1.77
2N4221	3.95
2N4222	3.95
2N4223	3.95
2N4224	3.95
2N4234	1.30
2N4236	45p
2N4237	1.60
2N4238	95p
2N4239	1.00
2N4240	3.00
2N4248	15p
2N4249	17p
2N4250	17p
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2N4285	35p
2N4287	45p
2N4288	22p
2N4289	22p
2N4290	45p
2N4291	45p
2N4292	45p
2N4294	45p
2N4297	2.50
2N4302	39p
2N4303	40p
2N4304	41p
2N4314	60p
2N4342	68p
2N4347	2.26
2N4351	1.16
2N4400	20p
2N4401	27p
2N4402	30p
2N4403	30p
2N4409	36p
2N4410	42p
2N4427	1.87
2N4440	12.58
2N4870	80p
2N4871	55p
2N4888	92p
2N4898	1.71
2N4901	3.26
2N4902	3.52
2N4903	3.24
2N4904	2.75
2N4905	3.25
2N4906	3.42
2N4907	3.20
2N4908	3.70
2N4909	2.90
2N4910	1.90
2N4913	2.59
2N4914	2.69
2N4915	2.95
2N4916	48p
2N4917	47p
2N4918	95p
2N4919	1.28
2N4920	1.34
2N4921	1.09
2N4922	1.29
2N4923	1.34
2N4924	92p
2N4926	95p
2N4927	95p
2N4928	1.59
2N4964	27p
2N4965	25p
2N4966	25p
2N4967	25p
2N4968	25p
2N4969	31p
2N5010	8.50
2N5011	9.37
2N5030	44p
2N5033	48p
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2N5036	1.95
2N5039	3.90
2N5086	36p
2N5087	36p
2N5088	37p
2N5089	37p
2N5126	48p
2N5127	38p
2N5128	38p
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2N5130	37p
2N5131	22p
2N5133	22p
2N5135	38p
2N5136	38p
2N5137	23p
2N5138	28p
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2N5172	20p
2N5175	58p
2N5179	46p
2N5180	43p
2N5183	1.00
2N5184	1.10
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2N5189	1.00
2N5190	68p
2N5191	70p
2N5193	90p
2N5194	1.34
2N5209	24p

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2N5220	15p
2N5221	25p
2N5222	28p
2N5223	15p
2N5224	38p
2N5225	25p
2N5226	25p
2N5227	25p
2N5232	30p
2N5232A	32p
2N5245	37p
2N5246	40p
2N5247	45p
2N5248	46p
2N5249	48p
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2N5293	98p
2N5294	1.28
2N5295	1.37
2N5296	1.28
2N5298	1.37
2N5302	3.20
2N5303	3.80
2N5305	25p
2N5306	37p
2N5307	40p
2N5308	25p
2N5354	19p
2N5355	19p
2N5358	73p
2N5366	25p
2N5367	28p
2N5401	35p
2N5415	1.10
2N5416	1.54
2N5447	16p
2N5448	19p
2N5449	21p
2N5450	23p
2N5451	25p
2N5457	35p
2N5458	35p
2N5459	35p
2N5460	72p
2N5461	60p
2N5462	80p
2N5484	40p
2N5485	40p
2N5490	1.37
2N5492	1.56
2N5494	1.37
2N5496	1.59
2N5543	5.00
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2N5640	45p
2N5654	35p
2N5786	80p
2N5813	23p
2N6027	30p
2N6030	6.80
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2N6101	1.30
2N6109	1.15
2N6111	1.00
2N6121	54p
2N6122	56p
2N6123	59p
2N6124	56p
2N6125	59p
2N6126	71p
2N6129	79p
2N6130	93p
2N6131	98p
2N6132	83p
2N6133	1.14
2N6134	1.36
2N6253	1.45
2N6254	1.55
2N6288	90p
2N6289	97p
2N6290	1.10
2N6318	1.72
3N81	2.57
3N128	1.98
3N138	3.50
3N139	3.30
3N140	2.37
3N143	2.85
3N152	3.00
3N153	2.47
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3N200	6.93
3N201	2.98
40250	2.42
40251	2.77
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40264	2.63
40280	2.00
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40311	97p
40312	1.64
40313	1.89
40315	1.94
40316	1.63
40324	1.86
40326	2.46
40327	1.98
40346	1.30
40347	1.40
40348	1.95
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40361	50p
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40363	2.22
40364	2.90
40372	1.80
40373	2.60
40374	2.84
40389	1.24
40390	2.72
40392	1.20
40394	1.10
[illegible]	1.70
40406	1.39
40407	1.10
40408	1.59
40410	1.80
40411	3.00
40412	1.50
40422	2.95
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40513	1.75
40537	96p
49543	1.60
40594	1.15
40595	1.20
40600	2.58
40601	2.36
40602	1.68
40603	2.06
40604	1.85
40608	2.44
40622	1.45

40625	1.60
40626	3.20
40631	1.90
40632	2.12
40635	1.35
40637	2.00
40643	1.80
40673	95p
40822	1.80
40871	1.00
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AC125	35p
AC126	25p
AC127	25p
AC128	25p
AC132	39p
AC151	51p
AC152	45p
AC153	55p
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AC176	27p
AC176K	37p
AC187	25p
AC187K	28p
AC188	25p
AC188K	40p
ACY17	70p
ACY18	90p
ACY20	75p
ACY21	75p
ACY22	75p
ACY28	75p
ACY44	98p
AD136	7.90
AD145	1.65
AD149	1.10
AD150	1.31
AD161	52p
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AF106	75p
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AF118	89p
AF124	72p
AF125	72p
AF126	72p
AF139	53p
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AF172	88p
AF178	88p
AF200	65p
AF201	75p
AF239	1.24
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AF280	75p
AU110	2.20
AU113	2.30
BC107	13p
BC107A	14p
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BC108	12p
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BC108C	14p
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BC119	38p
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BC123	82p
BC125	37p
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BC143	34p
BC147	11p
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BC147C	18p
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BC159B	13p
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BC559B	16p
BC559C	17p
BC560	32p
BC560C	34p
BC727	44p
BC737	44p
BCW32R	60p
BCY30	1.15
BCY30A	1.30
BCY31	1.15
BCY31A	1.30
BCY32	1.15
BCY32A	1.30
BCY33	80p
BYC33A	1.00
BCY34	80p
BYC34A	1.00
BCY54	1.91
BCY58	32p
BCY59	33p
BYC66	1.80
BYC67	2.00
BYC70	17p
BYC71	17p
BCY72	36p
BYC77	36p
BYC78	22p
BCY79	22p
BCY87	6.60
BYC88	4.90
BYC89	4.10
BCZ10	4.60
BCZ11	4.60
BD115	58p
BD116	2.50
BD121	2.25
BD124	1.50
BD131	44p
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BD135	40p
BD136	40p
BD137	42p
BD138	42p
BD139	44p
BD140	44p
BD142	2.40
BD153	1.25
BD155	1.20
BD157	1.20
BD158	1.40
BD160	3.80
BD181	1.75
BD182	2.50
BD183	2.70
BD187	1.09
BD201	1.30
BD202	1.39
BD204	1.44
BD220	1.00
BD221	95p
BD223	1.00
BD224	95p
BD232	1.11
BD233	70p
BD234	72p
BD235	72p
BD236	76p
BD239A	57p
BD239C	64p
BD240A	59p
BD240C	73p
BD241A	61p
BD241C	67p
BD242A	65p
BD242C	70p
BD243A	72p
BD243C	85p
BD244A	82p
BD244C	1.00
BD245A	1.14
BD245C	1.30
BD246A	1.20
BD246C	1.50
BD249A	2.00
BD249C	2.31
BD250A	2.11
BD250C	2.46
BD433	79p
BD434	79p
BD435	81p
BD436	81p
BD437	88p
BD438	88p
BD439	90p
BD440	91p
BD441	91p
BD442	93p
BD529	1.20
BD530	1.30
BD535	75p
BD536	75p
BD537	80p
BD538	80p
BD539	80p
BD539C	1.10
BD540	85p
BD540C	1.20
BD675	72p
BD676	77p
BD677	78p
BD678	83p
BD711	1.32
BD712	1.32
BDX14	1.30
BDX18	1.59
BDX32	3.47

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BDY11	2.50
BDY17	2.89
BDY23	3.40
BDY25	3.75
BDY38	1.74
BDY54	1.98
BYD55	2.09
BDY56	2.35
BDY57	5.25
BDY58	6.15
BDY60	2.80
BDY61	2.80
BDY62	2.34
BDY92	3.75
BF115	38p
BF119	1.00
BF121	75p
BF123	70p
BF127	80p
BF153	39p
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BF157	58p
BF158	58p
BF159	58p
BF160	55p
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BF163	50p
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BF167	30p
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BF177	25p
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BF355	60p
BF362	85p
BF363	85p
BF450	35p
BF451	35p
BF457	46p
BF458	56p
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BFR79	25p
BFR80	25p
BFR81	25p
BFS21A	4.50
BFS28	2.95
BFS61	1.00
BFS98	1.10
BFT19	1.65
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BFT66	2.48
BFW10	1.48
BFW10	1.48
BFW11	1.48
BFW43	2.47
BFW59	1.08
BFW87	1.53
BFW90	1.53
BFX12	1.00
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BFX19	50p
BFX20	80p
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BFX30	35p
BFX34	1.00
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BFX68	1.00
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BFX86	40p
BFX87	32p
BFX88	33p
BFX89	1.08
BFY18	1.15
BFY19	1.10
BFY37	1.20
BFY39	50p
BFY41	1.16
BFY50	25p
BFY51	25p
BFY52	25p
BFY53	45p
BFY56	70p
BFY56A	65p
BFY75	75p
BFY76	50p
BFY77	80p
BFY78	80p
BFY80	95p
BSV81	1.87
BSW41	95p
BSW67	1.00
BSW70	1.00
BSX19	25p
BSX20	25p
BSX21	40p

BSX26	60p
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BSX39	80p
BSX60	75p
BSX61	80p
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BSY95A	25p
BU104	3.00
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BU205	1.75
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BU326S	2.25
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BU407	1.45
BU408	1.35
BU409	1.25
BU500	2.80
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BUV23	13.60
BUV24	12.10
BUV25	15.00
BUX20	17.00
BUY18S	3.95
J300	48p
J310	53p
MA8001	45p
MA8002	62p
MA8003	39p
MD7000	2.60
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ME0402	30p
ME0404	25p
ME0411	35p
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ME0413	35p
ME0414	48p
ME0461	45p
ME0462	45p
ME1001	45p
ME1002	45p
ME1075	45p
ME1100	45p
ME1120	48p
ME3002	25p
ME4001	45p
ME4002	45p
ME4003	45p
ME4101	25p
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ME4103	25p
ME4104	25p
ME6001	25p
ME6002	25p
ME6003	25p
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ME6102	28p
ME8001	47p
ME8002	62p
ME8003	50p
ME9001	56p
ME9002	56p
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MJ802	4.48
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MJ1000	2.50
MJ1001	3.00
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MJE340	55p
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MP8111	1.00
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MP8122	1.40
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MP8512	1.59
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MPF105	40p
MPF112	50p
MPF121	1.21
MPS3638	27p
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MPS4356	60p
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MPS6518	47p
MPS6530	37p
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MPS6562	32p
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MPSA12	28p
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MPSU06	56p
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MSPU55	84p
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MPSU57	1.20
MRF421	39.95
MFR450A	24.10
MRF453	27.65
MRF454	40.80
MRF475	7.65
MRF477	21.95
MRF479	12.32
MRF604	7.29
NKT124	63p
NKT125	48p
NKT126	47p
NKT128	42p
NKT129	40p
NKT135	40p
NKT137	42p
NKT210	42p
NKT215	40p
NKT216	65p
NKT218	44p
NKT219	40p
NKT224	40p
NKT225	40p
NKT229	40p
NKT238	48p
NKT239	44p
NKT240	42p
NKT241	40p
NKT242	40p
NKT243	88p
NKT243	88p
NKT244	40p
NKT254	40p
NKT261	40p
NKT262	40p
NKT271	40p
NKT272	40p
NKT275	40p
NKT281	47p
NKT404	2.00
NKT405	2.80
NKT406	2.50
NKT453	2.40
NKT603F	56p
NKT613F	65p
NKT674F	58p
NKT677F	60p
NKT713	47p
NKT717	62p
NKT734	65p
NKT736	59p
NKT773	40p
NKT781	43p
NKT12329	50p
NKT12429	67p
NKT13329	60p
NKT13429	54p
NKT16229	60p
NKT20329	38p
OC20	2.30
OC22	2.00
OC23	2.00
OC25	2.60
OC28	1.70
OC29	2.36
OC35	2.36
OC41	80p
OC43	70p
OC44	82p
OC70	60p
OC71	60p
OC72	50p
OC82	60p
OC82D	70p
OC83	75p
P346A	50p
R2008B	2.14
R2010B	1.80
SC107	27p
SC108	27p
SC109	27p
TIP29A	36p
TIP29C	49p
TIP30A	39p
TIP30C	49p
TIP31A	44p
TIP31C	62p
TIP32A	44p
TIP32C	58p
TIP33A	75p
TIP33C	88p
TIP34A	95p
TIP34C	1.25
TIP35A	1.25
TIP35C	1.58
TIP36A	1.00
TIP36C	1.70
TIP41A	64p
TIP41C	70p
TIP42A	60p
TIP42C	80p
TIP49	1.20
TIP50	1.40
TIP53	2.30
TIP54	2.60
TIP110	74p
TIP112	90p
TIP115	81p
TIP117	96p
TIP120	86p
TIP122	1.00
TIP125	1.20
TIP127	1.27
TIP130	1.50
TIP132	1.80
TIP135	1.80
TIP137	1.80
TIP140	1.96
TIP142	1.40
TIP145	2.16
TIP147	1.40
TIP2955	77p
TIP3055	70p
TIS37	62p
TIS43	40p
TIS45	66p
TIS46	86p
TIS47	49p
TIS48	65p
TIS49	66p
TIS50	80p
TIS51	65p
TIS52	70p
TIS53	97p
TIS54	85p
TIS55	66p
TIS58	92p

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C = 300V
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TIC106C 48p
TIC106D 59p
TIC106M 68p
8A TIC116A 66p
TIC116B 68p
TIC116C 71p
TIC116D 73p
TIC116M 80p
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TIC126B 72p
TIC126C 73p
TIC126D 77p
TIC126M 95p

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1N3493R 2.20
1N3602 38p
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1N3766 3.00
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1N4009 20p
1N4148 6p
1N4150 18p
1N4448 22p
1N4517 22p
1N5172 30p
1N5176 94p
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1N5401 13p
1N5402 14p
1N5403 15p
1N5404 16p
1N5405 17p
1N5406 18p
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BA102 25p
BA115 25p
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BA138 30p
BA142 20p
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BA155 15p
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BA202 26p
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BA317 25p
BA318 30p
BAV10 16p
BAV19 15p
BAV20 15p
BAV49 15p
BAX13 10p
BAX16 11p
BAY38 20p
BAY44 15p
BAY93 10p
BB103B 70p
BB103G 70p
BB104B 80p
BB104G 80p
BB105 52p
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BB105B 58p
BB109G 85p
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BY127 22p
BY134 52p
BY182 1.26
BY188A 65p
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BY207 36p
BY223 1.56
BY297 48p
BY299 55p
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BYW11-1000 2.00
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BYW12-200 1.40
BYW12-400 2.00
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BYX71-600 1.52
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K06 (600) 3.40
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LD36A 12p
LD37A 12p
LD52A 12p
LD56A 15p
LD57A 15p
LD52C 30p
LD56C 30p
LD57C 30p
LD80A 18p
LD86A 22p
LD87A 22p
LD242 75p
LD271 40p
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TIL66 2.30
TIL67 2.35
TIL78 60p
TIL81 1.60
TIL99 1.35
TIL116 1.10
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E299DDP218 40p
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E299DDP226 40p
E299DDP228 40p
E299DDP230 40p
E299DDP232 40p
E299DDP234 40p
E299DDP236 40p
E299DDP238 40p
E298EDA258 40p
E298EDA260 40p
E298EDA262 40p
E298EDA265 40p
E298EDA268 40p
E299DDP336 40p
E299DDP338 40p
E299DDP340 40p
E299DDP342 40p
E299DDP344 40p
E299DDP346 40p
E299DDP348 40p
E299DDP350 40p
E299DDP352 40p
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AY5-2376 10.50
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CA3002 4.60
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CA3007 4.92
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CA3012 1.75
CA3013 4.12
CA3014 2.35
CA3015 2.62
CA3018 75p
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CA3020 2.00
CA3020A 3.90
CA3021 3.20
CA3022 3.12
CA3026 1.52
CA3028A 1.21
CA3028B 2.53
CA3029 1.44
CA3030A 2.97
CA3033 5.44
CA3034 5.18
CA3036 2.75
CA3039 1.50
CA3041 3.47
CA3042 3.47
CA3043 3.92
CA3046 69p
CA3047 4.60
CA3048 2.99
CA3049 3.21
CA3050 4.11
CA3051 3.80
CA3052 2.92
CA3053 1.00
CA3054 1.66
CA3059 1.95
CA3060 4.09
CA3062 13.84
CA3085E 4.62
CA3068 4.23
CA3070 3.20
CA3071 3.30
CA3075 2.25
CA3076 3.42
CA3078T 2.25
CA3080 1.89
CA3080A 3.95
CA3080E 1.00
CA3081 1.90
CA3085 1.35
CA3086 55p
CA3088E 2.35
CA3089E 1.95
CA3099E 2.80
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ICL8038 3.20
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LM307N 55p
LM308AH 3.15
LM308AN 2.14
LM308H 95p
LM308N 88p
LM309K 2.80
LM310H 1.95
LM310N 1.89
LM311H 1.04
LM311N 70p
LM317K 2.80
LM317MP 1.04
LM317T 1.50
LM318H 2.40
LM318N 2.00
LM319H 2.48
LM319N 2.10
LM320 – See 79XX Series Volt. Regulators
LM324N 50p
LM337K 4.76
LM337MP 1.65
LM337T 1.99
LM339AN 1.60
LM339N 51p
LM340 – See 78XX Series Volt. Regulators
LM345K 3.60
LM348N 70p
LM349N 1.16
LM350K 4.60
LM359N 1.44
LM360N 3.88
LM376N 65p
LM377N 1.55
LM378N 3.40
LM379S 5.60
LM380N14 75p
LM380N8 1.50
LM381AN 2.26
LM381N 1.40
LM382N 1.25
LM383T 3.40
LM384N 1.40
LM386N1 88p
LM386N4 1.20
LM388N 1.32
LM391N60 1.70
LM391N80 1.93
LM392N 76p
LM393N 96p
LM394H 3.80
LM396K 13.52
LM709N8 64p
LM709CH 1.00
LM710CH 89p
LM710CN 52p
LM711CH 1.38
LM711CN 80p
LM723CH 1.21
LM723CN 40p
LM725CH 3.40
LM725CN 2.50
LM733CN 77p
LM741CH 96p
LM741CN 20p
LM741CN14 80p
LM747CN 70p
LM748CH 1.00
LM748CN 39p
LM1303N 1.20
LM1304N 2.00
LM1305N 3.10
LM1307N 2.75
LM1310N 1.45
LM1330N 2.25
LM1458 48p
LM1496 1.08
LM1800 3.24
LM1801 3.47
LM1812 8.00
LM1818 2.99
LM1820 2.15
LM1828 4.79
LM1830 2.75
LM1845 4.12
LM1848 2.89
LM1850 2.75
LM1871 4.75
LM1872 4.75
LM1886 7.44
LM1889 3.77
LM2907N 2.75
LM2907N8 2.60
LM2917N 1.95
LM2917N8 1.90
LM3254 6.77
LM3301 1.60
LM3302 95p
LM3401 95p
LM3403 85p
LM3405 1.65
LM3900 48p
LM3905 1.25
LM3909 70p
LM3911 1.68
LM3914 2.25
LM3915 2.25
LM3916 2.25
LM4250CH 2.63
LM4250N 2.39
LM13600 1.25
MB3712 2.36
MB3756 3.80
MB8719 7.95
M53200 8.54
MC1303 = LM1303N
MC1304 = LM1304N
MC1305 = LM1305N
MC1307 = LM1307N
MC1310 = LM1310N
MC1330 = LM1330N
MC1352 1.75
MC1456 1.80
MC1458 = LM1458
MC1466L 6.77
MC1495L 3.75
MC1496 = LM1496
MC3340 1.45
MC3401 = LM3401
MC3403 = LM3403
MC3405 = LM3405
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NE543N 2.50
NE544N 1.80
NE555 20p
NE556 57p
NE558 1.43
NE560 4.99
NE562 6.13
NE565 1.25
NE566 1.65
NE567 1.37
NE570 4.40
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PLL03A 12.75
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SL641C 6.00
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SN76008 3.90
SN76018 3.90
SN76003N 2.95
SN76013N 1.95
SN76023N = SN76033N
SN76033N 2.95
SN76110 2.25
SN76115 2.65
SN76116 2.75
SN76226 3.45
SN76228 2.90
SN76477 1.70
SN76530 1.80
SN76550 80p
SN76666 2.90
SO41P 1.60
SO42P 1.60
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TA7204 2.75
TA7205 2.20
TA7222 2.30
TA7310 2.00
TAA263 1.50
TAA300 3.95
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TAA350 3.60
TAA521 1.50
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TAA640 1.50
TAA661B 1.70
TAA700 2.60
TAA930 2.50
TAA930B 2.63
TAA970 2.45
TAA991D 2.45
TAD100 2.00
TBA120AS 75p
TBA231 1.50
TBA341 2.09
TBA350 1.85
TBA396 1.50
TBA450 1.95
TBA460 1.53
TBA500 2.97
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TBA510 2.95
TBA510Q 3.05
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TBA520Q 2.75
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TBA530Q 2.76
TBA540 2.72
TBA540Q 2.89
TBA550 3.42
TBA550Q 3.62
TBA560C 2.87
TBA570 2.37
TBA570Q 2.48
TBA581 3.11
TBA641 3.00
TBA651 90p
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TBA700 2.38
TBA720A 2.35
TBA720AQ 2.60
TBA750 2.25
TBA750Q 2.46
TBA790A 2.11
TBA800 83p
TBA810 1.00
TBA820 75p
TBA820M 75p
TBA920 2.70
TBA920Q 2.82
TBA950 3.00
TBA990 2.85
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TCA160C 2.67
TCA220 3.23
TCA270 2.44
TCA280 2.20
TCA440 2.65
TCA640 4.15
TCA650 4.15
TCA660B 4.15
TCA730 4.80
TCA740 4.80
TCA750 4.85
TCA760 2.75
TCA800 3.50
TCA800Q 3.60
TCA830S 1.90
TCA910 2.00
TCA940 2.25
TDA1002 3.00
TDA1003 3.60
TDA1004 3.00
TDA1005 3.60
TDA1010A 2.59
TDA1022 5.60
TDA1024 1.00
TDA1034 3.20
TDA2020 3.20
TDA2030 3.20
TDA2522 4.20
TDA2530 3.30
TDA2540 4.10
TDA2541 4.10
TDA2560 4.10
TDA2571 4.40
TDA2581 3.75
TDA2590 5.20
TDA2591 4.73
TDA2600 6.15
TDA2610 3.90
TDA2611A 2.50
TDA2640 3.64
TDA3000 2.76
TL061 40p
TL062 60p
TL064 1.10
TL071 36p
TL072 50p
TL074 1.30
TL081 50p
TL082 75p
TL083 85p
TL084 1.10
TL170 60p
TL430 1.71
UAA170 1.97
UAA180 1.97
ULN2003 1.00
UPC575C2 2.75
UPC1156 2.75
XR2206 3.00
ZN414 1.00
ZN419 2.25
ZN1034 2.00
ZN1040 7.75
ZTK22 89p
ZTK33 89p

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7401 11p
7402 11p
7403 13p
7404 12p
7405 18p
7406 26p
7407 26p
7408 18p
7409 16p
7410 15p
7411 21p
7412 21p
7413 25p
7414 33p
7416 25p
7417 25p
7420 15p
7421 22p
7422 20p
7423 25p
7425 26p
7426 28p
7427 25p
7428 30p
7430 15p
7432 20p
7433 30p
7437 26p
7438 26p
7440 15p
7441 65p
7442 38p
7443 80p
7444 80p
7445 60p
7446 55p
7447 40p
7448 60p
7450 15p
7451 15p
7453 15p
7454 15p
7460 15p
7470 34p
7472 25p
7473 30p
7474 23p
7475 38p
7476 28p
7480 44p
7481 1.08
7482 68p
7483 40p
7484 79p
7485 90p
7486 26p
7489 2.20
7490 26p
7491 45p
7492 36p
7493 30p
7494 55p
7495 45p
7496 40p
7497 1.28
74100 80p
74104 54p
74105 38p
74107 30p
74109 32p
74110 40p
74111 95p
74116 80p
74118 75p
74119 98p
74120 80p
74121 30p
74122 40p
74123 45p
74125 40p
74126 41p
74128 40p
74132 48p
74136 40p
74141 80p
74142 1.99
74143 2.48
74144 2.55
74145 68p
74147 1.10
74148 75p
74150 80p
74151 48p
74153 48p
74154 72p
74155 48p
74156 50p
74157 50p
74159 1.00
74160 62p
74161 62p
74162 62p
74163 62p
74164 65p
74165 62p
74166 69p
74170 1.60
74172 3.08
74173 76p
74174 75p
74175 75p
74176 75p
74177 75p
74178 1.00
74180 60p
74181 1.60
74182 90p
74184 90p
74185 1.20
74186 4.95
74188 3.30
74190 72p
74191 72p
74192 72p
74193 72p
74194 72p
74195 63p
74196 63p
74197 63p
74198 1.00
74199 1.00
74221 77p

74LS TTL
74LS00 11p
74LS01 14p
74LS02 14p
74LS03 14p
74LS04 14p
74LS05 15p
74LS08 15p
74LS10 15p
74LS11 15p
74LS12 15p
74LS13 15p
74LS14 48p
74LS15 16p
74LS20 20p
74LS21 15p
74LS22 20p
74LS27 18p
74LS28 22p
74LS30 17p
74LS32 18p
74LS33 16p
74LS37 16p
74LS38 18p
74LS40 25p
74LS42 39p
74LS47 40p
74LS51 16p
74LS54 22p
74LS55 18p
74LS73 25p
74LS74 18p
74LS75 20p
74LS76 30p
74LS78 30p
74LS80 1.20
74LS83 50p
74LS85 80p
74LS86 24p
74LS90 36p
74LS92 38p
74LS93 35p
74LS95 1.00
74LS96 1.00
74LS107 45p
74LS109 29p
74LS112 33p
74LS113 31p
74LS114 31p
74LS122 50p
74LS123 50p
74LS124 1.80
74LS125 30p
74LS126 31p
74LS132 48p
74LS136 29p
74LS138 36p
74LS139 36p
74LS145 75p
74LS147 1.62
74LS148 90p
74LS151 35p
74LS153 60p
74LS154 1.99
74LS155 40p
74LS156 40p
74LS157 35p
74LS158 36p
74LS160 41p
74LS161 44p
74LS162 44p
74LS163 49p
74LS164 49p
74LS165 1.00
74LS168 2.66
74LS169 2.42
74LS170 90p
74LS173 71p
74LS174 59p
74LS175 52p
74LS181 1.40
74LS183 3.25
74LS190 51p
74LS191 48p
74LS192 51p
74LS193 59p
74LS194 58p
74LS195 52p
74LS196 66p
74LS197 69p
74LS221 65p
74LS240 81p
74LS241 92p
74LS242 80p
74LS243 80p
74LS244 64p
74LS245 90p
74LS247 1.00
74LS248 65p
74LS249 67p
74LS251 40p
74LS253 40p
74LS257 46p
74LS258 46p
74LS259 85p
74LS261 2.30
74LS266 29p
74LS273 90p
74LS275 3.22
74LS279 55p
74LS280 2.80
74LS283 1.59
74LS289 4.70
74LS290 65p
74LS293 50p
74LS295 2.25
74LS298 1.59
74LS299 4.56
74LS323 3.00
74LS324 2.21
74LS325 3.33
74LS326 3.51
74LS327 3.33
74LS347 1.61
74LS348 1.90
74LS352 1.95
74LS353 1.95
74LS362 9.35
74LS365 36p
74LS366 45p
74LS367 36p
74LS368 51p
74LS373 79p
74LS378 75p
74LS386 33p
74LS390 70p
74LS393 60p
74LS395 2.15
74LS396 1.99
74LS398 2.80
74LS399 2.00
74LS445 1.30
74LS490 3.00
74LS540 1.35
74LS541 1.35
74LS640 2.20
74LS641 2.25
74LS643 2.25
74LS644 2.75
74LS668 2.00
74LS669 2.10
74LS670 1.75
74LS673 5.50
74LS674 7.50

74S TTL
74S00 60p
74S02 60p
74S04 60p
74S08 75p
74S20 60p
74S30 60p
74S32 1.00
74S40 1.45
74S64 60p
74S65 1.45
74S74 1.00
74S85 3.25
74S86 2.05
74S112 90p
74S113 1.00
74S124 3.50
74S132 1.80
74S133 1.00
74S138 2.35
74S139 2.35
74S140 2.50
74S153 2.75
74S157 2.75
74S163 3.00
74S174 2.60
74S175 3.00
74S188 3.20
74S189 3.50
74S194 3.50
74S200 4.75
74S201 4.00
74S225 5.60
74S251 3.00
74S262 10.00
74S287 3.71
74S288 3.71
74S289 2.81
74S301 3.99
74S470 6.75
74S471 6.75
74S473 12.50
74S474 4.25
74S475 13.10
74S571 9.00
74S573 9.00

74H TTL
74H00 1.45
74H01 1.45
74H04 1.55
74H05 1.55
74H10 1.45
74H11 1.45
74H20 1.45
74H21 1.45
74H30 1.45
74H40 1.55
74H51 1.65
74H53 1.65
74H54 1.45
74H55 1.45
74H60 1.70
74H62 1.75

74L TTL
74L02 1.00
74L10 1.70
74L47 3.27
74L74 1.20
74L85 4.20
74L86 1.50
74L93 2.30
74L98 2.99

74C CMOS/TTL
74C00 27p
74C04 29p
74C10 28p
74C14 89p
74C20 28p
74C30 38p
74C42 96p
74C48 1.40
74C73 54p
74C76 57p
74C83 1.74
74C85 1.34
74C86 1.50
74C89 5.96
74C90 1.05
74C93 1.44
74C95 1.00
74C107 1.20
74C151 2.55
74C154 4.95
74C157 2.20
74C160 1.54
74C161 1.15
74C162 1.16
74C163 1.15
74C164 1.15
74C165 2.00
74C173 98p
74C174 1.22
74C175 1.00
74C192 1.15
74C193 1.13
74C194 1.20
74C195 1.06
74C200 10.00
74C221 1.20
74C901 1.91
74C902 71p
74C903 2.30
74C904 1.84
74C905 10.88
74C907 1.91
74C908 1.87
74C911 9.59
74C912 8.00
74C914 2.88
74C915 1.99
74C918 2.50
74C920D 8.50
74C922 4.50
74C923 5.00
74C925 6.00
74C926 6.58
74C928 6.00
74C929 5.20
74C930J 7.80
74C932 3.12

40 CMOS
4000 15p
4001 16p
4002 15p
4003 60p
4007 17p
4008 62p
4009 37p
4010 39p
4011 15p
4012 18p
4013 30p
4014 58p
4015 60p
4016 27p
4017 48p
4018 60p
4019 32p
4020 58p
4021 65p
4022 64p
4023 19p
4024 38p
4025 19p
4026 1.30
4027 30p
4028 60p
4029 75p
4030 38p
4031 1.95
4032 1.40
4033 1.90
4034 1.61
4035 78p
4036 3.00
4037 1.00
4038 1.22
4040 54p
4041 69p
4042 61p
4043 61p
4044 70p
4045 1.20
4046 68p
4047 68p
4048 50p
4049 29p
4050 29p
4051 56p
4052 68p
4053 58p
4054 1.20
4055 1.18
4056 1.30
4059 5.60
4060 88p
4063 90p
4066 34p
4067 3.90
4068 17p
4069 18p
4070 19p
4071 19p
4072 20p
4073 19p
4075 20p
4076 60p
4077 19p
4078 22p
4081 20p
4082 20p
4085 65p
4086 72p
4089 1.50
4093 38p
4094 1.45
4095 90p
4096 90p
4097 3.20
4098 87p
4099 90p
For higher numbers in 40 Series, substitute 74C for 40 prefix. eg 40107 = 74C107

45 CMOS
4502 80p
4503 60p
4507 39p
4508 1.80
4510 65p
4511 48p
4512 64p
4514 1.49
4515 1.46
4516 75p
4518 47p
4519 43p
4520 68p
4521 1.48
4526 78p
4527 1.10
4528 72p
4532 88p
4534 5.00
4536 3.10
4538 1.20
4539 1.20
4543 1.10
4553 2.90
4555 60p
4556 60p
4560 2.00
4566 1.75
4569 2.20
4584 52p
4585 1.00

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2708 3.00
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4027 3.00
4044 7.00
4060 9.50
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4118-3 5.00
4164 8.40
5204 7.50
6116 6.50
6514 3.30
6810 1.99
7489 2.65
74189 4.00
74LS289 4.00
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40 pin 11.37

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MC1488 75p
MC1489 75p
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MC4044 3.25
MK50250 10.00
MK50398 8.25
MM5303 6.25
MM5307 12.75
MM5357 22.50
MM57105 14.00
MM57109 12.00
MM57160 9.00
MM57161 9.00
MM58174 10.80
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RO2513UC 7.50
SAA5000 3.00
SAA5010 7.10
SAA5012 7.10
SAA5020 6.50
SAA5030 10.00
SAA5040 15.00
SAA5041 15.00
SAA5050 8.50
SAA5052 8.50
TMS6011 4.25
ULN2003A 1.15
8T26 1.35
8T28 1.35
8T95 1.35
8T97 1.35
81LS95 1.25
81LS96 1.25
81LS97 1.25
81LS98 1.25
6522 5.30
6532 7.85
6821 1.80
6845 10.00
6847 10.00
6850 1.90
6852 4.00
6875 6.30
8131 3.75
8154 9.59
8155 8.00
8156 1.80
8212 1.80
8216 1.80
8223 1.80
8224 2.50
8226 2.50
8228 2.50
8238 5.75
8243 4.68
8250 8.65
8251 3.95
8253 8.00
8254 10.00
8255 3.75
8257 8.00
8259 8.00
8279 9.95
8304 4.50
8544 1.50
8601 1.20
8678CABN 19.50
8832 2.60
8833 2.35
9097 3.00
9099 3.00
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Z80ADART 8.00
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ZN426E8 3.75
ZN427E8 6.75
ZN428E8 5.25

