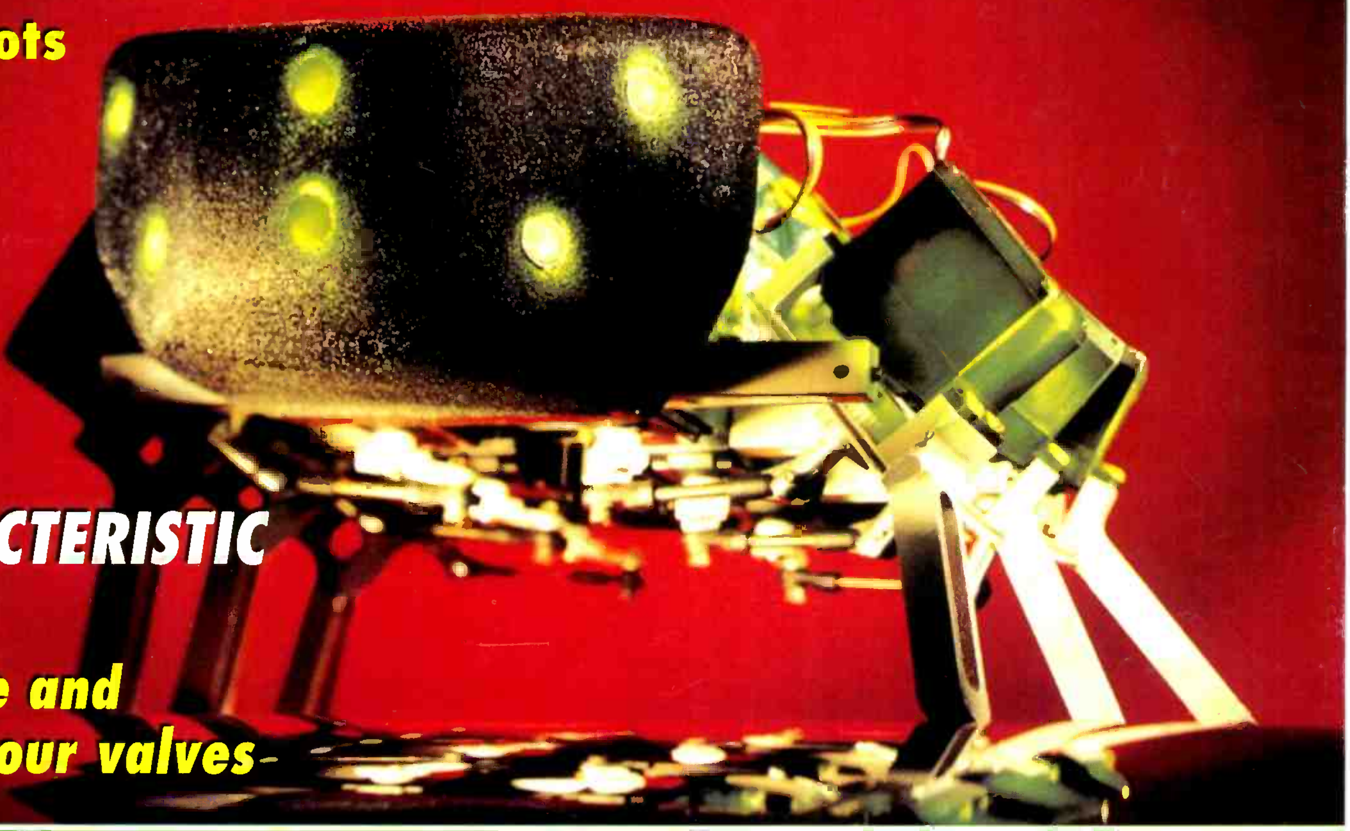
ETI
ELECTRONICS TODAY INTERNATIONAL

HIGHER EDUCATION SPECIAL

DIGITAL VOICE EFFECTS BOX

Pitch-shift, vibrato - and robot!

THE SECRET OF THE MACHINES



Will robots develop minds of their own?

VALVE CHARACTERISTIC TESTER

Measure and match your valves

PLUS

Brake Light Tester

Fast Fivers - A Process Timer

Speed Controlling DC Motors

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FOR ENTHUSIASTS BY ENTHUSIASTS NEXUS

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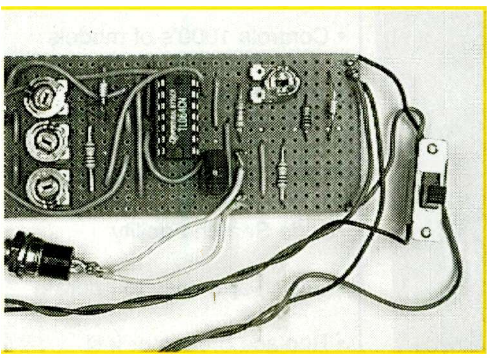
Features & Projects

Next Issue 15th August 1997



Regulars

SATELLITE POWER SUPPLY REPAIR KITS

ALBA	CODE
SAT660	SATPSU2

AMSTRAD	CODE
SRD510, SRD520, SRD540, SRD550	SATPSU3
SRDR45	
SRD500	SATPSU4
SRX320, SRX340, SRX345, SRX350	SATPSU5
SRX100	SATPSU6
SRD600	SATPSU14
SAT250, SR950, SRD700, SRD950, SRX1002, SRX2001, SRX301, SRX501, SRX502	SATPSU16
SRD2000	SATPSU18

BRITISH TELECOM	CODE
SVS300	SATPSU17

BUSH	CODE
IRD150	SATPSU12
IRD155	SATPSU19

CHURCHILL	CODE
D3MAC DECODER	SATPSU7

ECHOSTAR	CODE
SR5500 EARLY PSU WITH ADJ	SATPSU12
6500, SR7700, SR8700	SATPSU13

FERGUSON	CODE
SRD 5, SRD16	SATPSU1
SRV1	SATPSU2
SRDE4	SATPSU11

FINLUX	CODE
SR5700	SATPSU12

GOODMANS	CODE
ST700	SATPSU1

GRUNDIG	CODE
STR1	SATPSU1
GIRD200, FIRD3000	SATPSU2

MANHATTAN	CODE
850, 950	SATPSU1

MASPRO	CODE
SRE250S/1, SRE350S/1	SATPSU1
SRE250S, SRE350S, SRE450S	SATPSU2

MIMTEC	CODE
SOPRENSON TYPE PSU ONLY	SATPSU15

NETWORK	CODE
9000, 9200	SATPSU2

NOKIA	CODE
SAT1500	SATPSU2

PACE	CODE
PRD800, PRD900, PSR800, PSR900	SATPSU1
MRD920, SS9000, SS9010, SS9200, SS9210, SS9220	SATPSU2
D100, D150,	SATPSU6
MSS100	SATPSU8
APOLLO, MSS200, MSS300	SATPSU9
MSS500, MSS1000	SATPSU10

PHILIPS	CODE
STU802/05M	SATPSU1
STU801	SATPSU2

THOMSON	CODE
SRS4	SATPSU2

TOSHIBA	CODE
SAT99, TU-SDU200	SATPSU1

CODE	PRICE	CODE	PRICE	CODE	PRICE	CODE	PRICE
SATPSU1	650p	SATPSU6	650p	SATPSU11	835p	SATPSU16	730p
SATPSU2	650p	SATPSU7	650p	SATPSU12	1735p	SATPSU17	850p
SATPSU3	650p	SATPSU8	730p	SATPSU13	3125p	SATPSU18	1175p
SATPSU4	650p	SATPSU9	900p	SATPSU14	3135p	SATPSU19	650p
SATPSU5	650p	SATPSU10	1230p	SATPSU15	77.5p		

PACE SATELLITE TUNERS

MODELS	CODE	PRICE
PRD800, MSS200 (2GHZ) (221-2077062)	TUNER01	1650p
PRD900, MSS500, MSS1000 (2Ghz) (221-2177012)	TUNER02	1650p

PACE SWITCH MODE TRANSFORMERS

MODELS	CODE	PRICE
PACE9000	PACE9000	800p
PACEPRD800, PRD900	PRD800	550p

SATMETER

THE SATMETER IS A PROFESSIONAL PORTABLE SATELLITE STRNGTH METER DESIGNED FOR THE INSTALLATION AND MAINTENANCE OF SATELLITE TV SYSTEMS. THE SATMETER CAN BE USED AS STAND ALONE METER WITH POWERING THE LNB AS WELL AS IN LOOP. THROUGH OPERATION WITH SATELLITE RX POWERING THE LNB.

ACOUSTICAL SIGNAL: ON SIGNAL STRENGTH
INPUT IMPEDENENCE: 75 Ohm
MAX.INPUT SIGNAL: -10 DBM

LED INDICATOR: VERTICAL/HORIZONTAL
POWER AMPLIFIER: 18 DB

FREQUENCY RANGE: 900 TO 2050 MHZ
DETECTION RANGE: -60 TO -10 DBM

ORDER CODE: TOOL 22 PRICE: 8500p

SATELLITE LNB'S

MAKE & MODEL	ORDER CODE	PRICE
Cambridge AE22/AE5 0.8dB standard 10.95-ll.70 GHz Gold Range	LNB1	2160p
Cambridge AE14 Universal LNB 10.7-11.7/11.7-12.75 GHz	LNB2	2500p
Cambridge AE21/AE5 Single O/P Switching LNB 1.0dB Standard	LNB3	2050p
Cambridge AE19/AE6 Single O/P Switching LNB 1.0dB Enhanced	LNB4	2050p
Cambridge AE23/AE12 0.8dB Enhanced 10.7-11.8GHz Gold Range	LNB5	2160p
Cambridge AE8 Dual O/P H-V Separate Enhanced	LNB6	4000p
Cambridge AE7 Twin O/P H+V Both Enhanced	LNB7	4000p
Cambridge AE2 Dual O/P H-V Separate Enhanced	LNB8	3550p
Grundig Super Universal 'Anis' 10.7-12.75 GHz 0.8dB	LNB9	2600p
Grundig Universal 'Anis' 10.7-12.75 GHz 1.0dB	LNB10	2250p
Cambridge AE1 Twin O/P H+V Both Standard	LNB11	4000p

FUSES

	TIME LAG (20MM)		QUICK BLOW (20MM)	
CURRENT RATING	ORDER CODE	PRICE	ORDER CODE	PRICE
100mA	FUSE36	75p	FUSE37	60P
160mA	FUSE01	75p	FUSE17	60p
250mA	FUSE02	75p	FUSE18	60p
315mA	FUSE03	75p	FUSE19	60p
400mA	FUSE04	75p	FUSE20	60p
500mA	FUSE05	75p	FUSE21	60p
630mA	FUSE06	75p	FUSE22	60p
800mA	FUSE07	60p	FUSE23	60p
IA	FUSE08	60p	FUSE24	60p
1.25A	FUSE09	60p	FUSE25	60p
1.6A	FUSE10	60p	FUSE26	60p
2A	FUSE11	50p	FUSE27	60p
2.5A	FUSE12	50p	FUSE28	60p
3.15A	FUSE13	55p	FUSE29	50p
4A	FUSE14	55p	FUSE30	50p
5A	FUSE15	60p	FUSE31	50p
6.3A	FUSE16	60p	FUSE32	50p

NB.
ALL FUSES ARE MADE IN THE UK AND FULLY MEET BS4265 & BS1362 SAFETY STANDARDS AND SHOULD NOT BE COMPARED WITH CHEAP IMPORTED TYPES.

CERAMIC PLUG TOP

CURRENT RATING	ORDER CODE	PRICE
3A	FUSE33	100p
5A	FUSE34	100p
13A	FUSE35	100p

20mm CERAMIC TIME LAG

CURRENT RATING	ORDER CODE	PRICE
6.3A	FUSE38	100p
8A	FUSE39	100p
10A	FUSE40	100p
3.15A	FUSE41	85p
4A	FUSE42	85p
5A	FUSE43	85p

38mm CERAMIC TIME LAG

CURRENT RATING	ORDER CODE	PRICE
10A	FUSE48	815P

32mm CERAMIC SLOW BLOW

CURRENT RATING	ORDER CODE	PRICE
8A	FUSE44	185P
10A	FUSE45	185p
15A	FUSE46	185p
20A	FUSE47	210p

****ALL THE ABOVE PRICES ARE FOR PACKS OF 10 FUSES****

TRANSISTORS

PART	PRICE
AC125	30P
AC126	30P
AC127	30P
AC128K	40P
AC141K	45P
AC176	22P
ACY18	48P
ACY19	48p
AD149	60P
AF125	50P
AF139	30P
BC107	8P
BC108	8P
BC109	8P
BC109C	10P
BC140	20P
BC142	20P
BC143	20P
BC147	8P
BC149	8P
BC159	8p
BC160	30P
BC171	10P
BC172	10P
BC177	14P
BC178	14P
BC179	14P
BC182	7P
BC182L	7P
BC183	7P
BC183L	7P
BC184	7P
BC184L	7P
BC212	7P
BC212L	7P
BC213	7P
BC213L	7P
BC214	7P
BC214L	7P
BC237	7P
BC238	7P
BC239	7P
BC300	20P
BC301	20P
BC302	20P
BC303	20P
BC304	25P
BC327	7P
BC328	7P
BC337	7P
BC338	7P
BC441	28P
BC446	8P
BC477	18P
BC516	22P
BC537	25P
BC546	8P
BC547	8P
BC548	8P
BC549	8p
BC550	8P
BC556	8P
BC557	7P
BC558	8P
BC559	8P
BC560	8P
BC637	20P
BC639	20P
BC640	20P
BCY33	200P
BCY34	200P
BCY70	16P
BCY71	16P
BCY72	16P
BD115	30P
BD124P	50P
BD131	25P
BD132	25P
BD133	50P
BD135	20P
BD136	20P
BD137	20P
BD138	20P
BD139	20P
BD140	20P
BD144	90P
BD157	38P
BD166	30P
BD175	30P
BD177	30P
BD179	32P
BD181	45P
BD182	60P
BD184	60P
BD187	30P
BD201	33P
BD202	38P
BD203	42P
BD204	42P
BD222	31P
BD225	31P
BD232	31P
BD233	30P
BD234	32P
BD235	28P
BD236	30P
BD237	21P
BD238	24P
BD239	30P
BD240	40P
BD241A	40P
BD243A	50P
BD244	50P
BD245	50P
BD246A	50P
BD265	45P
BD267	45P
BD269	45P
BD278	50P
BD311	100P
BD314	100P
BD315	150P
BD317	150P
BD331	40P
BD332	40P
BD361	60P
BD362	60P
BD370	30P
BD371	30P
BD410	50P
BD433	28P
BD434	30P
BD435	31P
BD436	30P
BD437	28P
BD438	36P
BD439	40P
BD440	40P
BD441	40P
BD533	50P
BD534	38P
BD535	38P
BD536	38P
BD537	40P
BD538	40P
BD643	50P
BD645	50P