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78L05A 30p
78L12A 30p
78L15A 30p
78L24A 30p
100mA To5
78L05CH 80p
78L12CH 80p
78L15CH 80p
78L24CH 80p
500mA T0202
7805M 47p
7812M 47p
7815M 47p
7824M 47p
1 Amp T0220
7805T 50p
7812T 50p
7815T 50p
7824T 50p
1.5 Amp T03
7805K 1.40
7812K 1.40
7815K 1.40
7824K 1.40
– Negative –
100mA T092
79L05 70p
79L12 70p
79L15 70p
500mA T0202
7905M 55p
7912M 55p
7915M 55p
7924M 55p
1 Amp T0220
7905T 60p
7912T 60p
7915T 60p
7924T 60p
1.5 Amp T03
7905K 2.20
7912K 2.20
7915K 2.69
7924K 2.69
– Variable –
L200 (2A Pos) 2.50
LM137K 12.00
LM309K 1.50
LM317K 3.42
LM317MP 1.64
LM317T 2.00
LM337K 4.60
LM337MP 1.73
LM337T 2.25
LM345K 3.60
LM350K 4.50
LM396K 13.52

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200KHz 3.50
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1.008MHz 3.60
2.00MHz 2.50
2.097152MHz 3.50
3.2768MHz 3.00
4.00MHz 3.00
4.194394MHz 3.00
4.433619MHz 1.45
5.00MHz 3.50
6.00MHz 2.75
6.9375MHz 3.50
8.00MHz 2.75
10.00MHz 2.75
18.00MHz 2.75
20.00MHz 3.25
27.648MHz 2.60
48.00MHz 3.00
100.00MHz 5.50
5.5 MHz Ceramic filter 90p

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ECC82 1.22
ECC83 1.22
ECC84 1.22
EF86 1.80
EL34 2.89
EL84 2.50
KT66 10.76
KT88 12.50
PC900 1.78
PCC84 3.00
PCC85 3.40
PCC89 1.89
PCF86 2.30
PCF201 3.00
PCF801 2.57
PCF802 2.11
PCL82 1.80
PCL85 2.20
PCL86 2.10
PCL805 2.20
PD510 4.95
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PL508 2.36
PL509 4.75
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PY500A 2.63
6L6 2.59

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Female 1.65
Sockets (Chassis)
Male 1.50
Female 2.35

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3½mm Stereo 36p
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¼" Stereo 30p
¼" Stereo Metal 40p
3½mm Mono 15p
3½mm Mono Line 20p

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1KV (DC)
750V (AC)
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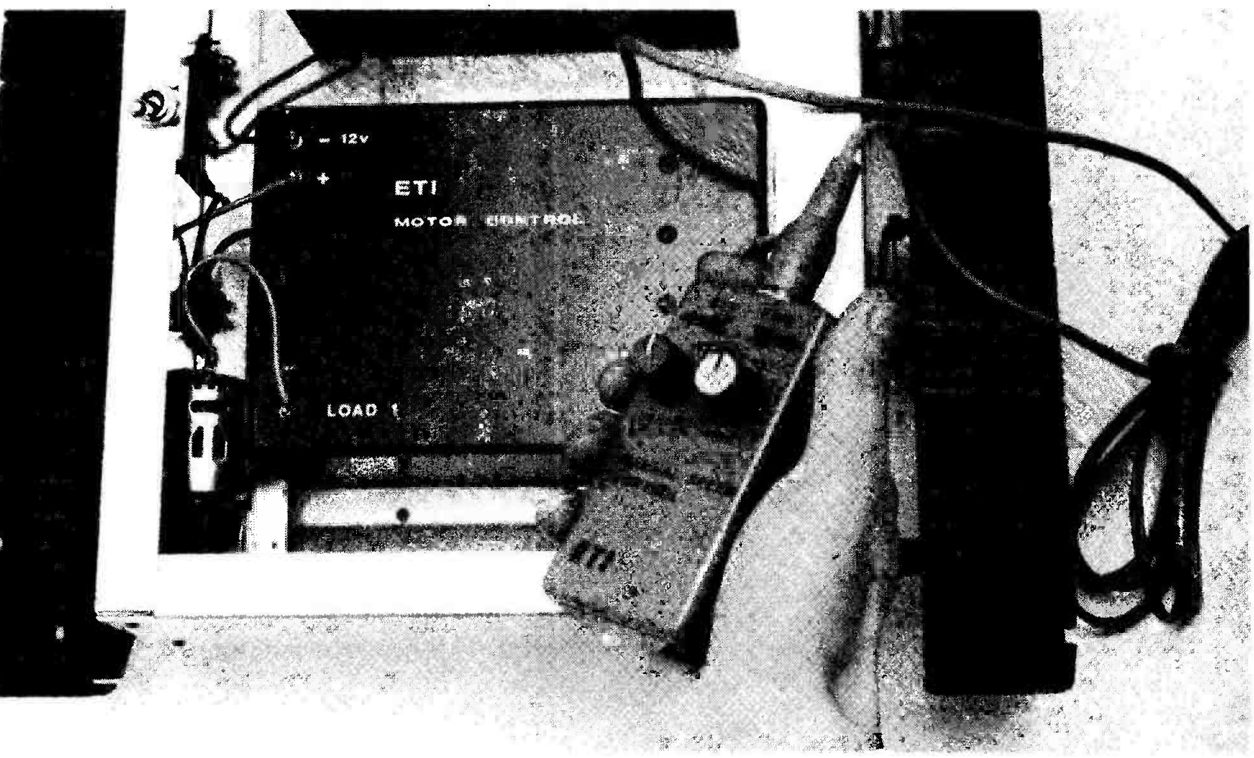
(SAE brings specs)

ROBOT MOTOR CONTROL PART 3

This month we describe the construction of the analogue pulse width modulator and show how to interface it to the dual motor controller. Design and development by Rory Holmes.



The overlay diagram for the analogue pulse width modulator described last month is shown in Fig. 2. Assemble the PCB following the component orientations indicated and soldering in sockets for the ICs. If only one channel is required, the board can be cut in half along the dividing line, omitting the two links and assembling the circuit for channel 1. Overlay pictures for the transistors are correct for the specified 'L' versions and pin outs should be identified carefully if other types are used.

Veropins should be soldered in at all the points marked for terminations (18 in all). Spare positive and ground terminals have been included near the input and output points for flexibility. The resistor shown on the circuit diagram in last month's issue as the speed feedback input and marked as Rx on the overlay, should be included on the board; a value of 100k is required. A 1M0 shorting resistor should also be connected between the terminal pins marked for speed feedback input (GND and INPUT). This resistor prevents stray interference in the basic unit and can be easily removed for later addition of closed loop velocity control.

After mounting the two presets they should be set at about half-travel. (Ceramic base presets can crack quite easily, so take care when inserting these into the PCB.) These presets are used to apply a DC offset to the voltage summing amplifier, so shifting the control voltage range to the required level.

Installation

Without plugging in the ICs, a 12 V power source can be connected to the board as shown. The power rails should be checked at the relevant pins on the IC sockets; also check that the 8 V reference is present at the positive end of C13 and C6. If all is well, the power can be disconnected and the ICs plugged in. At this stage the board can now be mounted using brackets or insulating pillars directly above the power switching PCB in the diecast box. The 12 V power source is taken from the existing bridge-rectifier tags, and the two output signals, PWM and FOR/REV, should be wired to the corresponding pins on each channel of the power switching PCB. Have a look at the internal photographs with the analogue board.

The two manual control potentiometers, RV1 and 2 can now be wired up to the control voltage input. In the circuit diagram the positive ends of RV1 and 2 are shown connected to the +8 V reference; a four core cable would thus be needed for the remote attachment of these potentiometers with their limiting resistors R8 and R22.

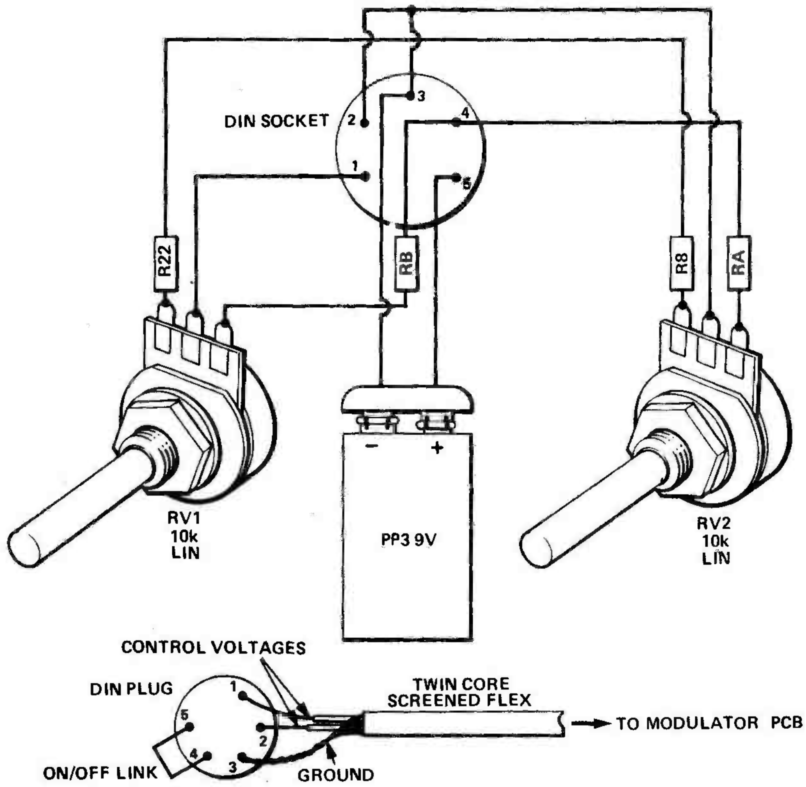
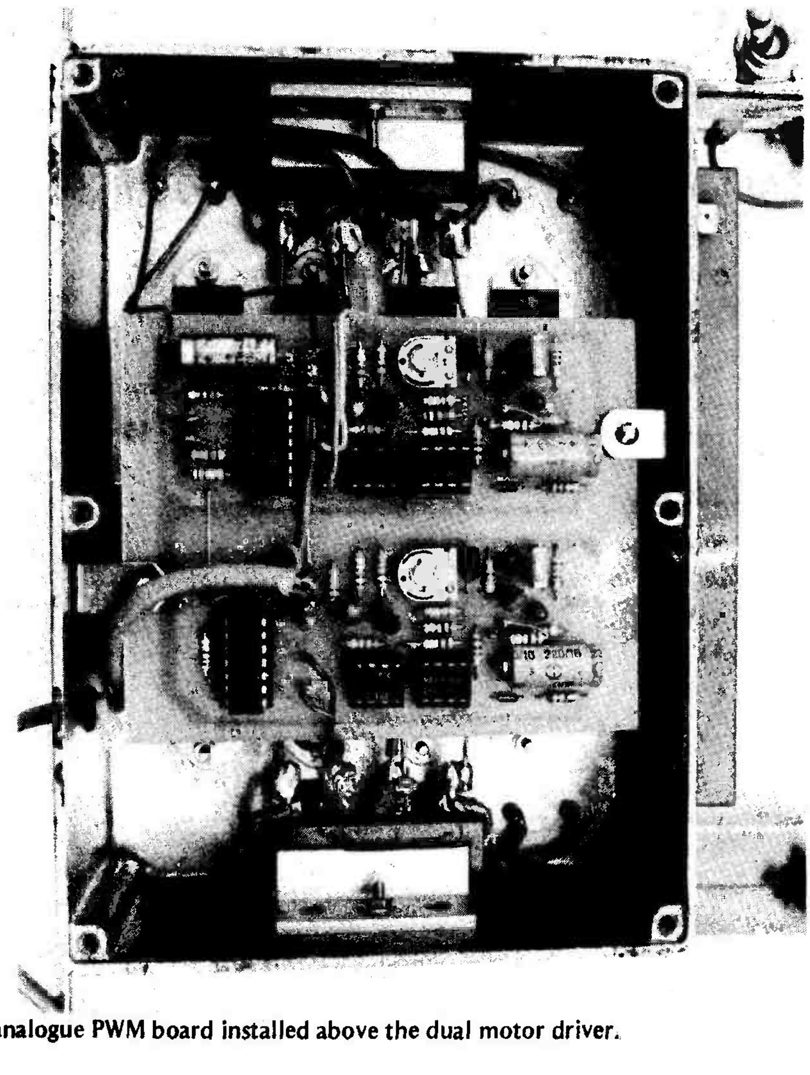


Fig. 1 Wiring diagram for the manual control unit.



The analogue PWM board installed above the dual motor driver.

Essentially all that's required is a voltage variable from 0 to 8 V applied to the base of Q3, so to allow the use of cheaper twin core screened cable we mounted our pots in a small hand-size box with their own 9 V PP3 battery power source. A five pin DIN plug and socket mounted at one end connects the control voltages from the pot sliders, via the cable, to the modulator PCB. The cores are wired to the input terminals at the bases of Q3 and Q6, with the screen taken to the adjacent ground pin. Figure 1 illustrates the manual control wiring, the accompanying photo the internal appearance.

R8 and R22 are shown on the circuit diagram as 1k0; these may be altered as required to limit the maximum reverse speed. RA and RB however are optional resistors for limiting the maximum slider voltage to 8 V; we used 1k0 resistors to suit the 9 V battery.

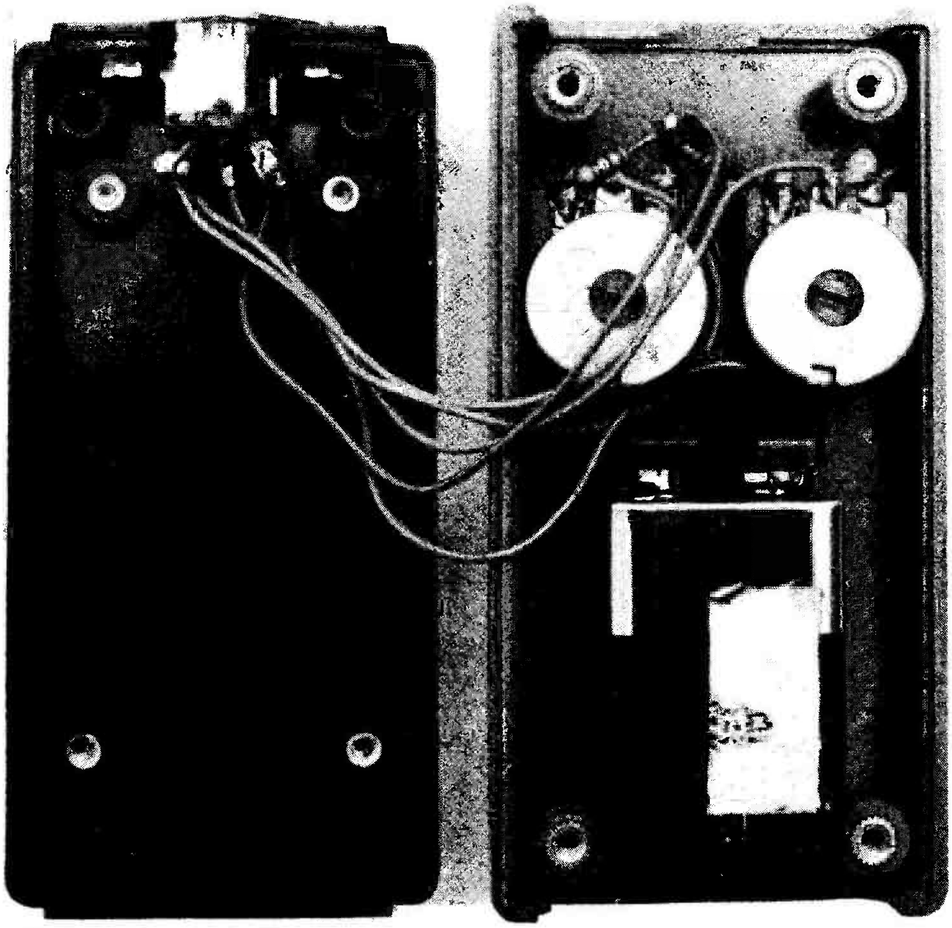
If this type of manual forward/reverse control is not required the associated components can be omitted during assembly (C4, C11, Q3, Q6, IC2, IC5, R9, R23, R10, R24). Pin 6 of sockets IC2 and 5 now becomes the FWD/REV logic control, the unused collector pad of Q3 and 6 becomes the control voltage input.

The ratio of R15 to R13 determines the gain of this input, and with the specified 1M0 values is set at unity. Thus an input variation over a 3 V range will provide 0% to 100% duty-cycle control. The input should be referenced to the 0 V ground, and PR1 and 2 can provide full offset adjustment of the control ranges. To increase the gain, the value of R13 should be decreased.

Testing

Once the manual potentiometers have been wired up in a suitable fashion the completed controller may be set up for proper operation. Temporarily disconnect the PWM signal wires and solder them to the adjacent ground terminals; this will prevent the power stages being damaged if there are any errors.

Connect a 12 V supply to the main controller; two glowing LEDs are the first signs of success! A voltmeter or scope set for 12 V FSD should now be hooked up to the FWD/REV output; depending on the pot position a 0 V or 12 V level will be present, and should sharply change state as the pot is turned through its centre travel. A ramp waveform of 3 V peak should be observed if a scope is put on pin 6 of IC3 or IC6. The PWM output can now be measured for each channel with the meter, indicating a voltage



The manual control unit.

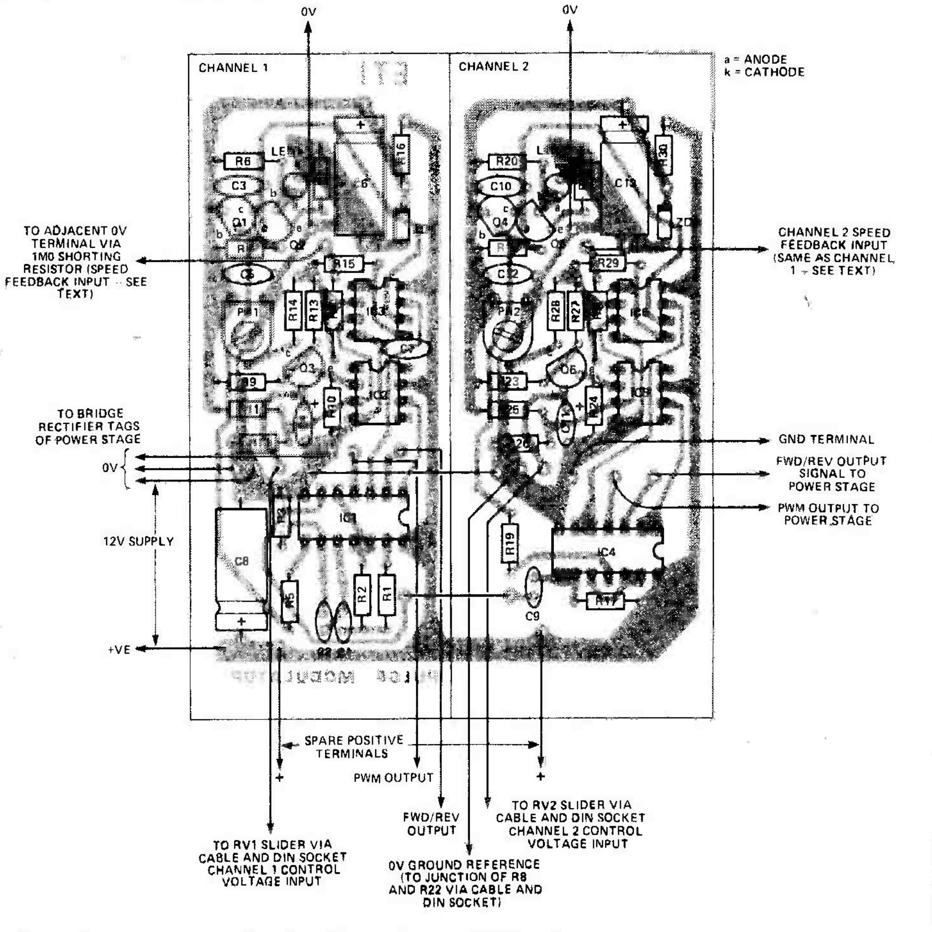


Fig. 2 Component overlay for the analogue PWM unit.

proportional to duty-cycle, or a scope to show the pulse waveform. For a given position of the control pot, clockwise adjustment of the corresponding preset will increase the duty cycle. Leaving the preset and now turning the manual pot towards centre travel will decrease the duty-cycle linearly until the pulse width vanishes, giving a dead band of 0 V. Turning the presets again, anticlockwise this time, will increase the deadband. A small proportion of the pot rotation should be left as deadband, so enabling the motor stop position to be easily located. Adjustment is more difficult with a meter than a scope, but with patience the desired setting can soon be achieved.

The PWM signal wires can now be reconnected to the outputs and the chosen motors wired across the power amplifier load terminals. A 20 A toggle switch wired in series with the positive battery supply is strongly recommended at this stage. (WARNING: If the motors used are rated at less than 6 V, the maximum obtainable duty-cycle should be limited accordingly by increasing the deadband; good motors are usually expensive.) A 12 V bulb will provide a good motor substitute for the purposes of testing. Each manual pot will now independently control the average power into any load; bidirectionally!

PARTS LIST

MANUAL CONTROL BOX

Resistors RA and RB; 1k0 (¼ W, 5%) (see text)
Case (see Buylines)
5 pin DIN plug and socket
PP3 9 V battery
Twin core screened cable (length to suit remote operation)
Two control knobs

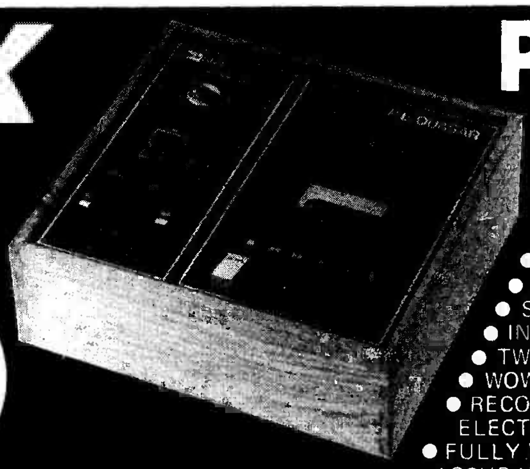
BUYLINES

You shouldn't have any supply problems with the components for this project — everything is absolutely standard. The case we used is a Vero type 65-2514F and should be available from any Vero stockist. We can supply the PCB — the order form is on page 45.

Coming next month: not only the digital PWM board for direct computer control of the motors, but an infra-red proximity detector too. We also begin to assemble the modules into a working mobile.

LOOK

P.E. STEREO CASSETTE RECORDER KIT



Kit includes tape transport mechanism, ready punched and back printed quality circuit board and all electronic parts i.e. semiconductors, resistors, capacitors, hardware, top cover, printed scale and mains transformer. You only supply solder & hook-up wire.

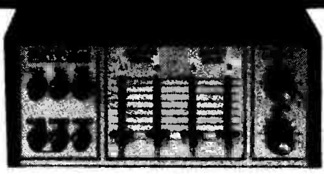
Self assembly simulated wood cabinet. £4.50 + £1.50 p+p.

Featured in April issue Practical Electronics, reprint 50p - Free with Kit.

INTRODUCTORY OFFER – ONLY **£32.95** + £2.75 p&p.

- NOISE REDUCTION SYSTEM
- AUTO STOP
- TAPE COUNTER
- SWITCHABLE E.Q.
- INDEPENDENT LEVEL CONTROLS
- TWIN V.U. METER
- WOW & FLUTTER 0.1%
- RECORD/PLAYBACK I.C. WITH ELECTRONIC SWITCHING
- FULLY VARIABLE RECORDING BIAS FOR ACCURATE MATCHING OF ALL TAPES

STEREO AMPLIFIER KIT



- **Featuring latest SGS/ATES TDA 2006 10 watt output IC's with in-built thermal and short circuit protection.**
- **Mullard Stereo Preamplifier Module.**
- **Attractive black vinyl finish cabinet, 9"x 8¼"x 3¾" (approx).**
- **10+10 Stereo converts to a 20 watt Disco amplifier.**

To complete you just supply connecting wire and solder. Features include din input sockets for ceramic cartridge, microphone, tape or tuner. Outputs - tape, speakers and headphones. By the press of a button it transforms into a 20 watt mono disco amplifier with twin deck mixing. The kit incorporates a Mullard LP1183 pre-amp module, plus power amp assembly kit and mains power supply. Also features 4 slider level controls, rotary bass and treble controls and 6 push button switches. Silver finish fascia with matching knobs and contrasting cabinet. Instructions available, price 50p. Supplied FREE with kit.

£16·50 + £2.90 p&p.

SPECIFICATIONS:	Suitable for 4 to 8 ohm speakers
Frequency response	40Hz – 20KHz
Input sensitivity	P.U. 150mV. Aux. 200mV. Mic. 1.5mV.
Tone controls	Bass ±12db @ 60Hz Treble ±12db @ 10KHz
Distortion	0.1% typically @ 8 watts
Mains supply	220 – 250 volts 50Hz.

8" SPEAKER KIT Two 8" twin cone domestic speakers. **£4.75** per stereo pair plus £1.70 p&p. when purchased with amplifier. Available separately **£6.75** & £1.70 p+p.

125W HIGH POWER AMP MODULE

KIT: **£10·50** + £1.15 p&p BUILT: **£14·25** + £1.15 p&p.

The power amp kit is a module for high power applications – disco units, guitar amplifiers, public address systems and even high power domestic systems. The unit is protected against short circuiting of the load and is safe in an open circuit condition. A large safety margin exists by use of generously rated components, result, a high powered rugged unit. The PC board is back printed, etched and ready to drill for ease of construction and the aluminium chassis is preformed and ready to use. Supplied with all parts, circuit diagrams and instructions.

ACCESSORIES: Suitable mains power supply kit with transformer: £7.50 plus £3.15 p&p.
Suitable LS coupling electrolytic: **£1.00** plus 25p p&p.

SPECIFICATIONS:
Max. output power (RMS): 125W.
Operating voltage (DC): 50 - 80 max.
Loads: 4 - 16 ohms.
Frequency response measured @ 100 watts: 25Hz - 20KHz.
Sensitivity for 100 watts: 400mV @ 47K.
Typical T.H.D. @ 50 watts, 4 ohms: 0.1%.
Dimensions: 205 x 90 and 190 x 36 mm.

HI-FI SPEAKERS AT BARGAIN PRICES

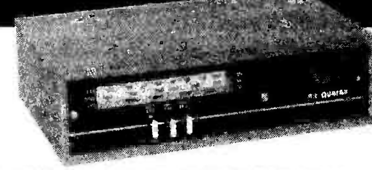
GOODMANS TWEETERS
8 ohm soft dome radiator tweeter (3¾"sq.) for use in up to 40W systems; with 2 element crossover.
£3.50 each (p&p £1) or **£5.95 pair** (p&p £2).

35 WATT MICRO 2-WAY SPEAKER SYSTEM

Unit comprises one 50w (4"app.) Audax soft dome tweeter HD100. And one 5" Audax bass/midrange 35w driver HIF11JSM. Complete with 2 element crossover. Total impedance of system 4 ohms.

£7.95 PER SET + £2.70 p&p.

P.E. STEREO TUNER KIT



This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with Practical Electronics (July 81 issue). For ease of construction and alignment it incorporates three Mullard modules and an I.C. IF. System.
FEATURES: VHF, MW, LW Bands, interstation muting and AFC on VHF. Tuning meter. Two back printed PCB's. Ready made chassis and scale. Aerial: AM - ferrite rod, FM - 75 or 300 ohms. Stabalised power supply with 'C' core mains transformer. All components supplied are to P.E. strict specification. Front scale size: 10½" x 2½" approx. Complete with diagram and instructions.

£17·95 Plus £2.50 p&p.

Self assembly simulated wood cabinet sleeve to suit tuner only. Finish size: 11¼"x8½"x3¼". **£3.50** Plus £1.50 p&p.

SPECIAL OFFER! TUNER KIT PLUS:
• Matching I.C. 10 watt per channel Power amp kit. • Mullard LP1183 built pre-amp, suitable for ceramic pick-up and aux. inputs. • Matching power supply kit with transformer. • Matching set of 4 slider controls for bass, treble and volumes. **£21.95** + £3.80 P&P.

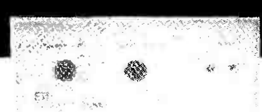
PRACTICAL ELECTRONICS CAR RADIO KIT SERIES II

2 WAVE BAND, MW – LW
• Easy to build. • 5 push button tuning. • Modern design. • 6 watt output. • Ready etched and punched PCB. • Incorporates suppression circuits.
All the electronic components to build the radio, you supply only the wire and the solder, featured in Practical Electronics. Features: pre-set tuning with 5 push button options, black illuminated tuning scale. The P.E. Traveller has a 6 watt output neg. ground and incorporates an integrated circuit output stage, a Mullard IF Module LP1181 ceramic filter type pre-aligned and assembled, and a Bird pre-aligned push button tuning unit.

Suitable stainless steel fully retractable aerial (locking) and speaker (6"x4"app.) available as a complete kit. **£2.50**/pack + £1.50 p&p.

£12·95 + £2.00 p&p.

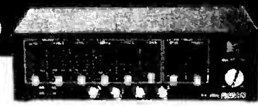
TV SOUND TUNER KIT



£11·45 + £1.50 p&p.

As featured in E.T.I. December '81 issue. Kit of parts including PCB, UHF tuner and selector switch with all components excluding case.
• Transformer **£1.50 + £1.50** p&p (p&p free on transformer if ordered with kit). • Ready built LP1183 Module for simulated stereo operation. **£1.95 + 75p p&p.**

MONO MIXER AMP



£39·95 + £3.70 p&p.

50 WATT Six individually mixed inputs for two pick ups (Cer. or mag.), two moving coil microphones and two auxiliary for tape, tuner, organs, etc. Eight slider controls – six for level and two for master bass and treble, four extra treble controls for mic. and aux inputs. Size: 13¼"x 6½"x3¾"app. Power output 50 watts R.M.S. (continuous) for use with 4 to 8 ohm speakers. Attractive black vinyl case with matching fascia and knobs. Ready to use.

BIRD AUDIO STEREO CAR RADIO BOOSTER

To boost your car radio or radio cassette to 15W r.m.s. per channel.

£9·95 + £1.50 p&p.

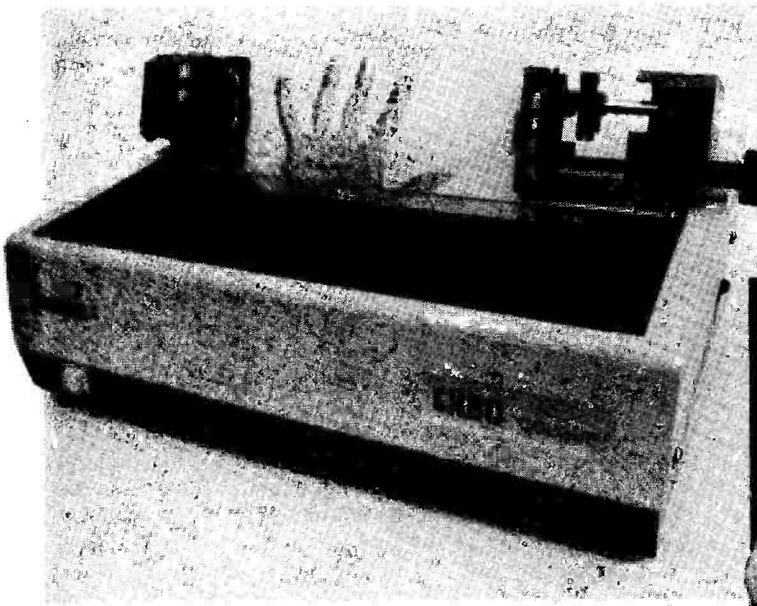
ALL MAIL TO:
21E HIGH STREET, ACTON, W3 6NG.
Note: Goods despatched to UK postal addresses only. For further information send for instructions 20p plus stamped addressed envelope. All items subject to availablity. Prices correct at 31/1/82 and subject to change without notice. Please allow 7 working days from receipt of order for despatch.
ALL PRICES INCLUDE VAT AT 15%.

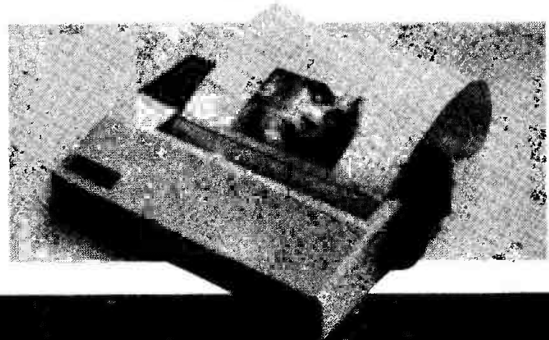
ALL CALLERS TO: **323 Edgware Rd, London W2. Telephone: 01-723 8432.**
Open 9.30 – 5.30pm. Closed all day Thursday.
RTVC Limited reserve the right to update their products without notice.

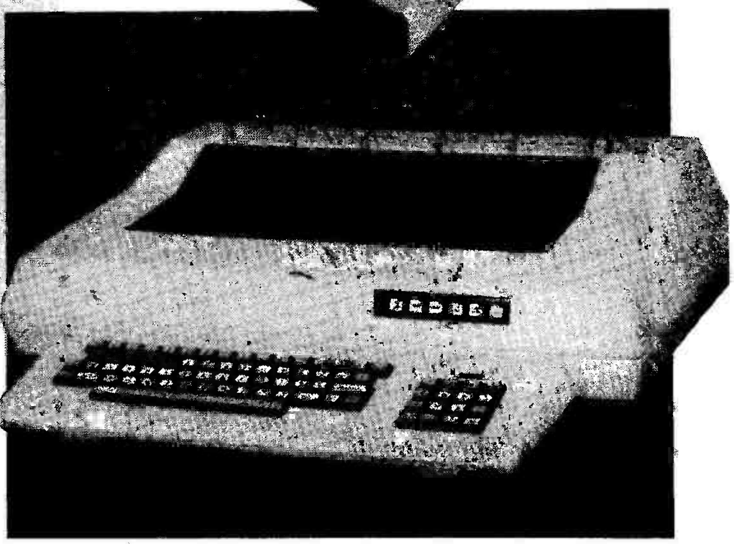
RTVC

ENGINEER'S GUIDE TO PRINTERS

Whether you type LPRINT or OPEN 1, 4, not much is going to happen unless you've got a printer hanging off the back of the computer. Robert Traub helps you decide which one is right for you.