PART	PRICE
BD647	50P
BD649	50P
BD675	40P
BD676	40P
BD677	38P
BD678	40P
BD679	40P
BD680	40P
BD681	45P
BD682	45P
BD705	50P
BD707	50P
BD709	50P
BD711	50P
BD736	50P
BD826	50P
BD828	50P
BD839	55P
BD897	50P
BD899	50P
BD977	50P
BDX33	60P
BDX37	100P
BDX44	100P
BDX47	75P
BDX54C	75P
BDX62C	150P
BDX63C	175P
BDX64C	175P
BDX65	80P
BDX66C	175P
BDX67C	275P
BDX71	70P
BDX77	175P
BDX87C	175P
BDX88C	150P
BDW24	55P
BDW93	50P
BDW94	50P
BDY29	225P
BDY56	225P
BDY58	500P
BDY90	125P
BDY92	100P
BF137	35P
BF167	30P
BF181	18P
BF183	20P
BF195	7P
BF199	8P
BF200	16P
BF225	30P
BF240	16P
BF245	25P
BF254	15P
BF255	12P
BF256	18P
BF257	18P
BF259	18P
BF262	25P
BF270	18P
BF273	15P
BF311	21P
BF336	20P
BF337	20P
BF338	20P
BF362	30P
BF367	13P
BF371	17P
BF421	18P
BF422	21P
BF423	25P
BF455	12P
BF458	19P
BF462	50P
BF471	28P
BF472	28P
BF479	30P
BF494	16P
BF495	16P
BF595	16P
BF596	16P
BF615	30P
BF617	30P
BF760	40P
BF763	40P
BF870	22P
BF871	22P
BF960	38P
BF961	35P
BF964	38P
BFQ232	75P
BFQ252A	60P
BFR90	85P
BFR91	99P
BFT43	30P
BFX29	20P
BFX84	20P
BFX85	20P
BFX87	15P
BFX88	15P
BFX89	60P
BFY50	14P
BFY51	24P
BFY52	14P
BFY56	25P
BFY64	25P
BFY90	45P
BLY48	85P
BR100	14P
BR103	37P
BR303	85P
BSX20	15P
BU105	80P
BU108	100P
BU109	80P
BU110	90P
BU111	100P
BU124	60P
BU125	100P
BU126	65P
BU128	125P
BU133	125P
BU137	150P
BU180	100P
BU184	100P
BU204	65P
BU205	70P
BU206	100P
BU207	150P
BU208	70P
BU208A	75P
BU208AT	200P
BU208B	200P
BU208D	130P
BU209	90P
BU225	120P
BU226	120P
BU312	90P
BU325	55P
BU326A	75P
BU406	60P
BU406D	85P
BU407	55P
BU407D	75P
BU408	60P
BU408D	75P

PART	PRICE
BU409	85P
BU412	175P
BU413	175P
BU414B	250P
BU415A	170P
BU426A	70P
BU433	120P
BU500	100P
BU500D	225P
BU505	90P
BU505D	90P
BU505DF	90P
BU506	100P
BU506D	70P
BU506DF	120P
BU508A	70P
BU508AF	95P
BU508APH	80P
BU508D	90P
BU508DF	115P
BU508DR	130P
BU508V	110P
BU508VF	100P
BU526	75P
BU536	100P
BU546	125P
BU603	125P
BU606D	225P
BU608D	120P
BU626	120P
BU705	130P
BU706DF	175P
BU706F	150P
BU724A	100P
BU801	70P
BU806	70P
BU807	60P
BU807F	75P
BU808DF	300P
BU810	110P
BU824	450P
BU826	120P
BU826A	160P
BU902	110P
BU903	110P
BU910	80P
BU912	100P
BU920	100P
BU922	110P
BU930	130P
BU932	175P
BU941	250P
BU2508A	130P
BU2508AF	130P
BU2508D	130P
BU2508DF	150P
BU2520AF	225P
BU2520DF	225P
BU2525A	325P
BU2525AF	325P
BU2527AF	400P
BUF405A	200P
BUH315	200P
BUH15D	250P
BUH515	200P
BUH515D	250P
BUH517	275P
BUH517D	175P
BUH715	425P
BUV93	375P
BUK444/ 500B	200P
BUK444/ 800B	200P
BUK445/ 600B	200P
BUK446/ 800B	400P
BUK455/ 600B	200P
BUK456/	200P
BUW81A	150P
BUR51	1900P
BUR52	1900P
BUS11A	200P
BUS12A	200P
BUS14A	500P
BUS23	225P
BUS48A	175P
BUT11A	55P
BUT11AF	55P
BUT12	80P
BUT13	310P
BUT18	80P
BUT18AF	80P
BUT30V	1700P
BUT56A	100P
BUT76A	80P
BUT90	1300P
BUT92	1200P
BUV18	650P
BUV20	650P
BUV21	400P
BUV23	475P
BUV24	350P
BUV25	110P
BUV26	150P
BUV27	125P
BUV28	110P
BUV37	175P
BUV46A	75P
BUV47	120P
BUV48A	175P
BUV48AF	325P
BUV48C	250P
BUV50	425P
BUV61	100P
BUV70	200P
BUV90	175P
BUZ30A	475P
BUW11A	200P
BUW1AF	225P
BUW12	125P
BUW12A	150P
BUW12F	250P
BUW13A	200P
BUW32A	500P
BUW48	550P
BUW49	550P
BUW50	400P
BUZ73AF	60P
BUW84	75P
BUW85	85P
BUX10	150P
BUX11	200P
BUX12	150P
BUX20	350P
BUX21	450P
BUX22	450P
BUX23	900P
BUX32	175P
BUX37	200P
BUX39	450P
BUX40	210P
BUX41	200P
BUX42	200P
BUX47A	200P

PART	PRICE
BUX48A	150P
BUX55	800P
BUX80	180P
BUX81	160P
BUX84	50P
BUX85	50P
BUX86	30P
BUX87	50P
BUX98A	350P
BUY18S	150P
BUY47	150P
BUY57	125P
BUY69A	200P
BUY71	250P
BUZ10	65P
BUZ11	200P
BUZ11A	175P
BUZ14	550P
BUZ20	225P
BUZ21	250P
BUZ24	350P
BUZ25	450P
BUZ32	125P
BUZ36	800P
BUZ44A	525P
BUZ45A	800P
BUZ50B	500P
BU53A	800P
BUZ71	75P
BUZ71AF	100P
BUZ72A	100P
BUZ72AF	100P
BUZ73A	150P
BUZ76A	110P
BUZ80	200P
BUZ80AF	200P
BUZ83	200P
BUZ90A	180P
BUZ91A	400P
BY448	20P
BYT11	25P
C106D	28P
CQY80	40P
IRF120	225P
IRF130	475P
IRF140	550P
IRF230	550P
IRF240	425P
IRF250	375P
IRF330	600P
IRF340	325P
IRF350	750P
IRF450	650P
IRF10	150P
IRF520	150P
IRF530	150P
IRF540	200P
IRF610	150P
IRF611	150P
IRF620	160P
IRF630	150P
IRF640	350P
IRF642	200P
IRF650	200P
IRF710	150P
IRF720	150P
IRF730	150P
IRF740	150P
IRF820	150P
IRF830	160P
IRF840	150P
IRF9140	1000P
IRF9510	150P
IRF9511	150P
IRF9520	150P
IRF9530	400P
IRF9531	200P
IRF9540	300P
IRF9541	200P
IRF9610	150P
IRF9620	150P
IRF9622	200P
IRF9630	325P
IRF9640	375P
IRFD9220	100P
IRFBC30	200P
IRFBC40	400P
IRFP140	250P
IRFP150	300P
IRFP240	300P
IRFP250	400P
IRFP350	325P
IRFP450	400P
IRFP460	775P
IRFP9140	1450P
IRFP9240	500P
IRFPC50	600P
IRFRC20	250P
IRFZ20	65P
IRFZ42	275P
IRFZ44	275P
MJ900	200P
MJ10001	200P
MJ1001	200P
MJ2501	100P
MJ2955	55P
MJ3000	100P
MJ3001	100P
MJ4032	175P
MJ4035	175P
MJ4502	300P
MJ10012	300P
MJ11015	250P
MJ11016	300P
MJ11032	800P
MJ11033	800P
MJ15003	250P
MJ15004	300P
MJ15015	250P
MJ15016	350P
MJ15022	250P
MJ15023	400P
MJ15024	400P
MJ15025	700P
MJE29A	30P
MJE30A	30P
MJE210	70P
MJE340	25P
MJE350	80P
MJE520	30P
MJE2955T	65P
MJE3055T	65P
MJE13004	100P
MJE13005	60P
MJE13007	100P
MJE13009	100P
MJE15028	200P
MJE15029	200P
MJE15030	250P
MJE15031	400P
MJE18004	125P
MJF18004	175P
MJF18204	350P
MPSA05	15P
MPSA06	15P
MPSA10	15P
MPSA13	15P

PART	PRICE
MPSA14	15P
MPSA20	15P
MPSA42	15P
MPSA43	15P
MPSA44	40P
MPSA55	12P
MPSA56	12P
MPSA70	15P
MPSA92	20P
MPSA93	20P
MPSU10	200P
MPSU45	550P
MPSU56	400P
MPSU60	350P
MR510	35P
MR856	36P
OC28	350P
OC29	250P
OC35	350P
OC36	250P
OC45	50P
OC200	180P
R2008B	100P
R2010B	100P
S2000A3	175P
S2000AF	175P
S2055A	175P
S2055AF	200P
S2530A	100P
S2800M	72P
TIP29	15P
TIP29A	22P
TIP29C	25P
TIP29E	40P
TIP30	25P
TIP30C	25P
TIP31A	22P
TIP31C	27P
TIP32	24P
TIP32A	21P
TIP32C	28P
TIP33	50P
TIP33C	60P
TIP34	65P
TIP34C	60P
TIP35C	65P
TIP36C	65P
TIP42A	20P
TIP41C	22P
TIP42A	20P
TIP42C	22P
TIP47	40P
TIP48	40P
TIP50	60P
TIP51	80P
TIP52	80P
TIP54	85P
TIP102	70P
TIP105	65P
TIP106	65P
TIP107	65P
TIP110	40P
TIP111	40P
TIP112	35P
TIP112H	50P
TIP115	30P
TIP116	30P
TIP117	30P
TIP120	37P
TIP121	35P
TIP122	30P
TIP125	30P
TIP126	40P
TIP127	35P
TIP130	30P
TIP131	30P
TIP132	30P
TIP136	40P
TIP137	65P
TIP162	110P
TIP141	65P
TIP143	75P
TIP145	50P
TIP146	70P
TIP147	80P
TIP150	90P
TIP151	60P
TIP2955	50P
TIP3055	50P
TIPL760	100P
TIPL762A	200P
TIPL763A	200P
TIPL791A	80P
TIS61	15P
TIS90	15P
TIS93	20P
ZTX107	11P
ZTX108	11P
ZTX109	12P
ZTX212	20P
ZTX300	10P
ZTX301	16P
ZTX302	10P
ZTX303	20P
ZTX304	10P
ZTX320	20P
ZTX501	13P
ZTX502	10P
ZTX503	18P
ZTX504	25P
2N696	26P
2N697	22P
2N698	40P
2N78	22P
2N914	28P
2N918	30P
2N930	18P
2N1131	28P
2N1132	28P
2N1304	350P
2N1305	225P
2N1613	24P
2N1711	24P
2N1893	30P
2N2102	50P
2N2218A	24P
2N2219	24P
2N2221	23P
2N2222	23P
2N2243	40P
2N2369	15P
2N2484	15P
2N2646	40P
2N2894	50P
2N2904	20P
2N2905	20P
2N2906	18P
2N2907	18P
2N3019	28P
2N3053	18P
2N3054	40P
2N3055	38P
2N3055H	50P
2N3439	40P
2N3440	45P
2N3441	175P
2N3442	85P

PART	PRICE
2N3553	100P
2N3585	650P
2N3702	9P
2N3703	9P
2N3704	9P
2N3705	9P
2N3706	9P
2N3707	9P
2N3710	12P
2N3711	12P
2N3771	85P
2N3772	90P
2N3773	100P
2N3792	150P
2N3799	18P
2N3819	29P
2N3820	70P
2N3823	40P
2N3866	110P
2N3903	11P
2N3906	11P
2N3924	375P
2N3958	375P
2N4031	25P
2N4033	25P
2N4036	29P
2N4220	175P
2N4347	130P
2N4391	60P
2N4392	50P
2N4393	55P
2N4399	200P
2N4401	12P
2N4403	12P
2N4416	120P
2N4420	75P
2N4427	75P
2N4920	50P
2N4922	30P
2N4923	30P
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2N5061	20P
2N5088	20P
2N5109	100P
2N5116	175P
2N5154	150P
2N5160	600P
2N5179	40P
2N5192	50P
2N5241	500P
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2N5460	55P
2N5461	75P
2N5462	45P
2N5484	55P
2N5551	12P
2N5671	350P
2N5672	400P
2N5680	55P
2N5884	175P
2N5886	325P
2N6031	250P
2N6049	55P
2N6059	150P
2N6098	50P
2N6099	45P
2N6107	40P
2N6109	40P
2N6211	400P
2N6248	150P
2N6284	250P
2N6287	225P
2N6292	40P
2N6385	120P
2N6403	160P
2N6427	25P
2N6476	250P
2N6488	90P
2N6491	90P
2N6547	300P
2N6609	375P
2N6660	375P
2N6675	175P
2N6678	225P
4N35	50P

RECTIFIER DIODES

PART	PRICE
BY127	8P
BY133	8P
BY164	40P
BY179	35P
BY184	32P
BY206	11P
BY207	20P
BY227	19P
BY228	28P
BY298	15P
BY299	18P
BY329-1200	150P
BY448	20P
BYT11	25p
BYT13-1000	30P
BYV96E	25P
BYW96E	36P
BYX10	15P
BYX55/600	25P
OA47	10P
OA91	10P
IN4001	3P
IN4002	3P
IN4003	3P
IN4004	3P
IN4005	3P
IN4006	3P
IN4007	4P
IN4148	2P
IN5400	9P
IN5401	8P
IN5402	8P
IN5403	8P
IN5404	8P
IN5405	11P
IN5406	12P
IN5407	12P
IN5408	12P
RGP10	25P
RGP15	25P
RGP30	16P
SKE4F2/06	60P
SKE4F2/08	80P
SKE4F2/10	100P
SR2M	60P

TRANSISTORS

PART	PRICE
I.C. SOCKETS	
8 PIN	4P
14 PIN	5P
16 PIN	6P
18 PIN	9P
20 PIN	10P
22 PIN	12P
24 PIN	13P
28 PIN	13P
40 PIN	15P
ZENER DIODES	
400m	WATT
2V7 TO 39V	5P
1.3	WATT
2V7 TO 39V	9P
VOLTAGE REGULATORS	
7805	25P
7806	25P
7808	25P
7812	25P
7815	25P
7818	25P
7824	25P
7905	25P
7906	30P
7908	30P
7912	30P
7915	30P
7918	30P
7924	30P
78L05	24P
78L08	24P
78L12	24P
78L15	24P
78L18	24P
78L24	24P
79L05	35P
79L08	35P
79L12	35P
79L15	35P
LM309K	100P
LM317T	100P
LM323K	350P
78H09KC	800P
79H12KC	700P
79HGKC	800P
L.E.D.'s 3mm	
RED	5p
YELLOW	8p
GREEN	8p
5mm	
RED	5p
YELLOW	8p
GREEN	8p
RECTANGULAR LED's	
5mm x 2.5mm	
RED	5p
YELLOW	8p
GREEN	8p
BRIDGE RECTIFIER	
W005	16p

PART	PRICE
1A/50V	
W01	18p
1A/100V	
WO2	19p
1A/200V	
W04	21p
LA/400V	
W06	23p
LA/600V	
W08	28p
1A/800V	
BR81D	33p
2A/100V	
BR82D	33p
2A/200V	
BR84D	37p
2A/400V	
BR86D	43p
2A/600V	
BR88D	43p
2A/800V	
BR32	43p
2A/200V	
BR34	43p
2A/400V	
BR36	44p
2A/600V	
BR62	80p
6a/200V	
BR64	72p
6A/400V	
BR251	150p
25A/100V	
BR252	165p
24A/200V	
BR254	185p
25A/400V	
BR2156	200p
25A/600V	
BR258	240p
25A/800V	
BR351	185p
35V/100V	
BR352	200p
35V/200V	
BR354	220p
35V/400V	
BR356	230p
35V/600V	
BR358	260p
35V/800V	
BY164	40p
1.5A/100V	
BY176	40p
1.5A/800V	
TRIACS	
TIC206D	60p
4A/400V	
TIC225D	69p
6A/400V	
TIC226D	68p
8A/400V	
TIC235D	85p
12A/400V	
TIC246D	105p
16A/400V	
TIC253D	190p
20A/400V	
TIC263D	205p
25A/400V	
THYRISTORS	
2N5061	20p
0.8A/60V	

PART	PRICE
TIC116C	59p
8A/300V	
TIC116D	70p
8A/400V	
TIC126D	75p
12A/400V	
TIC126M	90p
12A/600V	
C106D	28p
4A/400V	
BR103	37p
BR303	85p
BT106	180p
BT119	100p
17088	200p
17089	200p
17127	200p
15/80H	230p
15/85R	230p
SG 264	800p
SG613	1500p
COMPUTER IC's	
Z80ACPU	100p
Z80ADMA	200p
Z80ACTC	140p
Z80ASIO-1	210p
Z80ASIO-2	210p
75107	65p
75110	75p
75113	100p
75122	110p
75154	100p
75162	700p
75182	95p
75183	95p
75195	185p
2114	150p
2532	200p
26LS32	75p
2716	100p
2732	200p
2732A	220p
2764	150p
27C64	200p
27128	150p
27256-25	150p
27512	300p
4116	40p
4164-15	80p
4164-12	90p
41256-15	80p
41256-12	100p
41256-10	110p
41464-12	150p
6116	80p
6264-10	210p
62256-12	300p
6502A	360p
65C02	930p
6522	280p
6800	210p
6802	220p
6803	500p
6808	500p
6809	500p
6810	150p
6818	380p
6821	130p
6840	290p
6845	200p
6850	90p
74F244	35p
8085A	300p
8086	500p
8088	480p

PART	PRICE
8156	300p
8224	240p
8226	240p
8250	750p
8251	200p
8253	160p
8257	220p
8271	340p
8279	270p
8283	400p
8284	440p
8287	260p
8288	650p
82C206PLCC	500p
8748	700p
8755	800p
8T26	95p
8T28	110p
CMOS IC's	
4000	13p
4001	13p
4002	13p
4006	34p
4007	13p
4009	20p
4010	21p
4011	13p
4012	13p
4013	19p
4014	32p
4016	18p
4018	30p
4019	28p
4020	33p
4021	36p
4022	36p
4023	13p
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4041	36p
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4043	36p
4045	72p
4046	42p
4047	45p
4048	26p
4049	18p
4050	20p
4051	38p
4052	35p
4053	35p
4054	53p
4055	52p
4056	52p
4060	40p
4063	52p
4066	20p
4067	120p
4068	13p
4069	13p
4070	13p
4071	13p
4072	13p
4073	13p

PART	PRICE
4075	13p
4076	42p
4077	13p
4078	13p
4081	13p
4082	13p
4085	36p
4086	30p
4089	75p
4093	18p
4094	44p
4094	58p
4098	50p
4099	42p
4501	26p
4502	36p
4504	35p
4505	80p
4506	58p
4507	30p
4508	67p
4510	32p
4511	30p
4512	38p
4514	65p
4515	65p
4516	36p
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4518	36p
4519	28p
4520	36p
4521	86p
4526	38p
4527	41p
4528	38p
4529	65p
4532	48p
4553	140p
4555	29p
4556	36p
4557	140p
4583	60p
4584	30p
4585	40p
40103	120p
40105	140p
40106	35p
40107	50p
40110	170p
40114	180p
40160	55p
40161	55p
40174	48p
40192	48p
40193	48p
40194	58p
40257	120p
74 SERIES	
7400	20p
7401	16p
7402	18p
7403	20p
7404	35p
7405	10p
7406	30p
7407	30p
7408	25p
7409	20p
7413	30p
7414	45p
7416	32p
7417	32p
7420	20p
7421	25p
7425	15p

PART	PRICE
7430	25p
7437	28p
7438	30p
7442	38p
7447	60p
7450	22p
7451	10p
7454	25p
7473	25p
7481	90p
7482	60p
7485	25p
7489	75p
7493	35p
7495	48p
74132	42p
74141	55p
74145	70p
74157	45p
74160	50p
74HC SERIES	
74HC03	14p
74HC08	18p
74HC10	20p
74HC11	14p
74HC14	26p
74HC20	19p
74HC27	20p
74HC51	20p
74HC73	24p
74HC74	24p
74HC76	28p
74HC77	35p
74HC85	33p
74HC86	29p
74HC107	28p
74HC123	35p
74HC125	32p
74HC126	33p
74HC132	33p
74HC133	33p
74HC137	52p
74HC138	33p
74HC147	42p
74HC153	32p
74HC154	90p
74HC157	34p
74HC158	34p
74HC160	44p
74HC161	44p
74HC162	44p
74HC163	44p
74HC164	44p
74HC165	56p
74HC166	60p
74HC174	38p
74HC175	38p
74HC190	46p
74HC192	53p
74HC193	41p
74HC194	46p
74HC195	46p
74HC221	80p
74HC238	55p
74HC240	48p
74HC241	47p
74HC242	55p
74HC243	60p
74HC245	48p
74HC251	25p
74HC257	40p
74HC259	52p
74HC273	42p
74HC280	61p
74HC283	61p

SERVICE AIDS

DESCRIPTION	VOLUME	CODE	PRICE
VIDEO HEAD CLEANER	75ML	SP01	180p
VIDEO HEAD CLEANER	200ML	SP27	250p
SWITCH CLEANER	176ML	SP02	180p
SUPER 40	400ML	SP15	250p
SILICONE GREASE	200ML	SP03	210p
FREEZE IT	170ML	SP04	320p
FREEZE IT	400ML	SP16	600p
FOAM CLEANER	400ML	SP05	200p
ANTI STATIC	200ML	SP06	190p
AEROKLEANE	200ML	SP07	220p
AERO DUSTER	150ML	SP08	310p
AERO DUSTER	400ML	SP17	550p
PLASTIC SEAL	200ML	SP09	250p
GLASS CLEANER	250ML	SP10	160p
COLDKLENE	250ML	SP13	230p

DESCRIPTION	VOLUME	CODE	PRICE
EXCEL POLISH 80	250ML	SP18	150p
ADHESIVE 120	400ML	SP19	190p
LABEL REMOVER 130	200ML	SP20	240p
REFURB 140	400ML	SP21	240p
TUBE SILICON GREASE	50 GRAMMES	SP11	220p
TUBE TUBE SILICON SEALANT WHITE	75ML	SP22	280p
TUBE SILICON SEALANT CLEAR	75ML	SP23	280p
TUBE HEAT SINK COMPUND	25 GRAMMES	SP12	150p
DRIVE CLEANER	200ML	SP24	150P
SCREEN CLEANER	200ML	SP25	150p
COMPUTER CARE KIT		SP26	2100p
ANTI STATIC FOAM CLEANER	400ML	SP28	175p
AIR DUSTER	400ML	SP29	450p

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ETI News...

ELECTRONICS TODAY INTERNATIONAL

New semiconductor design centre

Fears expressed over decline in science students

Cypress Semiconductor Corporation is making a multi-million pound investment in one of the largest microchip design centres in the UK, in Basingstoke, Hampshire. The new centre will design various semiconductor products including SRAMS, CPLD and FCT logic chips. Working with Cypress design centres in North America and Asia the UK centre will participate in the company's 24-hour, round-the-clock design projects. At the end of one working day, a project can be handed over to another centre in a different time zone. As many as 60 new design posts will be created. Cypress is working with educational establishments in the UK to encourage the training of future electronics design engineers. Fears have been expressed that a decrease in the number of good science students will have an adverse effect on recruitment in the UK where there have traditionally been high levels of expertise in semiconductor design. "This is particularly important in the light of falling numbers of school pupils studying subjects such as physics," says design centre director David Rees. "When young people are thinking about their future career paths, we need to be sure that the understand the advantages and opportunities available to engineering graduates."

David Rees of Cypress Semiconductor: concern about school leavers

Cypress Semiconductor's product lines include static rams, eproms and specialty memories; programmable logic devices (PLDs), data communications products and personal computer chipsets, timing devices and USB microcontrollers. The company has a World Wide Web site at http://www.cypress.com.

Free licenses for Radio Amateurs under 21

The Radiocommunications Agency has announced that Amateur Radio Licences will be issued free of charge to all qualified users under the age of 21 from 1st July 1997. New applicants registered on or after 1st July will be issued free of charge, and existing licence holders will not be charged this year providing their expiry falls on or after that date.

Technology Minister John Battle said: "The Agency has taken this step to encourage more young people into amateur radio. Radio in its many forms has made a massive impact this century on all aspects of our life. We should do all we can to help young people develop an interest in one of the key technological areas for the next century."

There is widespread concern that the attractions of home computing, and also the falling standards that many fear have taken place in education, have combined to discourage younger people from taking up amateur radio. Another factor is that miniaturisation and integration have made high level radio electronics now inaccessible to most Amateurs, even with higher qualifications, so that amateur radio's contribution to the cutting edge of radio has been shifted to experimental or low power areas, and out of what many see the mainstream.

The Novice Licence was launched in 1991 to help young people enter Amateur Radio in easier stages. In 1996 the Radio Society of Great Britain (RSGB) announced that it was to concentrate on keeping prices down and extending services to encourage Amateurs to pursue their hobby. The saving of the £15-per-year License fee will help younger people who are not earning or earning low wages. Amateur radio has also been a major factor in bringing youngsters into Electronics.

For more information contact the Radiocommunications Agency Tel. 0171 211 0158.

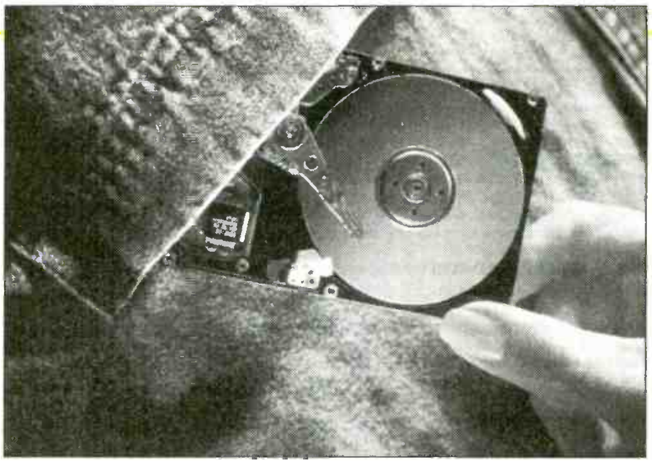
Old PCB retirement scheme in Basingstoke

Cradle-to-Grave electronics Capital of the UK, Basingstoke is now the home of a new recycling scheme aimed at recovering and reprocessing valuable electronic parts instead of allowing their wasteful disposal in landfill sites. The electronics take-back scheme is launched by Project Integra, the waste management strategy, in conjunction with Intex Logistics of Horndean, and local firm PW Recycling. Electronic scrap will be collected and stripped down to recover re-useable ics and other components before the PCBs are refined for their residual value of tin, lead, copper, gold and other metals. The plastic casings will also be analysed for type and then broken down for re-sale to the plastics industry. If the trial is a success, a similar scheme could be set up countrywide.

OVERSEAS READERS

To call UK telephone numbers, replace the initial 0 with your local overseas access code plus the digits 44.

The World's first 5 GB laptop disk drive



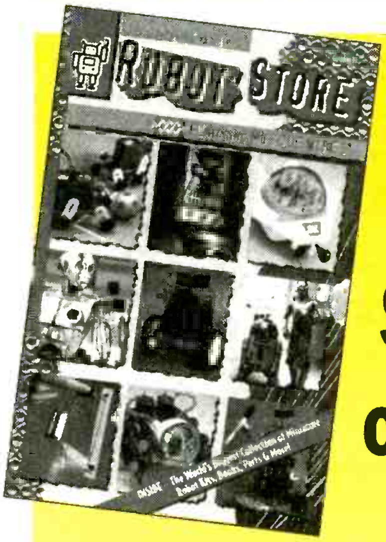
IBM have produced a laptop hard disk drive not much bigger than the palm of a child's hand, but able to hold a record-breaking 5 billion bytes (5.1 gigabytes) of data.

The IBM 2.5 in Travelstar 5GS can store 50 years' worth of a typical daily newspaper, or about 1 million printed pages - a stack of paper as tall as a 62-story building. (No wonder newspaper libraries are looking at compact data storage.)

Whereas the Travelstar 5GS, which is about two-thirds of an inch (17 mm) thick, will go into premium notebook computers. Aimed mainly at notebook users who don't want to store their newspaper collection, the compact drive will allow users to take advantage of space-demanding applications such as long multimedia presentations, games with advanced graphics and video conferencing. The main contributor to this compact storage is IBM's new MRX (magneto-resistive extended) drive-head technology. No bigger than the head of a pin, the MRX head component sends out stronger signals than older heads, enabling it to reach and write larger volumes of information. "MRX is a major step beyond the older-generation magneto-resistive head technology," said Bob Scranton, vice president of technology at IBM/s Storage Systems Division.

Another IBM 2.5 in disk drive with MRX head technology sets a new density record, storing the most data per square inch of any disk drive: 2.64 billion bits. The Travelstar 4GT is only half an inch (12.5 mm) thick and it destined for new ultra-portable laptops. The 4GT is also designed to be the most rugged 2.5 in disk drive, based on its non-operational shock rating. (This is the measurement of how much force is applied to the drive before it no longer functions fully.)

IBM expects to ship the drives to OEMs (Original Equipment Manufacturers) in July, and manufacturers including Dell Computer, Gateway 2000 and IBM expect to have them on the market in their notebook computers this year.