Printers vary greatly in their functions and features. There are a great number of types to choose from and the choice can be almost impossible. Some very basic points about printers may assist in the selection of a printer for personal use.

The first point to cover is columns. What is a column? Some printers will print 132 columns, some only 40 columns and some just about everything in between and more. A column is the space occupied by a single character. Consider first printers with fixed pitch. Fixed pitch means that each character occupies the same amount of space on the page. The common fixed pitch is 10 characters per inch; this standard pitch would allow 85 columns across an 8½ inch wide paper if no room is allowed for margins.

If the page were allowed to have margins of approximately ⅝ inch on each side, that would leave 7.2 inches. At 10 characters per inch, that would give us 72 columns, and this is the standard print page for TTY type printers (and others). If the printer were to offer 132 columns, then the paper would have to be at least 10 characters per inch divided into 132 columns equals 13.2 inches wide. If margins were to be included it would bring the width of the paper to 15⅞ inch. Therefore a common 132 column page would be 15⅞ inches wide by 11 inches deep.

Some fixed pitch printers offer the ability to select the pitch at which the characters will be fixed. Some common values are 12 characters per inch and 13.5 characters per inch. A bit of math would soon tell us that a printer with a fixed pitch of 13.5 characters per inch could print up to 96 characters or columns on a standard page with margins, while a printer with a fixed pitch of 12 characters per inch could print 87 columns in the same space. The 13.5 character per inch printers compress the characters much closer together and may be a bit harder to read if they don't use a good quality print head. Some dot matrix printers offer a very compressed print of 132 columns in eight inches or 16.5 characters to the inch.

Next we will look at printers that are not fixed pitch. A few printers offer the ability to allow a given amount of space on the line to each character. With this type of printer, less space would be allowed for the letter "i" than would be allowed for letters such as "m" or "w". Each letter is assigned a given amount of space on the line, as well as the distance between each letter. (With fixed pitch printers the amount of space allotted is the same for all characters.) This type of print is referred to as proportional spaced print.

With this type of print you can develop excellent quality documents and avoid the common "river of white" that is found running through the body of text done with fixed pitch printers. Proportional spaced printers are the type required for professional word processing systems; the quality of print is excellent, and the overall appearance of the documents produced on the system is outstanding. These types of printers are very expensive, and very elaborate software is required for their operation in order to exploit their full potential.

Before leaving this subject, there are a couple of terms that you may run across and not be sure of their meaning, these being *pica* and *elite*. The term *pica* refers to typewriter type providing 10 characters to the inch, while *elite* is typewriter type that provides 12 characters to the inch.

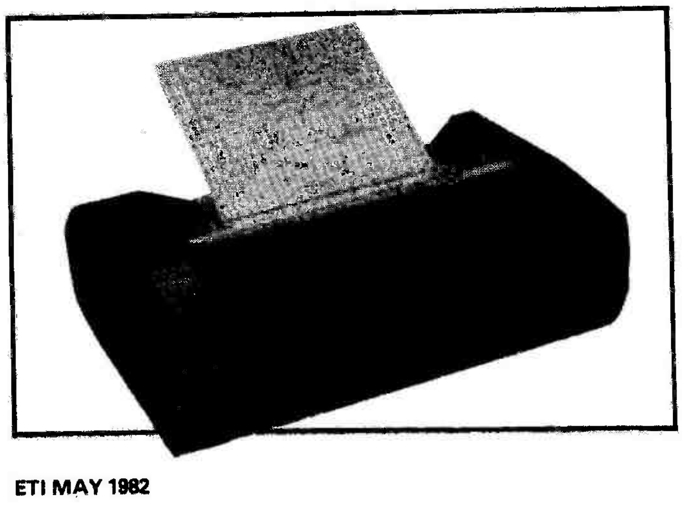
Type Of Type

The next thing to consider is the type of print. One common type is dot matrix print. This type of printer comes in many dot matrix forms; some may be 5 by 7, some 7 by 9, some 9 by 9, and some even greater. The dot matrix is comprised of a number of small wires or pins that are struck against a ribbon and the paper leaving a dot on the paper. The number of dots that the matrix has will determine the fullness of the character that it is reproducing. A 5 x 7 dot matrix is comprised of 35 small dot positions arranged in such a manner as to have a total of five dots across (horizontal) and seven vertical rows of five dots each. This arrangement is the minimum number of dots required to produce a decent upper case letter set and numerals. The characters are not always well formed as can be seen by the "S" not being curled around at the top and bottom, and by such characters as the slash (/). The slash will have a small vertical line on both ends rather than being a single straight line.

A 7 x 9 dot matrix is arranged in such a manner as to have seven dots across (horizontal) and nine vertical rows of seven dots each for a total of 63 dots. This type of matrix will produce much better letters, and give a more natural look to the overall print. As the number of dots in the matrix increases, the ability to reproduce characters increases and some very nice natural-looking print can be found with such printers. Of course, if graphics are being considered, the greater the matrix dot count, the better the quality of graphic representation. Better quality print will be produced by matrixes with greater numbers.

The least expensive of the dot matrix printers will generally have a standard 5 by 7 matrix print head. This printer is satisfactory for general use, but is not intended for word processing as it does not have descenders. A descender is the tail of lower case characters such as 'p', 'q', 'j', 'y', etc. Note that the tail of these characters will extend below the base line on a normal typewriter quality printer. On dot matrix printers this is not always available, and never on a 5 x 7 dot matrix. As the number of dots in the matrix increases, so does the price and overall general quality of the printer. The very elaborate dot matrix printers that are now available can rival almost any type of print, but are very expensive and therefore not generally appropriate for hobby applications.

Printers that offer fully-formed characters such as found on typewriters are the best quality for word processing at a more reasonable cost. Fully formed characters are the type found in typewriters and are cast in metal or plastic. Some systems have the characters formed on a ball, some have them formed on a cylinder and others use a daisy wheel, to name but a few methods.



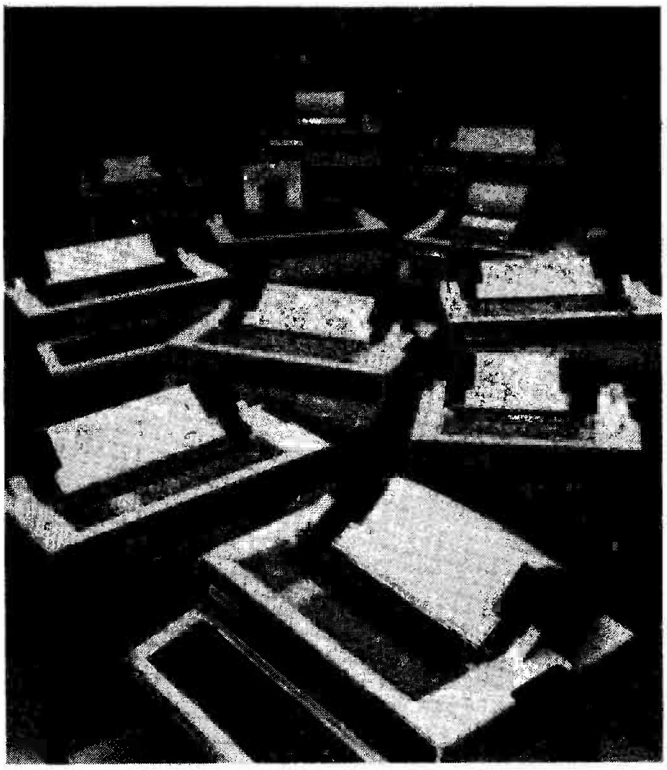
The daisy wheel comes in different sizes with 88, 92 or 96 characters per wheel and can be cast in either plastic or metal. Some of the cheaper printers, whether dot matrix or full formed character type, do not offer lower case characters; again, this may or may not be important to the user, although lower case is a must if word processing is being considered. Each printer must be studied in order to determine if it offers lower case characters, descenders and other features (graphics) that would be of interest to the user.

Feed For Thought

This brings us to the question of friction feed or tractor feed. In the case of friction feed, the paper is held in place by some small pinch rollers that press against the printer's platen. The paper is inserted between these pinch rollers and the platen. This is fine in most cases where each line is advanced one at a time by a carriage return-line feed combination, but if the lines were to be advanced by the inch with a sudden command, as is the case with the form feed character, the paper could 'slip' as the platen first starts its fast advance. To overcome this problem, the tractor feed type of paper advance systems can be used. With this type of printer option, paper can be advanced rapidly with assurance that the print will start at the same line on each page or form.

One other type of paper feed system is the pin feed; this system is used on TTY printers to ensure that forms such as telegraphs will always line up properly. Another feature offered by the tractor feed and pin feed systems is the assurance that the printed line is horizontal with respect to the top and bottom edge of the paper. With friction feed systems, the page can slip slightly one way or the other.

As there are different systems that can be used to feed paper, the choice will depend on the type of work the printer will be required to do. If a lot of forms are going to be filled out, then of course a printer with the tractor feed option would be a good choice. If individual letters are the order of the day, then the standard friction feed type of paper advance will serve well.



BAUDy Stories

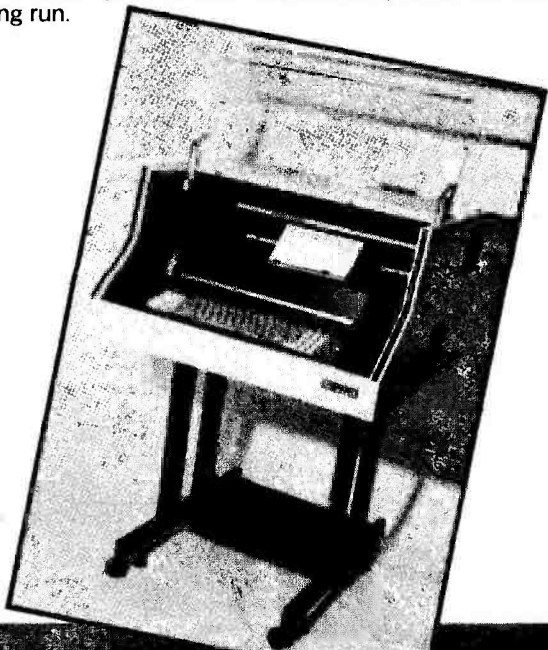
Briefly we will take a look at the question of baud rates. The baud rate or just plain baud means number of code elements per second. If the ASCII code were taken as a 10 unit code, then a baud rate of 1200 baud would transfer data at the rate of 1200 elements per second divided by 10 units per character for 120 characters per second. If the ASCII code were to be considered as an eight unit code, then 1200 baud would represent a rate of 1200 elements per second divided by eight units per character for total of 150 characters per second. Many printers will accept data at a rather high baud rate, say 9600 baud; this is the rate at which they accept data into their buffers and not the rate at which they print. The printer may only be able to produce 150 characters per second on paper; therefore, that printer's true baud rate is 1200 baud if an eight unit ASCII code is assumed. The baud rate then is the speed at which the data or information can be printed.

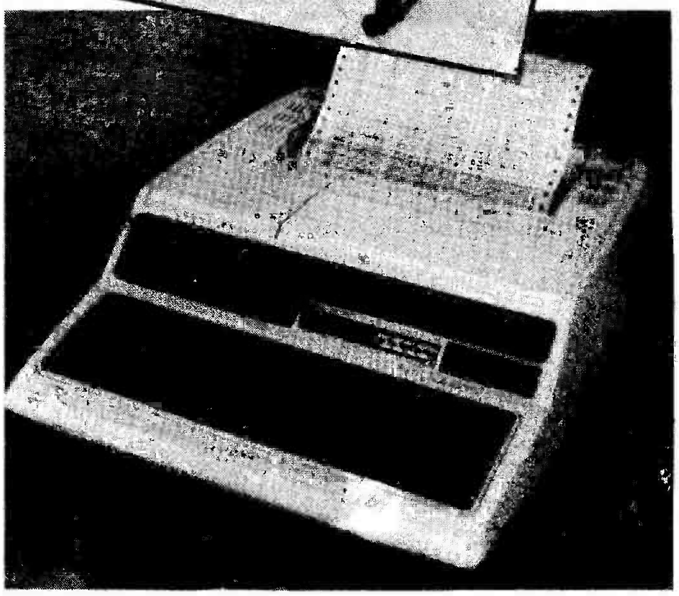
There are many reasons why a faster speed is needed in some cases and not at all needed in other cases. Typical baud rates range from a slow 110 baud to a fast 9600 baud, but be sure to check if the baud rate is the rate that the printer will print characters or if it is the rate at which the host computer can send characters to its internal storage area (buffer).

Drop Me A Line

Some printers you hear about are called *line printers*; a line printer is a special type of printer that will not print each character as it is received, but rather will wait for the complete line and then print the entire line at once, a character at a time. The length of the line that it prints is determined by the sending of the RETURN character, as a return signifies the end of that line in text. Line printers require special handling by the host computer and provisions must be made for *handshaking*. Line printers have buffers to store the data in before it is printed and handshaking is simply the printer's method of telling the computer when to send more data to the buffer and when to stop sending data as it cannot handle any more at the moment. Printers are generally slower than the host computer, although there are some very fast printers not generally used by the hobbyist.

One other thing that you might run across is the term *bi-directional* printer. What this means is that the print head will print a line from left to right across the paper, advance the line (line feed) and then print the next line from the right side back to the left. The *bi-directional* printer requires fewer mechanical parts and movements than single direction types and this is one reason for increased printer speeds. With the conventional type of printers, a carriage return is required in order to bring the print head back to the start of the next line. This takes time and computers have to send the printer a *pad* or *fill* character in order to assure that the head has returned to the far left before it starts printing again. After many, many line feeds and carriage returns the amount of time wasted can be considerable. Therefore the bi-directional printer, which does not return the head every line, is capable of greater speeds (throughout). Because there are fewer mechanical parts to wear out, reliability is also increased in the long run.





Summary

At this point there are a few things to consider. If the printer is going to be used for listing BASIC or assembly programs, the dot matrix type of printer or the teletype printer may do the job very well. If a teletype printer is used, you will have upper case only, a slower 110 baud rate and require a 20 mA loop interface. Printers of the dot matrix type vary by a great amount and will require either a parallel or RS232 serial interface.

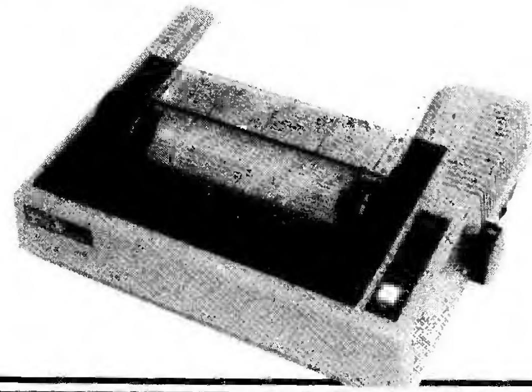
The lower priced 5 x 7 dot matrix printers have a great deal to offer those wishing listings. They can be found in a variety of speeds ranging from 110 baud to 9600 baud, and vary greatly as to the size of paper that they can accommodate. If you require listings at 10 characters per inch on an 11 x 8.5 sheet of paper (11 inches horizontal and 8.5 inches vertical), you may find that the printer will not accommodate this size of paper and, in fact, the largest that it can handle is 9.5 inches horizontal.

If the printer cannot handle wide paper, check out the print quality of the printer at its most compressed setting, 13.5 characters per inch for instance, and use a very complex BASIC program line with as many characters and commands as possible. This will allow you to see first hand the type of printout you will be trying to work with. You may find it unsatisfactory for long listings, as the heavily compressed text makes it very hard to find semi-colons and other required BASIC syntax characters. If you will be doing a lot of amortization charts, or charts of any type, then it is recommended that you look at a printer that falls into the line printer category, as the speed will be needed. You would soon go broke trying to produce amortization charts at 110 or even 300 baud.

There are as many reasons for getting a printer as there are printers on the market; it is advised that the first thing you do when thinking about getting a printer is sit down in your computer room and try to determine exactly what service you want that printer for, and then proceed to find one that will do those limited number of things. You can never be sure that you have covered all the bases, so be sure to explain to the dealer what use you wish to put the printer to, and he will be in a position to advise you as to what you might need that you have overlooked. Try to stay away from a printer that will do everything; they require special features and will do all the different things *if* you buy a lot of extras, for example.

Some printers offer tractor feed as an option; this may be a valuable option to have, as trying to stop the printer at the right time to change paper for the next page is not always desirable. Check your computer program and see if you can stop the printer from the terminal keyboard at any given time, or if the software will do that automatically. If not, you will need tractor feed and continuous form paper for the job you are doing or roll paper if friction feed. If the printer is to be used for word processing, even on a small scale, it is recommended that you have lower case with descenders at the very least. Speed is not important in this type of printer and print rates of 30 to 55 characters per second are common. What is important is the quality of print and that is what you should look at first and last.

There are other things to consider in purchase of a printer, such as whether a warranty or service contract is available. Second-hand equipment often does not come with service contracts. The application the printer will be used for will largely determine the quality of print required, but the cost could be the main consideration for the hobbyist.



ETI

ETI PCB SERVICE

Up until now PCBs were always the hardest component to obtain for a project. Of course you *could* make your own, but why bother anymore?
Now you can buy your boards straight from the designers — us! As of this issue all (non-copyright) PCBs will be available automatically from the ETI PCB Service. Each board is produced from the same master used to build our prototypes, so you can be *sure* it's accurate, and will be finished to the high standard you would expect from ETI.
In addition to the PCBs for this month's projects, we are making available some of the more popular designs from our recent past. See the list below for details. Please note that NO OTHER BOARDS ARE AVAILABLE. If it's not listed, we don't have it!

APRIL 79
- ☐ Guitar Effects Unit £1.98
- ☐ Click Eliminator £4.98

JUNE 79
- ☐ Accentuated Beat Metronome £2.70

FEBRUARY 80
- ☐ Tuning Fork £1.98

MARCH 80
- ☐ Signal Tracer £1.70

AUGUST 80
- ☐ CMOS Logic Tester £1.98
- ☐ Capacitance Meter £2.20
- ☐ Ultrasonic Burglar Alarm £2.15

OCTOBER 80
- ☐ Cassette Interface £2.20
- ☐ Fuzz/Sustain Box £2.45

NOVEMBER 80
- ☐ Touch Buzzer £1.45
- ☐ Light Switch £1.45
- ☐ Metronome £1.45
- ☐ 2W Power Amp £1.45
- ☐ RIAA Preamplifier £1.45
- ☐ Audio Test Oscillator £2.35

DECEMBER 80
- ☐ Musical Doorbell £2.10
- ☐ Bench Amplifier £1.90
- ☐ Four Input Mixer £1.98

JANUARY 81
- ☐ LED Tacho £3.10
- ☐ Multi-Option Siren £2.40
- ☐ Universal Timer £2.48

FEBRUARY 81
- ☐ Infra-red Alarm (four boards) £4.98
- ☐ Pulse Generator £2.68

MARCH 81
- ☐ Engineer's Stethoscope £1.99

APRIL 81
- ☐ Musical Box £1.98
- ☐ Drum Machine (two boards) £4.20
- ☐ Guitar Note Expander £2.40

JUNE 81
- ☐ Mini-drill Speed Controller £2.20
- ☐ Antenna Extender £2.40
- ☐ Alien Attack £1.98
- ☐ LED Jewellery: Cross £1.10
- ☐ Spiral (two boards) £1.98
- ☐ Star (two boards) £1.99
- ☐ Waa-phase £1.15

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ELECTROMUSIC TECHNIQUES

The second in this design series by leading-expert-in-the-field Tim Orr features voltage controlled filters, voltage controlled amplifiers and ring modulators.

The first group of circuits we consider this month are voltage-controlled filters. Figure 1 shows the circuit for a state variable filter with four frequency responses; lowpass, highpass, bandpass and notch. All four responses can be controlled by varying the gain of the two integrators. The Q factor of the filter can also be voltage controlled. If the Q is set to maximum, by turning off the feedback CA3080, then the circuit will become a sine wave oscillator (because the damping has been reduced to zero). Prior to this, very high Q factors can be obtained, of the order of 400. The frequency responses are shown in Fig. 2. Most synthesisers use a −24 dB/octave lowpass VCF, but the more responses that are available, the wider is the choice of sound that can be produced.

VCFs are usually swept with a control voltage from an ADSR. Every time a note is played on the keyboard the VCF is swept, the shape of the ADSR signal and its polarity determining the type of sound that is heard. Figure 3 is a circuit for sweeping a VCF. Both positive and negative sweeps are obtained on one control pot. Curtis make a VCF chip, the CEM3320 (Fig. 4). The configuration shown is a four pole (−24 dB/octave) lowpass filter with a +1 V/octave sensitivity and voltage control of the Q factor.

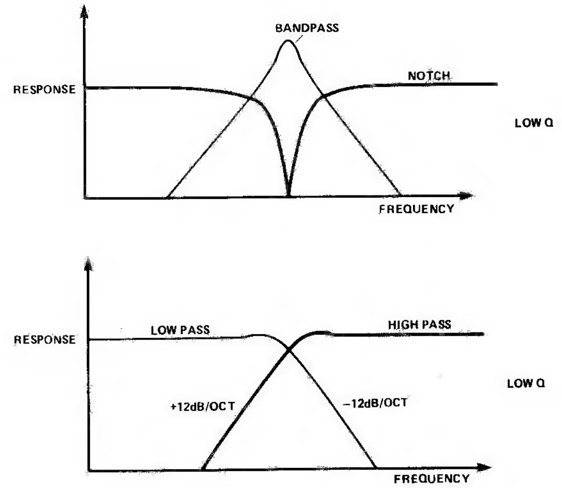


Fig. 2 State variable filter responses.

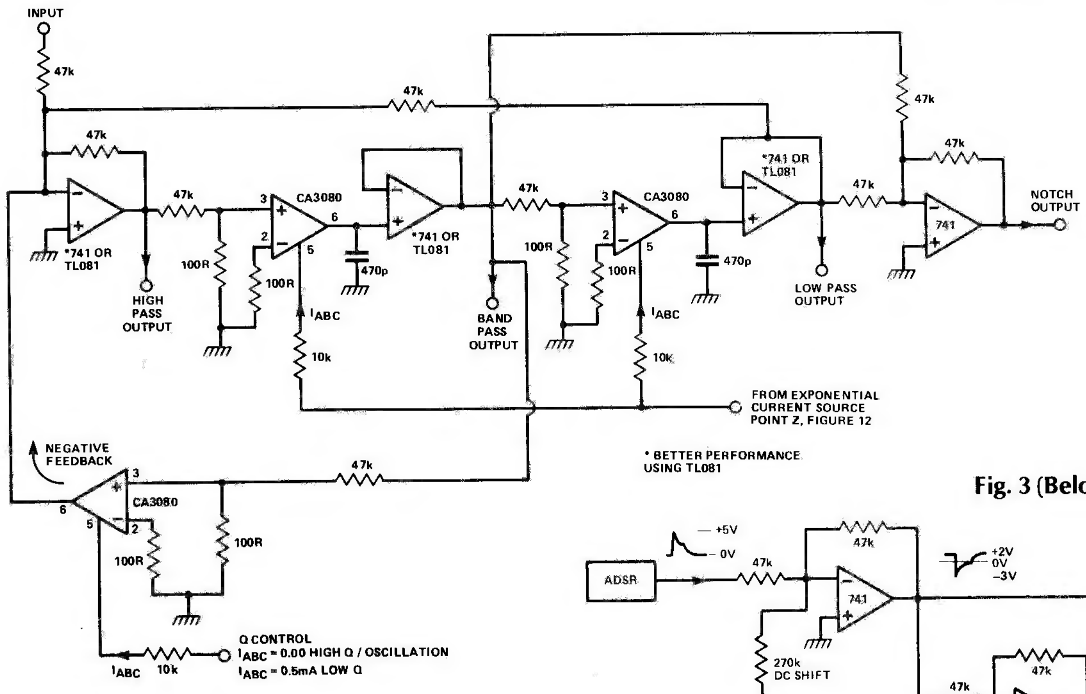
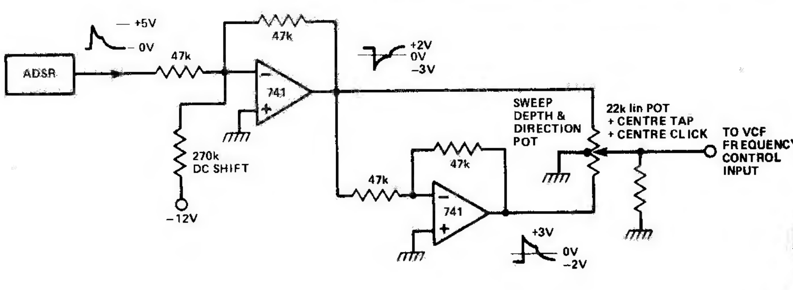


Fig. 1 State variable VCF.

Fig. 3 (Below) VCF sweep control unit.



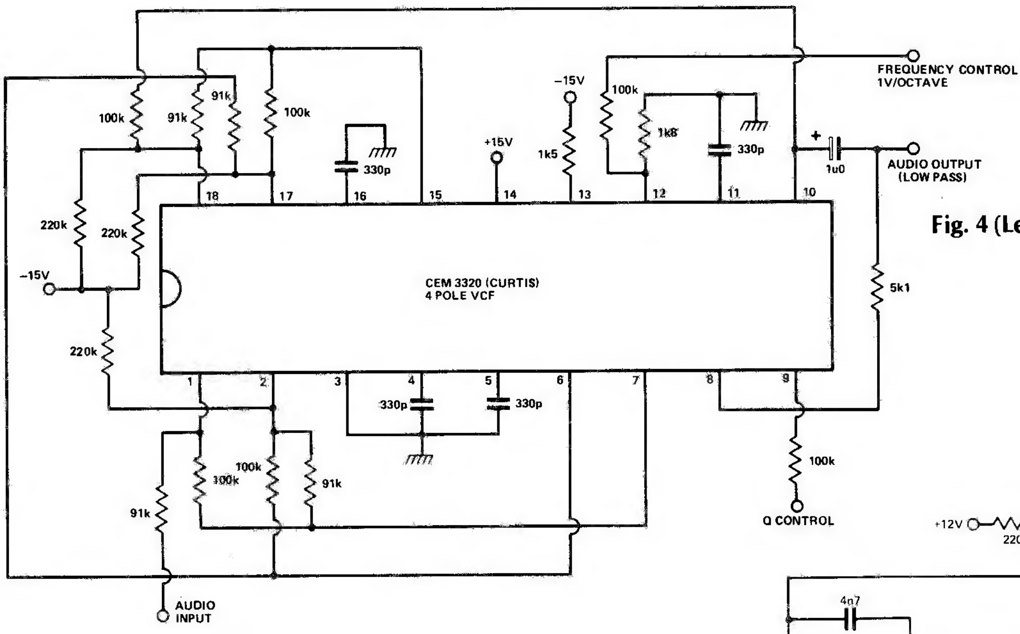


Fig. 4 (Left) Monolithic VCF circuit.

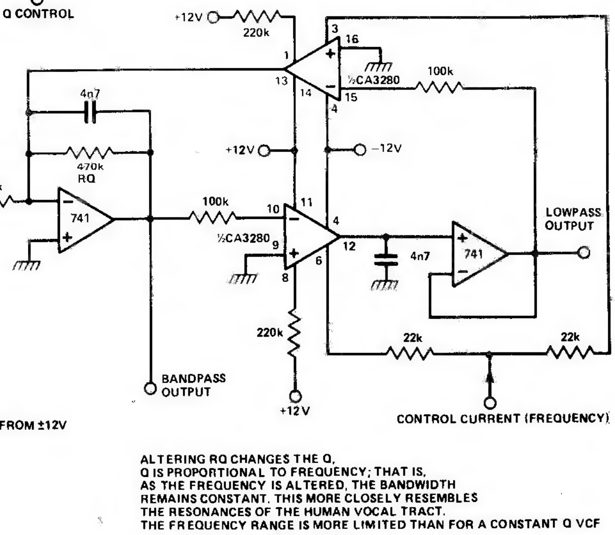


Fig. 6 (Above) Biquadratic VCF.

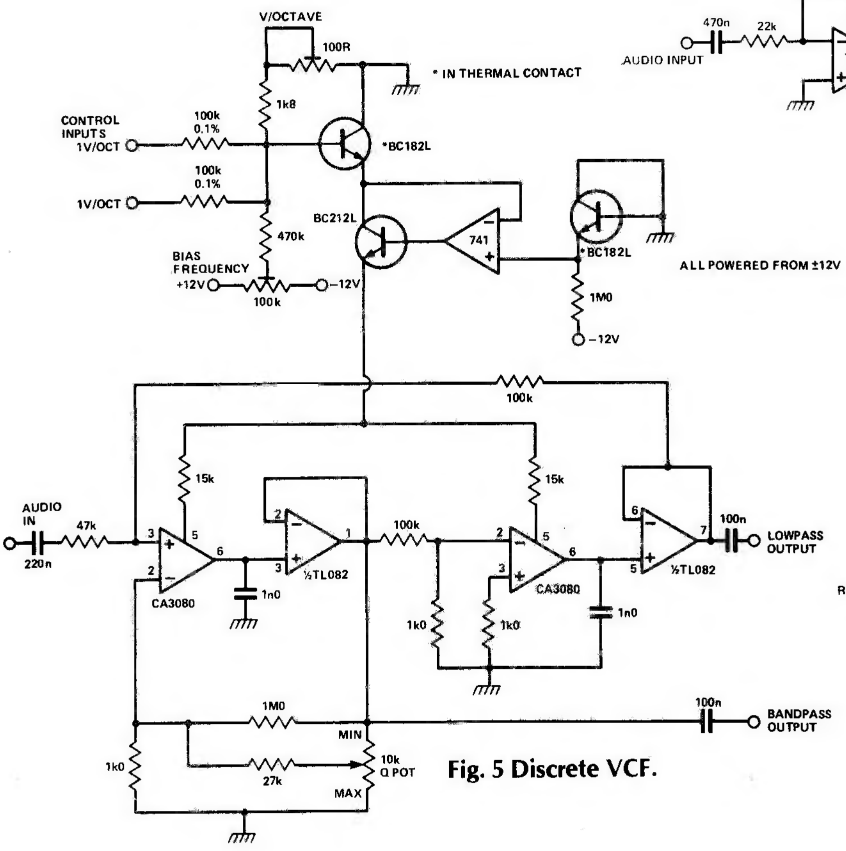


Fig. 5 Discrete VCF.

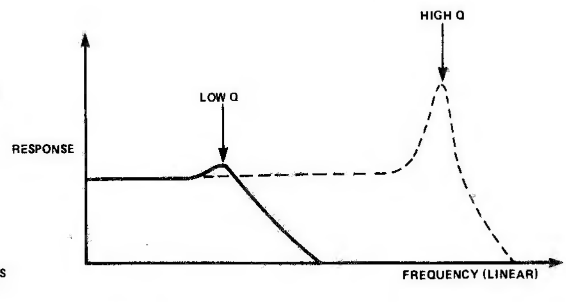


Fig. 7 Biquadratic lowpass response.

Another CA3080 VCF is shown in Fig. 5. Note that the accuracy of the exponentiator need not be as good as that needed for a VCO (unless you are going to make the VCF oscillate and track a VCO). Therefore the Q81 resistor has been left out. A somewhat different VCF is shown in Figs. 6 and 7. The biquadratic filter has a Q factor that is proportional to the cut-off frequency. So, as this frequency is increased, the Q factor will increase. This gives a constant ringing time which is independent of frequency. All the previous VCFs have a constant Q operation.

VCA And Ring Modulators

Voltage controlled amplifiers are one of the easier synthesiser building blocks to make, as long as you don't want low noise and low distortion operation. Figure 8 shows a standard linear VCA. The audio input is attenuated to about 40 mVpp and then fed into the CA3080, the gain of which is controlled by the I_{ABC} current. If the audio input is removed, control breakthrough will probably be seen at the output. Most of this is caused by the input offset voltage of the CA3080 being multiplied by the I_{ABC} control current. The offset can be nulled out by adding a small DC voltage to the non-inverting terminal, which should eliminate most of the control breakthrough. Any residual breakthrough is due to current mirror mismatches in the CA3080 and is unavoidable. Distortion may also be rather high, perhaps in the region of 0.5%, but this is not generally considered to be a problem in synthesiser circuits. Lowering the input signal level will reduce the distortion at the expense of an increase in the noise level.

A better VCA is shown in Fig. 9, the CEM3330 made by Curtis. This is a dual device with both log and linear control inputs, low noise and low distortion plus very low control feedthrough. A third VCA is shown in Fig. 10, this one being constructed from a CA3046 transistor array. It uses two of the transistors as a predistortion circuit so that a higher operating signal level can be used for the same level of distortion. In fact, the predistortion principle is used in several multiplier chips, including the LM13600 which is used in the next circuit, (Fig. 11). The two LM13600 circuits are used a low distortion VCAs. A predistortion diode bias current is inserted into the IC at pins 2 and 15. The gain of each VCA is controlled by the I_{ABC} current (pins 1 and 16), this current being derived from a pair of complementary control voltages. As the gain of the channel increases the other decreases. Some interesting effects can be obtained with this circuit; for example a note can pan from left to right every time it is played.

The VCAs mentioned so far have all been two quadrant multipliers. The operation of a four quadrant multiplier (sometimes called a balanced modulator or ring modulator) is very different (Fig. 12). When two sine waves are multiplied together the result is a signal composed of sum and difference tones. For example, if the two input sine waves have frequencies of 100 Hz and 1 kHz, then the output will be composed of two tones, one at 1100 Hz (sum) and one at 900 Hz (difference). If the same sine wave is applied to both inputs, then the sum tone is twice the original frequency, and the difference tone is a DC voltage. Ring modulators are used to produce discordant sounds and special effects such as the BBC Dalek voice.

Figure 13 is a simple ring modulator circuit. The performance suffers a bit from poor X and Y feedthrough, which can be minimized by adjustment of the two presets. A better modulator is shown in Fig. 14; this circuit employs a balanced modulator chip made by National Semiconductor and others.

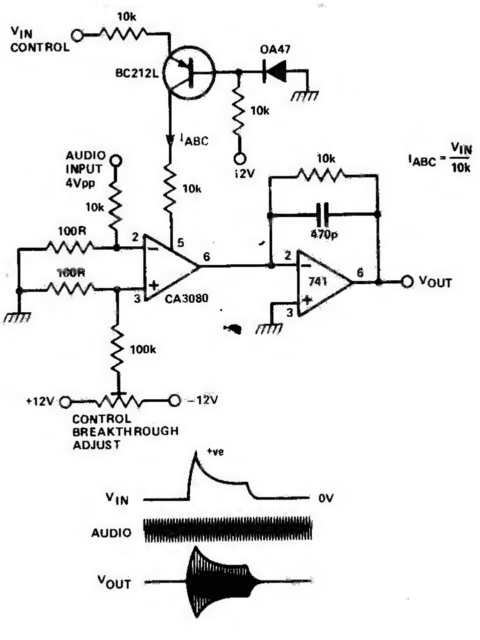


Fig. 8 (Above) Simple VCA.