Robot Store Catalogue

Robot builders can now obtain the Mondotronics Robot Store catalogue no. 13, "The World's Biggest Collection of Miniature Robot Kits, Books, Parts and More".

The current catalogue features touching and seeing robots, programmable robots, robot muscle wires, many gear and motor kits, and the MicroBench (tm) Pic-driven 24-channel user-definable I/O workbench, able to take downloaded programs and run independent of the main computer. Also new this time is the Soccer'bot Kit, six-legged football-playing robots. No soldering with this kit.

For a catalogue with more information contact Mondo-tronics Inc., 524 San Anselmo Ave. 107-13, San Anselmo CA 94960. Tel. (USA) 415 455 9330 Fax 415 455 9333 email info@mondo.com. Web site: wwwIRobotStore.com.

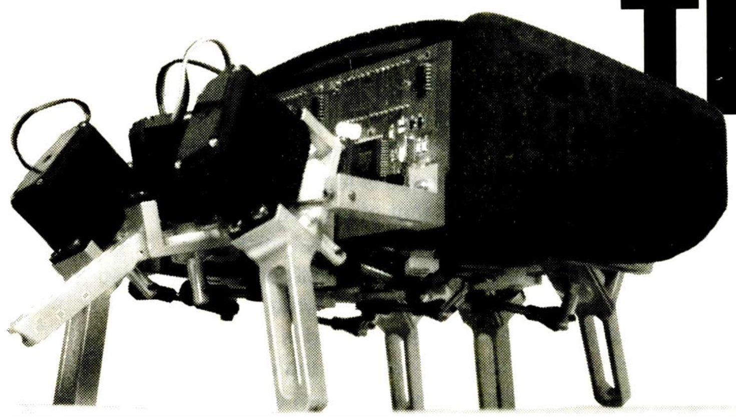
Maritime radio is handed over by the RA

Responsibility for maritime radio operator exams and certification, maritime radio performance specifications and type approval of maritime radiocommunications equipment, including compliance with the Electromagnetic Compatibility Directive, has been transferred from the Radiocommunications Agency to the Marine Safety Agency of the Department of Transport as of 30 June 1997.

Announcing the changes, Minister for Science, Energy and Industry Mr John Battle said: "This transfer will bring a number of benefits to the maritime community and marine radio industry, including rationalisation of seafarer training and certification in the UK. It will also allow resources to be better used and aid consistency in decision taking through single Agency participation in specification-setting work at European level."

Parliamentary Under-secretary of State for Transport Glenda Jackson said, slightly more succinctly: "This transfer represents a rationalisation of the functions carried out by the two Agencies, resulting in a 'one-stop shop' for manufacturers of radio equipment and mariners wishing to become qualified in seafaring competencies."

The MSA will also take over the power to revoke an Authority to Operate held by an individual. The RA will continue to be responsible for licensing of maritime radio use under the Wireless Telegraphy Act 1949, the enforcement of licence conditions, and investigation of reports of radio interference.



The Secret of the Machines

Robots are playing an increasingly pivotal part in modern life. Now some people fear that they will become a 'new species' that will take us over. Douglas Clarkson examines the evidence.

Artificial intelligence is a rapidly expanding component of our society. As an integral component of economic competitiveness, market economies prosper by utilisation, for example, of industrial robots in car assembly lines. There are so many issues raised, for example, by Professor Kevin Warwick's book *March of the Machines* that it is difficult to know where to begin in sampling its many messages. Also, the work of Professor Warwick's group at Reading University tends to handle topics in a constructive way - finding ways and means to develop a specialist wheelchair for the disabled. There are indications, however, within the world military sector, of massive investment and development of 'intelligent systems' to wage war. This means that by no means all R & D is communicated to the public at large.

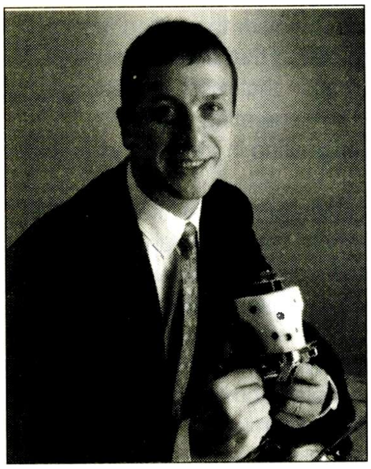
Professor Warwick's book is deliberately slanted to be read by someone with no background in science, so its technical and scientific content is deliberately limited. This can be something of a disappointment for those able to find their way around publications with more technical content.

Professor Warwick, shown with one of the 'Seven Dwarfs' in figure 1, has in a way singled out identity in a particular aspect - autonomous units, each with an apparent identity of its own - in order to isolate and demonstrate the potential for machine independence and development. Books like March of the Machines are more perhaps designed to stimulate a debate than provide definitive predictions about the future. The book airs several key questions - none more important than an understanding of the Nature of Self.

The nature of Self

A central question in the study of machine intelligence relates to the nature of human consciousness. There are expressions of belief that the human brain is no more than a complex telephone exchange which is connected across various interfaces to a higher energy or non physical spiritual force. There is also the viewpoint that 'neurons are us' - we are no more and no less than our vast tangled web of brain cells. This is the viewpoint of 'strong' Artificial Intelligence, which maintains that, if the human identity is no more than a complex collection of miniature electrical circuits, then it should eventually be able to copy this and replicate human faculties. Also, according to this theory, even circuits of intermediate complexity would have some degree of human type characteristics.

Figure 1: Professor Warwick shown with one of the current generation of the Seven Dwarfs.



According to the belief in the higher spiritual force theory of consciousness, or 'magic' theory, it will never be possible to develop a 'self aware' robotic machine because the element of higher human development - will and consciousness - cannot be replicated in purely physical form. It is in the progression of machine 'cleverness', however, that many in this field anticipate an apparent attribute or mimic of machine self awareness. It will, however, be a clever deception.

The mind of the mathematician

The Artificial Intelligence community is too busy designing, programming and training AI systems to spend much of their time engaging in philosophical thought of the nature of awareness and consciousness. But they do prompt mathematicians like Roger Penrose to put a shot across the bows of the barge of 'strong AI' - that bastion of belief that considers that consciousness is no more than the activation of vast arrays of neural connections in our brain. Twinned with this belief is the assumption that if a connected system can be made to process algorithms as complex as those taking place in the human brain, then it too will be conscious. Penrose's book, the *Emperor's New Mind* is effectively a move back to the common sense approach that consciousness is something quite separate and different from simulated sensory spikes in silicon.

In tracing through observations across diverse fields of mathematics, physics, neurophysiology and computing, Professor Penrose presents some interesting observations.

One of these is that in identification of the 'road map' of sensory mappings in the brain, where, for example, the area is activated that causes the right arm to move, this will be done without the wish to move the left arm being aroused. In one conscious patient, the right arm in fact tried to stop such 'involuntary' motion taking place.

While the site selected was the origin of nerve pathways to control the arm, it was not the centre which controlled the 'will' to undertake such activity.

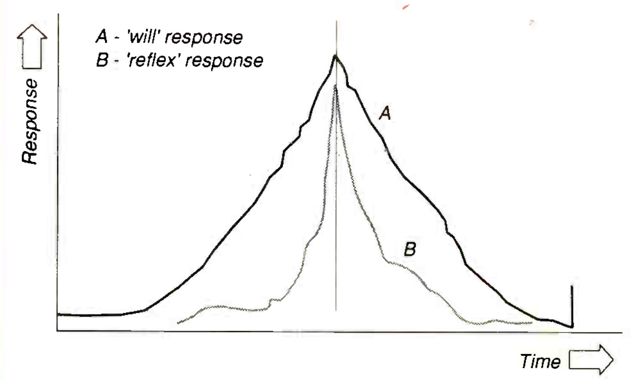


Figure 2: Differences is response of 'willed' action and 'automatic response' action in movement of finger. The 'willed' response is spread over a greater period of time.

Another subtle observation is that of anticipated action - such as wiggling a finger compared with moving a finger in response to a buzzer or a light signal. The differences in response are indicated in figure 2, where the 'willed' action takes place over a longer time period that the 'response' action. This is perhaps an indication that more interesting differences could be detected by separating actions originating in 'will' and those originating in 'reflex' and 'response'?

One very interesting observation of general interest is the phenomenon of 'blindsight'. Where the retinal function is intact but damage occurs to the visual cortex so that vision is lost over part of the visual field, some sensory awareness can in fact be retained since visual data is also routed to other centres in the brain. This was proved by a patient with this problem correctly 'guessing' simple geometrical shapes presented in the visual field that was 'missing'. This suggests therefore, that the brain is undertaking some sort of image assessment and characterisation that is not directly related to seeing objects.

Leastways, Professor Penrose gives us plenty to think about. It is an indication that the pendulum is moving steadily away from a Newtonian model of the universe and with it strong artificial intelligence concepts of the nature of human consciousness. Professor Penrose, however, has not actually stepped outside the stockade of 20th century physics, though he has climbed its highest tower and gazed into new territories yet to be discovered.

The march of popular science

The area of machine consciousness and emerging theories of cosmology is very much the core material of an expanding core of books appearing under 'Popular Science'. One interesting contribution is '*Who's Afraid of Schrodinger's Cat*' by Ian Marshall and Darah Zohar, which acts like a road map of old, transitional and new theories. *The Life of the Cosmos* by Lee Smolin provides a perspective on Newtonian Science and emerging views of cosmology and related matters. *Goodbye Descartes* by Keith Devlin continues in the same vein. In a reinforcement of an earlier book, Hubert Dreyfus has recently published *What Computers Still Can't Do* to remind us that computers in the 1990s are fundamentally not really any smarter than they were in the 1970s. Are these titles evidence that thinking on artificial intelligence is really moving away from equating all human faculties to that of connected neural circuits? Most book publishers at least must think so.

The heightened debate on machine intelligence comes also at an interesting phase in science which, while fascinated as ever with the diversity of the physical world is giving some space to more esoteric topics. The Big Bang is one thing and the first three minutes was a very interesting time, but now the attention of physicists is being directed on conditions before the Big Bang. Why did it take place? This takes science into a plane of thought rather than into a profile of measuring observables. Once science sets forward questions to be asked, it tends to be persistent and not let go of them. In looking for new answers, physicists have been fundamentally influenced by their discoveries in quantum physics.

Concepts of Self Awareness

There are, however, some problems in basic understanding of sensory awareness. It is one thing to understand how the eye - retina - visual cortex can process a series of nerve impulses, quite another to understand how this is transformed to something that we can see. Seeing is just not a process of receiving a processed series of nerve signals - it is about an awareness of seeing. Likewise with hearing - yes, we can understand how the cochlear microphonic signal is created. The question is really: how are these signals translated into an awareness of hearing? It is this awareness of the senses - awareness of being - that remains a stubborn question and is really at the core of machine 'awareness' studies.

To thus make references to machines becoming self-aware touches on some very deep philosophical issues that certainly deserve to be addressed diligently. It is quite convenient to dismiss the whole argument and say that human beings have no real awareness of themselves and that what the human brain can do machines will one day do better.

There is also a paradox in being self-aware. The possession of self-awareness may provide, potentially, awareness of a more expansive world beyond our own immediate awareness. Thus while we are aware of ourselves, and go about our business, there is also the interaction, albeit at a subconscious level, with more expansive dimensions. So the question of self awareness on a non physical level has massive implications for future theories of Everything.

The question, however, is how can scientific diligence be extended to areas that as yet have no formal acknowledgement. We must leave that, however, to new generations of scientists to grapple with. It is certainly a paradox, however, that we may know more of the existence of black holes in distant spiral galaxies billions of light years distant than we do of our own inherent nature - self-mind-brain nature.

The drive for self-awareness

It should be borne in mind, however, that homo sapiens has primarily through genetic development acquired a highly developed sensory processing system to allow him to cope and survive in his environment. As the prime rivals and threats to his existence possessed roughly equivalent systems, but were perhaps stronger, faster or had bigger teeth, his compliment of senses was adequate for the job. It has been argued that this trend has resulted from the need to be successful, to stand a greater chance of surviving.

Another viewpoint on this process is the interpretation that one of the prime drives of evolution appears to be the creation of species that are increasingly self aware. This is a fact noted in evolution that brain sizes have increased across numerous species including our own. One attribute of mankind's handiwork has been to seek to manifest a degree of sophistication and complexity in his technological creations. There is now even the theory that the physical constants of the universe have been so devised that life forms - such as us - can exist within it. The Anthropic Cosmological Principle by John Barrow and Frank Tippler is a book very much for the physicist and which provides a conducted tour of physical laws and relationships to provide some perspective on what they all add up to in this context.

The Higher Self model

When commentators reference the 'magic' theory, this is usually without a great degree of specificity of detail. It is described almost as a factor X which may be present in some way but, its attributes are not distinct. This does not help us try to work out in some way how consciousness may operate. By trawling through mainstream esoteric philosophies, it is possible to be slightly more specific about what this could entail.

This particular model, highlighted in figure 3, is a condensation of various esoteric traditions, some quite ancient, some more relatively recent which try to place the real human identity in some perspective.

The physical body is well known to us. According to the 'magic' theory, this is considered to be directly linked to the

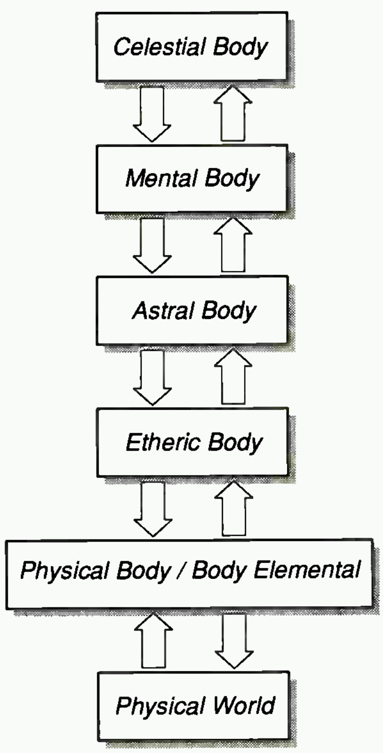


Figure 3: Summary of the 'higher self' model of human makeup. Elements of 'will' and 'awareness' and 'conscience' would originate at higher than physical levels. emphasis on trying to understand the nature of things.

etheric body, which due to its vibrational characteristics is generally invisible to us. There is also a body elemental, a structure closely linked to the needs of the physical body. This aspect has also been linked in some instances to the emotional makeup.

There are other vibrational states above the etheric which are similarly invisible. Energy is applied to the etheric body at various points of contact - the chakras - with the principle ones identified on the crown of the head, the brow, the throat, the heart, the solar plexus, the spleen and the base of the spine.

Various classification schemes may include additional centres. In this context, the physical body is very much a system sustained by energy systems which for most individuals are apparently undetectable.

A key aspect of the 'magic' theory interpretation is the interaction between the brain and etheric body and higher components. Thus an expression of will which originates above the etheric, for example, to move a finger is communicated through the etheric interface to the brain which in turn duly activates the neurons in the brain to move the finger. This level of control requires the correct part of the brain to be stimulated to undertake the required action.

Scientists have been able to use techniques such as PET (Positron Emission Tomography) and MRI (Magnetic Resonance Imaging) to identify brain activity associated with a range of processes such as reading aloud or squeezing a rubber ball. In this aspect, however, there are two paths of information. One is to cause the stimulation to take place and the other is the sensory feedback resulting from the stimulus. It is quite simple, to stimulate muscles by activating elements of the cerebral cortex. This is in fact the way in which a 'road map' of the brain's mapping system is determined. This excitation, however, does not activate the will to initiate the various motor responses - only the action.

It would be quite interesting, therefore to seek to map the points of contact of the will within the brain.

Human Sensory Extensions

A favourite topic of science fiction writers is the concept of machines more directly participating in our neural or sensory processes. One of the most direct approaches to this is that of the cochlear implant, where external sounds are detected by conventional microphone and processed and fed along the pathway of the Organ of Corti within the cochlea where electrodes make contact with nerve fibres which in turn are connected to auditory centres in the brain. There is in fact, no direct connection between the outside world and the inner ear. This is achieved by inductive coupling.

This development is therefore very much showing the way forward. While various groups are working on the artificial retina, this is still several years away at best.

The Robots at Reading

The optimising of neural network parameters can be directly considered as a learning process. Robots developed at Reading, however, have generally a low number of effective neurons - the latest generation of the Seven Dwarfs with the equivalent of 500.

The topical third generation of Seven Dwarfs robots at Reading University, shown in a group in figure 4, have been established with the following attributes:

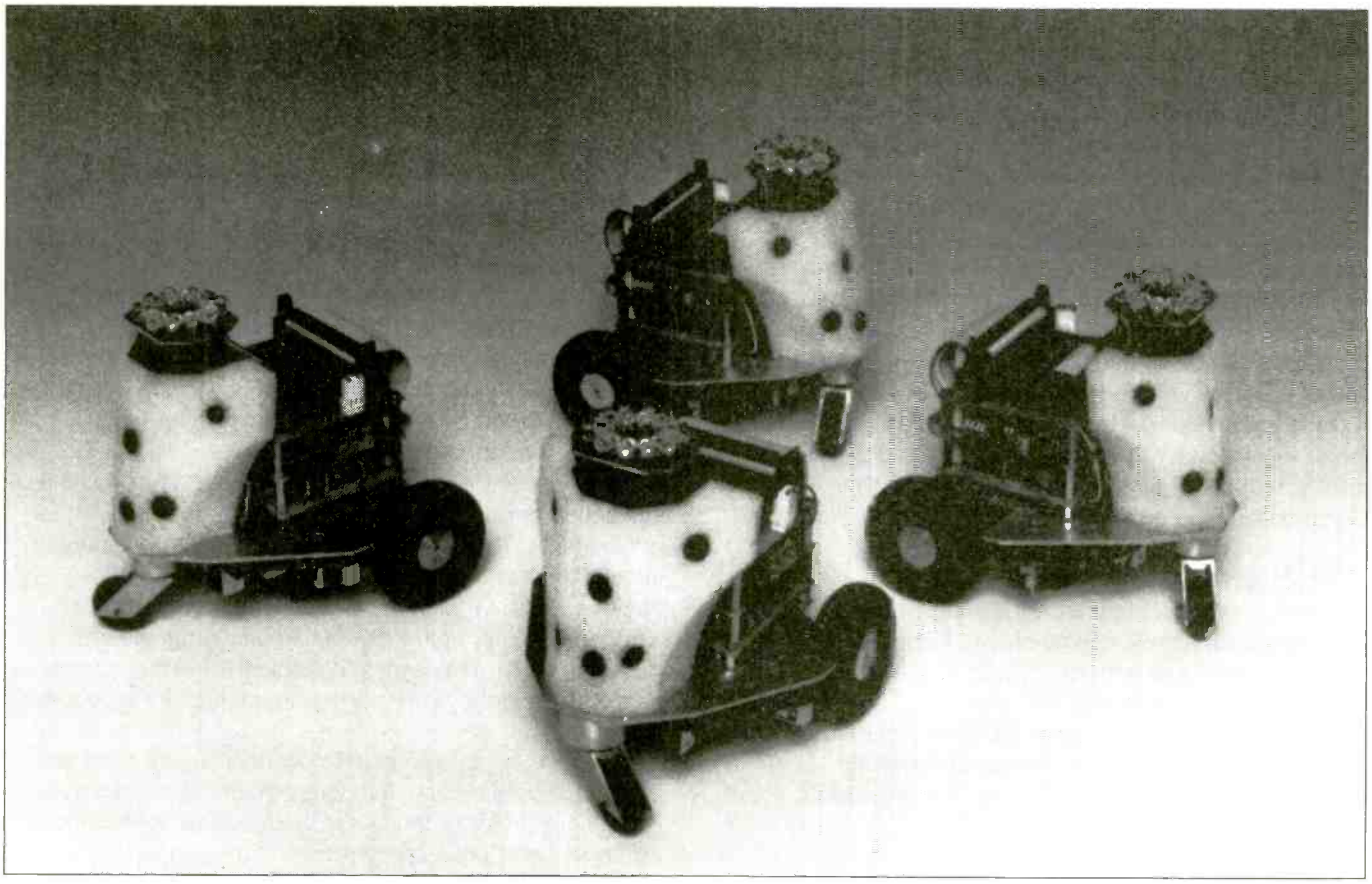


Figure 4: Group of current generation of the Seven Dwarfs (the third).

a) avoid obstacles as determined by two front sensing ultra sound detectors
b) dock in a recharge bay when power is required
c) opt to be a 'leader' robot if no other robots near
d) follow the 'leader' signal of greatest strength if not already a 'leader'

In their design, the left and right rear wheels can move independently. On top of each unit is located a mini array of infra red transmitters with infra detectors on the front portion of the unit. Each robot is provided with its own carrier frequency on which is superimposed pulses of information. A left and right side ultrasonic detector is used to provide two independent object locating signals.

An early version of Bashful is shown in figure 5.

The relevance of this set of robots is that their sensory systems, number of neural network processing elements and desired behaviour are all in balance so that they form a system that trains towards a 'smart' conclusion.

Elma is a six legged walking robot which has evolved from the previous design of Walter. Elma has sensors on her legs which allows her to detect the weight distribution along her frame. These signals are in turn routed to her processing brain which contains around 100 neurons and which maintains her stability. Elma is much more stable in walking than apparently Walter ever was. At present Elma is controlled by radio link with directions being sent to her for example to make for a given location but to avoid certain areas of the immediate area.

At present the self learning modes of neural network training is being used to train Elma to walk to that she can negotiate difficult surfaces. It is anticipated that the command system will be fully incorporated within future versions of Elma. Thus wherever Elma goes, she learns

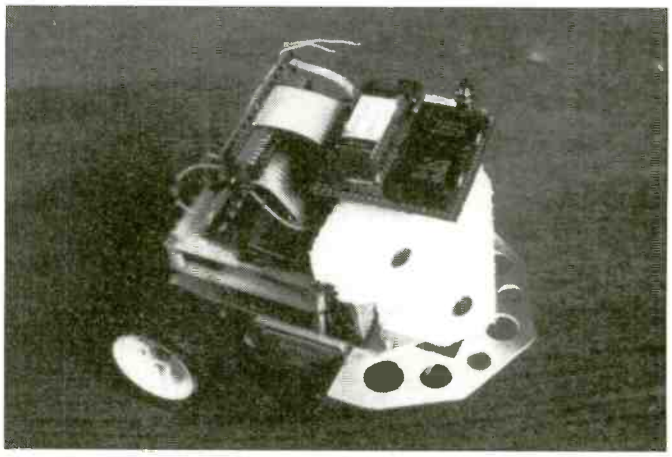


Figure 5: Close up of Bashful when he was first given a new 'neural' brain that could be simply plugged in.

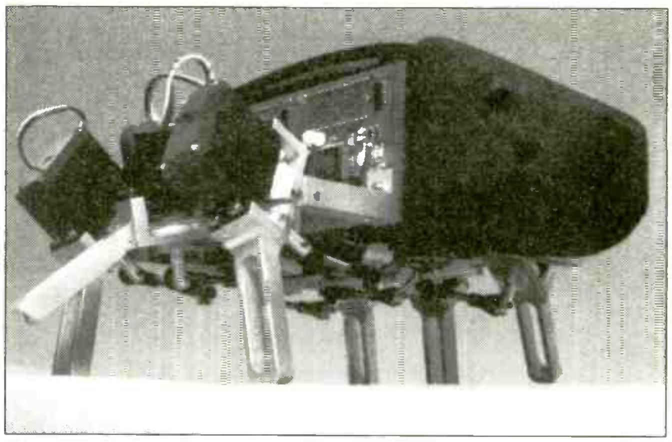


Figure 6: View of Elma, which is at present controlled remotely but which learns through training of neural network circuits to walk over difficult terrain.

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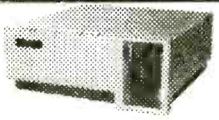

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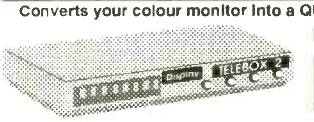

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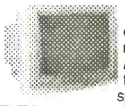

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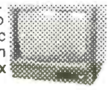

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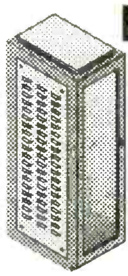

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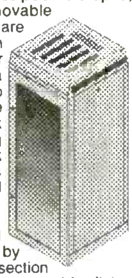

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Elma, shown in figure 6, and also on the front cover of Professor Warwick's book, could have practical applications in working in dangerous environments - such as decommissioning nuclear power stations, mapping minefields and autonomous vehicles for space exploration, for example on the surface of Mars. European Space Agency, please take note. In a mechanical sense, Elma is considerably more complex than the Seven Dwarfs. The relevance of a device such as Elma is that it learns to cope with problems of the real world, by adapting its neural network to cope with real problems.

Neural networks and learning

It is the 'self learning' mode of neural network interaction that has principally been developed at Reading. Figure 7 indicates a typical neural network, with a row of inputs feeding forward through intermediate lines to a line of outputs. A training set of data is required to establish the function of the network. With initially random weights added, in the example of one of Professor Warwick's robots, the robot will move about, encounter other robots and other objects. Each of the lines indicated represents a specific value of weighting - with 50 defines in this particular example.

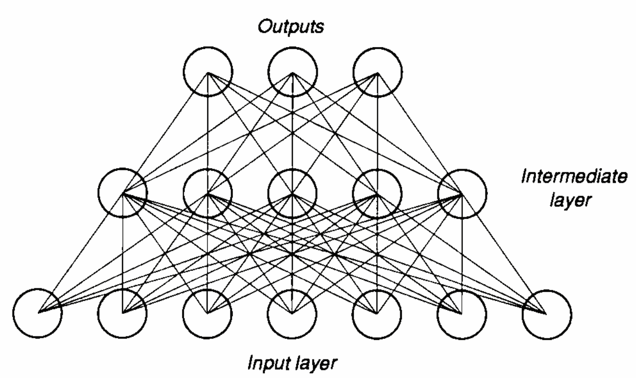

Figure 7: Typical neural network, with input layer, intermediate layers and outputs.

In time through a series of interactions with its environment, the robot will learn not to bump into things. The parameters of the weightings will tend to stabilise, for a particular robot and environment, at a given value. If after a process of learning, all the weightings are reset to the same initial set of random values, and the robot begins to learn all over again, then the final set of weightings will be comparable but not identical since the weightings will reflect exactly what happened to the robot on its way. It is also possible to reset one weighting to a random value and then observe the robot make mistakes as it relearns a more appropriate value of the weighting.

Of course, it is possible to load a set of learned parameters from one robot, transfer these to an identical but untrained robot and the new robot will behave as if it had been trained. By networking robots either in physical close proximity or, for example, across the Internet, it is possible to collate and speed up the learning process. This training across the Internet has in fact been demonstrated successfully.

Raising the AI Profile

The work at Reading has in some ways been centred on developing autonomous devices - self powered through batteries. This has allowed observation of learning modes of such devices and with also the added bonus that such devices are fun to watch and excellent for demonstrations. To the public, one inspection of the robots at close hand is worth hours of lectures on the technology of such devices. One of the achievements at Reading has been to make such technology much more visible and allow it to be captured by today's 'sound byte' media brigade, hungry, as ever, for unusual images.

In conventional approaches to design and construction of electronic systems, the unit is designed, tested and usually after a few minor modifications put into use. In the way that neural networks are developing, more complex development systems are able to adapt their network design to cope with improved power of problem-solving within a given framework. There is not only an ability to solve problems within a given framework, but there is scope to improve the power of the problem solving algorithm. This can involve optimising neural network topologies. This level of self driven enhancement within a framework of increasing complexity of function is seen also as a component of the ability of machine smartness and effectiveness to be enhanced.

So far at Reading we have the aspect of small autonomous objects responding to a very basic subset of environmental requirements and directives, really demonstrating potential usefulness rather than actual usefulness itself.

Elements of Control

In this sense, robots will remain extensions of our will. If some deranged individual develops a highly developed technology which is designed to inflict death and destruction on fellow human beings using robot technology, then this is not because the systems that wreak the havoc are self-aware and know what they are doing. As any software designer knows, however, the more complex systems become, the more liable they are to develop or manifest errors. So there is also the finite possibility that a system developed with positive intent could fail or become unsafe simply through error in its design at some level.

There is also a paradox here. If systems become self adapting and modify their neural network topology to increase complexity and general processing ability, then can such changes be validated as they take place to ensure system integrity? In this sense, the more it modifies its design to do things in a more efficient way, the more there is a potential risk of error.

AI Propaganda

There is also a discrete psychological approach to the development of robotic technology. This tends to demonstrate that after all, *homo sapiens* is nothing startling. Only a few generations of applied technology will produce machines that are much better at everything we have been trying to do.

A sober warning from Professor Warwick is that before long we will lose control of our robot inventions and they will become our masters. All things are possible. If you look carefully, however, at the vast legislative bureaucracy of the European Union, taking extreme care to define the limits of milk content in 'ice cream' then it would be unlikely that the EU would readily sanction the development and release of super robots that would dominate us.

Security

Although it was not a key remit of Professor Warwick's book, the greatest threat to the efficiency of such systems in present circumstances is to break their security and subvert their software. As disaffected groups feel resentful of the increased level of bureaucratic control of social and economic infrastructure, key computer systems may become even more a 'soft' target and one that, mistakenly, such groups could accept as justifiable. It would appear also more satisfying to subvert such systems than to destroy them.

The Really Useful Robot

It is perhaps useful to guess what a Really Useful Robot Company could develop in the future. It would be possible to program in some directives to autonomous machines. For free moving units, these could be described as:-

- do not run out of power
- do not get lost
- do not run into objects
- always take note of external commands
- undertake tasks efficiently
- fail safely in event of malfunction
- do not present a risk to other objects
- keep a log of everything that has taken place

At a level below this is the computational power to address all these issues. Such systems are becoming smarter, as increasing processing power becomes available. In terms of the effects of such systems on our society, the fact they may or may not be self aware is irrelevant. The coming reality that machines are going to get relatively smarter and smarter.