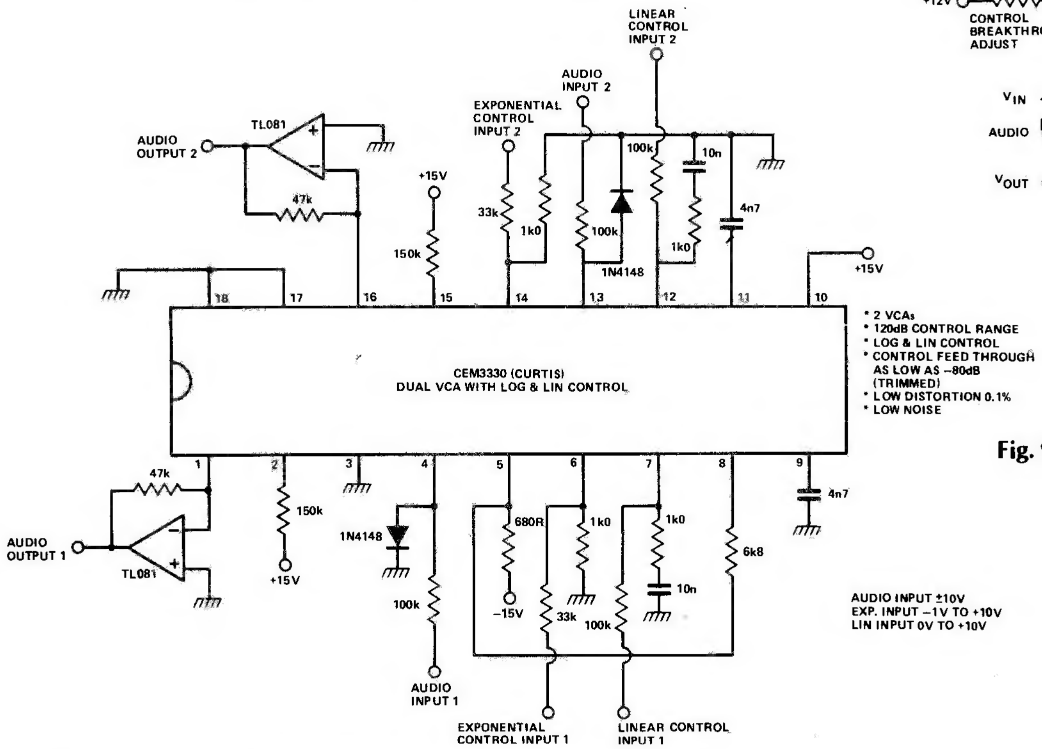
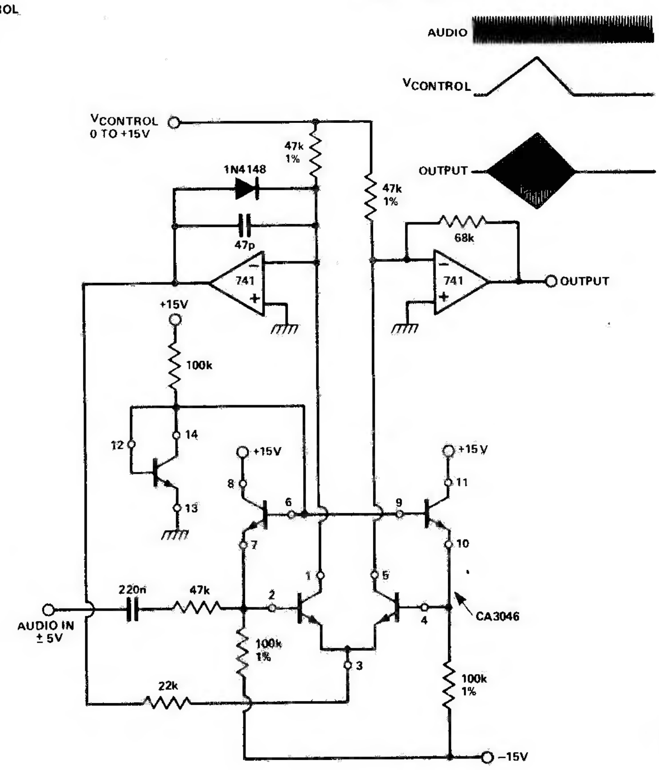


Fig. 9 (Left) Monolithic VCA circuit.

Fig. 10 (Below) Discrete VCA.



The feedthrough adjustments are very sensitive and so it is necessary to run the circuit from a stable pair of supply rails. Adjustment of the presets is as follows. Insert a carrier signal (1 kHz at 2 Vpp), look at the output and adjust the carrier fundamental and then the carrier second harmonic presets for minimum feedthrough. Repeat this for the signal path. Feedthrough should be the order of 60 dB down on the maximum output level.

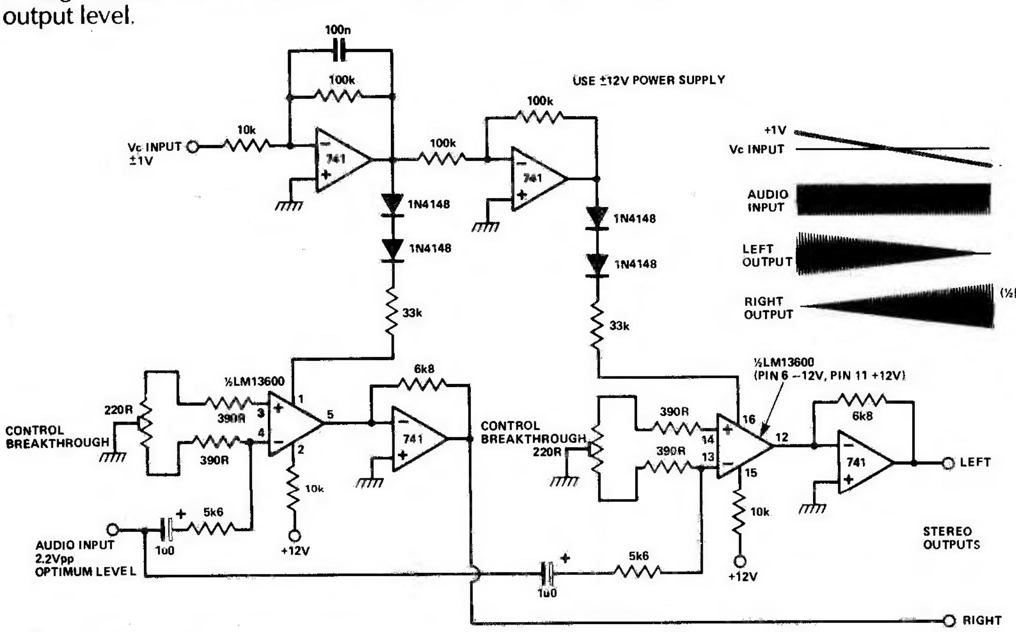


Fig. 11 (Above) Voltage controlled panning.

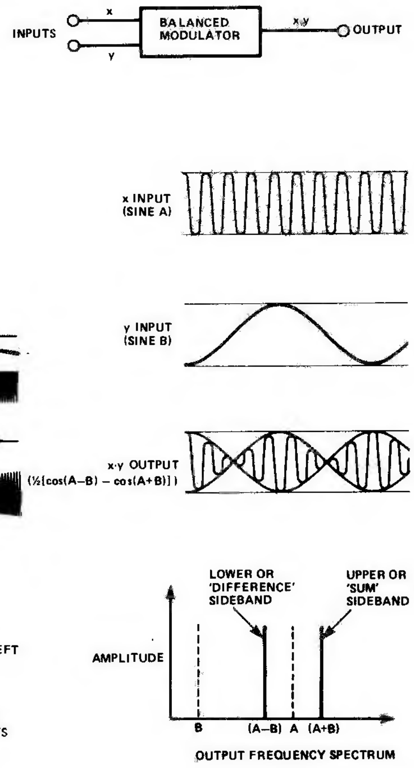


Fig. 12 (Above) Ring modulation.

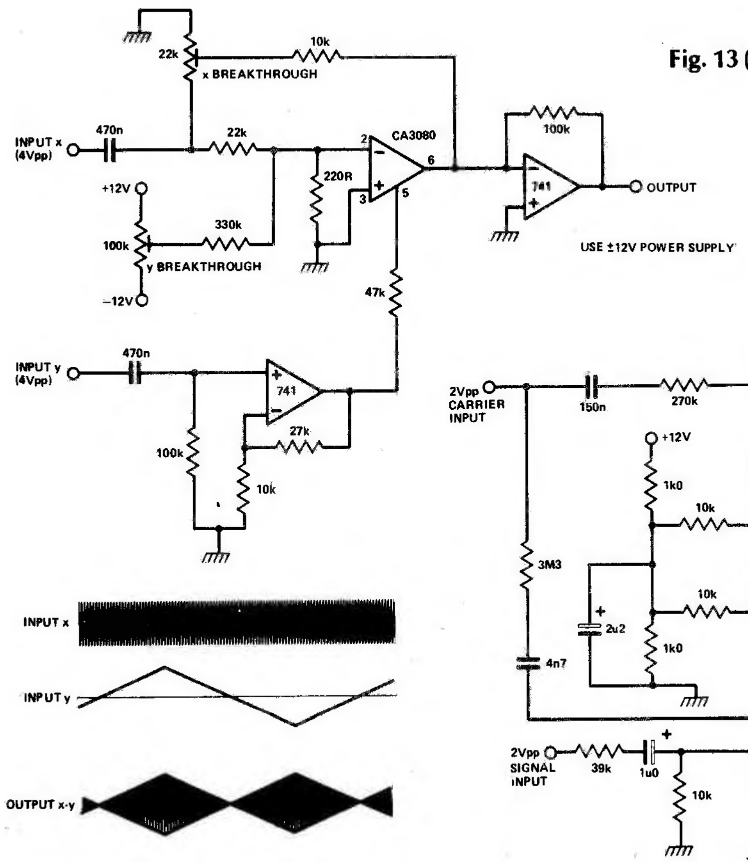
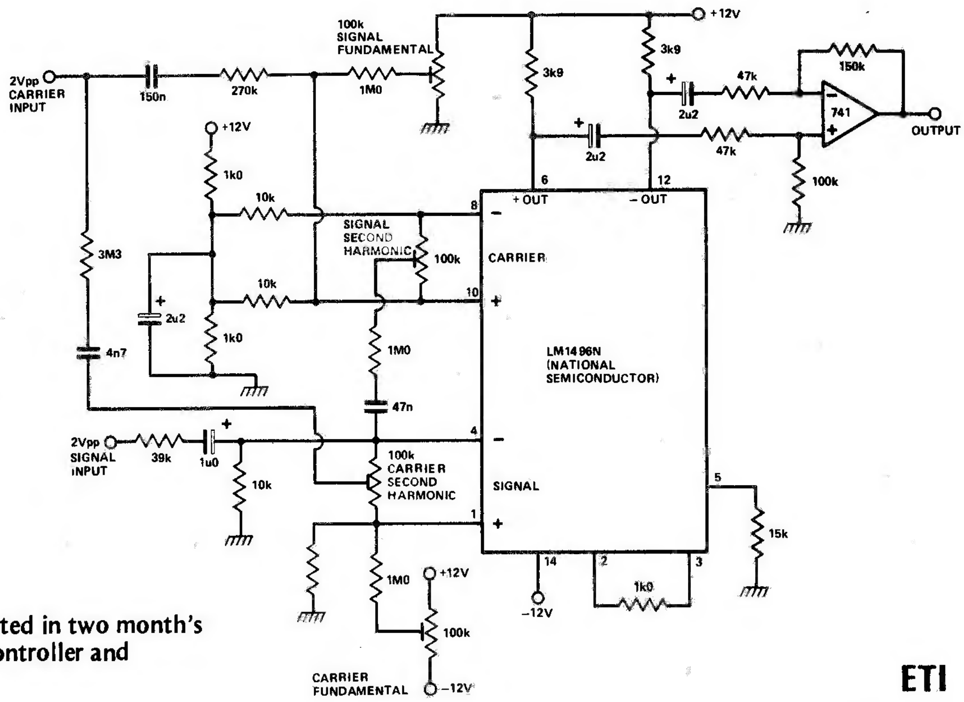


Fig. 13 (Left) Four quadrant multiplier (ring modulator).

Fig. 14 (Below) Another ring modulator circuit.



The final part of this series, to be presented in two month's time, will look at ADSR, signal input, controller and sequencing circuits.

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74C20	28p	74C93	90p	74C192	£1.15	74C909	£1.69	80C95	85p
74C30	28p	74C99	£1.06	74C193	£1.15	74C910	£7.46	80C96	92p
74C32	28p	74C107	£1.27	74C195	£1.00	74C911	£7.39	80C97	85p
74C42	96p	74C150	£3.81	74C200	£7.45	74C912	£7.39	80C98	92p
74C48	£1.43	74C151	£2.56	74C221	£1.41	74C914	£1.46	82C19	£6.20
74C73	57p	74C154	£3.81	74C373	£1.79	74C915	£1.15	88C29	£2.90
74C74	50p	74C157	£2.29	74C374	£1.79	74C918	£1.10	88C30	£2.90
		74C160	£1.40	74C901	57p	74C921	£17.07		
		74C161	£1.15	74C902	79p	74C922	£3.78		
		74C162	£1.15	74C903	57p	74C923	£5.49		
						74C925	£6.99		

74LS

74LS00	12p	74LS55	30p	74LS151	39p	74LS243	85p	74LS367	37p
74LS01	13p	74LS63	£1.50	74LS153	39p	74LS244	80p	74LS368	66p
74LS02	14p	74LS73	25p	74LS154	£1.70	74LS245	£1.18	74LS373	75p
74LS03	14p	74LS74	25p	74LS155	39p	74LS247	40p	74LS374	75p
74LS04	15p	74LS75	28p	74LS156	39p	74LS248	65p	74LS375	48p
74LS05	15p	75LS76	20p	74LS157	35p	74LS249	68p	74LS377	90p
74LS08	15p	74LS78	24p	74LS158	36p	74LS251	40p	74LS378	69p
74LS09	15p	74LS83	50p	74LS160	41p	74LS153	40p	74LS379	65p
74LS10	15p	74LS85	70p	74LS161	41p	74LS257	48p	74LS384	86p
74LS11	15p	74LS86	38p	74LS162	41p	74LS258	40p	74LS386	86p
74LS12	15p	74LS90	35p	74LS163	41p	74LS259	86p	74LS390	62p
74LS13	30p	74LS91	80p	74LS164	48p	74LS260	21p	74LS393	60p
74LS14	48p	74LS92	36p	74LS165	75p	74LS261	£1.96	74LS395	£1.99
74LS15	15p	74LS93	38p	74LS166	85p	74LS266	25p	74LS396	£1.90
74LS20	15p	74LS95	45p	74LS170	£1.70	74LS273	£1.18	74LS398	£2.75
74LS21	15p	74LS96	£1.16	74LS173	72p	74LS275	£2.50	74LS399	£2.20
74LS26	18p	74LS107	43p	74LS174	72p	74LS279	88p	74LS445	£1.40
74LS27	15p	74LS109	30p	74LS175	58p	74LS283	45p	74LS447	£1.44
74LS28	20p	74LS112	30p	74LS181	£1.30	74LS290	57p	74LS490	£1.80
74LS30	18p	74LS113	40p	74LS183	£2.75	74LS293	46p	74LS668	£1.75
74LS32	15p	74LS114	35p	74LS190	58p	74LS295	£2.15	74LS669	£1.50
74LS33	16p	74LS122	44p	74LS191	58p	74LS298	£1.30	74LS670	£1.75
74LS37	16p	74LS123	55p	74LS192	58p	74LS324	£2.00		
74LS38	16p	74LS124	£1.05	74LS193	65p	74LS325	£2.90		
74LS40	16p	74LS125	30p	74LS194	40p	74LS326	£2.90		
74LS42	35p	74LS126	30p	74LS194	40p	74LS326	£2.94		
74LS47	40p	74LS132	45p	74LS195	40p	74LS327	£2.86		
74LS48	60p	74LS136	28p	74LS196	58p	74LS347	£1.48		
74LS49	60p	74LS138	35p	74LS197	85p	74LS348	£1.86		
74LS51	15p	74LS139	38p	74LS221	60p	74LS352	£1.85		
74LS54	15p	74LS145	75p	74LS240	96p	74LS353	£1.85		
		74LS147	£1.70	74LS241	96p	74LS365	37p		
		74LS148	99p	74LS242	85p	74LS366	37p		

74S

74S04 73p

QUARTZ

32.768KHz (watch)	£2.50
60 KHz	£9.95
100.0 KHz	£2.90
200.0 KHz	£3.70
204.8 KHz	£3.92
262.144 KHz	£3.92
307.2 KHz	£3.92
312.5 KHz	£3.92
455.0 KHz	£3.83
1.000 MHz	£2.95
1.008 MHz	£3.50
1.280 MHz	£3.92
1.6 MHz	£4.25
1.8 MHz	£4.25
1.8432 MH	£2.99
2.000 MHz	£2.80
2.097152 MHz	£3.23
2.4576 MHz	£2.99
2.500 MHz	£3.23
2.56250 MHz	£3.62
3.000 MHz	£3.62
3.2768 MHz	£2.70
3.579545 MHz	£1.75
3.93216 MHz	£3.92
4.000 MHz	£1.99
4.032 MHz	£1.99
4.096 MHz	£1.99
4.194304 MHz	£1.99
4.433619 MHz	£1.25
4.608 MHz	£1.99
4.800 MHz	£1.99
4.9152 MHz	£3.23
5.000 MHz	£1.99
5.0688 MHz	£2.70
5.120 MHz	£3.23
5.185 MHz	£3.23
5.24288 MHz	£4.25
6.000 MHz	£2.70
6.144 MHz	£2.70
6.400 MHz	£3.23
6.55360 MHz	£1.99
7.000 MHz	£1.99
7.168 MHz	£2.50
7.680 MHz	£1.99
7.86432 MHz	£3.23
8.000 MHz	£1.99
8.08333 MHz	£3.62
8.388608 MHz	£3.23
8.867237 MHz	£2.99
9.375 MHz	£3.23
10.000 MHz	£1.99
10.245 MHz	£3.23
10.700 MHz	£3.23
10.92 MHz	£3.92
11.000 MHz	£3.92
12.000 MHz	£3.50
14.0 MHz	£3.92
14.31818 MHz	£3.62
16.000 MHz	£2.90
18.000 MHz	£2.50
18.432 MHz	£2.90
19.968 MHz	£3.00
20.000 MHz	£2.80
20.1134 MHz	£3.23
24.0 MHz	£3.92
26.690 MHz	£2.90
27.0 MHz	£3.92
27.145 MHz	£3.00
27.648 MHz	£3.23
38.6666 MHz	£3.50
48.000 MHz	£2.70
100.000 MHz	£2.90
116.000 MHz	£3.00

VEROBOARD

0.1" Pitch with copper strips

2½" × 1" (pack of 5)	£1.01
2½" × 3¾"	73p
2½" × 5"	83p
2½" × 17"	£2.51
3¾" × 3¾"	83p
3¾" × 5"	95p
3¾" × 17"	£3.26
4.7" × 17.9"	£4.26

0.1" Plainboard (no strips)

3¾" × 2½"	52p
3¾" × 5"	79p
3¾" × 17.0"	£2.11
Terminal pins	£1.50 /500
V-Q DIP board	£1.58
DIP breadboard	£3.59
Spot face cutter	£1.18
Pin insertion tool	£1.62

SOLDERCON PINS

100 70p
500 £3.25 1000 £6.00

DIL SOCKETS

8/14/16 pin 8p/10p/10p
18/20/22 pin 16p/22p/25p
24/28/40 pin 25p/28p/30p
24 pin Textool lever type zero insertion force £6.95

EDGE CONNECTORS

43 way 0.1" pitch, wire wrap, polarizing slot pin 37
Single sided (1 × 42) £3.11
Double sided (2 × 42) £4.10

TIMER ICs

555/556 16p/45p

OP-AMPS

(All Mini dips)

CA 3130E	90p
CA 3140E	48p
741	14p

LED DISPLAYS

DL-704E	99p
DL-727E/728E	£2.00
DL-747E/750E	£1.80
FND 500/560	£1.20

LIQUID CRYSTAL DISPLAY

4 × 0.5" Digits 40 pin DIL £9.75

CLOCK CHIPS

AY-5-1224A	£2.60
MK 50253	£5.50
MK 50366	£6.50

SIX DECADE COUNTERS

MK 50395/6/7	£9.90
50399	£7.50

TRANSISTORS

BC 107/8/9	10p
BC 177	20p
BC 213L	10p
BC 461	34p
BC 548	14p
2N 3703/4/5/6	10p
2N 3820	45p
TIP 2955	60p
TIP 3055	60p

DIODES

IN 4148	4p
IN 4001/2	5p
IN 4003/4/5	6p
IN 5401	15p
IA BRIDGE 150V	22p

SIL RESISTORS

7 × 10K (8 pin)	42p
8 × 10K (9 pin)	46p
8 × 4K7 (9 pin)	46p
8 × 1K (9 pin)	46p

DIL RESISTORS

8 × 33R (16 pin) 62p

RESISTORS

Carbon film, high stability ¼W E12 range 2p each
100 of one value £1.00

CERAMIC CAPACITATORS

10pF, 15pF, 22pF, 33pF, 47pF, 68pF, 100pF, 150pF, 220pF, 470pF, 1n5F, 2n2F, 3n3F, 4n7F, 6n8F, 10nF all at 4p each
15nF, 22nF, 47nF at 5p each
100nF at 7p

MICROPROCESSORS

6502

6502	£4.25
6520/21	£2.99
6522	£3.50
6532	£6.95

Z80

Z80A CPU	£3.30
Z80A P10	£2.90
Z80A CTC	£2.90
Z80A-S10/10	£13.95

6800

6800 MPU	£2.95
6802 MPU	£3.99
6809	£8.75
6810 (128 × 8 RAM)	£1.20
68A10 (128 × 8 RAM)	£1.30
6820, 6821 P1A	£1.25
6840	£4.20
6845	£9.50
6850 ACIA	£1.50
MC6880	£1.20

SC/MP II RAM I/O

SC/MP II (4MHz)	£10.47
INS 8070	£22.37
INS 8154 RAM I/O	£9.52
INS 8255 I/O	£3.50

CMOS

COSMAC CDP 1802CE	£6.60
COSMAC CDP 1802E	£10.95
CDP 1864	£6.45

STATICS (Mostly 450nS)

2114L 200nS	84p
2114L 300nS	83p
6116 CMOS 2K RAM 200nS	£4.75
4118 — 1K × 8	£3.25

DYNAMICS

4116 16K 200nS	74p
8 × 4116	£5.95
4164	£7.95

UV ERASABLES

5204 (512 × 8)	£7.95
2708 1K × 8	£1.75
2716/2516 2K × 8 single 5v	£1.95
2532 4K × 8 (5v)	£4.05
2732 4K × 8v	£3.99

PROM WASHING SERVICE
50p each prom

SPARE ERASER TUBE
U-V tube (12") £10.00

UV PROM ERASER

UV140	£61.20
UV141	£77.70
EPROMPT	£33.00

INTERFACE

81LS 95	90p
81LS 96/97	90p
81LS 98	90p
1488	59p
1489	59p
75491	70p
75492	92p
8T26	£1.20
8T28	£1.40
1L74	48p
AY-3-8910	£5.95
FD 1771	£18.00
8131	£2.60
8136	£2.60
ICM 7209 IPA	£2.89
COM 8116 (Baud Rate)	£8.00

SAA5050	£8.51
SAA5020	£5.33

CRT CONTROLLER Uarts

AY-5-1013	£3.45
AY-3-1014A	£5.50
AY-3-1015	£3.00
6402	£3.92
1402	£4.50
96364E	£5.94

CHAR. GEN. KEYBOARD ENCODER

MK 2302	£15.29
RO-3-2513 (5v Uppercase)	£5.75
AY-5-2376	£5.99

FIRMWARE

2K ZYMON for Z80 (1 × 2516) includes commented listing	£14.95
1K ZMON Z80 (1 × 2516 or 1 × 2708)	£14.95
2K Tiny Basic for Z80 (1 × 2516)	£14.95
4K NIBL for SC/MP (4 × 2708)	£49.95
4K NIBL-MM for SC/MP (4 × 2708)	£49.95
(Description leaflet available)	
1K Elektor Junior (1 × 2708)	£19.85
1½K ELBUG (3 × 5204)	£35.00
ETIBUG (1 × 5204)	£35.00
ETIBUG (1 × 5204)	£14.95
ETIBUG 2 (1 × 5204)	£14.95
SCMP/KB (1 × 5204)	£14.95

UHF MODULATORS

UM1111 E36 Vision modulator, TV game or cheap computer type £2.80

UM1233 E36 Wide bandwidth, computer VDU type .. £4.50

UM1286 E36 Combined wide bandwidth vision modulator with intercarrier sound, high performance £8.25

VOLTAGE REGULATORS

7805	45p
7905	55p
7812	48p
7912	55p

VOLTAGE CONVERTER MODULES

Ideal for use in otherwise 5V only systems, to obtain +12V 12V, or dual 12V power for ASCII keyboards, RS 232 Interfaces, dynamic RAMs, etc. All types need +5V input. Size of each module (excluding pins) 34 × 26 × 10mm

Type AOIP-12A10
+12V output (25-84mA) £4.95
Type ADIN-12A10
12V output (25-84mA) £4.95
Type AOID-12A10
± 12V, dual output, 2 × (12-42mA) £5.25

10 MHz OSCILLOSCOPE

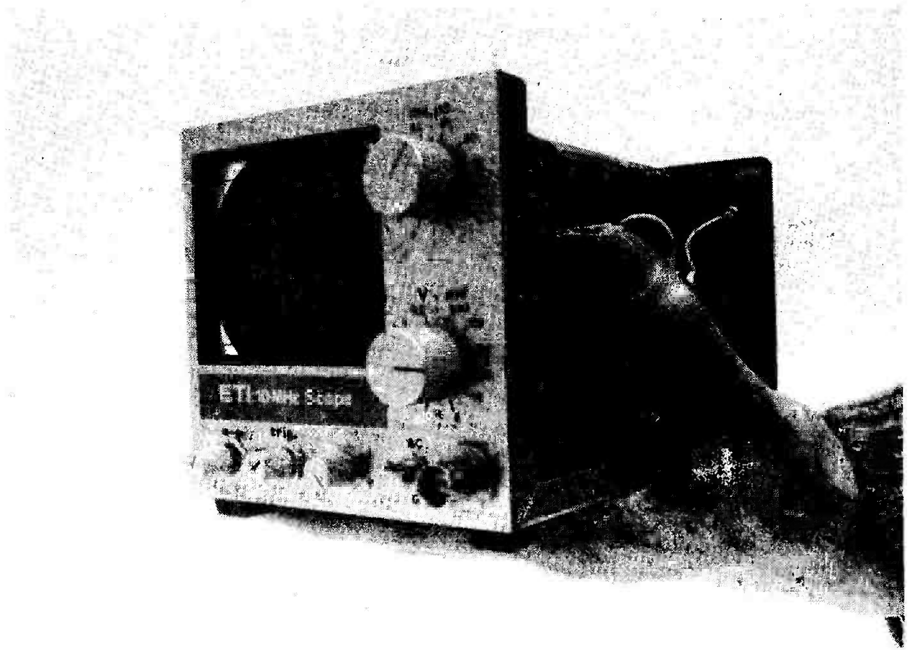
Fed up with those awkward moments when you want to measure a sine wave and your oscilloscope's at home? This instrument is everything you could wish for — small, handy, efficient and independent of the mains. Design by K.W. Dugge.

Compared with conventional instruments this oscilloscope is smaller, lighter and better value for money. It is barely larger than a house brick and about as heavy as a good multimeter; thus it is ideally suited to mobile usage on building sites, in installation work, in motor vehicles and so on. The instrument can be powered either from the mains, using a separate 240 V to 12 V transformer, or direct from a 12 V battery. The specifications are given in the table.

The individual circuit blocks are connected by ribbon cable. The 12 V DC or AC supply enters via two connectors on the rear of the instrument, passing through a two-pole switch (linked to the X-position potentiometer) to the power supply card. After stabilisation to 10 V, the various working voltages are generated here using a 25 kHz switching circuit. Stabilisation of the input has the advantage that all the output voltages are thereby simultaneously stabilised, ie they are independent of supply variations. Because a switching regulator represents a voltage source having a low internal resistance and the current output to the individual circuit blocks is largely constant, further secondary stabilisation measures are unnecessary.

Also on the power supply card are the individual trimmers (focus, astigmatism, brightness) and the voltage multiplier for the tube supply, so that the tube (up to the deflection plates) can be connected directly from here by means of a six-way ribbon cable. The connections for the tube are made direct to the base. No socket is used, because the additional capacitance would considerably reduce the bandwidth.

A seven-way ribbon cable connects the main circuit board with the various supply voltages, and the



Now this is what we call small . . . . .

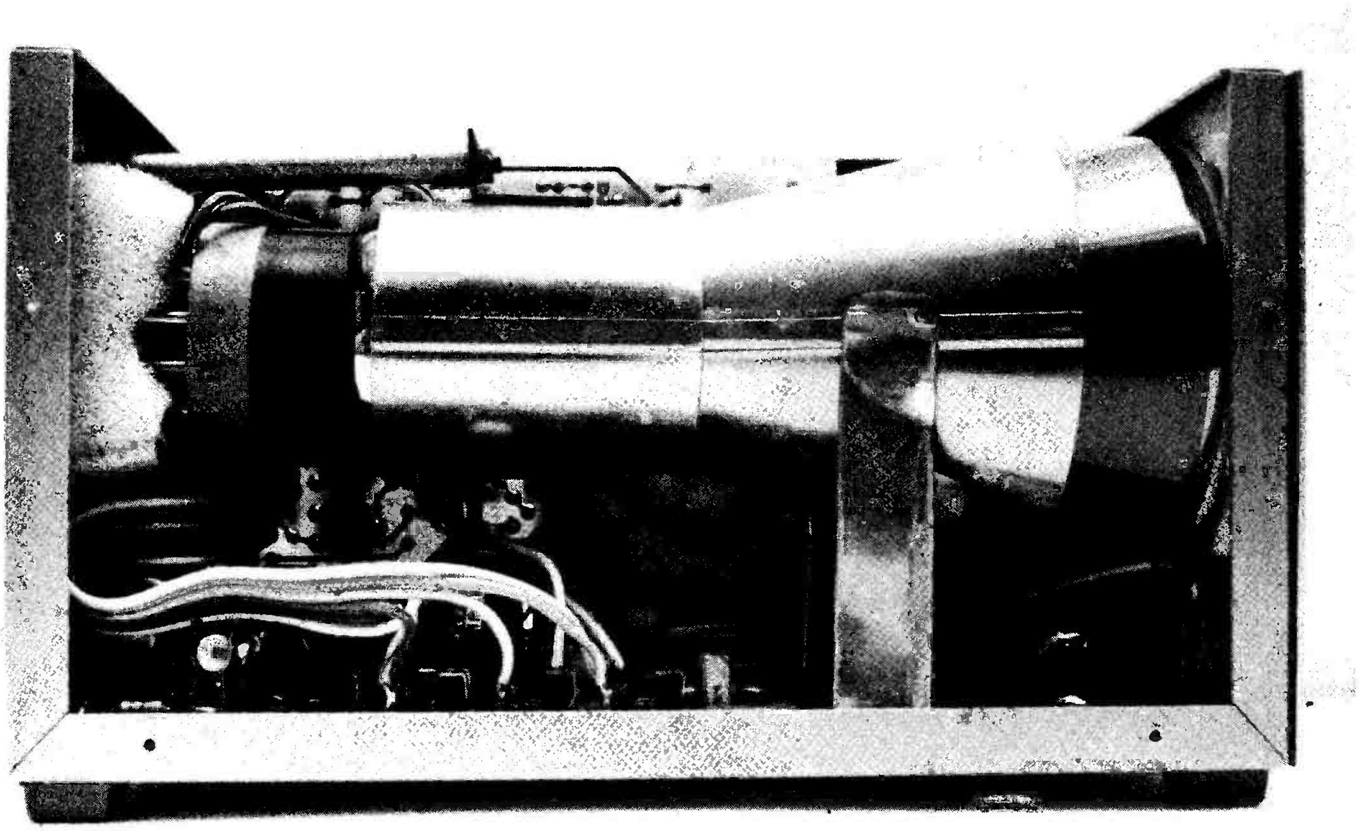
(flyback) blanking pulse goes from the main board to the grid G1 of the tube. The main board contains the trigger switching, the sawtooth generator and the X- and Y-deflection amplifiers.

The three potentiometers mounted on the front panel (X- and Y-shift, trigger level) are connected by a five-way ribbon cable to the main or preamplifier boards, as appropriate. Similarly the time-base selector on the front panel is connected by three single wires to the main board.

The input voltage divider forms a complete screened assembly, comprising switch SW1 and the voltage divider and preamplifier boards — thus no additional external wiring is required. The complementary output of the Y-amplifier passes to the Y-deflection amplifier on the main board.

SPECIFICATION

Bandwidth: 0-7.5 MHz (−3 dB) for six divisions (one div = 7 mm)
0-10 MHz (−3 dB) for four divisions.
Input: BNC connector, switchable AC/DC/ground.
Sensitivity: 5 mV/div to 20 V/div in 12 calibrated 1/2/5 steps.
Case Size: approximately 175 x 105 x 100 mm.
Weight: approximately 1 kg.



The tube is supported by its metal screen and cushioned by foam draught excluder. The power supply is mounted beneath it.

HOW IT WORKS

VOLTAGE DIVIDER AND PREAMPLIFIER
The input signal reaches the input voltage divider from the BNC connector and the mode selector SW2. After passing through the voltage dividers, the signal goes via R3 (over-voltage protection for Q1) to the gate of the dual FET Q1. The second gate of this transistor is connected to the Y-shift potentiometer RV1 and permits vertical shifting of the 0 V line on the screen. Any mismatch between the two halves of Q1 can be trimmed out by means of trimmer PR1. Q1, which is connected in the source-follower mode, serves merely to buffer the high impedance of the instrument input and the voltage divider from the low input impedance of the preamplifier IC1. The gain is fixed and determined by R12. Complementary output signals appear at Q and Q' and pass along single wires from here to the Y-deflection amplifier on the main board.

MAIN BOARD
The two transistors Q2 and Q3 on the left of the diagram take care of the final amplification of the Q and Q' signals provided by the preamplifier. The amplified signal is connected to the Y and Y' deflection plates using short, single wires (lowest possible capacitance!) going directly to the base pins. The working point of the stage is adjusted by PR3, the gain by PR2. C10 and CV10 serve to linearise the frequency response.

The trigger signal is taken from Q1 via C8. Q4 and Q5 form a preamplifier whose working point is adjusted by the trigger level potentiometer, RV2. Q5 feeds the Schmitt trigger IC2a which converts the input signal into rectangular pulses. These rectangular pulses are differentiated into 'spikes' by C17 and R43, and are fed to the 'set' input of the gating flip-flop (pin 4 of IC26). The gating flip-flop enables the sawtooth generator for one beam-sweep (in a horizontal direction on the tube).

In order that a 0 V line will be traced in the absence of an input signal (and therefore in the absence of the 'spikes') — for example, for direct voltage measurement, or for reference purposes with the input switch on 'G' — transistor Q6 is switched into conduction and thus gives a continuous 'set' condition. As long as rectangular pulses are present at the output pin 3 of the Schmitt trigger, they will be rectified by D1 and D2, generating a negative gate voltage for Q6, so that this stays non-conducting. Thus the 'Free-run/Automatic' Q6 only works when there are no trigger pulses available.

The output (pin 8) of the gating flip-flop switches on Q7. This provides base current — through R50 and PR4 — to transistor Q8, which is connected as a constant current source. The magnitude of the constant current which Q8 provides is determined by emitter resistors R44 to R49 (selected by the time base switch SW3). As soon as Q8 is switched on (by Q7) one of the two capacitors C19 or C20 will be charged (according to the position of the time base selector). Since this charging takes place from a constant current source, the voltage on the capacitor increases linearly with respect to time. This linear (sawtooth) voltage increase is fed to the X-deflection transistors Q12/Q13 by Q9 and Q10, so that the X and X' deflection plates receive a linear beam sweep (from left to right on the screen). A part of this voltage is fed via R54/R55 to the input pin 12 of the reset trigger (IC2d). As soon as the sawtooth voltage attains such a level that the beam reaches the right hand side of the screen, pin 11 of IC2b switches low (approximately 0 V). This switches Q11 on, and also supplies G1 of the tube (via C24) with a negative-going, 40 V pulse, which blanks the beam. At the same time, the timing capacitor (C19 or C20) is discharged, which returns the beam (blanked during the flyback) to the left-hand side of the screen. Pin 11 of the reset trigger also drives the 'reset' input (pin 10) of the gating flip-flop. This switches off Q7 and Q8. As a result there will be no new beam sweep for the moment, while the current source Q8, which charges the timing capacitors, is switched off. A new sweep will only be initiated by a trigger pulse on the 'set' input pin 4, and this will occur at exaotly the same point on the waveform of the input signal as for the preceding sweep. This ensures that successive traces in a continuous sequence are written on the screen in a uniform manner, provided that the input signal is not altered. Trimmer PR4 provides for calibration of the timing circuit (charging current adjustment), PR6 is the working point adjustment, and PR5 is the gain (picture width) control for the X-deflection amplifiers. The trace can be shifted from right to left on the screen, from the front panel, by RV3.

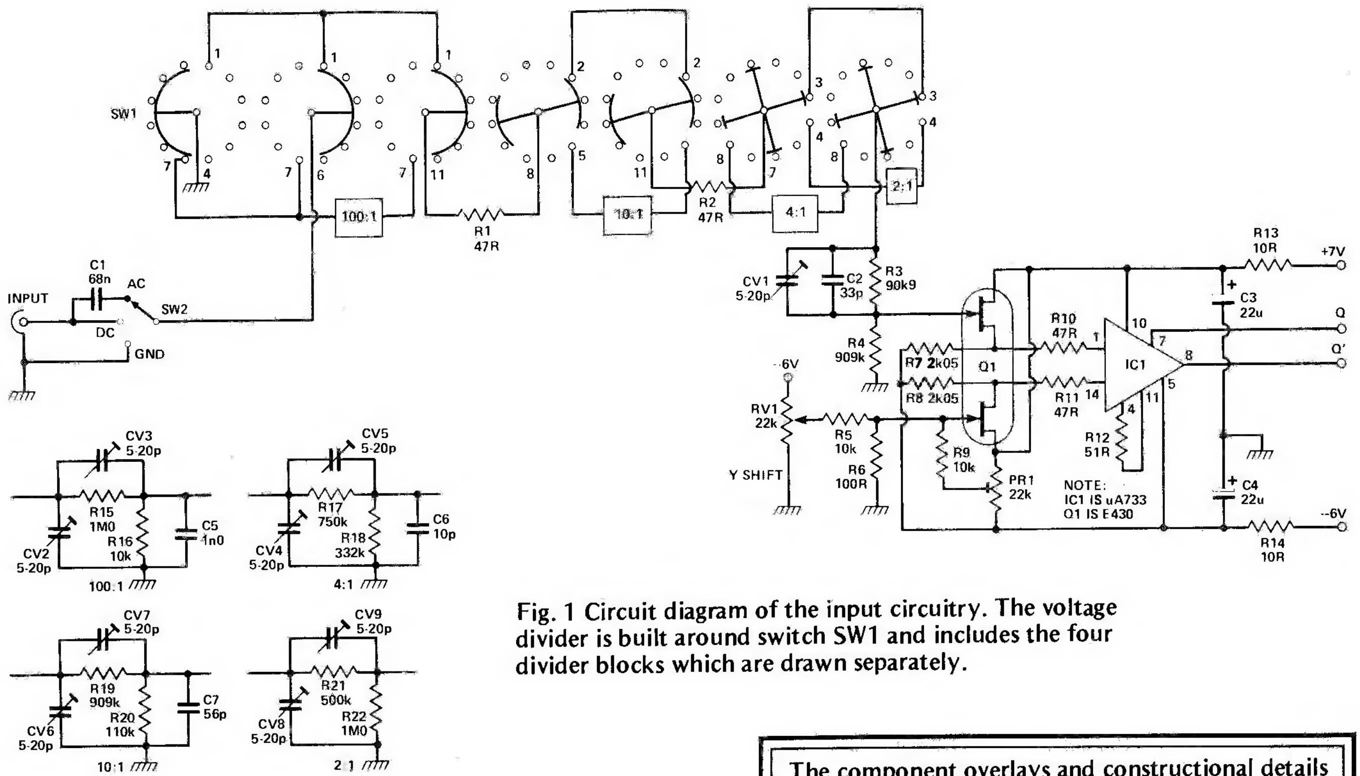


Fig. 1 Circuit diagram of the input circuitry. The voltage divider is built around switch SW1 and includes the four divider blocks which are drawn separately.

The component overlays and constructional details for the oscilloscope will be given next month.

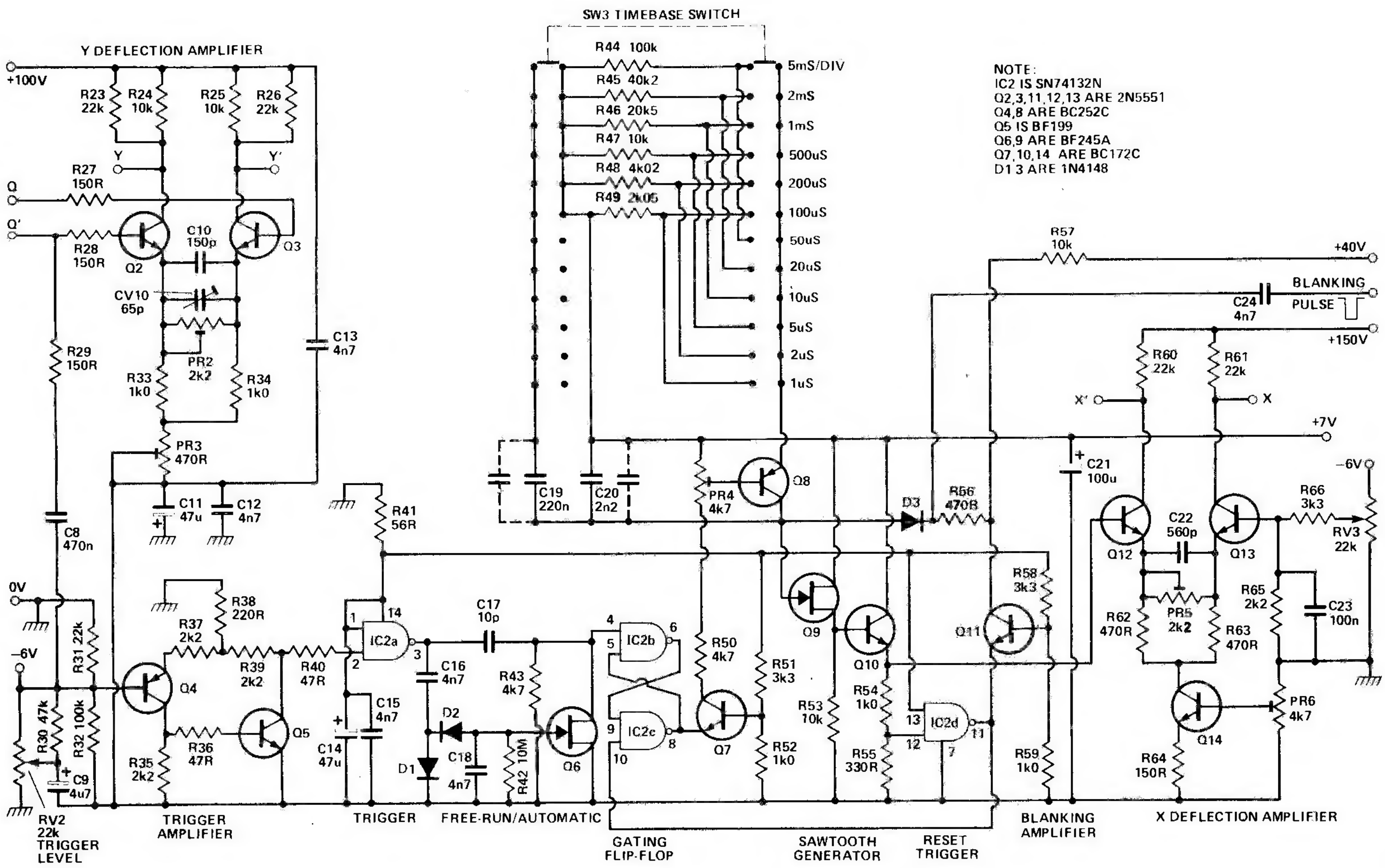
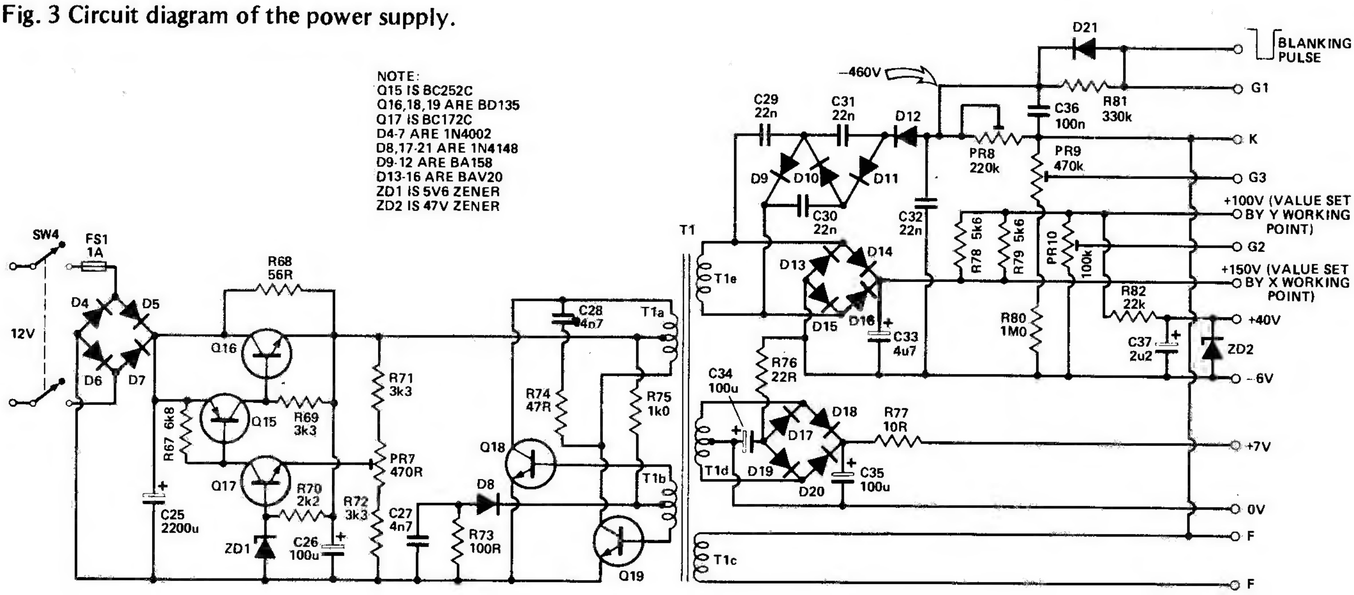


Fig. 2 Circuit diagram of the main board. The two dotted capacitors in parallel with C19 and C20 may be required for trimming purposes — this is covered next month.

Fig. 3 Circuit diagram of the power supply.



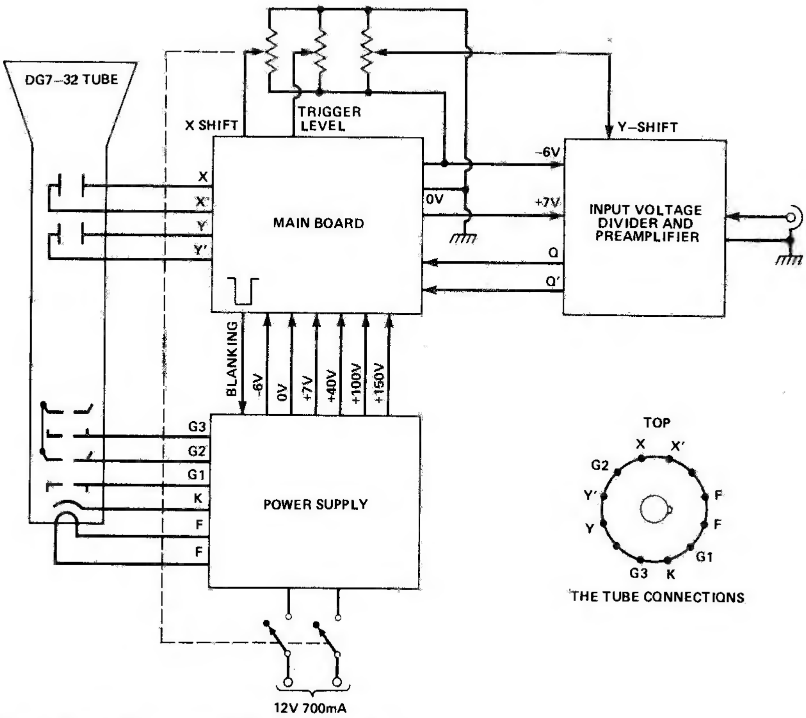
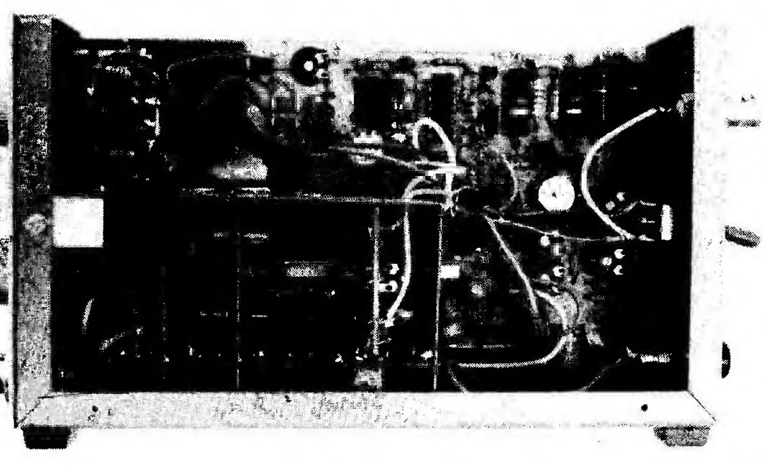


Fig. 4 Block diagram of the oscilloscope.



HOW IT WORKS

THE POWER SUPPLY

The incoming supply voltage from SW4 (coupled to the X-position potentiometer) and fuse FS1 is rectified by D4 - 7. These also ensure correct polarity of the input voltage in the case of a DC source. The supply voltage is stabilised to 10 V by Q15 Q16 and Q17. The constant and almost ripple-free voltage then passes to the transformer T1 and the 25 kHz oscillator formed by Q18 and Q19.

R73 limits the base current to Q18 and Q19. R74/C28 suppress switching voltage spikes. R75 in conjunction with D8 acts as a starting circuit (for the oscillation).

The tube heater voltage is generated by the transformer secondary winding T1c. Winding T1d delivers a 156 V square wave, which is rectified by diodes D13 - 16 and passed to the deflection amplifiers. Diodes D13-16 must be BAV20 and D9-12 must be BA158, as specified in the Parts List; on no account can ordinary bridge rectifiers or rectifier diodes (eg 1N400X) be used, as these are an order of magnitude too slow to rectify a 25 kHz signal.

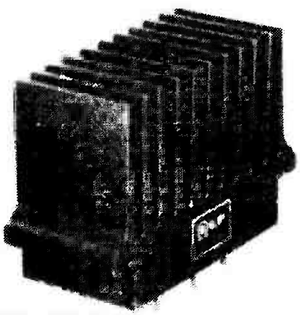
The 156 V is reduced to 100 V (for the Y-deflection amplifier) by R78/R79. From this is derived, through PR10, the tube G2 voltage (astigmatism adjustment) and also the 40 V DC for the flyback switching, via R82 and ZD2. All the voltage values given in the circuit diagram are measured with respect to ground.

T1d also feeds the voltage multiplier (D9 - 12, C29 - 32) for the generation of the tube EHT supply of –460 V. This voltage is fed to a potential divider (PR8 – brightness, PR9 – focus, R80) on which the individual electrode potentials for the tube are available.

The +7 V and –6 V supplies are generated by T1e. The asymmetry of these voltages is a result of the different values of resistors R76 and R77. This is necessary for the supply to the preamplifier IC1, whose inputs, pins 1 and 14, sit at about +1 V. The supply (source voltage of Q1) is therefore sufficiently compensated that the positive voltage (on pin 10) is somewhat greater than the negative voltage on pin 5.

ETI

It's the chance every constructor wants



POWER AMPS

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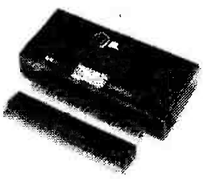

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TECH TIPS

Economy CMOS Vocoder

S.P. Giles, Edmonton

The principle of the vocoder has been well covered in ETI in the past but it is very expensive to construct such a project due to the high component count, especially op-amps. This circuit attempts to bring the vocoder nearer the pockets of those who would not normally have sufficient funds. CMOS inverters are used instead of op-amps for cheapness.

The signal to be analysed, normally the human voice, is fed into the mike input and amplified by inverter IC1a. IC1b, a bandpass filter, allows a very narrow band of the input through. The centre frequency of this band is determined by PR1. The amount of energy present in this narrow band is measured by an envelope follower consisting of inverters IC1c, d and D1.

If a sound source is connected to the other input it is necessary to transfer onto it the energy present at point A. This is done by Q1, a voltage-controlled amplifier with the level set by the envelope follower voltage. PR3 should be adjusted for zero output at point B with no input. Inverter IC2a is a simple mixer for all the VCA outputs.

The second diagram shows how the filter bank is built up. It is suggested that a minimum of 20 channels be used to get the best results. In this case PR1 and PR2 should be set to approximately 1k2 intervals from one channel to the next. The greater the number of channels the better the results.

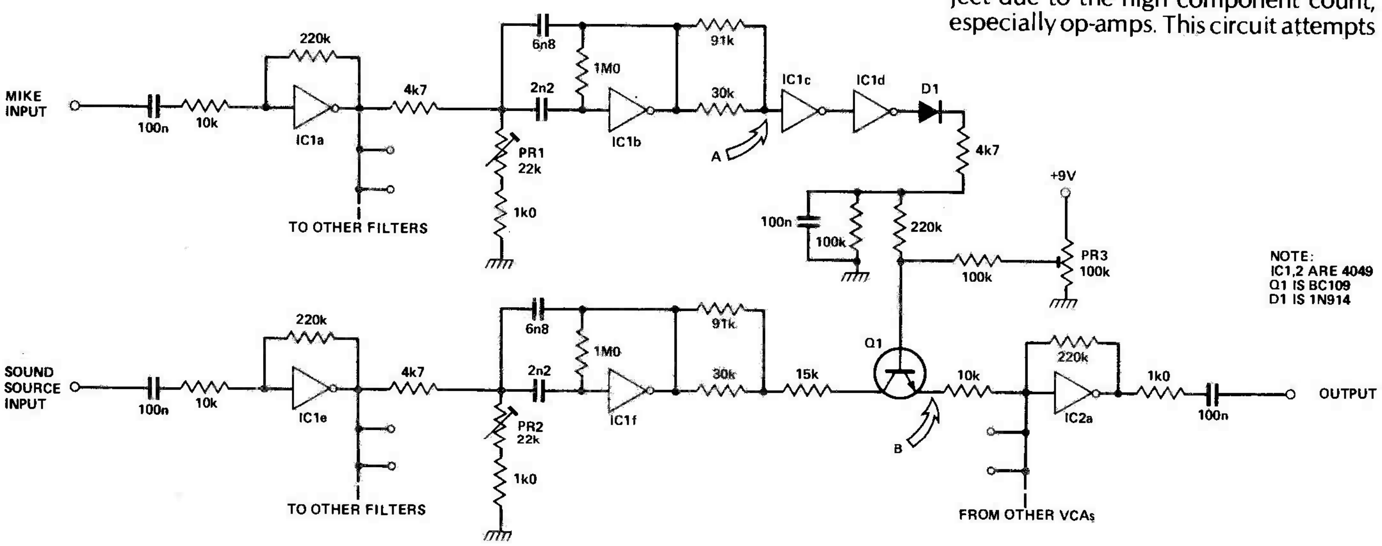

Fig. 1 Circuit of one channel of the CMOS vocoder.

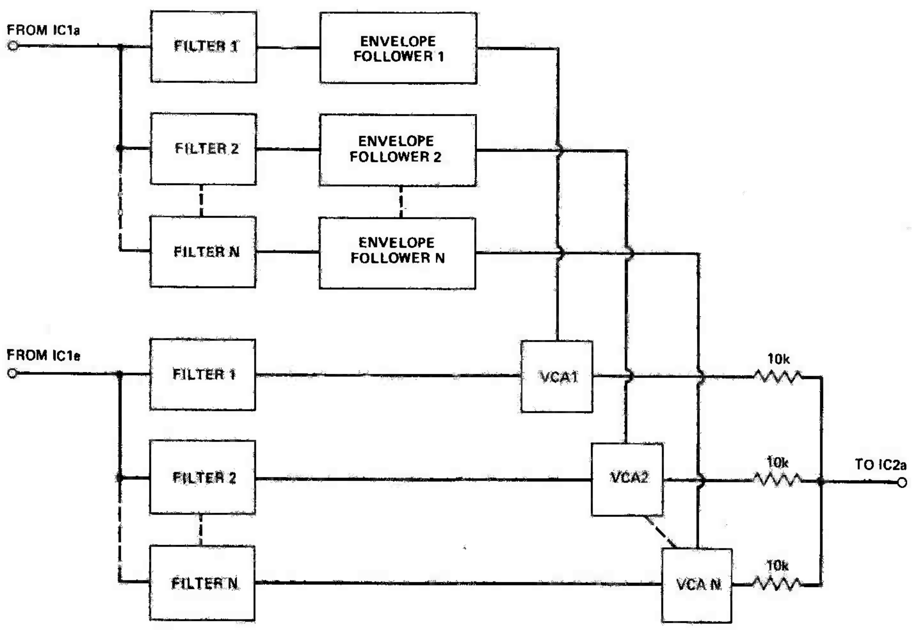

Fig. 2 Several channels are connected in parallel to form the complete vocoder.

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ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for at a competitive rate.
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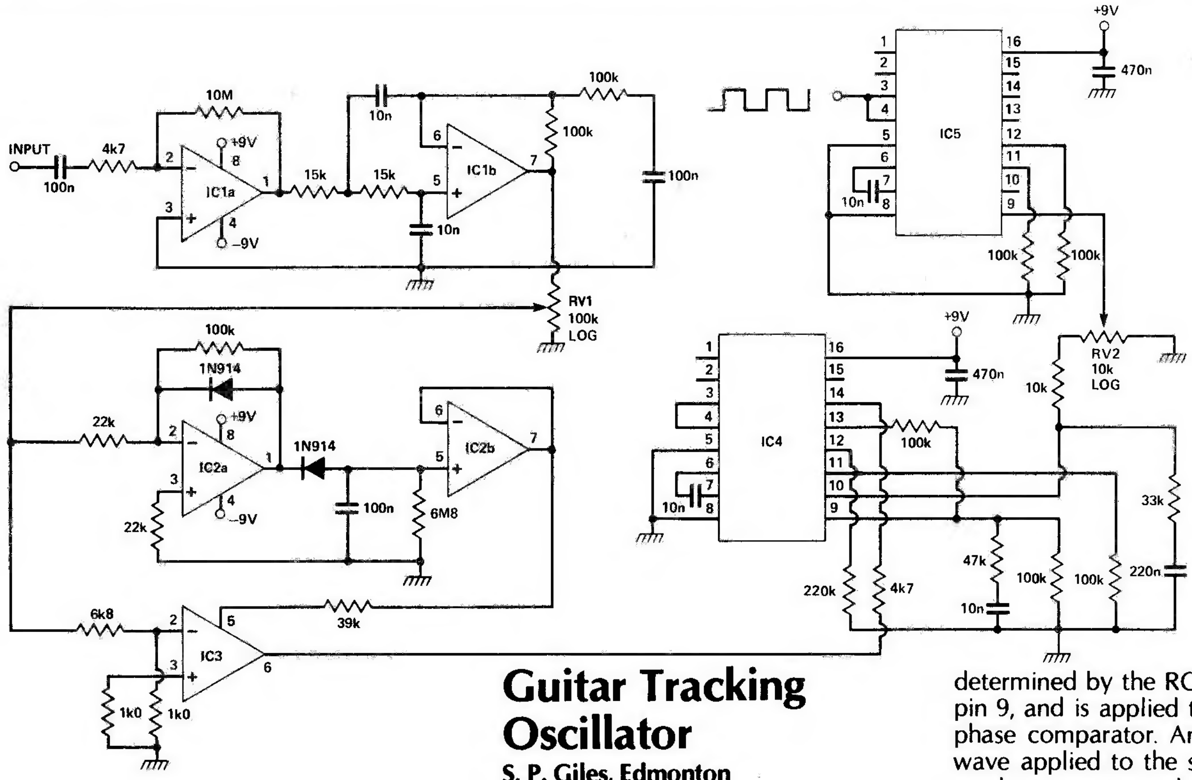


Guitar Tracking Oscillator

S. P. Giles, Edmonton

This circuit will enable a guitarist to produce a second note in harmony with the note he is playing. IC1a amplifies and squares up the incoming guitar signal which is then passed through 1 kHz lowpass filter IC1b. This is to remove most of the harmonics leaving a reasonable square wave at the fundamental pitch of the note played. IC2a, 2b and IC3 form a simple compressor so that phase-locked loop has a better chance of locking on to the square wave applied to pin 14. Inside the 4046, there is a VCO which oscillates at a frequency determined by the RC network around pin 9, and is applied to one input of a phase comparator. An external square wave applied to the second input will produce an error voltage which is proportional in magnitude to the difference between the external and VCO frequencies. The error voltage is passed to the VCO until the two frequencies are the same, ie the VCO is locked to the input signal.

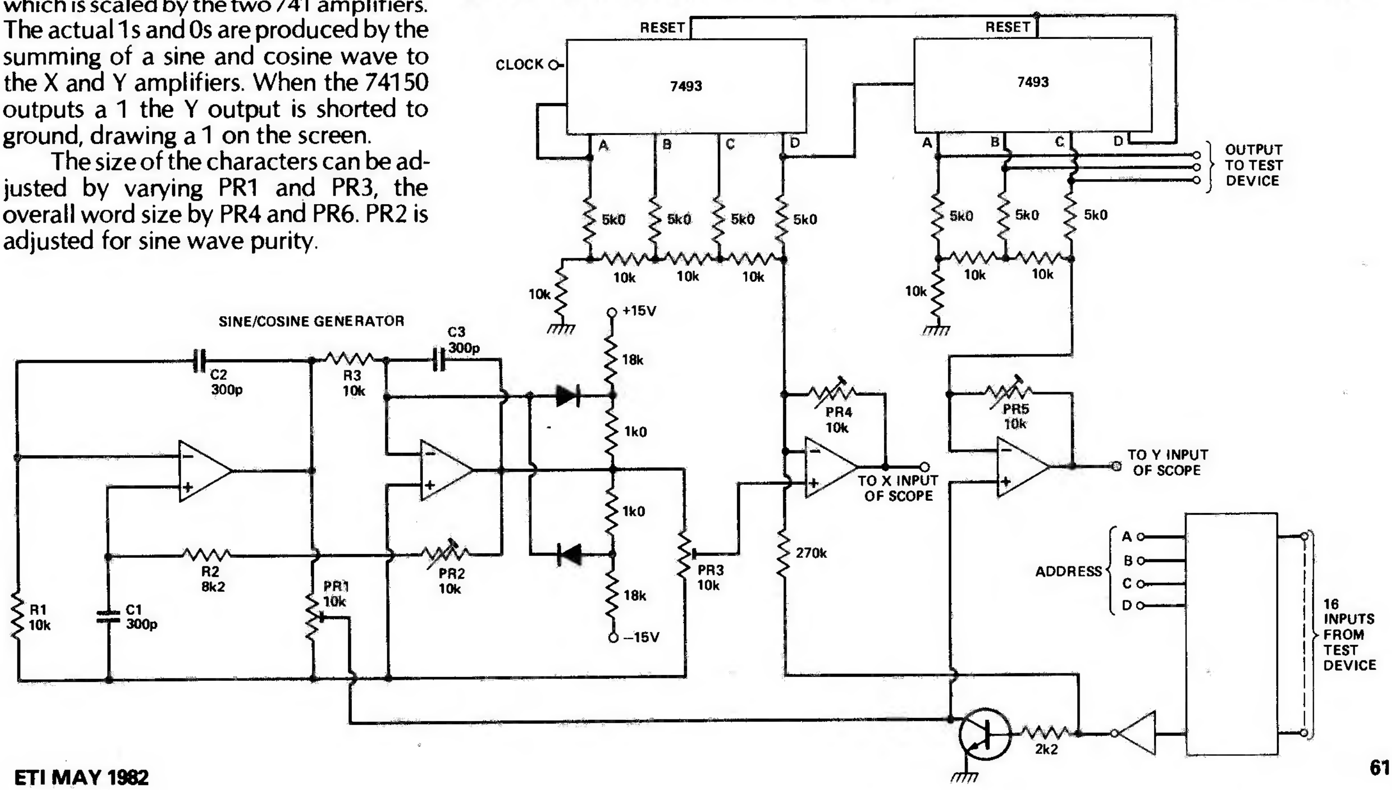
The error voltage can be extracted from pin 10 of IC4 and passed via RV2 to a second 4046, IC5. RV2 varies the level of the DC signal which controls the frequency of the VCO in IC5. The resistors from pins 11 and 12 of IC5 can be changed to alter the maximum and minimum frequencies of the internal VCO.

Simple Graphics On A Scope Screen

G. Heath, Oxted

The circuit described here will display eight 16-bit words on an oscilloscope screen. The counters and D-to-A converter provide positioning information which is scaled by the two 741 amplifiers. The actual 1s and 0s are produced by the summing of a sine and cosine wave to the X and Y amplifiers. When the 74150 outputs a 1 the Y output is shorted to ground, drawing a 1 on the screen.

The size of the characters can be adjusted by varying PR1 and PR3, the overall word size by PR4 and PR6. PR2 is adjusted for sine wave purity.



SOUND EFFECTS 3

The SN76488 is pretty versatile. So is our sound effects PCB. Hence their return this month with two new noises to astound and amaze, the first being a phasor and explosion. Design by Phil Wait.

This combines a 'phasor' effect and the explosion effect employed in the Bomb Drop and Explosion unit last month. One could liken the sound produced to what you would expect after shooting down a 'flying saucer' or somesuch! This project uses about as many components as the Bomb Drop and Explosion board.

The SLF sweeps the VCO up and down in pitch at quite a rapid rate — the push-button is held down to start the effect, which takes several seconds to complete. The explosion is heard following a period of the phasor sound. As with the other units, if you wish to vary any of the parameters of the effect it is best to vary the resistor values.

Take care with the orientation of the electrolytic and tantalum capacitors during construction. Note that, as with the Bomb Drop and Explosion unit, there are two links on the board; make sure you don't miss the small link at the 'notch' end of the IC.

PARTS LIST

Resistors (all ¼W, 5%)

R1,5	470k
R2	100k
R3	150k
R4	220k

Capacitors

C1,2,5	4u7 16 V PCB electrolytic
C3	4n7 polycarbonate
C4	470p ceramic
C6	100u 16 V PCB electrolytic

Semiconductors

IC1	SN76488

Miscellaneous

PB1	SPST push-button switch

PCB (see Buylines); 50 mm diameter 8 ohm speaker; PP3 battery and clip.

BUYLINES

The SN76488 is available from Technomatic at a price of £3.50, while the PCB (identical to last month's one) will cost £1.80 from our PCB Service (see page 45) if you don't want to etch it yourself. Everything else is pretty run-of-the-mill.

HOW IT WORKS

This unit is closely related to the Bomb Drop and Explosion. In fact, if you compare the two circuits you will find very little difference! In this unit the SLF is programmed to oscillate at several Hertz and the triangle wave output employed to control the VCO frequency. Thus the VCO is swept up and down in frequency several times per second. This creates the phasor sound. The explosion is triggered after the phasor sound runs for a few seconds, the whole sequence being controlled by the System Inhibit block in much the same way as done in the Bomb Drop and Explosion unit.