Sensory superiority

On the sensory side, with modern technology, a vast array of additional attributes can be bundled into a robot. Thus we can add equipment to detect and resolve in different parts of the electromagnetic spectrum outside the relatively narrow band of 380 nm to 720 nm. We can add x-ray spectrometer, gamma ray spectrometer, ultra violet detectors, infra red detectors. We can even add sensors via Doppler technology to determine if objects are coming towards us or going away from us. Also, as technology becomes more compact and efficient, it becomes even easier to extend the sensory armament.

Thus robots can be developed with significantly enhanced sensory systems. It is recognised, however, that the human retina/visual cortex is vastly superior in the processing of visual information compared to any machine. In its limited set of sensory inputs, the human 'machine' does exceptionally well.

Machine Profiles

While it may not be possible for a machine to experience self-awareness, it is entirely possible to provide it with sophisticated algorithms for it to operate within well defined guidelines. The general structure of an autonomous system are outlined in figure 8.

It is clear that the system would in fact be a mix of digital systems and also probably neural network components. The digital systems would provide the goal directive and components to tell how the system should respond in given circumstances. The system would require to verify its function so that it could report faults or move itself into a safe mode if required. It would require levels of security to sanction receipt of data from various sources and also security to transfer data to specific remote

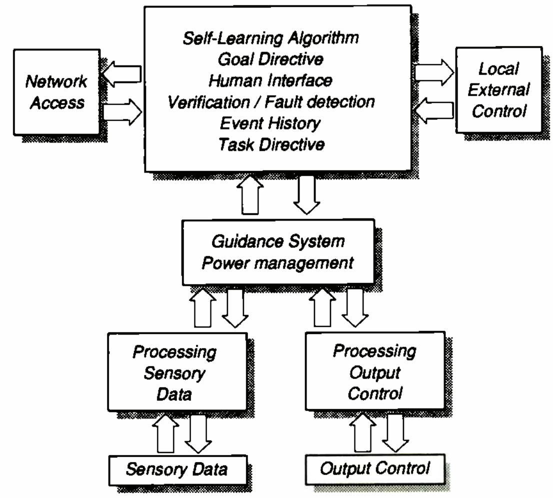

Figure 8: Possible general functional blocks of an autonomous robot.

systems. An event history could be either transmitted continuously or stored on line in order to be able to monitor system integrity or locate faults in event of failure.

Examples have been cited of robots talking to each other over the Internet. The security aspects of this would have to be looked at much more closely if it ever became commonplace. With modern processing speeds of 200 MHz, the potential data handling of such systems would be significant indeed. Technological advances with equivalent speeds of say 2000 MHz systems say in 10 years time gives even more scope to develop useful functionality.

It must be recognised, however, that the fundamental breakthrough with neural networks came about when it was realised how they could be trained. This was barely some ten years ago. While all the time incremental progress is being made in this discipline, it is quite conceivable that there are several major breakthroughs still to be experienced in this field which will allow the structuring and effective training of vastly more complex networks.

It must certainly mean that in a physical environment, smart machines will be doing physical things. To a very large extent robotic systems are already building the next generation of robots. Processes of chip manufacture and development are now so demanding that the most delicate stages of manufacture and design were long ago taken over by automated methods.

A safer society

There is no doubt that our dependence on machines will increase. So far, however (and hopefully) all these systems are very much under the control of their masters. It is our collective responsibility to ensure that this remains so. It is the complexity of our society that is pushing for increased computerisation. In the example of control of aircraft in national airspace, the trend is increasingly to hand more and more over to computers to monitor and direct flight paths. As we make such systems work harder, process more data, make more calculations per second, access data archives which expand rapidly, yes we are giving these systems a more important role in our society. This is primarily, however, because society is itself changing rapidly and these systems are being introduced to respond to this rapid technological change.

In fact key areas for additional implementation of computer/robotic technology are very clearly in evidence. They have a critical role in managing inherently unsafe systems such a transportation systems, nuclear power plants and many procedures processing dangerous chemicals. One argument could say that without the appropriate use of such technology the future would be a more dangerous and unsafe one.

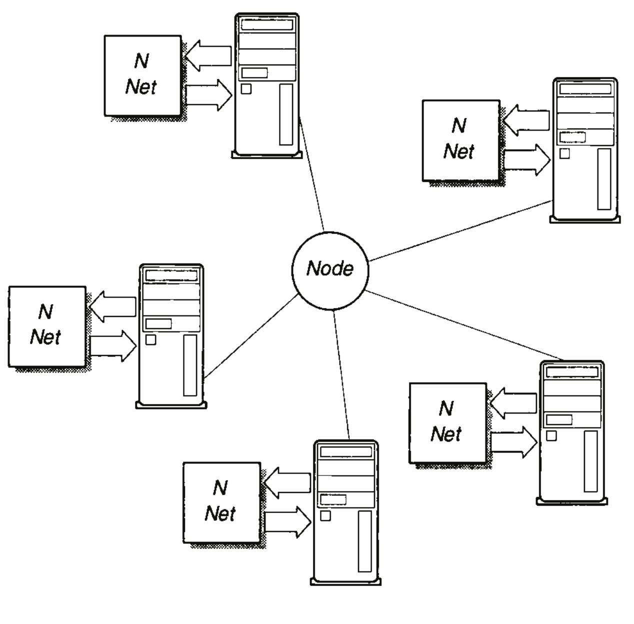

Figure 9: Possible mode of training of systems across a network.

Distributed Training of Machines

The collection of Reading robots presents an example where the small robots are moving about, learning about their environment and refining the training of their neural networks. With the high connectivity of computers today, it is relatively easy to anticipate how systems as networks can learn collectively.

Consider neural networks linked across numerous computers and which have access to a large flow of training data for the local neural networks, as shown in figure 9.

If all of these systems have an optimising algorithm where each system can receive its own training data set locally and also link to the network structure and input/output of other PCs, then the level of training of the PCs begins to increase as weighting factors are developed for the individual PCs and with dialogue from other systems. In this scenario it is imagined that all these systems are configured exactly the same in their neural network configuration. The network of PC's can be considered to be increasing in smartness over the network.

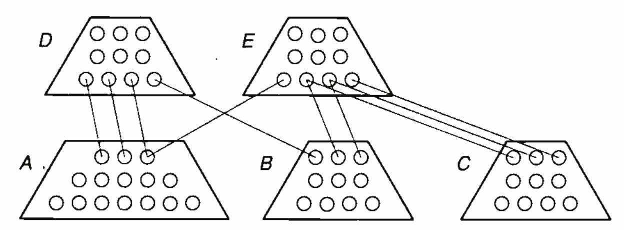

Figure 10: Scope of optimising local neural networks as part of larger problem solving system.

As part of the 'connected' nature of the system, it would be possible for validation of the effectiveness of each local system to be checked against a reference benchmark in order to rank the systems and allow the systems to select in some way the best training data set available across the network.

If however, things are taken a stage further where each local system is given an individual autonomous task where it can optimise the internal connected structure for effective functioning. In this scenario, each local neural network has well defined input/outputs relating to physical parameters. If these are cascaded together across another layer of processing in another layer of local neural networks, as shown in figure 10, again where inputs and outputs are independently defined and have real significance, then training of these local systems can be undertaken.

An so as a thought experiment in neural network development, these systems can be considered to optimise their own internal design to solve the particular problem assigned to them - assuming the physical problem assigned to them can be split up into such local processing modules. By linking these systems in a network, they can be informed of the states of processing in the other systems. One layer would be trained at a time before the next layer was trained from the outputs of the first section. If this model is established in principle, then it is simply a case of expanding it up according to the resources of hardware and software available. This is shown as a two dimensional problem, but it could equally well be developed in three dimensions.

Systems could therefore evolve where each 'box' represents an autonomous 'smart system'. Also, the network connectivity could be superseded by an optimising 'supervisory' system to monitor the functionality of the system and make adjustments to optimise performance.

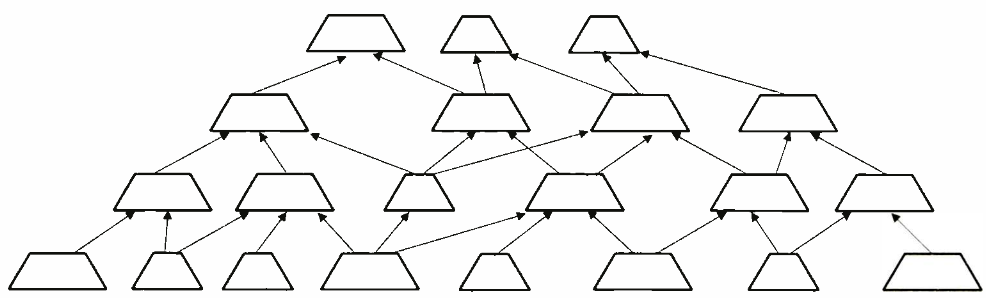

Figure 11: Evolution of connected local neural network units to form a complex connected system.

If a system such as this is to evolve 'organically', then it may require to be associated with a component of trial and error, where some configurations are abandoned while others are retained as they add efficiency to the solution. This would be a role, therefore for some aspect of genetic algorithms in the optimisation of such a system. A complex network could be developed in this way would approach the complexity of the structure of figure 11 where each cell is a relatively complex local neural network implementation. Once 'cell' could for example be a complex spoken language/command interface. Another could be a system for recognition of images.

Such a system, however, is not just a neural network. It is more like some system that has a natural property to make sense out of data, to order it by means of complex training techniques which are in the domain of conventional digital programming. This level of design requires wholly new design structures compared with conventional digital processing scenarios. No doubt this is the scenario which many in this field are seeking ways to implement. It is perhaps not the element of sheer computing power that is the daunting factor - it is the model of connectivity which is the key.

All the hard programming is in the optimising of the network and in the training. Once the network is trained, the inputs are presented and relatively simple programming feeds forward the results. At this stage, operating the network, is a relatively mechanical process. The result of the training procedures and any elements of system configuration would have been achieved

through highly advanced programming. Even if this process is driven to some sort of logical conclusion, where millions of neurons are trained together in a vast association of elements, all interconnected appropriately either with weightings in software or in on chip representations, does this represent machine self awareness? Probably not.

It would, however, represent a distillation of a vast amount of data and experience of the physical world. Such a system could be made to appear uncannily like a human being in various of its responses since this is an area in which training of some patterns of human behaviour would be relatively easy.

Does this also mean that much of the 'intelligence' of the brain is very much its sheer physical organisation. Once everything is set up, using it is very much like clockwork, as inputs feed forward through complex neuronal interconnections. After all, when we go for a walk, this is done without any conscious effort of what we are doing - it is all pre-connected. The human brain, however, is very adaptable. It learns new skills. It links to new memories. If part of it become damaged, it seeks out other functional pathways. We have yet to fully understand how it achieves this.

Socio-economic implications

Today manufacturers scour the world for sources of cheap labour. Plants are established, for example, in China, not with highly developed state of the art automated technology but where products are largely built by hand. The economics of this are still attractive, and the capital investment costs will be lower compared with setting up a highly automated production line. But with increasingly cost effective automation, there will be less demand, anywhere, for manufacturing labour. This could set in train global changes of a very unpleasant type - much more threatening to the status quo than the scenario of berserk robots. In this scenario, low skill/low labour cost economies will be particularly vulnerable to such technological change.

It is not in question that more 'smart' machines will play an increasingly important role in the future as techniques of production change the balance of people and technology. Whole new product ranges, however, will probably emerge to counter balance this trend.

There are issues of safety as more and more critical systems are controlled by high technology. There are employment issues as long term established industries fade rapidly away as technological change catches up with them. It is a measure of our loss of control of technology that we are adapting our social structure to cope with technological change rather than controlling technology to serve our social needs.

The new applications

Government agencies are very interested in advances in technology to intercept and monitor all manner of modern communications. Machines could, for example, be trained to be efficient at intercepting and assessing voice and data communications and especially Internet sites which may be undesirable.

It is therefore necessary to be constructive in how this technology will be used. David Brown, in his book Cybertrends, maps out some potential pitfalls and ways forward for the future.

Perhaps, more importantly, it is the debate over how such technology will be used that is of more relevance.

Summary

The media interest in the Reading Robots has arisen not because the technology of the Seven Dwarfs was complex or in any way revolutionary, but because they provided a means of communicating to the onlooker the potential of robotic technology for the future.

At the same time, mixed in with this message was the implied reality that one day such robots will surpass us in 'intelligence'.

While it is accepted that robots are set on an evolutionary path of their own and this will affect the nature of our society in fundamental ways, there is plenty of current and indeed increasing scientific opinion which indicates that the 'thinking' or 'conscious' machine will never materialise. The leading edge of scientific thinking is chasing much bigger issues than the cognitive potential of silicon.

In conclusion as a contrast, perhaps it is relevant, however, to contemplate the calmness reflected in some of the larger granite carvings of Ancient Egypt, where material progress was very basic and there was greater emphasis on trying to understand the bigger picture of things.

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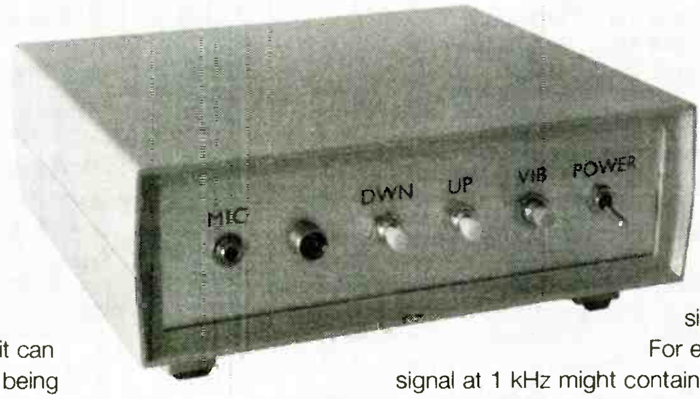
Digital Voice Modulator

Based on the HT-8950 voice modulator chip, Robert Penfold's 'voice-box' can add pitch-shift and vibrato to voice signals, with a 'robot voice' for would-be metal men!



This simple project is based on a single integrated circuit, but it provides a number of interesting voice effects that are generated using some basic digital signal processing. The pitch of the input signal can be shifted up or down, and in each case three levels of shift are available. A robot voice effect can also be produced, but this effect is quite strong and it can sometimes be difficult to understand what is being said. It is still a useful facility though, and will appeal to those who do not like to do things by halves. Frequency modulation (vibrato) can be added to both the pitch and robot effects. The audio quality is not in the hi-fi category since the system has only eight-bit resolution and uses a sampling rate of 8 kHz. The quality is adequate for a speech signal, though, and this project is only intended for "fun" applications such as producing sound effects for amateur dramatics productions.

The unit is economic to run as it is powered from a couple of HP7 size batteries that have an extremely long operating life. Inputs are provided at line and microphone levels, and the unit should work well with any low impedance dynamic or electret microphone. Outputs at line and microphone levels are available from separate sockets, and adding the unit into practically any set-up should therefore be very straightforward. The desired effect is selected using three pushbutton switches. One of these toggles the vibrato, and the other two cycle through the available effects in opposite directions. A front panel LED acts as a simple audio level indicator and makes it easier to obtain a suitable drive level, especially when using the unit with a microphone.