When PB1 is pressed, a high (+5 V) is applied to the input of the System Inhibit block, pin 9. This triggers the One Shot timing period, starting the SLF oscillating. This sweeps the VCO up and down as explained above and the signal passes to the speaker through the Mixer, Envelope Generator (which is inoperative at this time) and amplifier stages. When the One Shot completes its timing period the Envelope Select Logic becomes operative, the SLF is disabled and the Envelope Generator commences to do its thing. The Mixer now selects the Noise Generator/Filter output and the sound is heard to decay away, simulating an explosion.

The oscillation frequency of the SLF is determined by R2 and C2, while that of the VCO is determined by R3 and C3. The One Shot timing period is determined by R1 and C1, while the noise characteristic is determined by R4 and C4 on the Noise Filter programming pins (pins 5 and 6).

Audio output is coupled to the speaker via the obligatory 100uF electrolytic capacitor, C6.

Fig. 1 Circuit for the Phasor and Explosion effect.

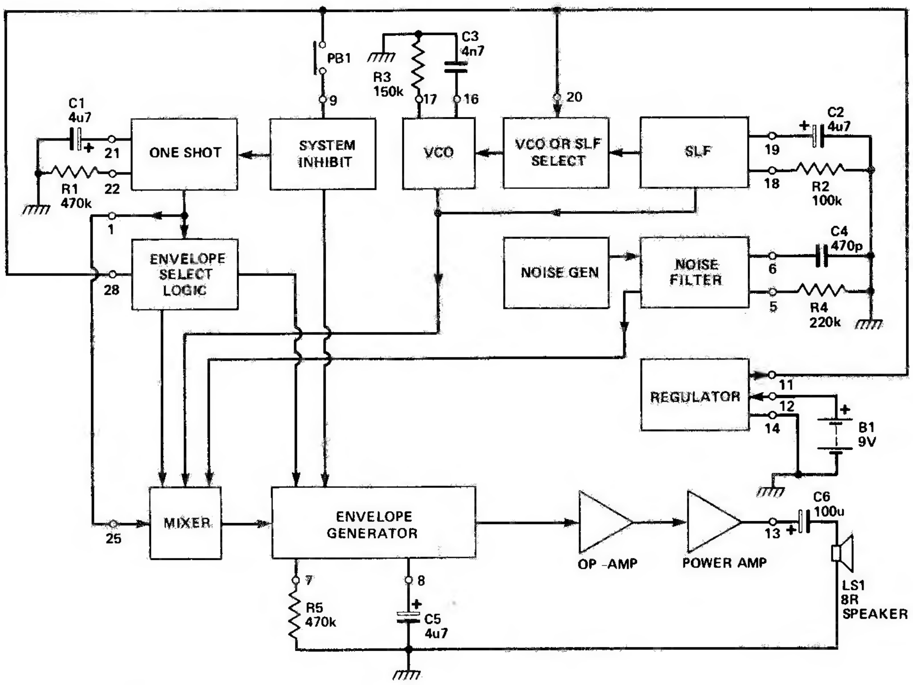
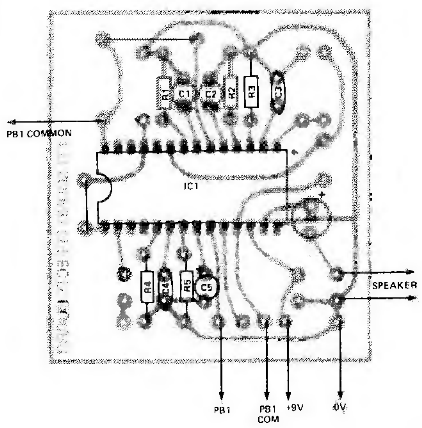


Fig. 2 Component overlay for this project.



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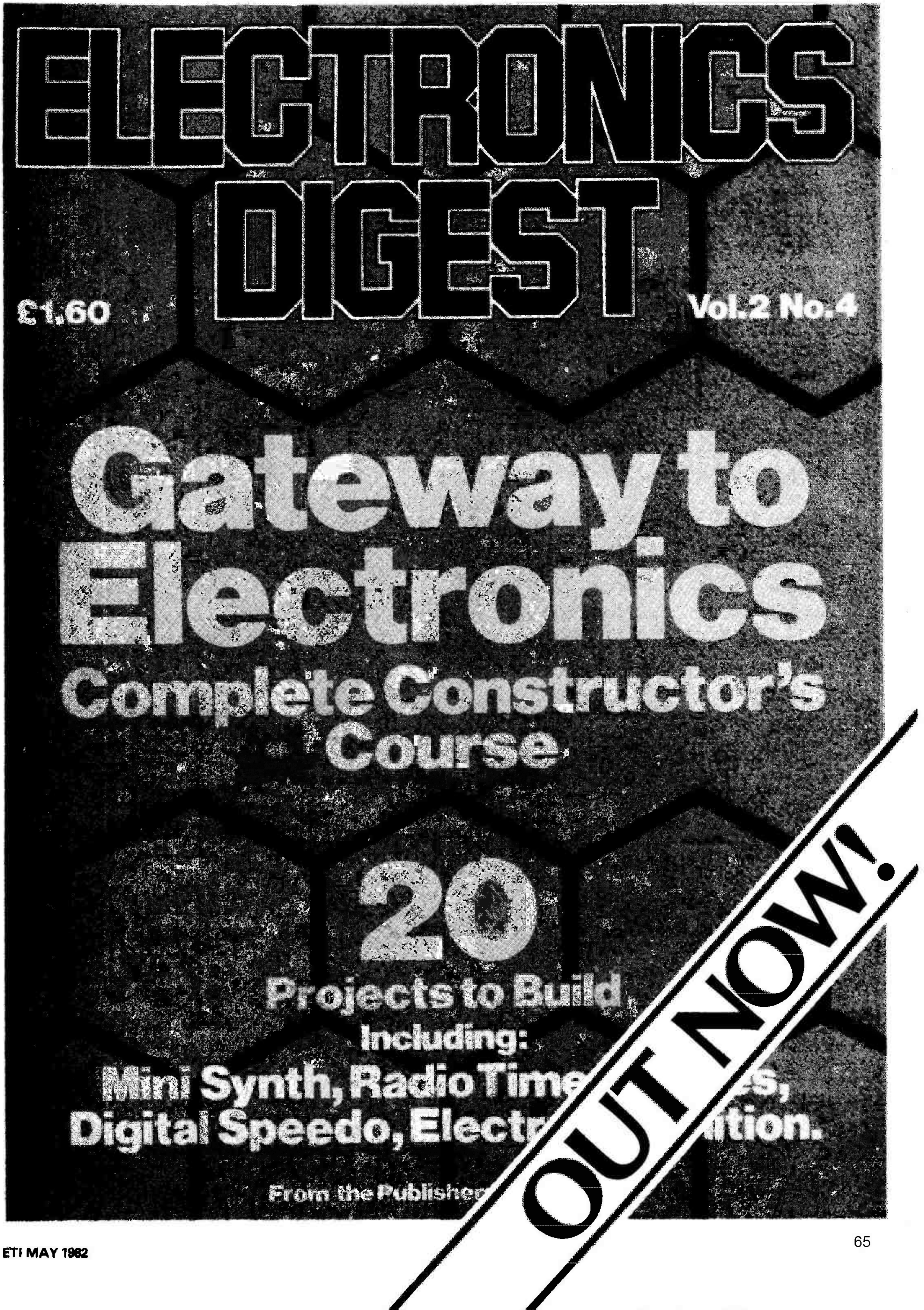
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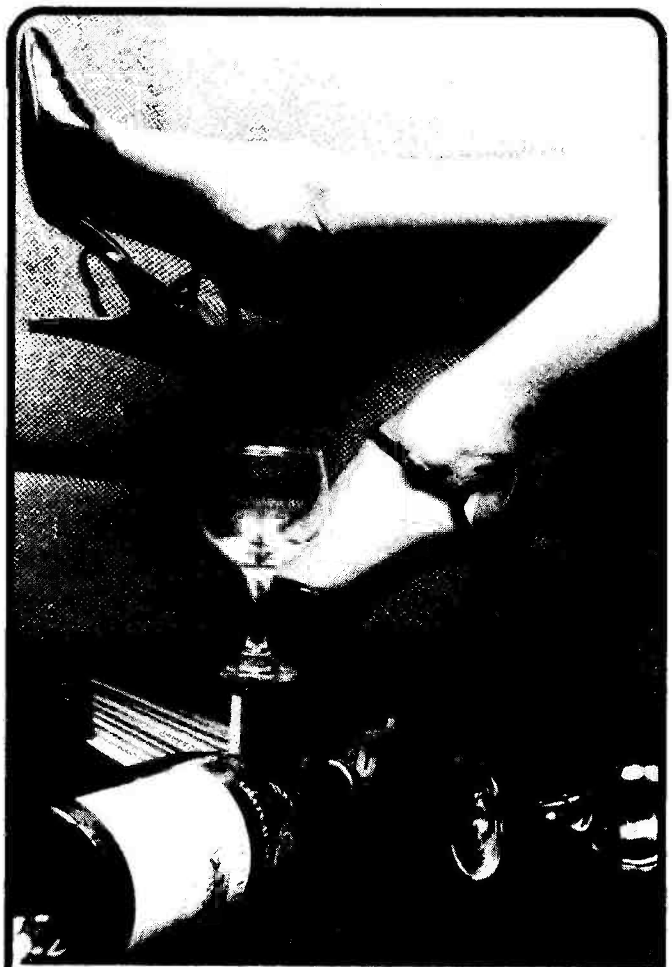

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DESIGNER'S NOTEBOOK

Remote control is this month's topic, as Don Keighley looks at ways to do things at arm's length — or further.

If you've followed ETI over the years you'll have seen how the trends in remote control have taken place — from simple, single-channel on/off ultrasonic systems through to super-duper luxury systems which allow you to adjust contrast or brilliance on your colour TV without even twitching your leg. The electronics industry being what it is, I don't suppose you will have been surprised by the rapid increases in complexity which were required to produce all the facilities of the later systems. What you may find surprising, however, is that the more complex the systems seem to be, the fewer components are actually inside them! For example, one of the most recent hand-controllers — which offers no less than 32 facilities — uses less than a dozen components (not including key-switches).

This great decrease in the number of components (and hence a new-found ease of system manufacture) is due to medium-scale and large-scale integration. With such integration one IC can do the work of literally hundreds of discrete components, making possible highly complex systems at low prices.

Distant Data

Quite a number of manufacturers of all nationalities have been jumping onto the remote-control bandwagon — each producing its own varieties. Plessey's 490/922 range provides for remote-control over ultrasonic, infra-red or simple cable links. Pulse position modulation (PPM) is used for data transmission and this gives good noise immunity — even with control distances of about 10 m. A block diagram of the remote-control encoder (SL490) is shown in Fig. 1.

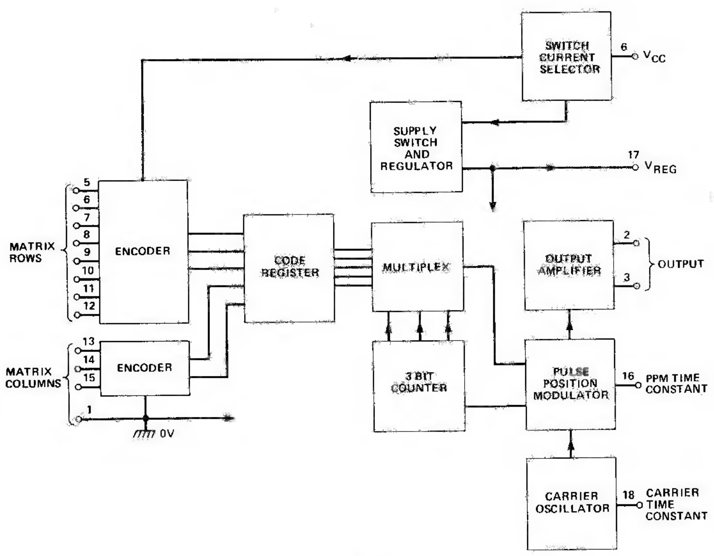

Fig. 1 Block diagram of the SL490 remote control encoder.

The circuit of a basic ultrasonic hand-held transmitter is shown in Fig. 2. A bank of 21 single-pole push-buttons is used in a key-matrix. As each push-button is operated the encoder IC detects closure at a matrix crosspoint and emits a modulated code word of six bits (five data bits and a synchronising bit). The code word is repeated at regular intervals until the push-button is released. A five bit data word allows a range of $2^5 = 32$ different code words — but the matching receiver/decoder IC (SL922) can only decode 21 code words: hence the 21 key matrix.

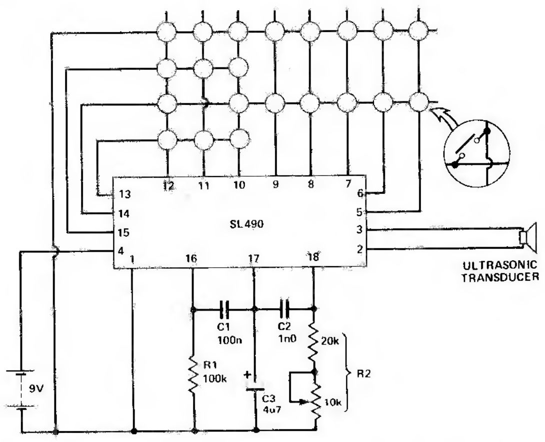

Fig. 2 Circuit of a 21-facility remote control transmitter using the SL490 encoder with an ultrasonic transducer.

The ratios of each part of a code word are shown in Fig. 3. Starting with a fixed pulse-length, L, the total length of the code word is dependent on the binary word to be transmitted. The example shown of the binary word 01011 (followed by a synchronising bit of length 18L) takes 54L to transmit.

The basic pulse length, L, is defined by the values of resistor R1 and capacitor C1 according to the equation

$$L = 0.14\ C1.R1 \text{ seconds},$$

so for the values shown, the pulse length is approximately 10 mS and so the code word given in the example would take 540 mS to transmit.

Capacitor C2 and resistor R2 set the carrier to a frequency given by the equation

$$f = \frac{1}{C2.R2}$$

The values shown give a carrier frequency range of 30-50 kHz. Most ultrasonic transducers are resonant at frequencies around 38-40 kHz so the component values shown in Fig. 3 are satisfactory.

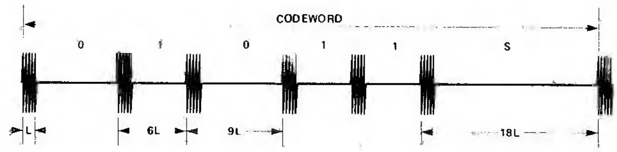

Fig. 3 Typical output code word of the SL490 encoder. Each part of the code word is defined as a multiple of the basic pulse length L. A pulse is formed by a burst of carrier frequency.

The outputs (pins 2 and 3) from the encoder are in antiphase and can interface directly with the transducer. The range of this circuit would be up to five or six metres. Adding transistors Q1 and Q2 to the circuit (Fig. 4) increases the range to approximately 10 m. A current drain of only 6 uA in standby and 8 mA in transmitting mode means that a standard PP3-sized battery will last for months with normal usage.

If the IC is to be used in an infra-red transmitter, no carrier is strictly required, so components C2 and R2 can be replaced by a single resistor (say 10k) from pin 18 to ground.

Are You Receiving Me?

The SL922 receiver is shown in block form in Fig. 5. From this you can see that the chip provides:

- a four-bit binary output to control system inputs: such an input could be a TV channel, audio signal, motor control and so on. With extra decoding circuitry one of a range of up to 16 inputs at a time can be selected
- three analogue outputs (for DC control of volume, tone, colour, brightness etc)
- a low-going pulse output (whenever an input change is selected)
- a toggle output (for muting etc)
- an on/standby output

A typical SL922 receiver circuit is shown in Fig. 6 and from the diagram you'll appreciate how simple it is to use this versatile device. Some form of receiver/preamplifier is necessary to provide positive-going PPM pulses of sufficient amplitude from the received infra-red or ultrasonic signals. Ultrasonic signals must also be demodulated in some way to remove the carrier. Such a receiver/preamplifier could be constructed using op-amp circuitry or a purpose-built IC.

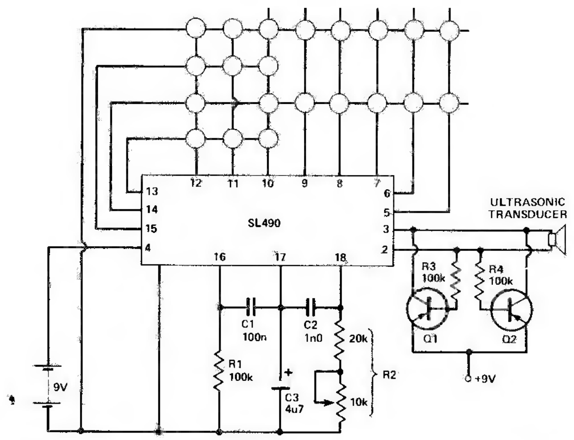

Fig. 4 The addition of transistors Q1 and Q2 increase the range of the transmitter to about 10 m.

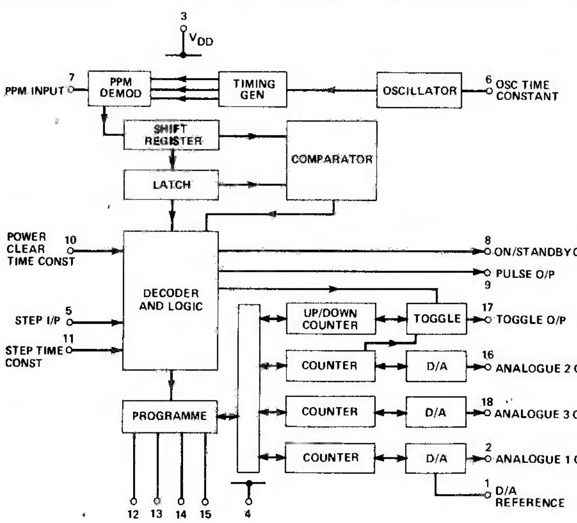

Fig. 5 Block diagram of the SL922 remote control receiver.

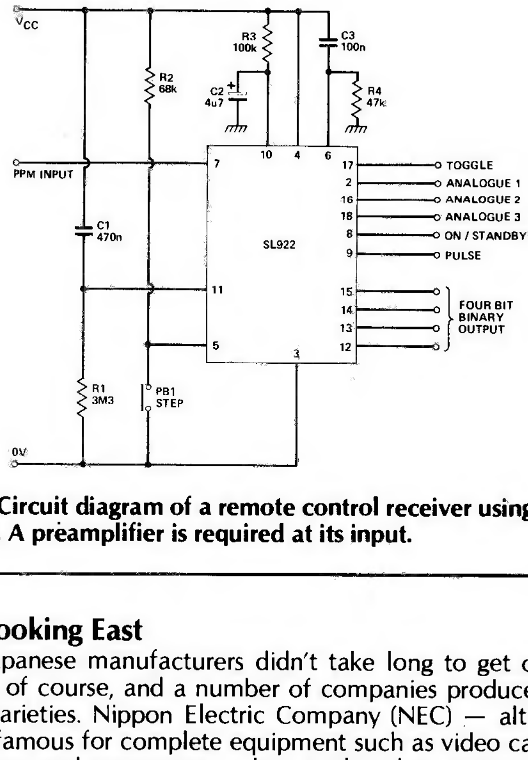

Fig. 6 Circuit diagram of a remote control receiver using the SL922. A preamplifier is required at its input.

Looking East

Japanese manufacturers didn't take long to get on the scene, of course, and a number of companies produce their own varieties. Nippon Electric Company (NEC) — although more famous for complete equipment such as video cassette recorders and computers — has produced its own range of remote control ICs which is ideal for the electronics designer.

NEC's uPD1986C is a similar device to the SL490, capable of transmitting up to 27 commands. Its block diagram is shown in Fig. 7 and you can see the IC is much simpler than the 490 and

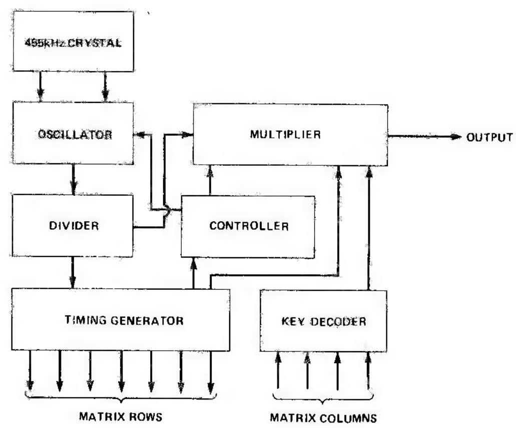

Fig. 7 Block diagram of NEC's remote control encoder — the uPD1986C.

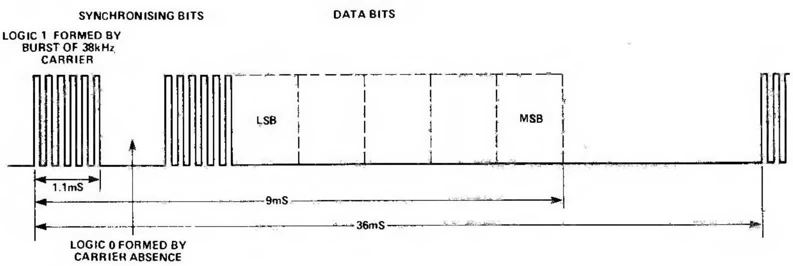

Fig. 8 The code word of the uPD1986C encoder, consisting of three synchronising bits and five data bits.

so is inherently easier to use with respect to circuit design. Standby current is low (less than 1 uA) so long battery life is obtained too.

A uPD1986C code word consists of eight bits as Fig. 8 shows. The first three bits transmitted (101) are synchronising bits to enable the receiver to detect whether a code word has arrived. A logic 1 bit is represented by a 1.1 mS burst of 38 kHz carrier with a 50% duty cycle. Logic 0 is represented by carrier absence. Thus, the IC should be usable with either ultrasonic or infra-red transducers without modification.

The remaining five bits of the code word are the data bits of the transmitted remote-control message — corresponding to the key pressed. The code word is repeated every 36 mS until the key is released.

Figure 9 shows the circuit of an 18-function infra-red transmitter circuit using the uPD1986C. Oscillator frequency is controlled by a 455 kHz crystal to give carrier and code word timing accuracy — a factor which obviously aids long-distance remote-control transmission.

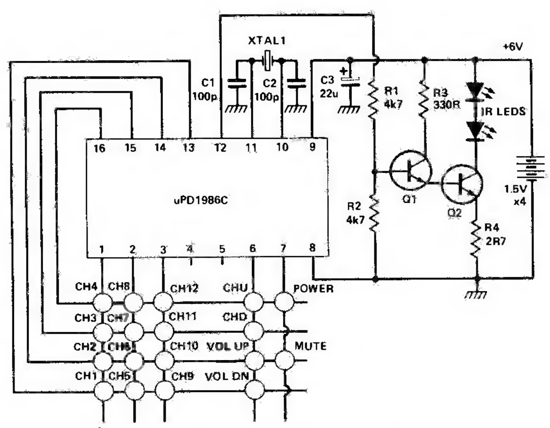

Fig. 9 Circuit of an 18-facility remote control transmitter using NEC's uPD1986C.

Reception and decoding of the transmitted code word is undertaken by the uPD1937C remote-control receiver IC. A block diagram of the IC is shown in Fig. 10, and a typical circuit using it is in Fig. 11. As with the 490/922 chip set, a preamplifier is required to detect and amplify the received low-level signal.

Input selection can be either sequential (ie stepping up or down at a fixed rate) or direct (ie straight to the required input). The output waveform for sequential input-select is shown in Fig. 12a. A sequence step-time of about 0.72 S means that it takes over 12 S to step through from input 1 to input 18. The output waveform for direct input selection is shown in Fig. 12b. The number of pulses in the shift pulse code is one less than the required input number.

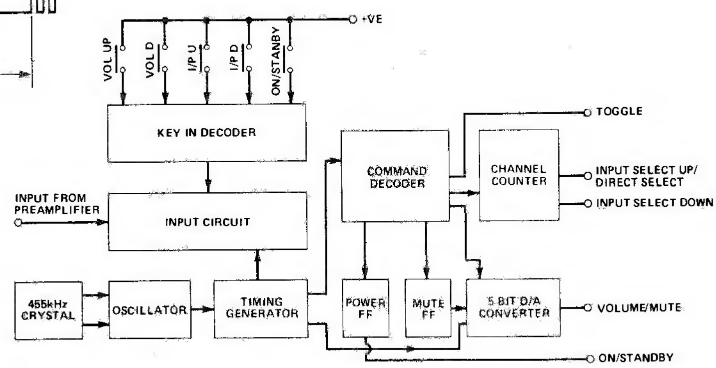

Fig. 10 Block diagram of the uPD1937C remote control receiver.

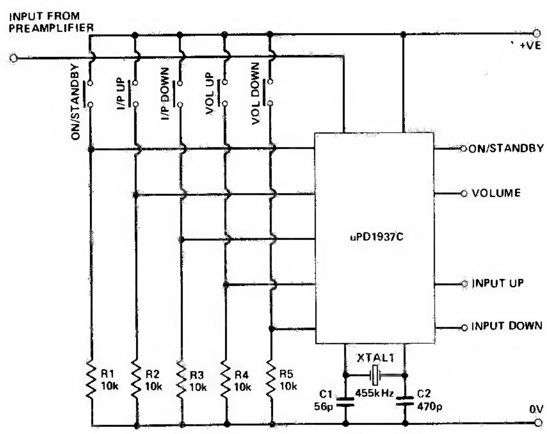

Fig. 11 A typical circuit for a remote control receiver using the uPD1937C. A preamplifier is needed at the input.

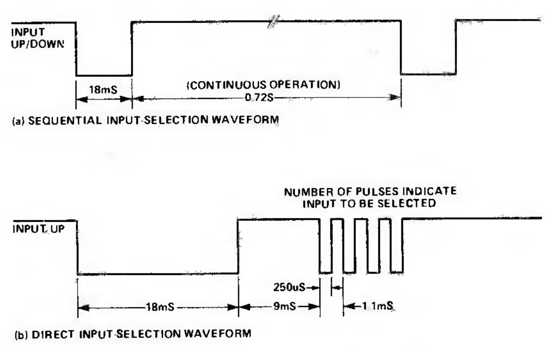

Fig. 12 (a) Sequential input select waveform, and (b) direct input select waveform of the uPD1937C remote control receiver.

These waveforms need to be interpreted by decoding circuitry so that the chosen input is switched through. A decoding interface could be easily made with a 4017 or similar counter — alternatively NEC manufacture input selectors specifically for the job. **ETI**

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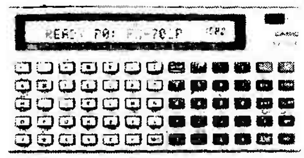

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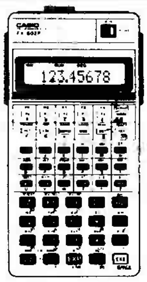

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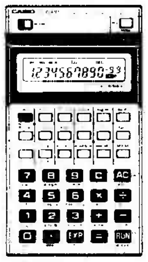

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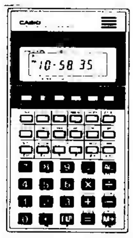

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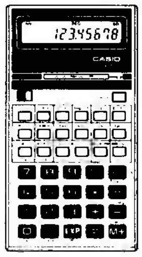

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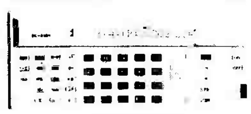

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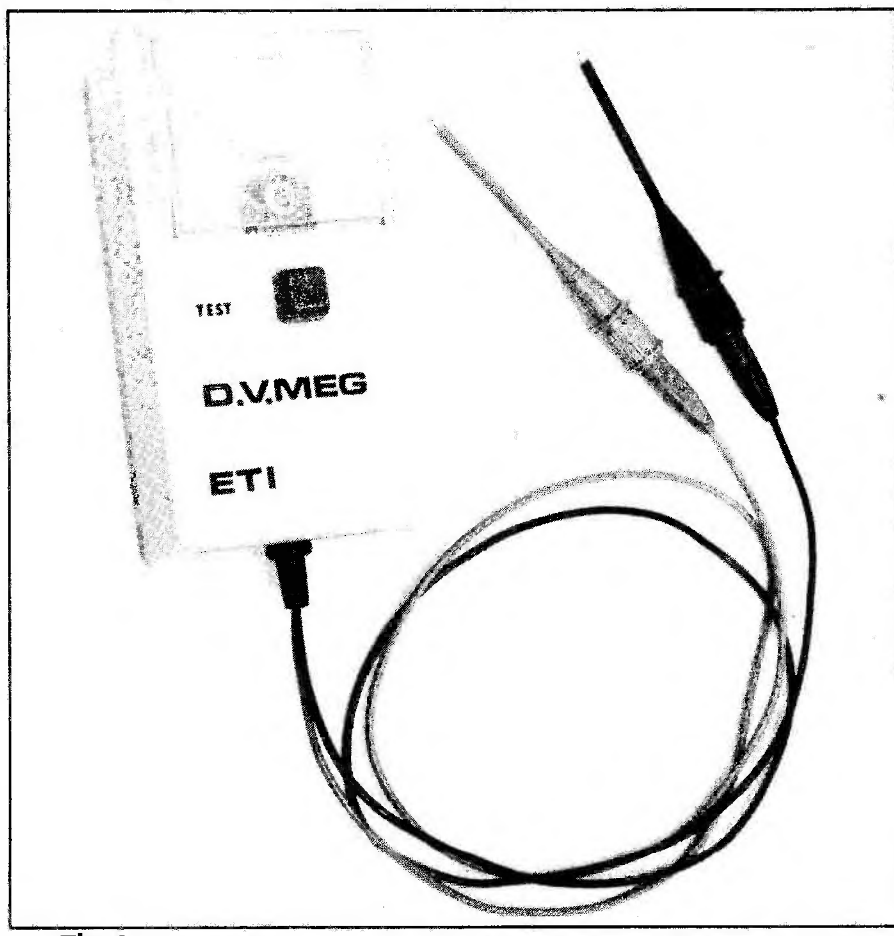
INSULATION TESTER

Some time ago we published a design for a very low resistance meter. Now we've built the DVMeg, for resistances up the other end of the scale. Design and development by Phil Walker.

The ohms range on most multimeters is fine for most electronics work but if you start dealing with hundreds rather than tens of volts then there is the possibility that damp, contaminated, or merely inadequate insulation could cause equipment failure or personal danger. In these circumstances the 1V5 or sometimes 15 V used by most multimeters is not sufficient to show up the dangers. To avoid the false sense of security which may be given by low voltage tests, a voltage somewhat higher than the normal working voltage of the circuit under test must be used. In the case of mains wiring this is often 500 V and this is about the level generated by our project. D is the Roman numeral for 500 and the instrument measures in the megohm range — hence the name, DVMeg.



HOW IT WORKS

When the device is turned on, Q2 will start to conduct due to current flowing via L1a and R1 into its base. This causes the supply voltage to appear across L1b, which by transformer action increases the voltage (and current) available in Q2's base circuit. This ensures that Q2 will be held on during this part of the cycle.

As L1 is an inductance and the voltage across it is by now fairly constant, the current flowing through it will rise linearly. However, the current also flows through R3, causing a voltage to appear across it which is proportional to the instantaneous value of this current. When the voltage across R3 becomes large enough, Q1 is turned on and robs Q2 of its base current. Q2 promptly turns off and its collector voltage rises sharply. This rise is coupled back to Q1 base via C2 to keep Q1 on during this period. At the same time, the voltage across L1c will be in a direction such that D3 conducts and charges C3. A short time later Q1 will turn off as it has no base drive once C2 is charged, and Q2 will turn on to start another cycle. D2 provides a discharge path for C2 at the start of a cycle as Q2 turns on.

If when C3 is being charged its voltage exceeds about 500 V, the voltage across L1a will be greater than the supply (due to transformer action with L1c) and D1 will conduct, diverting the excess energy back into C1 and the battery. The 500 V on C3 is applied via R5 to the circuit under test. The resulting current then passes through D5 in parallel with M1 and PR1. D4 provides protection if the probes are accidently connected to a live circuit, while D5 protects the meter from excess current and also modifies its response.

R4 in the high voltage section ensures that the output voltage dissipates quickly when the instrument is turned off.

The Instrument

The project is designed to use a standard PP6 9 V battery and contains a low power DC-DC converter to produce an output of about 500 V. This output is limited so that it does not rise too much even when off-load. The output current is also limited; about 500 uA maximum, even when short-circuited. Even so IT BITES! — so be careful!

In use the test leads are connected to the circuit under test and when the button is pressed, the circuit generates a high DC voltage which is applied to the test leads via a 1M0 resistor. The resulting current through the insulation is monitored by the meter and displayed as a resistance. When the button is released, the internal capacitor and the circuit under test are discharged fairly rapidly to avoid the risk of shock.

Construction

The coil is constructed using a

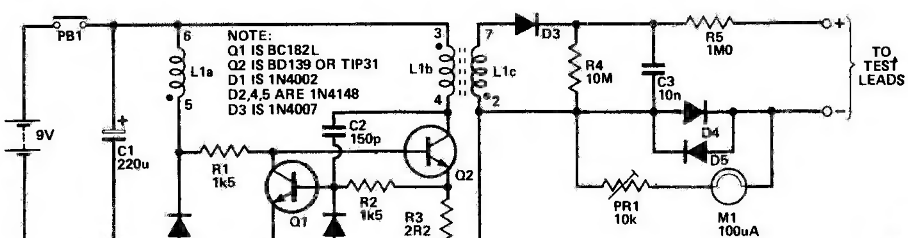


Fig. 1 Circuit diagram of the DVMeg insulation tester.

Neosid potcore. Wind 220 turns of 40 SWG enamelled copper wire on to the former in four layers; start at pin 2 and finish at pin 7. Each layer should be about 55 turns and as this is less than the width of the former, the space each side should be filled with a single layer of insulating tape 2-3 mm wide. A layer of tape the width of the former should be laid on top of each winding. Next wind on 22 turns of 32 SWG enamelled copper wire starting at pin 3 and finishing on pin 4. Insulate this as before and then wind another four turns of the same wire starting at pin 5 and finishing at pin 6.

Construction of the circuit board should pose no problems so long as component polarities are observed. The wires to the test probes should be flexible and well insulated.