Ups and downs

There are two basic approaches to providing a shift in the pitch of an audio signal. One method involves using the heterodyne principle to raise or lower the pitch of every frequency component by an amount that is controlled by an oscillator. This method is rather like generating a single sideband radio signal and deliberately demodulating it using the wrong carrier frequency. However, this method does not necessarily involve the use of high frequencies, and the desired effect can be produced using balance mixers, high quality audio filters, and phasing techniques. Although this system provides a very "clean" output signal it has a slight drawback in that it alters the harmonic relationship of the components in the processed signal.

For example, an input signal at 1 kHz might contain harmonics at 2 kHz, 3 kHz, 4 kHz, etc. If these are all raised in frequency by 500 Hz, the fundamental frequency would become 1.5 kHz but the first harmonic would be at 2.5 kHz. In other words, the first harmonic would no longer be at twice the fundamental frequency, and the other harmonics would be even further adrift from their correct frequencies. This would not be of importance in all applications, but it gives some "heavy metal" sounds when applied to a singing voice! Another problem with the heterodyne method is that it can only provide a very limited amount of downwards shift. This is simply because a large shift results in the lowest input frequencies being taken below 0Hz, which is obviously not possible. In reality the signal just becomes scrambled.

The second method involves recording the signal and then playing it back at the wrong speed. A higher playback speed proportionately increases the pitch of all the components in the signal, and a lower playback speed proportionately reduces the frequency of all the components. An advantage of this method is that it leaves the harmonic relationship of the individual frequency components intact. The main drawback is that it is very difficult to obtain a really "clean" output signal from a system that works in real-time. In a real-time system the input signal has to be recorded for a short period and then played back at a different speed. If the playback speed is faster than the recording speed, the playback time is shorter than the recording time. This leaves the problem of how to fill in the gaps in the output signal. A reduction in pitch gives the opposite problem with the output signal having a longer duration than the input signal. This means that some of the input signal has to be cut out in order to keep the duration of the output signal equal to that of the input signal. No matter how cleverly the sets of output samples are spliced together you can always "hear the join."

HT-8950

The chip used in this project is the HT-8950 voice modulator which is contained in a standard 18-pin DIL encapsulation (figure 1). While this device is not exactly dirt cheap, it costs very little when you consider the amount of circuitry it contains. As can be seen from the simplified block diagram of figure 2, it contains analogue to digital and digital to analogue converters as well as static RAM, an input amplifier, and a substantial amount of control logic.

The input amplifier is actually an operational amplifier that has a built-in bias circuit, and can be used in the inverting mode. This feeds into a comparator that forms part of the analogue to digital converter. The data sheet for the HT-8950 does not specify which type of conversion is used, but it is presumably a successive approximation converter. A block of static RAM is used to temporarily store the samples produced by the converter, and then they are output to the digital to analogue converter via a data latch. Of course, the samples are clocked out to the digital to analogue converter at a higher or lower rate than they were recorded, so that the required change in pitch is obtained.

A timebase generator is included in the chip together with all the necessary control logic. An oscillator can be used to frequency modulate the timebase circuit during playback so that the vibrato effect is generated. The mode of operation is governed by seven inputs to the control logic circuit. These really break down into two groups of inputs, and one of these groups (S0, S1, and S2) is intended to provide electronic control of the chip. In this case we require manual control and it is therefore the other four inputs that are used. These inputs are at pins 15 to 18, and they have internal pull-up resistors. In use they are connected to ground via pushbutton switches. Operating the switch connected to pin 15 toggles the vibrato effect on and off. The switches connected to pins 16 and 17 enable the chip to be cycled up or down through the available modes, and the list provided below shows the order that is used. The chip defaults to the robot mode at switch-on incidentally.

Up 2
Up 1.6
Up 1.33
Normal
Down 0.88
Down 0.8
Down 0.66
Robot

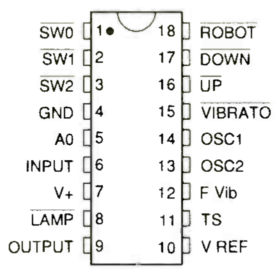


Figure 1: Pin assignments for the HT-8950 voice modulator chip

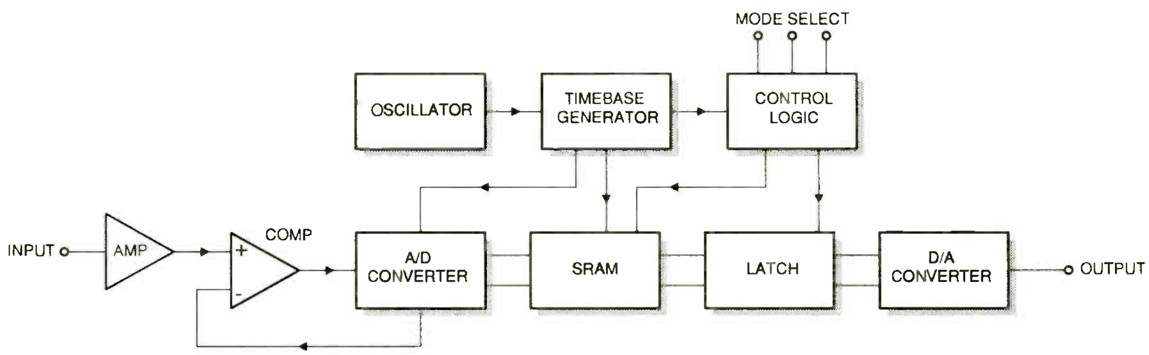


Figure 2: the block diagram for the HT-8950

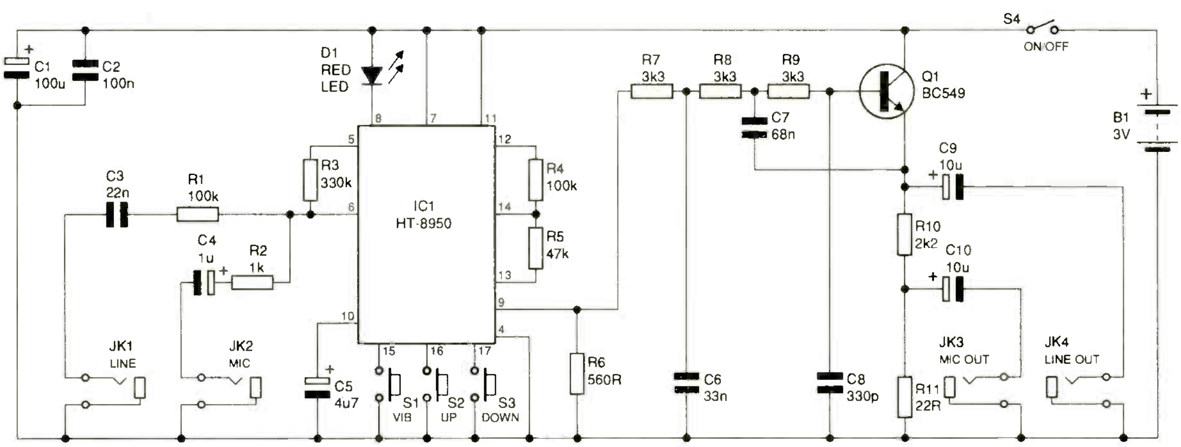
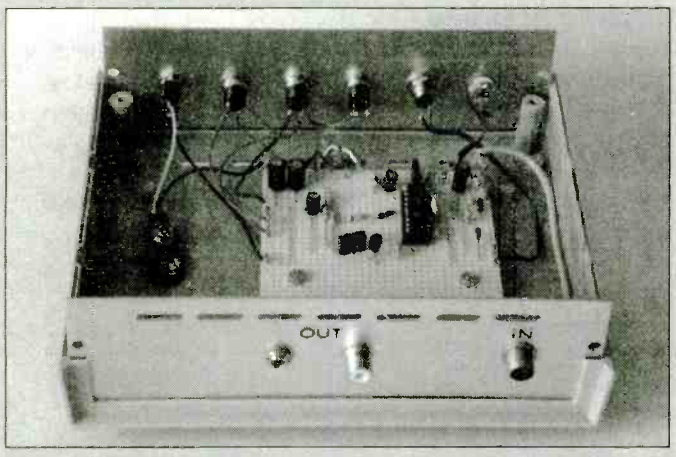


Figure 3: the full circuit diagram for the digital voice modulator



To get to the Up 1.33 mode after switching on you would therefore either press the "down" switch three times, or the "up" switch five times. Operating the switch connected to pin 18 enables the chip to be instantly switched into the robot mode, but this facility is not normally required.

Circuit operation

The full circuit diagram for the digital voice modulator is shown in figure 3. In order to provide inputs for both microphone and line levels the operational amplifier at the input of IC1 is used as a summing mode mixer. Resistor R3 is the feedback resistor and R1 plus R2 are the input resistors. The relatively high value of R1 results in a voltage gain of only 3.3 at the line input, but with an input impedance of 100k. The input amplifier mainly acts as a buffer stage for input signals at line level. R2 has a much lower value, which produces an input impedance of only about 1 k, but this is well suited to a low impedance dynamic or electret microphone. The voltage gain at this input is much higher at about 330, but this higher gain is needed due to the low output level from a low impedance microphone. Even with this much higher level of gain the microphone may have to be used quite close to the user's mouth. Capacitor C5 is the decoupling capacitor for the internal bias circuit for the input amplifier.

Resistors R4 and R5 are part of the built-in oscillator circuits. R4 controls the vibrato frequency, and the specified value gives an operating frequency of about 8 Hz. R5 is part of the main timebase generator circuit. Switches S1 to S3 are the mode control switches. A switch on pin 18 to provide a shortcut to the robot mode has not been included, but it could easily be added if desired. The digital to analogue converter is a type that provides an output current rather than a voltage, but load resistor R6 effectively converts the output stage to normal voltage operation. The audio output signal from pin 9 is a digitised type which requires the usual lowpass filtering to remove the high frequency components. Q1 is used as an emitter follower buffer stage in a third order lowpass filter that has a cut-off frequency of about 3.5 kHz. This bandwidth is adequate for a voice signal, and is approaching the absolute maximum bandwidth supported by the sampling frequency of 8 kHz. Resistors R10 and R11 form the emitter load for Q1, and they also act as an attenuator which provides the microphone level output. This output is at about -40 decibels compared to the line output level, which should be high enough to fully drive any microphone input, but low enough to avoid overloading.

The total current consumption of the circuit is approximately 2 mA, but it increases to about two or three times this level when audio level indicator D1 is operating brightly. Each set of two HP7 batteries should last about 500 to1000 hours. Note that the maximum operating voltage for the HT-8950 is just 4 volts, and that the absolute maximum supply rating is just 5.5 volts. Do not use a supply potential of more than 3 volts as this could cause a malfunction, and could even damage the HT-8950.

Construction

Figure 4 shows the component layout for the stripboard panel, which measures 32 holes by 24 copper strips. This is not a standard size in which stripboard is sold, and a larger piece will therefore have to be trimmed to size using a hacksaw. Then drill

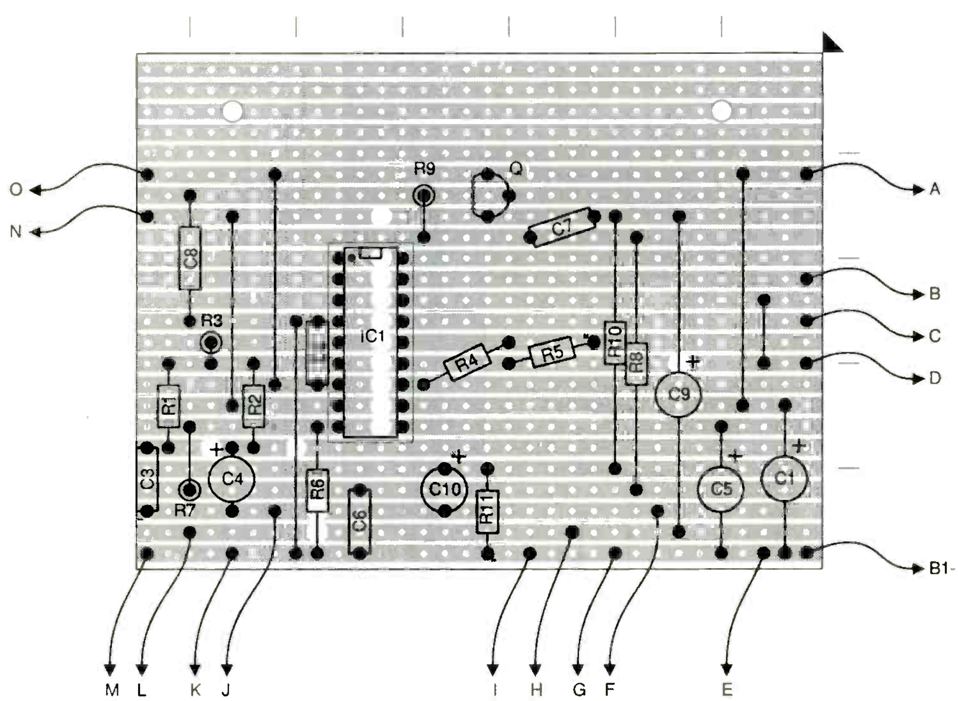


Figure 4: the component layout for the stripboard panel

the two 3.3 millimetre diameter mounting holes which will accept either metric M3 or 6BA mounting bolts. Next the breaks in the copper strips are made using either the special tool, or a hand-held twist drill bit of about 5 millimetres in diameter will do the job quite well.

The board is then ready for the components and link-wires to be added. The HT-8950 is a CMOS device and it therefore requires the standard anti-static handling precautions. As this chip is not particularly cheap it is a good idea to follow these precautions "to the letter." The most important one is to use a holder, and not to fit IC1 into the holder until the board and all the hard wiring have been completed. Until you are ready to fit IC1 into its holder it should be left in its anti-static packaging. When fitting it in place try not to touch the pins any more than is really necessary, and you should obviously keep well away from any known sources static charges.

Apart from IC1, the exact order in which the components and link-wires are fitted to the board is not too important, but it is best to work methodically rather than just fitting components at random. One or two of the link-wires are fairly long, and in order to avoid accidental short circuits they must either be kept quite taught or they must be insulated with PVC sleeving. Fit single-sided solder pins to the board at the points where connections to the off-board components such as the switches and sockets will be made. One millimetre diameter pins are needed for normal 0.1 inch matrix stripboard.

The prototype is housed in a plastic and metal instrument case which measures about 170 millimetres wide, but this is substantially larger than is really necessary. In most respects the general layout of the unit is not too critical, but the leads which connect the input sockets to the component panel must either be very short or screened cable must be used. Even when using a slightly oversized case it can be difficult to find space for everything on the front panel. It is probably better to move some or all of the sockets to the rear panel rather than cram everything on to an overcrowded front panel.