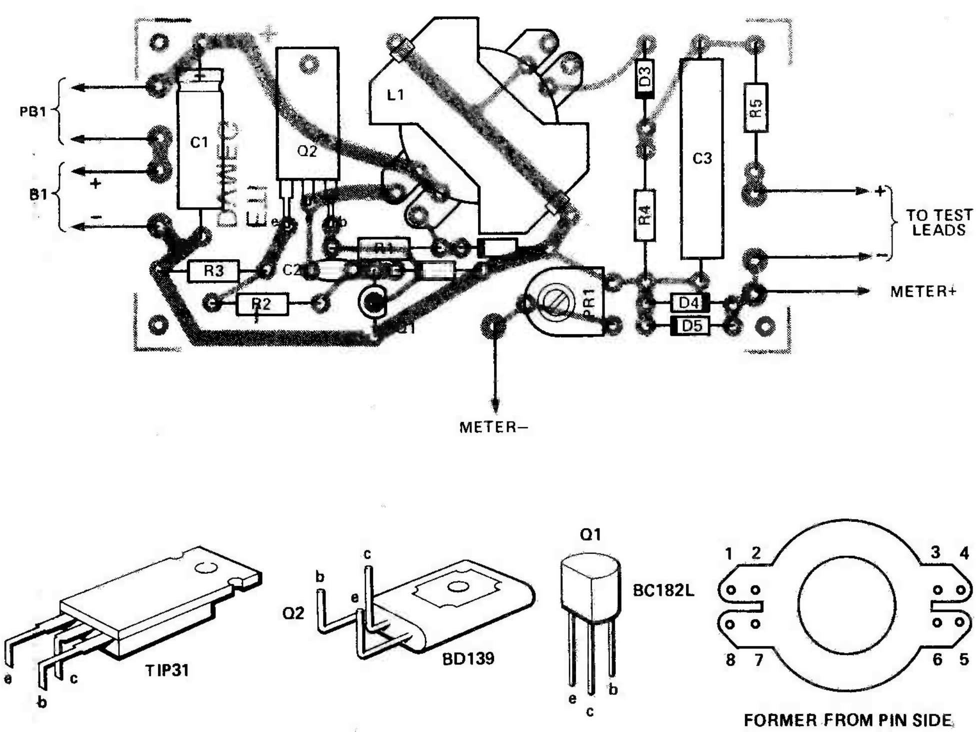
The two types of transistor specified for Q2 have different connections, so the TIP31 must be mounted 'upside-down' if used (see diagram).

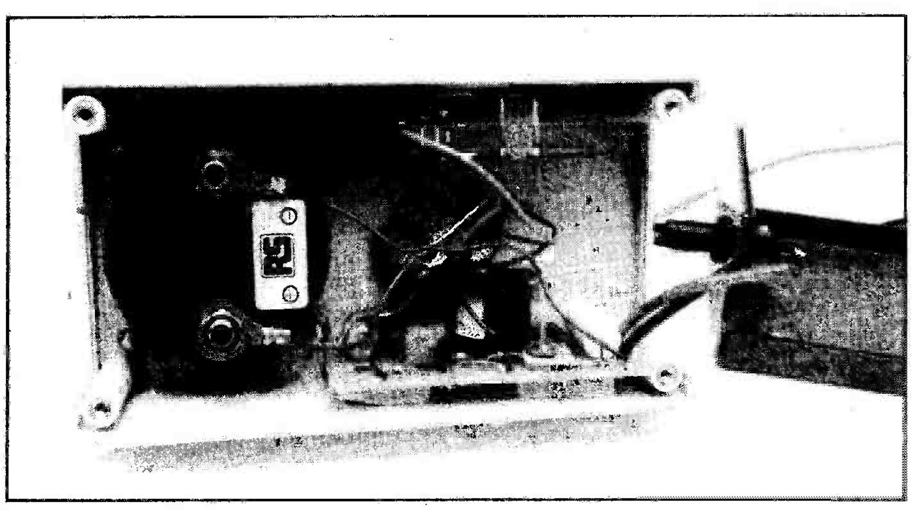
Installation into the box is also fairly simple. The meter is fitted at one end of the box lid and the push-button just below it, but a little to one side to allow the battery to fit inside the case. The circuit board is stuck or bolted to the inside of the case lid and the battery leads connected via the switch. The meter leads are also connected, after which the battery may be connected and fixed into place with sticky pads or wedged with foam.

PS

It also tests neons!

Fig. 2 Component overlay and component pinouts for the DVMeg.





PARTS LIST

Resistors (¼W 5% except where stated)	
R1,2	1k5
R3	2R2
R4	10M ½W
R5	1M0 ½W
Potentiometer	
PR1	10k miniature horizontal preset
Capacitors	
C1	220u 16 V axial electrolytic
C2	150p 160 V ceramic
C3	10n 1000 V mixed dielectric
Semiconductors	
Q1	BC182L
Q2	BD139 or TIP31
D1	1N4002
D2,4,5	1N4148
D3	1N4007
Miscellaneous	
L1	RM10 pot-core, former, clips (A_l about 400)
PB1	push-to-make non-latching
M1	100 uA meter

PCB (see Buylines); case (West Hyde ref. BOC440); grommet; flexible wire; test prods; PP6 battery and connectors.

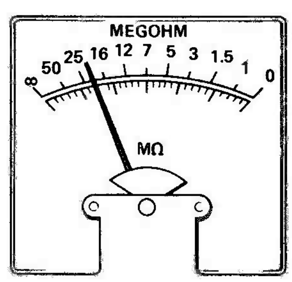


Fig. 3 A suitable meter scale.

BUYLINES

The pot core used to wind the inductor for this project is available from Neosid Small Orders, PO Box 86, Welwyn Garden City, Herts AL7 1AS; quote ref. 29-835-41 when ordering. West Hyde supply the case we used; for people who want to use substitutes the size is 150 x 80 x 55 mm. The PCB can be obtained using the order form on page 45.

ETI

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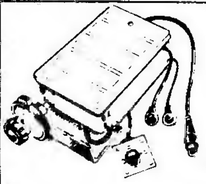

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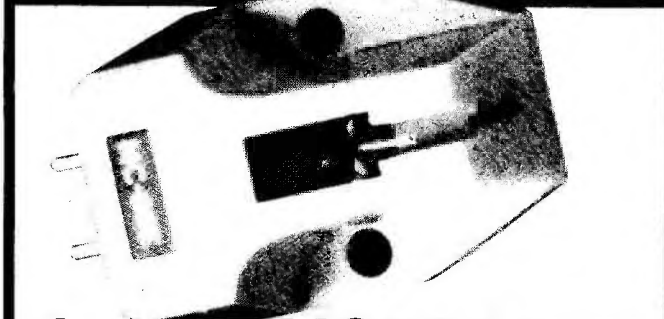

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PRIZE CROSSWORD

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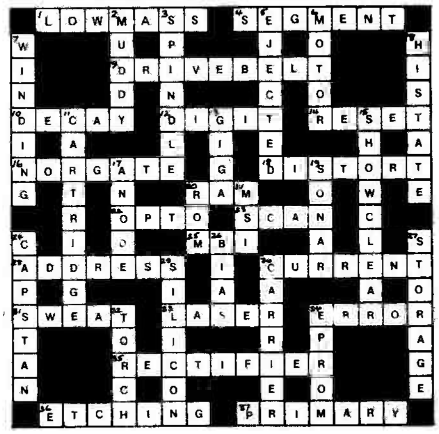
Time once again for our every-alternate-month stretching of your brains — the ETI Prize Crossword. Many of you obviously found Crossword No. 2 more difficult than the first one, since few readers were able to complete it correctly; but of those that did, the following three were picked out as our prizewinners:
FIRST PRIZE: H.R.W. Thurlow, Gravesend
SECOND PRIZE: A.M. Tucker, Dorchester
THIRD PRIZE: Nicholas Brasier, Frimley Green
Congratulations to them, and good luck to everyone who enters for Crossword No. 3; hopefully we've made it less obscure!

LAST MONTH'S SOLUTION

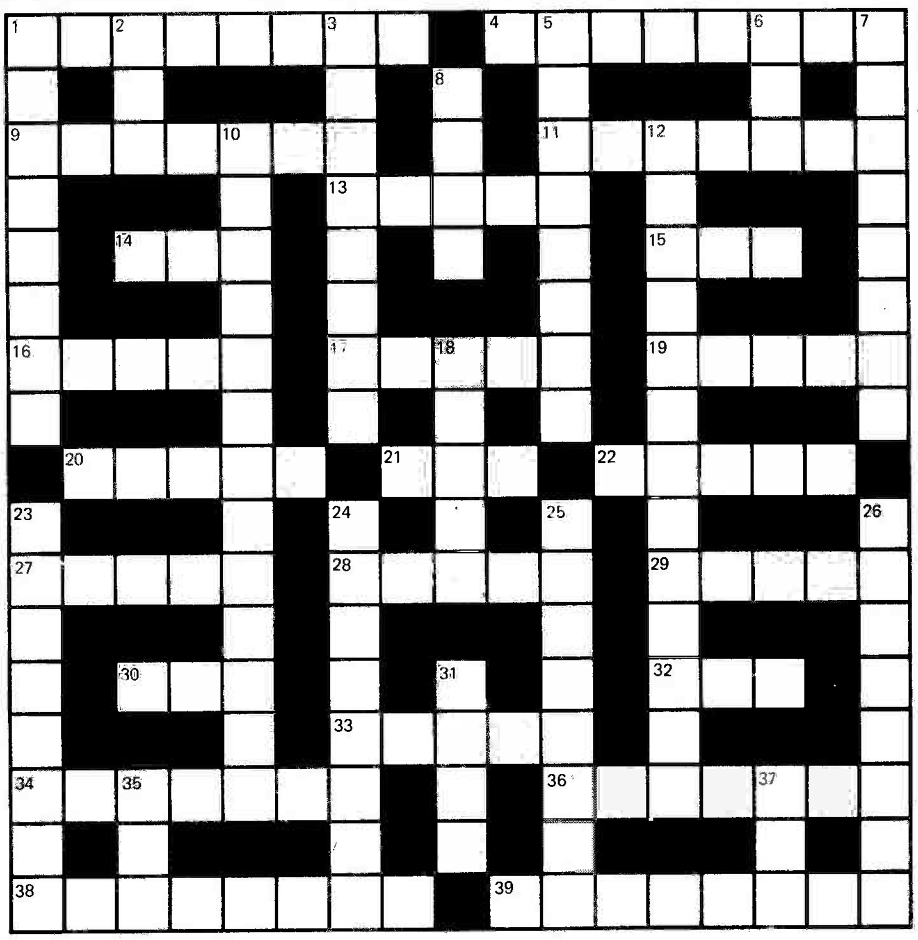


ACROSS

1. Switching device from RX to TX. (8)
4. Rotating member in the motor. (8)
9. 'Son of Crystal'. (7)
11. Roman numeral shapes up for a trip. (7)
13. Short magazine has centre spread between I and E to get picture. (5)
14. The initial effect on transistor by farmer's land. (3)
15. The right place for electronic discharge. (3)
16. Backwards or forwards it indicates the same. (5)
17. Something more than an ordinary BC182. (1,4)
19. Signal selector. (5)
20. West, central in twisted rope. (5)
21. Fix the result — Good Buddy! (3)
22. Timely happening. (5)
27. Re-organise magnetic formation. (5)
28. Airborne beacon electronic test set — may help initially. (5)
29. Unit of luminous flux. (5)
30. Broken cart — ideal vision. (3)
32. Perhaps an about turn would change a short sagging economy ready for inflation. (3)
33. A symbol no good ohm should be without! (5)
34. Reagan changes tune about radioactive weapon. (7)
36. Used by Ken Dodd to trigger laughter? (7)
38. Port side, one of a disc jockey's pair. (4,4)
39. Rest period for computers. (4,4)

DOWN

1. 10-1 your ears may ring at these excessive levels. (8)
2. Precisely the right approach for golfers when using radar. (3)
3. Go east, go north, then round and round. (8)
5. Found in radio cabin and Laker Airlines! (8)
6. The French are crazy about celestial visitors. (3)
7. Computer's credit card — not this side of the channel. (8)
8. Twice as good as stereo. (4)
10. Fortune finder? (5,8)
12. Backward thinking? (8,5)
18. Vertical reference. (1,4)
23. Trim Lane roundabout for meeting point. (8)
24. Hurt coin produces second wave attack. (8)
25. Floating input may be lonely. (8)
26. Mixed hen cargo — great top-up! (2,6)
31. Highest point of AC cycle. (4)
35. TV or not TV, that is the answer. (3)
37. Large Scale Integration. (3)



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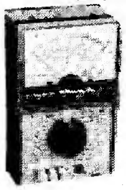

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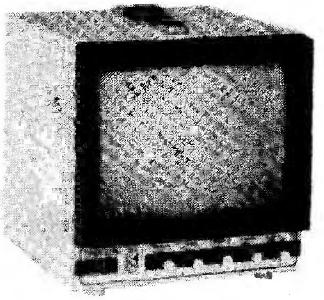

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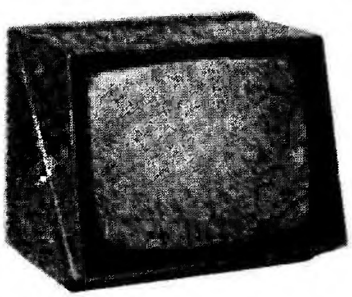

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4049	28p
4050	28p
4051	62p
4052	62p
4053	62p
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LS92	42p
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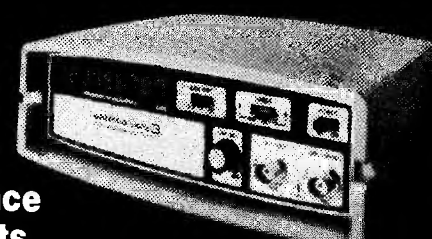

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SLOT CAR CONTROLLER

Some spare cash and an idle Saturday afternoon led into the labyrinthine world of slot cars. The basic slot car set is so basic that we decided to improve it, and this project is the result. Design and development by Jonathan Scott.

Well, let's not beat about the bush. Slot cars are fun. The genesis of this project was the purchase of a cheap set and the realisation that there was much room for improvement in the whole thing, especially the 'electronics'. Since then, we have built several controllers, purchased an alarming length of track, bought and modified many controllers and cars, and generally had a load of fun!

In the course of this research, use has been made of calculators, programmable calculators, desktop computers, plotters, engineering degrees, physics degrees, computer science degrees, a mound of components, a lot of paper and a *hell* of a lot of electricity — so be warned that one can get pretty involved. Closet racers, prepare for exposure!

The Ultimate Controller

If you're after something really exciting, then this is it — but it's not a project for beginners. The controller gives independent supplies for each lane and can operate in voltage and current modes; it can handle a wide range of maximum torques on sets of 4V5 to 12 V rating.

For superior performance, the controller has several 'extras'. First, there is *fuel tank simulation*; this means that the control box has a meter which represents fuel in the car. A button 'refuels' the car, provided it is stationary. When it has petrol, you can go again. As the petrol is used up the car gets more acceleration, corresponding to the 'reduction in weight'. The degree of the effect is presettable by a resistor (R7 — or R107 for the second car). It is rather exaggerated with the value given, but this is more fun. Of course, if you run out of fuel, the car slows down and finally coughs to a stop.

Next, the project offers *controlled overshoot*. If the output momentarily exceeds the level that your hand controller commands, the car responds more 'snappily'. This accelerates it a bit harder at first, corresponding to 'dropping the clutch', and brakes hard when it is slowing down corresponding to hard braking. You can even lock up, if you are too hasty!

The controller also informs you if it is folding, such as when the track is short-circuited. In the current mode, it warns of open circuit as well. It does not load the hand controller rheostats, as they do not carry the car current. (In some sets the controller handsets get very warm.) The controller is, of course, short-circuit protected.

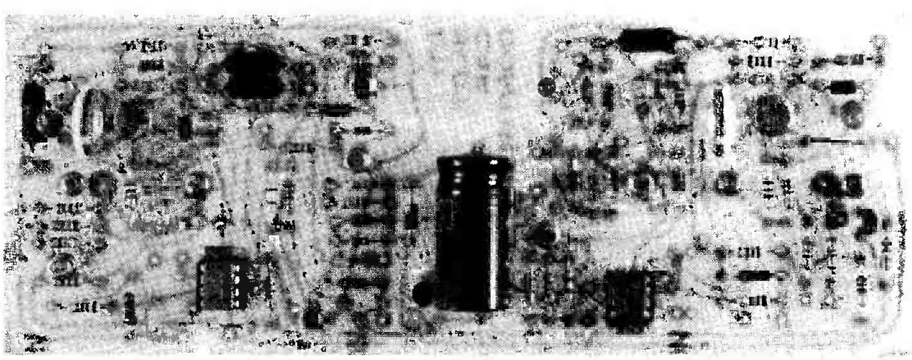
The two modes, current and voltage, each offer their own advantages. Current mode gives torque proportional to control depression, as torque is proportional to current. It has slower take-off and generally sloppier (though perhaps more realistic) operation. It is also more immune to bad contact in the track and brushes, if you are having trouble in that direction. Voltage mode, which we prefer, gives a very tight control with a snappy response from the car; perhaps less realistic, but more fun. It seems to demand more from the drivers, though performance is considerably superior.

Construction

Construction of this unit is fairly flexible and will depend somewhat upon how you plan to house the unit. It is advisable to use a fairly spacious housing as this demands less careful layout and allows easy access for adjustment or debugging. The only requirement for the case is that if you are using our PCB the meters must be spaced horizontally by the required amount, as the board mounts on the meter terminals.

First step in the construction is to drill the case and panel. Note that the power supply transformer and rectifier-filter components are not included on the PCB and are mounted on the case in a convenient position. You will have to position these components so that they do not foul any other components, and drill the case to suit. The power supply components are mounted off-board for a number of reasons. First, they are bulky and would add seriously to the PCB size and the space needed for it, and second, it means that a set of higher current capacity diodes and a higher VA-rating transformer may be used for powering more than two lanes. A 40 VA transformer will power two lanes, a 60 VA will power up to four lanes.

We found it convenient to mount



The slot car controller board before interwiring.

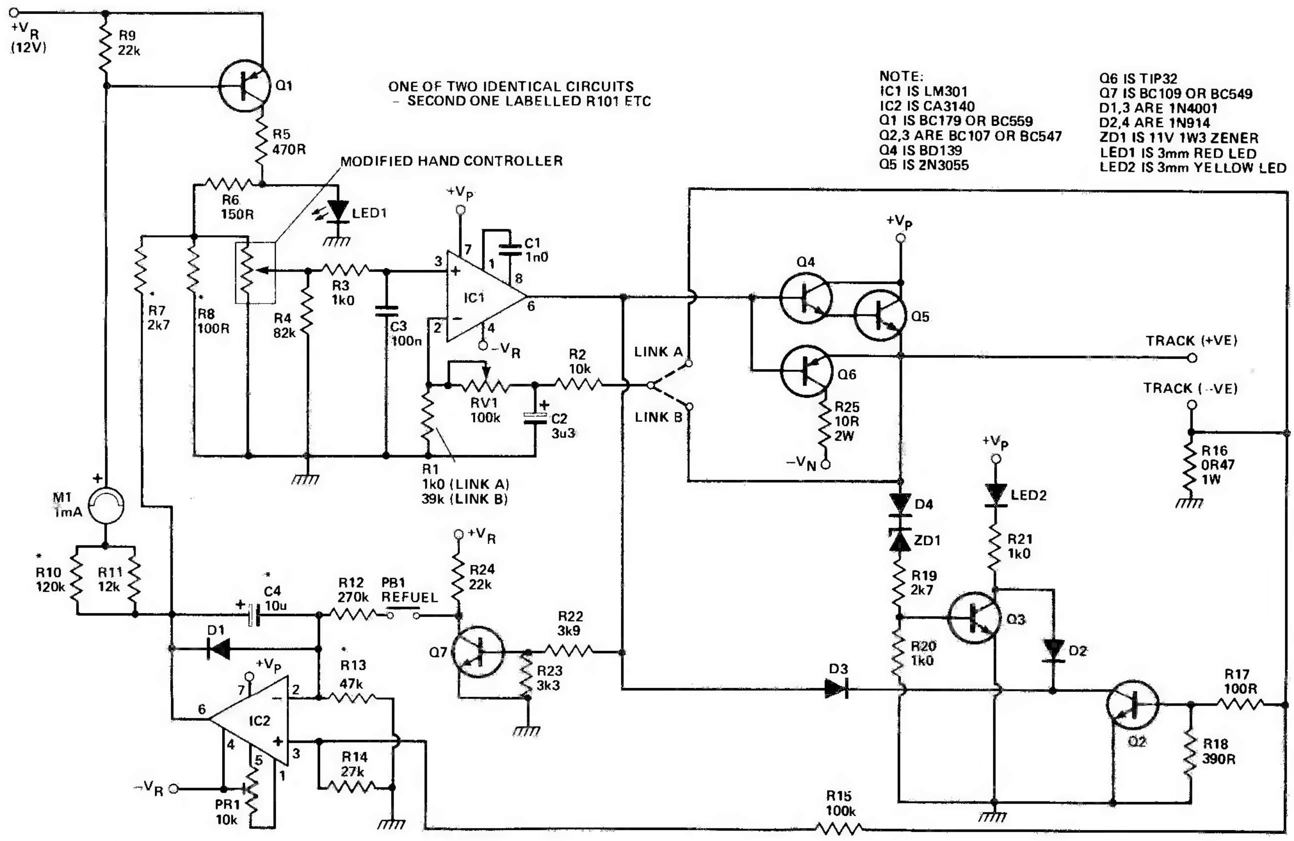


Fig. 1 Circuit diagram of one channel of the controller.

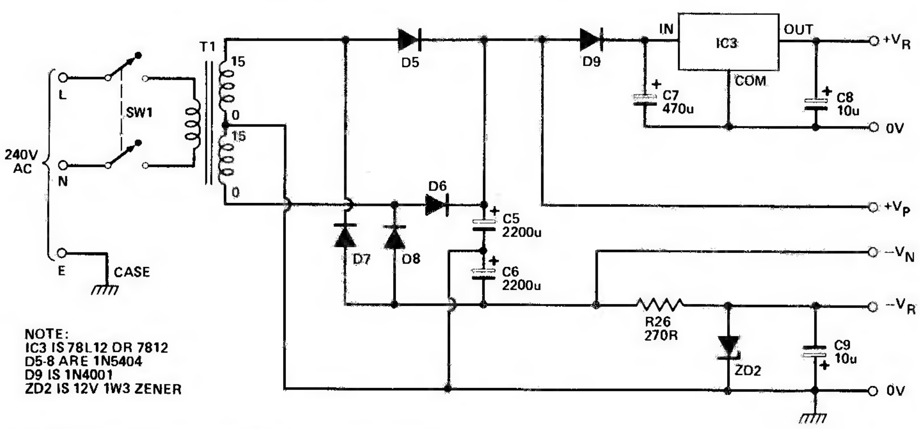


Fig. 2 Circuit diagram of the power supply.

the mains supply terminating block, cable clamp (or clamp-grommet), output terminals and presettable pots (RV1, RV101) on the rear panel of our box. We used ordinary potentiometers for RV1 and RV101, rather than preset types, cut the shafts short and cut a slot in the end of the shafts. To avoid fouling other components, mount the pots so that they are below the height of the transformer.

Next, prepare the front panel. Drill it first, locating the meter holes carefully as the PCB determines their spacing. For panel marking we used rub-down lettering (such as Letraset, etc) put directly on the panel after cleaning it.

Apply a spray-on lacquer to protect the panel markings. With this job finished, fit the meters, LEDs, and so on. Finally, drill the mounting holes for the power transistors, which are mounted off the board. These dissipate little heat so they merely need mechanical support.

The next step is to assemble the components to the PCB. As there are quite a few flying leads, it may pay to use pins for the termination of these to the board. Pay attention to all the usual details — orientation of tantalum and electrolytic capacitors, orientation of semiconductors, etc. Choose the components in Table 1 to suit your requirements, according to the instructions given with the Table. When all the components are soldered in place, fit the flying leads to the LEDs and push-buttons which are mounted on the front panel, along with the meters. These can be secured and the PCB bolted to the meter terminals before the leads to the main case are fitted. Be sure that all flying leads are long enough to allow the box to be fitted together and dismantled without straining the connections. Long leads can be kept neatly 'loomed' with plastic sleeving slipped over a bunch before one group of ends is terminated.

Assemble the transformer, power supply components and potentiometers in the case next and wire them up. Take particular care with the mains wiring. The rectifier components are supported on a tagstrip and we'll leave the wiring details to you for this one.

The final step before testing is to modify the hand-held controllers from rheostats to true potentiometers. Open up the case of a controller and you will find that it consists of a short coil of resistance wire wound on some sort of former, with a wiper contact which moves along the coil according to how far the thumb or finger control is depressed. When fully released, the wiper rests in a position where it does not touch the coil. There will be two wires coming from the hand controller — one leading to the wiper and one from an end of the resistance wire. It is

HOW IT WORKS

The unit comprises a power supply, a control section (involving IC1), a driver circuit (involving Q4, 5 and 6) and associated components), an overload protection and warning circuit (Q2, 3 etc), an 'electronic fuel tank' (Q1 plus IC2 and associated components) and a 'refuel' circuit (Q7 etc).

The circuit has two modes of operation — voltage and current. The mode to be employed is selected by means of a link on the PCB. In the voltage mode, the hand controller sets the voltage delivered to the track (and thus the slot car's motor). In the current mode the hand controller sets the current delivered to the car's motor via the track. In either mode, a potentiometer (RV1) sets the maximum value of the voltage or the current.

POWER SUPPLY

Transformer T1 has two 15 V (RMS) secondaries, connected in series. There are two rectifier circuits — one to provide a positive supply rail, the other to provide a negative supply rail. The joining of the two secondaries provides a 0 V connection.

Diodes D5-D6 and capacitor C5 provide a nominal +21 V supply rail ($+V_P$) while D7-D8 and C6 provide a nominal −21 V supply rail (V_N). From these two rails +12 V and −12 V regulated rails are derived. The +12 V rail is achieved by IC3, a three-terminal positive supply regulator (a 7812 or 78L12). This rail is used as a reference for the hand controller and metering crcuit. Capacitor C8 ensures high frequency stability for the three-terminal regulator and acts as a supply rail bypass. The −12 V rail is derived by a simple zener circuit involving R26 and ZD2. C9 is a supply rail bypass. The negative rail is limited to 12 V so that the maximum supply voltage limitation of the op-amps, which is about 36 V, is not exceeded.

CONTROL SECTION

This centres on IC1. A certain current (which we will discuss in detail a little later) is passed through the hand controller resistance. This develops about 200 mV drop across it. Thus, when the hand controller is operated, a voltage ranging between 0 and 200 mV is applied to pin 3 of IC1, the précise voltage depending on how far the 'driver' has depressed the controller lever. C3 smoothes out any variations — many hand controllers have momentary loss of contact between the wiper and the resistance as the wiper traverses the resistance element. You may need to vary the value of C3 according to how coarse the resistance variation happens to be in your controller. For the inexpensive controllers — which are really quite adequate despite the coarse variation they provide — a value of 470nF to 1uF is suitable.

Now, IC1 attempts to drive its output (pin 6) in such a fashion as to induce the same voltage on its inverting input (pin 2) as is on its non-inverting input (pin 3).

In the voltage mode, pin 2 of IC1 is connected via RV1, C2 and associated components to the positive track terminal so that the position of the wiper on the hand control resistance sets the output voltage. In the current mode, pin 2 of IC1 is connected to the end of the 'current sense' resistor (R16) so that current is defined by the position of the wiper on the hand controller resistance.

In either mode, RV1 — which is in series with the negative feedback path — in conjunction with R1 sets the maximum voltage or current delivered to the car's motor via the track. C2 induces some 'overshoot' in the feedback which enhances acceleration and braking according to controller movement.

DRIVER

The driver circuit comprises Q4, Q5 and Q6 plus R25. Its function is merely to amplify the current delivered from the output of IC1.

Transistors Q4 and Q5 are connected as a Darlington pair which provides considerable current gain (the beta of Q5 is multiplied by the beta of Q4). The output of IC1 (pin 6) swings positive during acceleration (depressing the hand controller lever) and Q4-5 amplify the current, the emitter of Q5 being connected to the track positive terminal. Q6 is reverse biased during this time. During braking, pin 6 of IC1 can go negative (particularly if you 'drop' the hand controller lever). This reverses the voltage delivered to the track or reverses the current flow (depending on which mode you're employing). When this occurs, Q4 and Q5 are reverse biased and Q6 is forward biased — and it amplifies the negative excursions from pin 6 of IC1.

The function of R25 is to protect Q6 against momentary current overload.

PROTECTION

The protection circuit involves Q2, Q3 and associated components. If the voltage output to the track exceeds about 13 V, ZD1 and D4 conduct, forward biasing the base of Q3. When Q3 turns on, it draws collector current via LED2 and R21. LED2 lights, providing warning of a fault. If the output current exceeds about 1A5 the current through R16 (which is in series to the supply to the track) induces a voltage drop across it of about 0V7 or so and this forward biases the base of Q2 via R17 and R18. Q2 thus turns on and it draws collector current via D2, R21 and LED2. However, the collector voltage of Q2 will be around a few hundred millivolts and the output of IC1 will be shunted to the 0 V rail via D3 and the collector-emitter junction of Q2.

Thus, you receive a warning of supply overload and the supply, track etc., is protected against overcurrent damage.

FUEL TANK

The 'fuel tank' is simulated by IC2 and associated components. This op-amp is connected as an integrator. A 'full' tank corresponds to 0 V on the output of IC2, an 'empty' tank to about 12 V. As current flows through the load (car motor), and hence via R16, a voltage is dropped across R16. This voltage is integrated by IC2 which has an RC network (R13-C4) in the feedback loop. As more load current is drawn, pin 6 of IC2 rises towards 12 V.

The meter, M1, indicates the output voltage of IC2 and is marked like a fuel gauge. While the fuel tank is full or partially full, the current through M1 flows via the base of Q1, forward biasing it. Thus, Q1 is held on while this current flows. The collector current of Q1 flows via LED1 (the hand controller and associated resistors). LED1 lights, indicating you have fuel in the tank. When the fuel 'runs out', pin 6 of IC2 is at 12 V and no current flows through M1; thus the base of Q1 receives no bias and it turns off. LED1 extinguishes at this stage and no voltage is delivered to the hand controller. IC1 interprets this as if you have the controller set to the rest or off position and no power is supplied to the track. Your car stops. . .

The 'capacity' of the fuel tank is defined by the values of C4 and R13. The values shown give a 'full tank' of about 60 amp-seconds — which corresponds to about 30 rapid laps of a 2½ metre long track in 1/64th scale. The values of C4 and R13 may be varied to suit your taste, as indicated in the table on page 33.

While there is fuel, LED1 is on and its terminal voltage is about 1V7. This voltage permits about 10 mA to flow through the resistance of the hand controller via R5. (Recall we have yet to see what its current is.) In addition, R7 permits some current to flow into the controller — generally between 0 and 5 mA — from pin 6 of IC2. This current increases as fuel is 'used up', corresponding to the car getting lighter, and you get more acceleration at any particular hand controller setting as you 'use up' fuel. R7 defines how much more acceleration is obtained when the car is 'lighter'.

When the fuel runs out and Q1 turns off, the current delivered through R5 to the hand controller plummets and only the 5 mA flowing via R7 is available. This gives a 'soft' end, allowing you to limp to the pits — if you aren't too far away on the track.

The parallel combination of R8 and the hand controller should be around 15 ohms. If your controller has a high resistance, or you want to substitute a 1k0 wirewound pot, for example, R8 should be derived from the following formula:

$$R8 = \frac{R_{CONTROLLER} \times 15}{R_{CONTROLLER} - 15}$$

REFUEL CIRCUIT

'Refuelling' is effected by PB1 and Q7. When the car motor is not drawing power, the output of IC1 is low (less than one volt) and thus Q7, which derives its base bias from pin 6 of IC1, is off. Pressing PB1 connects R12 to the +12 V rail via R24 and IC2 will discharge C4. The output of IC2 will drop to 0 V (which is the 'tank full' condition). Q1 will turn on again and current will be supplied to the hand controller circuit. When you power the car again, the voltage on pin 6 of IC1 will rise, the base of Q7 will be biased on and its collector will draw current via R24. Thus, if you try to 'top up' while the car is in motion, R12 will be virtually connected to the 0 V rail via the collector-emitter junction of Q7 and you won't be able to drive the output of IC2 low. In addition if you attempt to drive the car while refuelling, the refuelling action will be stopped by the same means.

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necessary to have a third contact, connected to the other end of the coil (the end without a connection). Remove the existing wires (some of these have considerable resistance themselves) and fit the two new wires, then the third. These run to the controller unit. Make sure you have plenty of length to play with. Now reassemble the hand controller, being careful to tie off the wires in the same way the original two were secured.

You should now be ready for a test run.

Test Run

Make up a simple circle of track. On powering up, the car should work to some degree. If not, stop and recheck. Once it works it is necessary to adjust the presets and so forth. PR1/101 should be adjusted to minimise 'fuel tank' circuit drift in the absence of power being delivered. (These are the integrator offset adjustments.) At this stage it is probably worth assembling the unit

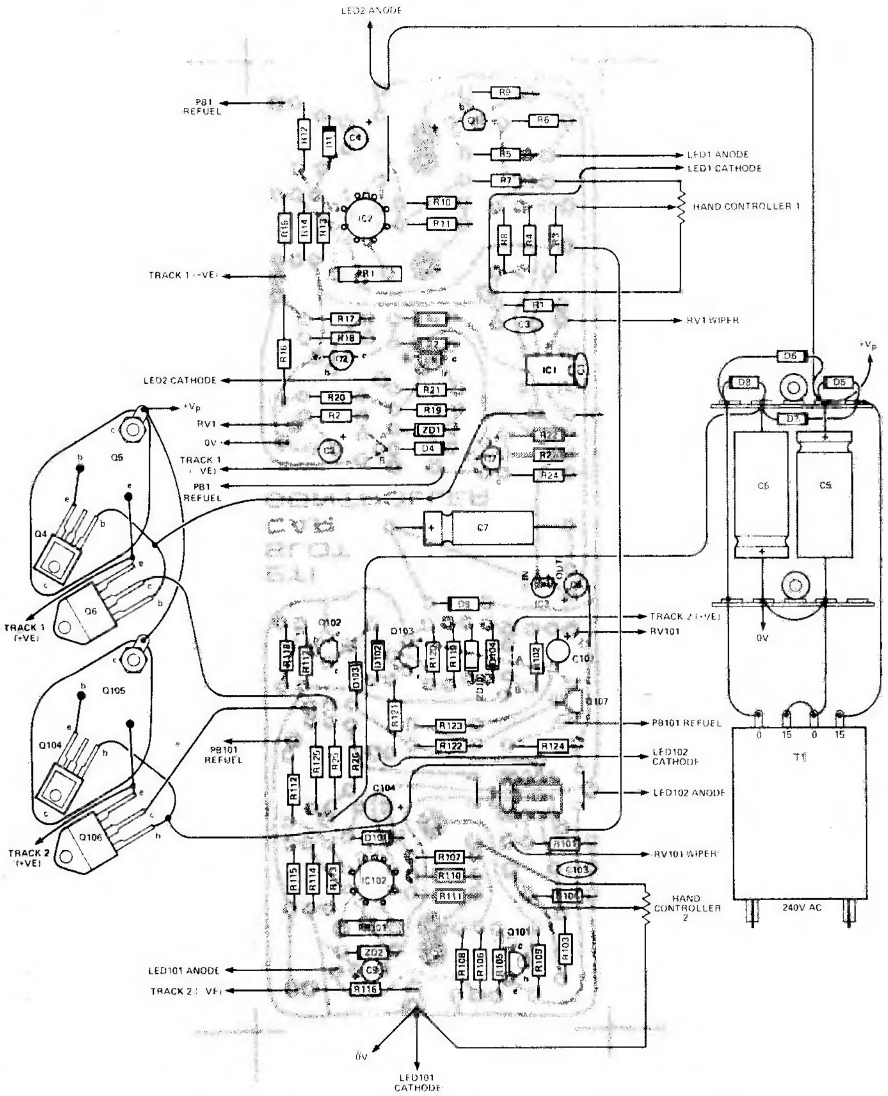


Fig. 3 Component overlay and interwiring diagram for the ETI Slot Car Controller. Note that we mounted three of the transistors for each channel on the case itself, and that some of the power supply components are mounted separately on a piece of tagstrip. The board itself is fastened to the front panel by means of the meters, which are bolted directly to the PCB (you can see the bolt heads in the photo on page 79). A choice of mounting pads is provided to allow for different meter dimensions — most 2" panel meters should fit, but check before buying.

TABLE 1

COMPONENT	NOMINAL VALUE	FUNCTION	HOW TO VARY IT
C4 (C104)	10u	Sets fuel tank capacity.	Increase its value to increase fuel tank capacity. Range: 10 to 47u.
R13 (R113)	47k	Sets fuel tank capacity, along with C4.	Increase its value to increase fuel tank capacity. Range: 10k to 100k.
R10,11 (R110, 111)	120k in parallel with 12k	Calibrates M1 for full scale deflection at 'full tank' status; allows other meter FSD values to be used.	Reduce R10 to increase reading. Choose R10/R11 to give value according to $11.4/I_{FSD}$. This should not need much adjustment if a 1 mA meter is used.
R7 (R107)	2k7	Sets the variation of engine power with remaining fraction of fuel.	Reducing R7 gives a greater gain in power as the fuel runs out. Range: 2k2 to 22k.
R8 (R108)	100R	Sets the effective controller resistance to about 15 ohms.	Choose R108 so that R8 in parallel with the controller resistance gives a combined resistance of 15 ohms.

PARTS LIST

Resistors (all ¼ W, 5% except where stated)

R1	1k0 (link A), 39k (link B)
R2	10k
R3,20,21	1k0
R4	82k
R5	470R
R6	150R
R7	2k7*
R8	100R*
R9,24	22k
R10	120k*
R11	12k
R12	270k
R13	47k*
R14	27k
R15	100k
R16	0R47, 1 W
R17	100R
R18	390R
R19	2k7
R22	3k9
R23	3k3
R25	10R, 2 W
R26	270R

Potentiometers

RV1	100k linear
PR1	10k miniature vertical preset

Capacitors

C1	1n0 ceramic
C2	3u3 10 V tantalum
C3	100n polyester
C4	10u 16 V tantalum
C5,6	2200u 25 V axial electrolytic
C7	470u 25 V axial electrolytic
C8,9	10u 16 V tantalum

Semiconductors

IC1	LM301
IC2	CA3140
IC3	78L12 or 7812
Q1	BC179 or BC559
Q2,3	BC107 or BC547
Q4	BD139
Q5	2N3055
Q6	TIP32
Q7	BC109 or BC549
D1,3,9	1N4001
D2,4	1N914
D5-8	1N5404
ZD1	11 V, 1W3 zener
ZD2	12 V, 1W3 zener
LED1	3 mm red LED
LED2	3 mm yellow LED

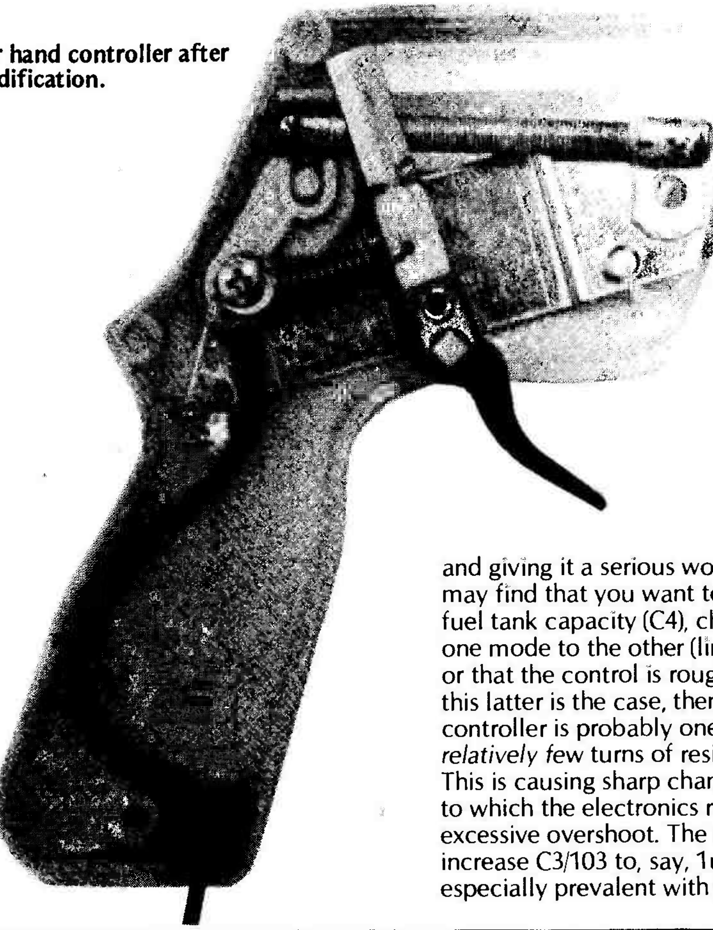
Miscellaneous

T1	0-15-0-15 40 VA transformer (or 60 VA)
SW1	DPDT mains-rated toggle switch
PB1	momentary action push-button
M1	1 mA FSD meter

PCB (see Buylines); case to suit (see Buylines); tagstrip; terminal block; mains cord and plug; clamp grommet; mounting hardware etc.

NOTE
The controller circuit is duplicated for the second track, so you will require two of each component with the exception of R26, C5-9, IC3, D5-9, ZD2, SW1 and T1. Components for the second controller are designated R101, C101, D101 etc.

*Components marked with an asterisk may need alteration to suit your particular requirement (see text).



Our hand controller after modification.

BUYLINES

There should be no problems obtaining any of the components used in this project. Note, however, that the PCB is laid out to accept TO5-packaged CA3140s — not the DIL type — so make sure you buy the correct ones. The case we used is one from the Vero range, order no. 65-2523E, but any similar-sized one will do (about 220 x 156 mm). The PCB can be obtained from us at a cost of £3.72 by filling in the order form on page 45.

and giving it a serious workout. You may find that you want to increase the fuel tank capacity (C4), change from one mode to the other (links A and B) or that the control is rough or jittery. If this latter is the case, then your controller is probably one with *relatively few* turns of resistance wire. This is causing sharp changes in level, to which the electronics respond with excessive overshoot. The cure is to increase C3/103 to, say, 1uF. This is especially prevalent with the cheap, 6 V operated sets. After you have had a while in the seat, remove the front panel and alter the appropriate components (marked with an asterisk) in order to produce the effects desired. To find out what these are, consult Table 1.

A note should be included on the correct adjustment of the maximum torque presets, RV1/101. This is much a matter of preference. They should be adjusted so that the car does not get ridiculous amounts of power just prior to running out of fuel, but so that the car can just be crashed on full power with a full tank. It is probably also a good idea to set the two channels alike with a multimeter to ensure fairness. (Be sure to have equal amounts of fuel when doing this adjustment!) **ETI**

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2200uF 100V cans 80 × 40mm dia **75p**; 10/**£5.50**; 220uF 10V axial **5p**; 100 **£2.30**; 1000 **£16**; 400 + 100uF 275V 102 × 44mm dia. **75p**; 10 **£5.50**; 200uF 350V, 100 + 100 + 50uF 300V can 75 × 44mm dia. **40p**; 10/**£3**; 100/**£20**; 100uF 25V Axial £3/100.
0.33uF 50V rad. **£1.50**/100, **£12**/1000
0.47uF 50V rad. **£1.50**/100, **£12**/1000 elec
22uF 50V rad **£3**/100, **£24**/1000
Electrolytics: 10u40V PC mntg 25/£1.25 100/£3; 4.7u/63V PC mntg **same price**
1250u/25V can **10/£1.60 100/£10**
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400u/400V can 10/**£8 100/£56**
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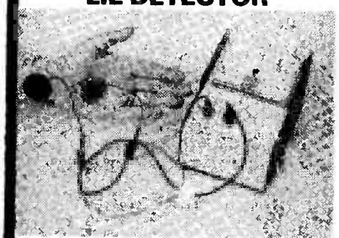
LIE DETECTOR



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'SIMON'

The object of this game is to repeat correctly a longer and longer sequence of signals in 3 different games. (Instructions included). PCB contains chips, switches, lampholders and lamps, and is tested working, complete with speaker. Needs PP3 and 2 × HP11. PCB size 130 × 130mm. Only **£3.95**

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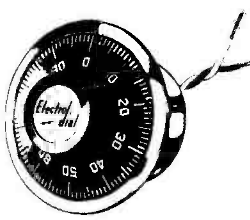

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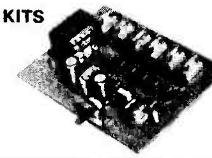

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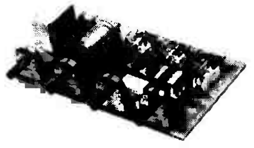

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READ/WRITE

Letters for this page should be addressed to Read/Write at our Charing Cross Road address.

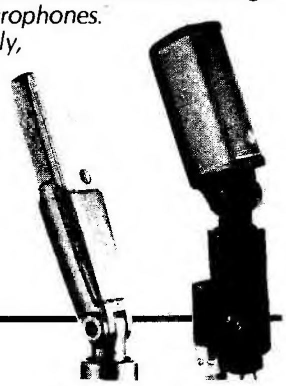
Dear Sir,

I am afraid Vivian Capel, in his User's Guide to Microphones in the Feb. 82 issue, is not quite correct in his otherwise excellent article when he states that the resonance of a ribbon microphone is "high, near or beyond the normal range." In fact, the resonance in most ribbon mikes is in the region of 35 to 45 Hz and is usually damped by the use of resistive screens placed close to the ribbon.

One of the reasons why the ribbon type exhibits a warm, natural tone is that the resonance is low down and not at, or above, the high frequency range as is the case with capacitor types, some of which display a very hard tone especially with stringed instruments. The upper end of the ribbon's frequency response trails away gradually and this gives the warm tone when compared with the capacitor.

For further information I would refer Mr. Capel to the excellent BBC Engineering Monograph No. 4 of 1955, which gives a lot of detail on the design of ribbon microphones.

Yours faithfully,
Cyril Gott,
Southall.



Dear Sir,

Did you know ETI has improved a lot lately. This is the first time I've ever written to a mag, I hope you will print this in your next ETI and answer my following questions:-

1) The Pest Control Feb 82 — can it give out more power, because I tried it near a cat and it didn't do anything.

2) The Computer Expansion System — can it be used on the VIC 20 and what is the difference between RAM and ROM.

Yours faithfully,
Sukkin Pang,
Harlow.
PS. Keep up the good work.
PPS. Happy birthday.

1) Stepping up the supply voltage would give more power but isn't recommended because the components would complain! It shouldn't really be necessary to get more power — we had a phone call from a large shopping centre whose automatic doors were letting in all the local cats and dogs until they fitted one with an Allez-Cat, whereupon the animals fled. They now intend using Allez-Cats on all the doors; are you sure the cat in question isn't deaf?

2) The computer expansion will work with the VIC 20; we'll provide details of how to do this in a later issue. RAM is random access memory which is easy to alter but forgets everything when the power supply is disconnected. ROM is Read-Only Memory which retains information even when the computer is turned off, but in the form the hobbyist normally uses (EPROM) data can only be changed by erasing the chip under ultraviolet light and then reprogramming it using a special series of pulses.

Dear Sir,

I recently purchased an amplifier kit from Hart Electronic Kits Ltd, Oswestry. When built, it worked the first time. The quality of parts was excellent and the packing was very good. Even the finish was first-class. However, there was one small omission — no base for the relay.

Upon phoning them (a lady was very helpful) the missing part arrived by return of post. So I am very pleased and will use this firm again because they obviously wish to provide a good service and should be encouraged. If you publish these facts in your Audiophile article perhaps other readers may benefit.

Oh yes, I almost forgot, I enjoy your magazine; especially the way things are explained, because it's hard to teach old dogs like me new tricks. Please keep Audiophile going — it's a great little article. I have purchased the Coral MC88F from your suggestion and, again, am very pleased with it — anyone should be at that price.

Cheerio now and watch that blood pressure!

Yours faithfully,
L.T. Bowler,
Cardigan.

My thanks for your medical meditation. My blood pressure is firmly under control at *most* **times in life (the exceptions are those things worth living for. .). It is a welcome change to hear tales of wonder rather than of woe. Any other readers who can recount the good and chivalrous deeds of companies — let's hear about it! We could** *all* **do with good news these days.**

Dear Sir,
With reference to your article Pickup Amp Design, Jan. 82.

I have a problem in determining the correct values of C and R to accommodate the pre-1955 standards for 78 rpm records where the bass turnover frequency can be between 300 Hz to 450 Hz depending on the manufacturer. Also the 50 uS time constant gives a 3 dB point at a different frequency from post-RIAA.

I would be grateful if your next article in the series could contain a figure to indicate the values of C and R for the time constants 3180 uS, 450 uS and 50 uS. Is it also desirable for the reasons mentioned in the article to attenuate the bass as per new RIAA?

The text and Fig. 2 of the article both indicate the old RIAA bass time constant to be 3150 uS, should this be 3180 uS?

Can you please pass this letter to Mr. Tilbrook.
With thanks,
Yours faithfully,
R.F. Butson,
Cardiff.

Your comments will be passed on to Dave Tilbrook; unfortunately he writes for our Australian edition, so it may be a while before we get a reply!

Dear Sir,
Re: Computer Controlled Live Music, Feb 82.

In recent months I have begun to see many cases of micro for micro's sake but I believe that some of the ideas in this article have blown the subject up out of all proportion to its usefulness and have gone about using it in the wrong way.

I am speaking from the point of view of someone who is working towards the use of computer (don't forget common-or-garden digital) control for both live music and studio recording and I have talked with several professional and semi-professional engineers and musicians about the subject.

Some of the points that have arisen are these:

1) Any small band (such as those at which this article was aimed) not using a

PA and/or mixer system, does so because they can't afford such things, or they want to keep their set-up simple for the benefit of the music. No one in this situation is going to want to buy a £500 micro and display to control their two or three amps.
2) I have never seen a band without a mixer, who are content to leave their amp and effect controls alone throughout a set, because they 'couldn't hear themselves' or they 'thought it could be that little bit better'. The point that arises here is that either the black box takes over from the amp controls completely, which no self-respecting musician would allow, or the controls work in parallel to the computer. In this case any itchy fingers on the controls would render any future changes by the computer totally wrong.
3) Any computer control system for live music must be continously monitored and updated. No two live performances are exactly the same, especially since any mix in an empty hall is generally wrong once you've got an audience. Such continuous control can only come from an engineer sitting at some sort of mixing console. For instance, what would happen if half way through your ZX81-controlled set, someone knocked the 16K RAM pack? The best place for any computer in a PA chain is therefore within the arm span of some single completely trustworthy person.

A live music system with computer control can therefore be reduced to a computerised, or even just digital, mixing desk. EQ changes during a performance are usually few and far between and stereo panning at high sound levels is too subtle for constant use and so can be left to the human side of the band (if there is one left). Your hyper-expensive-computerised-personal-amplifier system is thus reduced to a bank of voltage controlled amplifiers linked up to a small memory. You don't even have to spend a thousand quid on a Roland Computamix to do it either. Such a system comes into its own if it is part of the mixing desk in the first place.

No band or individual musician should be given the idea that if you don't tag along with computers you'll get left behind. It is the exception rather than the rule that any home brewed micro-systems will ever improve your music or even save time. If you want to use a computer for live music, first check your motives and reasons and if you're still certain, then start with it cheap, simple and easy to operate. It saves wasted time and money and the loss won't be so great as to put you off computers for good.
Yours,
Dave Pallant,
London.

Dear Audiophile,

Two years ago I built ETI's Audiophile 4000 system, the power amp is, I think, a very good design and the sound quality, for which I can vouch, is of the best quality.

I have used this power amp with many preamps including the one designed for the 4000, although in the case of the 4000 preamp I did a mod by deleting the filters.

Last year when System A was published I built the preamp with MM input because I thought it offered improvements over the 4000 preamp and also there are no tone controls.

I didn't really expect such marked improvement as I have got from this combination of '4000 power amp and System A preamp'. The improvement in sound detail, separation, clarity and bass response is really satisfying.

I wonder if any other readers have tried this combination.

I am about to change my tuner, it is an old Sony STR-6040 tuner amp from the early seventies but I only use the tuner section, it has been the most reliable piece of equipment I've ever owned. I am interested in a Sony ST-J75 tuner which I have seen mentioned in two of your Audiophile articles. I wonder if you would comment on its pros and cons.

My present system consists of:
System 'A' preamp with MM input
Audiophile 4000 power amp
Thorens TD160S SME Mk III with Technic EPC 205 Mk III
Technics RS615 Cassette Deck
Rogers Studio 1 Speakers

I have noticed that you never published a MOSFET Power Amp, I wonder why?

In conclusion I am a very satisfied reader of your very good magazine.

I remain,
Yours faithfully,
I.R. Worrell,
Wood Green.

The ST-J75 is a good tuner. A full review appeared in ETI June '81. It is capable of very clean reproduction indeed and should serve you well. (Listen to the Revox too if you get the chance.) Against the Sony is the fact that it could handle large scale works a little better than it does, having a tendency to sound confused. A minor blemish though.

What do you mean, we haven't published a MOSFET amp? Of course we have. As punishment for not knowing *instantly* which issue it was in I'm not going to tell you! Look to your indexes, sir.

Dear Mr Harris,

Your excellent magazine's latest article on 'Buying Mail Order' has prompted me to contact you.

I am currently trying to start my own business and most of the suppliers I am using at the moment are companies I have used in the past through my hobby.

The different ways in which companies treat their customers is almost unbelievable, and I think that if a magazine could run a 'league table' of particularly good and terribly bad suppliers it would be a useful guide to prospective customers and would also encourage suppliers to keep on their toes.

Example 1: I am in the process of buying a VDU for my home computer which I am adapting for business use. I wrote to two of your regular advertisers that claim to have VDUs for sale. In both cases I have asked for technical data, warranty conditions if any and delivery time and price.

Neither company has bothered to reply to my enquiry! — but they are both still advertising VDUs. I wonder why, if they will not sell them?

Example 2: I was recently stuck for some resistors. I had purchased some instrument kits and two kits were short of odd components. I telephoned to see if they could help out. They quoted me a fairly good price and said that they would despatch ASAP.

I couldn't believe it when the Postman handed me a 'Jiffy Bag' the following morning with all my resistors. Quite something when I tell you I hadn't rung until 4 pm the previous day and my mail arrived at 7.15 am!

One final point.

Some components that are used in vast quantities are rarely ever advertised, eg insulating materials, hardware such as screws, nuts and washers, grommets, etc and, most of all, wires and cables.

It doesn't matter how complex your PCB might be, it has to connect to the outside world sometime. But if nobody advertises wire, how do we do it?
Yours faithfully,
C.R. Tattersall M.Inst.E,
Haslingden.

If we did as you suggest and started publishing blacklists, the libel suits would start flying around faster than insults in the House of Commons!

Dear ETI,

Thank you for at last introducing the READ/WRITE forum.
Yours faithfully,
D.P. Allen,
Wembley.

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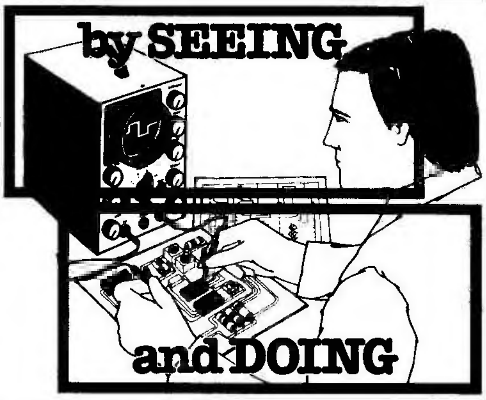

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SOUND EFFECTS 4

Our fourth and final sound effect using the SN76488 should come in handy for any amateur drama group contemplating Agatha Christie — it's a gunshot. Design by Phil Wait.

This unit is quite straightforward. The Noise Generator blocks in the IC are employed to produce a suitable sound, which is heard for about a fifth of a second, dying away rapidly. The effect is triggered (pardon the pun) by the push-button. Only half a dozen components are required apart from the IC! With care, patience and a little juggling, the unit could be fitted inside a toy plastic gun by simply soldering the components between the IC pins. You would have to obtain a tiny loudspeaker, headphone unit or rocking armature insert for a speaker — whatever will fit in the gun assembly.

Supply Bypassing

A short word on this subject may prevent difficulties in some cases. In general, we found that the power supply rail doesn't really need bypassing. However, provision has been made on the PCB for the inclusion of a bypass capacitor. This is located near the battery positive lead input on the board, which connects to pin 12 of the IC. Have a look at the component overlay for the Bomb Drop and Explosion unit, in last month's ETI. Locate C6, a 10nF polyester. This is the supply bypass. A capacitor having any value between 10nF and 10uF, and which will fit on the board, will do the job.

That's it! Have fun with your Sound Effects. We're sure that, with a little ingenuity and experimentation, you'll be able to devise a few effects of your own. (If you do, we'd like to hear from you and will pay for any items published.)

HOW IT WORKS

A gunshot is simulated by producing a burst of noise that decays very quickly. This unit employs the Noise Generator, Noise Filter, One Shot, Mixer and Envelope Generator to generate the required sound.

The Mixer select pin (25) and the Envelope select pin (28) are both held high (+5 V), selecting the One Shot output function from the Mixer. When the push-button, PB1, is pressed it puts a high on pin 9 and the Systems Inhibit block triggers the One Shot and activates the Envelope Generator. For the duration of the One Shot period, the modified noise from the Noise Generator/Filter is passed through the Mixer and Envelope Generator and then to the audio output stages.

The One Shot period, determined by R1 and C1, is quite short (about 1/5 second) and the decay period of the Envelope Generator a little longer. Audio output is coupled to the speaker via the 100uF DC blocking capacitor, C4.

PARTS LIST

Resistors (all ¼W, 5%)

R1,3	470k
R2	6k8

Capacitors

C1,3	470n 35 V tantalum or PCB electrolytic
C2	470p ceramic
C4	100u 16 V PCB electrolytic

Semiconductors

IC1	SN76488

Miscellaneous

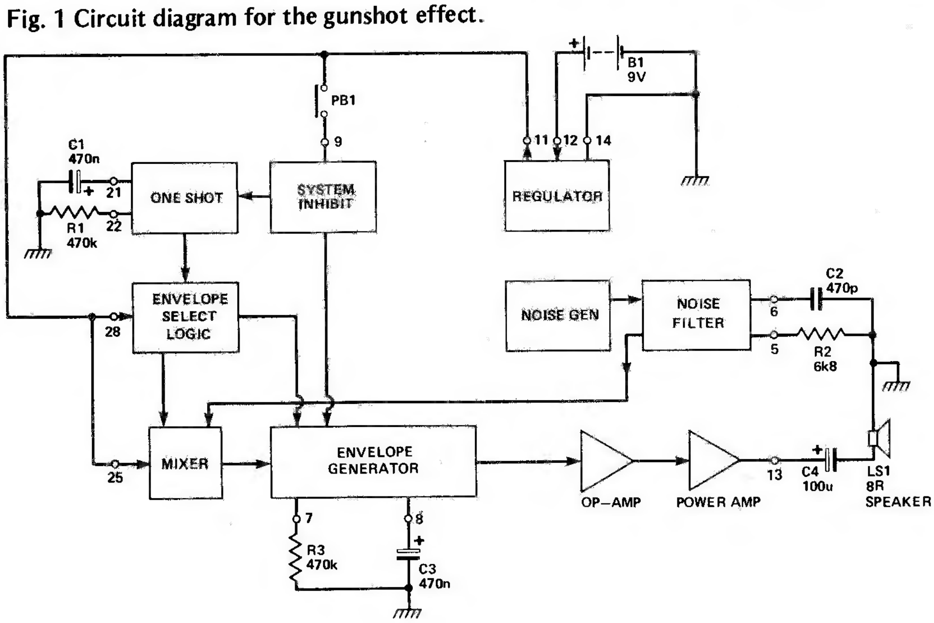
PB1	SPST push-button switch

PCB (see Buylines); 50 mm diameter 8 ohm speaker; PP3 battery and clip.

BUYLINES

As with the other projects in this series, no problems at all with supply — PCBs from us (page 45), IC1 from Technomatic, and everything else from anyone at all!

Fig. 1 Circuit diagram for the gunshot effect.



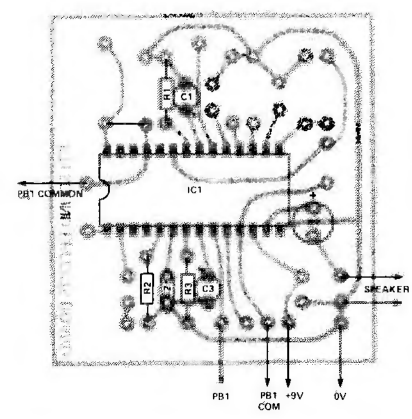


Fig. 2 Component overlay for the gunshot, using the same PCB as all the other sound effect projects. Don't forget to insert the link on the board.

ETI

WHAT'S ON NEXT?

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It's so simple it's almost laughable — but it provides an output of up to 1 volt RMS at any frequency from 20 Hz to 30 kHz, in three decade ranges. A most useful addition to any workshop.

Digital Thermometer

Based on display circuitry similar to that used in our Digital Capacitance Meter, last month this attractively finished project will find many uses around the house — or it would make perfect gift.

HE Reverb

Part of our **Project Music** series, this flexible device is mainly intended to add depth to flat recordings or to put a bit of life in vocal performances — but the creative musician will find many other uses for it, as well.

The Electronic Revolution

The first part of a new series, tracing the history and development of electricity and electronics, from the beginning. Once upon a time in a country far away . . . .

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We all know what sine waves are, don't we? If you think you know it all, this feature will give you a surprise — or two.

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Although these articles are being prepared for the next issue, circumstances may alter the final content.

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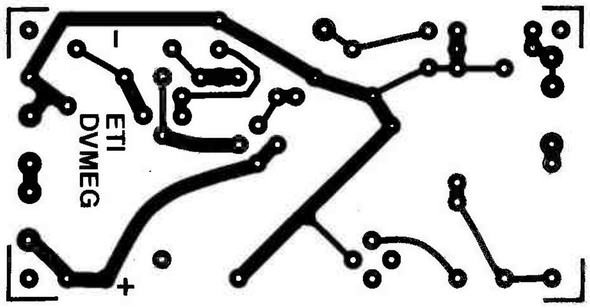
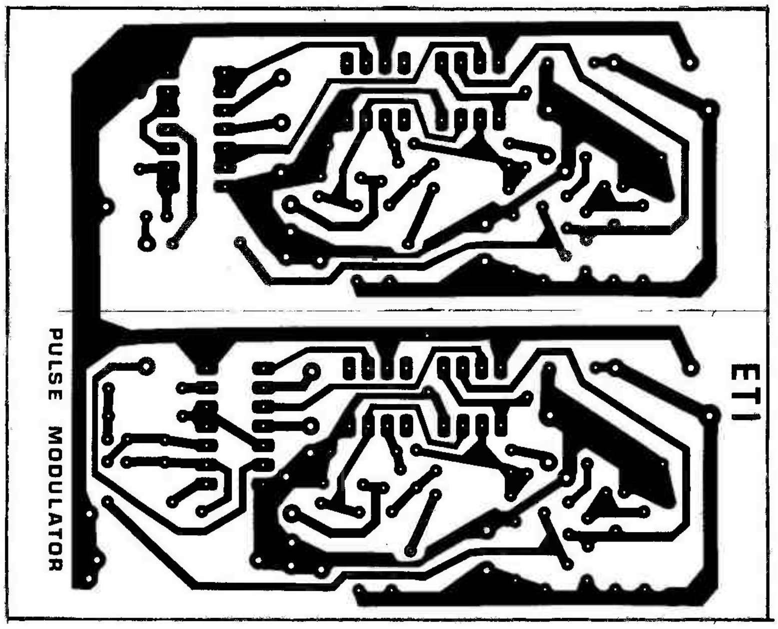
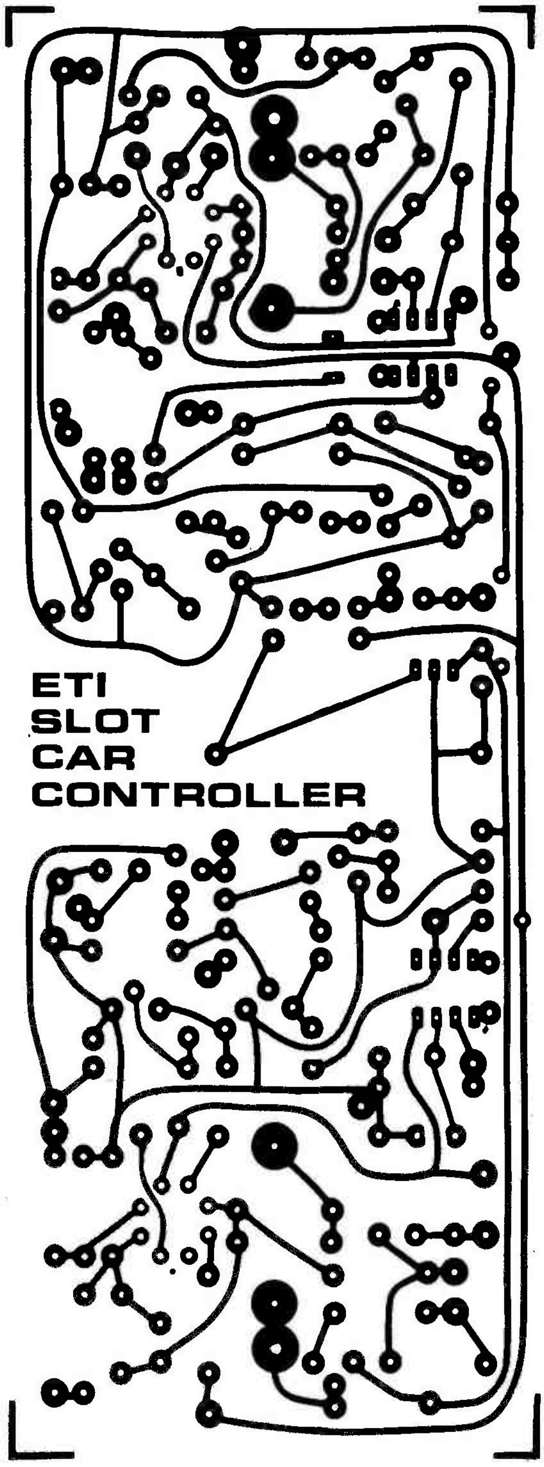
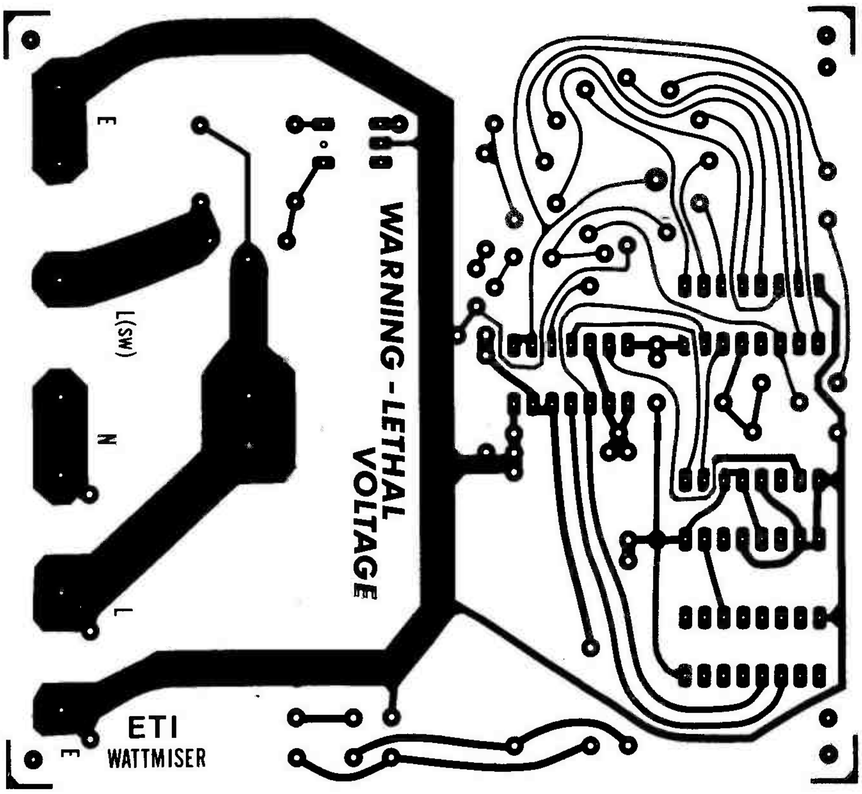


The foil pattern for the Sound Effects board appeared in last month's ETI. Lack of space has prevented us reproducing it a second time. The foil patterns for the oscilloscope will be published next month.







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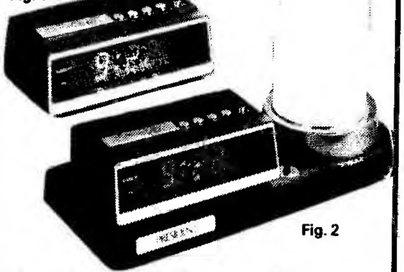

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