Details of the hard wiring are provided in figure 5, which should be used in conjunction with figure 4 (eg point "A" in figure 4 connects to point "A" in figure 5). I used 3.5 millimetre jack sockets for JK2 and JK3 and phono sockets for JK1 and JK4, but you can obviously use any audio connectors that match the equipment you will use with the voice modulator. A plastic holder is used for the two HP7 batteries and the connections to the holder are made by way of an ordinary PP3 style battery clip. LED indicator D1 is not driven at a particularly high average current and it is therefore advisable to use a high efficiency type. The cathode (k) terminal is usually indicated by having that lead shorter than the anode lead.

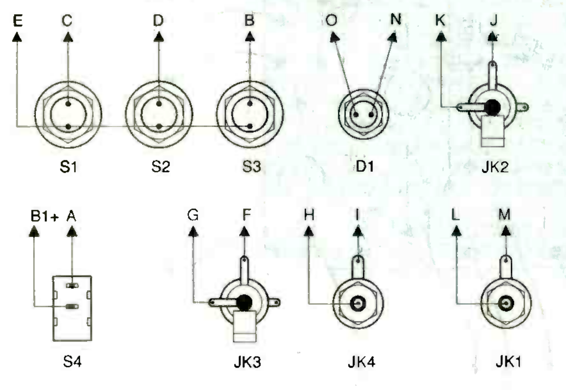
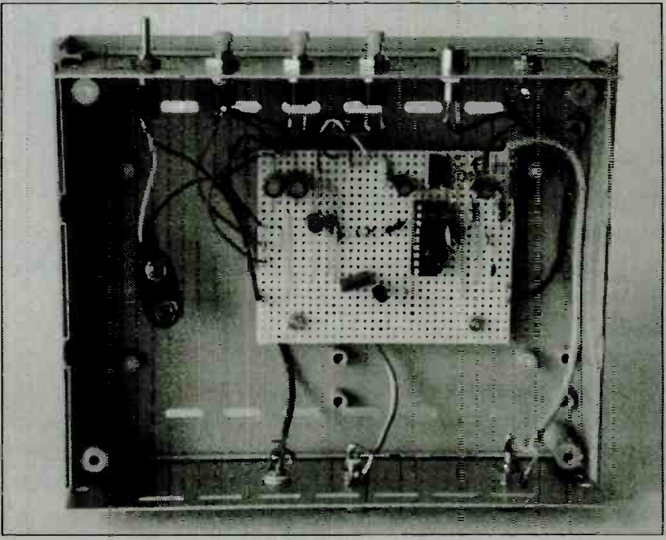


Figure 5: details of the hard wiring (use in conjunction with figure 4)

Testing and use

Mistakes are relatively easy to make when using stripboard, so it is a good idea to thoroughly check the finished unit before connecting the battery and trying it out. A good way of giving the unit an initial check is to monitor the line output using a crystal earpiece, with the input signal being provided by a microphone. At switch-on you should obtain the robot effect, and with or without the added vibrato, as you talk into the



PARTS LIST for the Digital Voice Modulator

Resistors

(All 0.25W 5 percent carbon film)

R1,4	100k
R2	1k
R3	330k
R5	47k
R6	560R
R7,8,9	3k3
R10	2k2
R11	22R

Capacitors

C1	100u 10V radial elect
C2	100n ceramic
C3	22n polyester
C4	1u 50V radial elect
C5	4u7 50V radial elect
C6	33n polyester
C7	68n polyester
C8	330p ceramic plate
C9,10	10u 25V radial elect

Semiconductors

IC1	HT-8950
Q1	BC549
D1	Red panel LED

Miscellaneous

JK1,4	Standard jack or phono socket
JK2,3	3.5mm jack socket
S1,2,3	Push to make, non-locking pushbutton switch
S4	SPST min toggle switch
B1	3 volt (2 x HP7 size cells in holder)

Small metal or plastic case, 18-pin DIL holder, 0.1 inch pitch stripboard measuring 32 holes by 24 copper strips, PP3 type battery connector, wire, solder, etc.

microphone its effect on your voice should be very obvious indeed. The data sheet for the HT-8950 does not give any precise details on how this effect is produced, but it apparently uses a "chopping" technique. Together with the vibrato this produces a sort of super "Dalek" effect! Remember that in any operating mode, pressing S1 toggles the vibrato effect on and off.

By operating S1 and S3 it should be possible to cycle the unit through all the available effects. Once again, the effects are very obvious, especially when using a large shift in pitch. In general it is best to move high pitched voices downwards and low pitched voices upwards. Moving a high pitched voice higher in pitch tends to take many of the voice frequencies outside the bandwidth of the modulator, and gives an output that can be difficult to understand. Similarly, shifting a low pitched voice even lower in pitch can give very poor intelligibility, and a very odd sound!

The input stage operates as a simple summing mode mixer, and the unit will work using microphone and line input signals simultaneously. However, using more than one input signal at a time might not give very good results, and the unit works best if it is only used with voice signals, and one signal at a time.

It is interesting to use the unit on the voices of the rich and famous. Try connecting the earphone output of a radio to the line input of the modulator, and then search the bands for victims. Results can sometimes be surprising, with the voice of someone famous being turned into the voice of someone else who is famous. Shifting the voice of John Major down a couple of notches produces a very good impersonation of Sir Edward Heath! No doubt many other interesting transformations are possible.

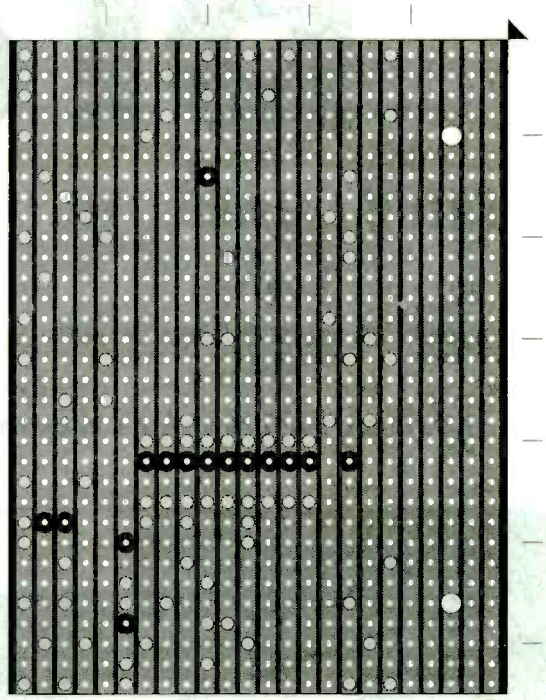
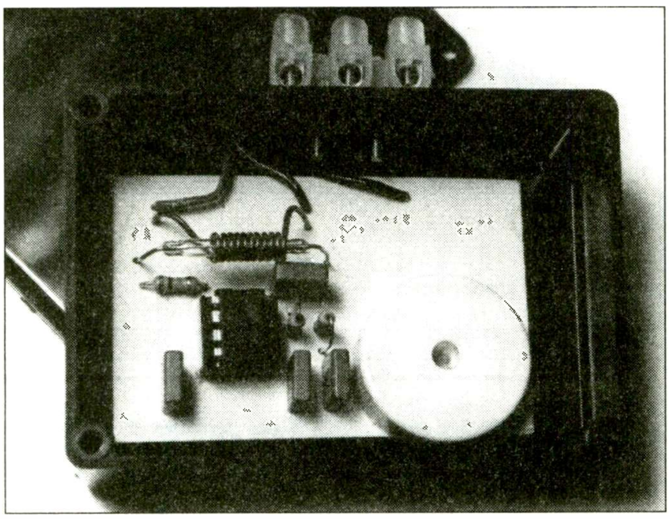


Figure 6: the stripboard reverse

Brake Light Checker

A self-test system for caravan and trailer brake lights by Terry Balbirnie



The law requires flashing indicators on towed vehicles to have some sort of built-in check to show the driver that they are working. This often takes the form of a small dashboard light which blinks in time with the car indicators if the corresponding one on the trailer is operating. Some systems use a buzzer instead.

Self-check

There is no such checking requirement for the brake lights. However, these are also very important - especially when the lamps on the towing vehicle cannot be seen by the driver behind. The present circuit fulfils this need by checking that the stop lights are both working. Under normal conditions of use nothing happens. However, when there is a fault, a high-pitched bleeping will be given each time the brakes are applied. This will probably be unlike any other sound in the car and, being high-pitched, will be easily heard above engine and other noises. As well as failure of one or both bulbs, faults which will trigger the unit include poor connections at the towbar plug and socket, broken wires, corrosion in cables or at the lampholders and bad earthing. Note that the unit will not operate in the event of a fault which would cause the brake lights on the car itself to fail. An example of this would be the fuse feeding them having blown. Since this fuse carries an additional load of 100 percent, it is necessary to follow the manufacturer's recommendation regarding uprating it if necessary.

How it works

The complete circuit for the Brake Light Checker circuit is shown on figure 1. The principle components are magnetic reed switch, S1, coil L1 and integrated circuit IC1. A complete description will be given presently.

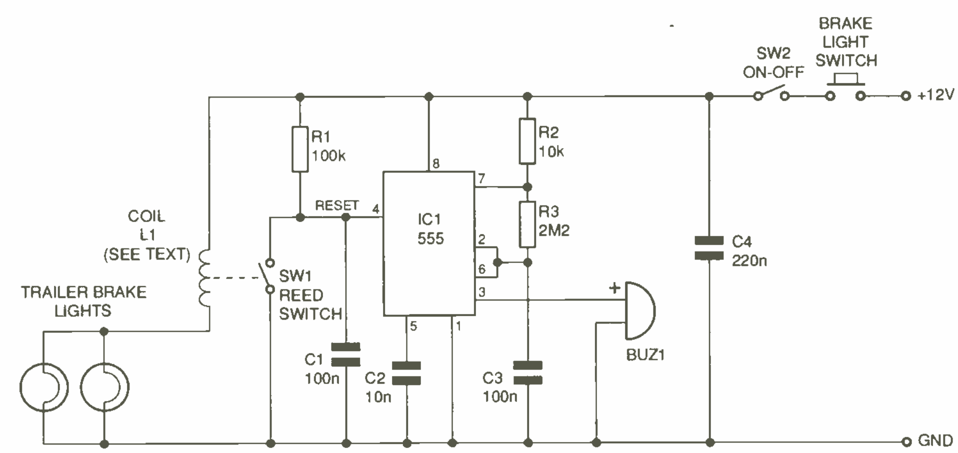


Figure 1: the circuit of the brake light checker

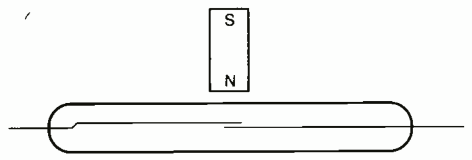


Figure 2: when the magnet is brought near the reed switch, the contacts close

A reed switch consists of a short glass tube containing two flat magnetic fingers which, under normal conditions, are held slightly apart by their own springiness (see figure 2). When a magnet is brought close to the device, the fingers, or "reeds", become magnetised with opposite polarity. They therefore attract and the switch contacts on them "make". They may be used to operate some external circuit although their current-carrying capacity is quite small. Reed switches have an extremely long mechanical life (in excess of 100 million operations). Providing they carry only a small current, they will therefore have an extremely long life. Their chief drawback is that they are easily broken.

The magnet which operates the reed switch need not be a permanent one. A coil carrying a current produces a magnetic field similar to that of a bar magnet. Such a coil may be wrapped around the reed switch body and, providing it carries sufficient current, will cause it to operate. This is the principle on which the Brake Light Check circuit works. The higher the current flowing through the coil and the greater the number of turns of wire, the stronger the magnetic effect will be. The specified reed switch will operate at between 20 and 50 amp-turns. To explain this, suppose a particular specimen of switch operates at 30 amp-turns. This means that a current of 1A flowing through 30 turns of wire would cause the contacts to close. Alternatively, a current of 2A flowing through 15 turns or 3A through 10 turns would produce the same effect.

Watt was that?

The number of turns on the coil will be chosen so that the current for one bulb is insufficient to operate the reed switch but the current for two will do so. The power rating of a standard brake light bulb is 21 watts. If this figure is divided by the nominal voltage of the car supply, ie 12V, it will give the operating current - that is, 1.75A. With both brake lights on, the current will be double this figure - 3.5A. If the reed switch operates with 30 amp-turns, the number of turns required so that the current for both bulbs will just cause the contacts to close will be 30 divided by 3.5, which gives a figure of about 9.

Since reed switches of the same type operate with different numbers of turns, it may be necessary to adjust the coil at the end of construction to make it work. With the specified switch, the correct number will lie between 6 and 15 turns. Trials suggest that these switches usually operate at the low end of the tolerance. It is suggested that 7 or 8 turns are used as a starting point. In the unlikely event of the switch operating at the high end of the tolerance, the coil will need to be re-wound with more turns. Using the specified thickness of wire (22 SWG) its resistance will be negligible and with 3.5A flowing, the voltage drop will only be about 20mV (0.02V). This is too small to have any noticeable dimming effect on the bulbs. Also, the coil will remain cool in use.

Pulse train

Referring once again to figure 1, the warning signal is given in the following way. IC1 is an integrated circuit timer configured as an astable. Assuming on-off switch SW2 is on, a supply will be provided from the 12V car system when the brake pedal is pressed. Providing reset input pin 4 is high, a train of pulses will be produced at the output, pin 3. The pulse repetition frequency depends on the values of fixed resistors, R2 and R3 in conjunction with capacitor, C3. With the values specified, there will be several pulses produced per second. No adjustment is provided since the exact rate is not thought to be important. These pulses operate buzzer, BUZ 1, which will switch quickly on and off to give a warbling tone. Capacitor C2 is needed to provide stability in the ic.

If both trailer brake lights are on, there will be sufficient current flowing in coil L1 to close the reed switch contacts and make pin 4 low. This disables the ic and no pulses will be produced. Capacitor C1 holds pin 4 low at the instant that the brake pedal is pressed and before the reed switch contacts take over. If insufficient current flows in L1 due to a faulty bulb or for any other reason, the contacts will fail to close. C1 will then charge through resistor R1 taking only a fraction of a second to do so. The voltage at pin 4 rises and the astable operates.

Dashboard switch SW2 prevents the circuit from working when a trailer is not being towed. Without this, the buzzer would sound each time the brakes were applied since the circuit would see the lack of trailer light bulbs as a fault..

Construction

Construction of the Brake Light Checker circuit is based on a single-sided printed circuit board (PCB) and the component overlay is shown in figure 3. Begin by soldering the ic socket in position and follow with all resistors and capacitors. Add the buzzer, observing the polarity - this is marked on the plastic body.

Prepare the reed switch by winding 7 or 8 turns of 22 SWG (0.71mm) enamelled copper wire around it. This must be done with extreme care to avoid breaking the glass. The turns should touch the body but must not be tight. The wire should be wound in one layer and occupy the central part of the reed switch as shown in the photograph. After winding the coil, grip each end lead of the reed switch close to the body using the tip of fine-nose pliers and bend the lead carefully through right-angles. Do not do this without supporting the wire at the body, since any bending pressure transmitted through the wire will crack the glass.

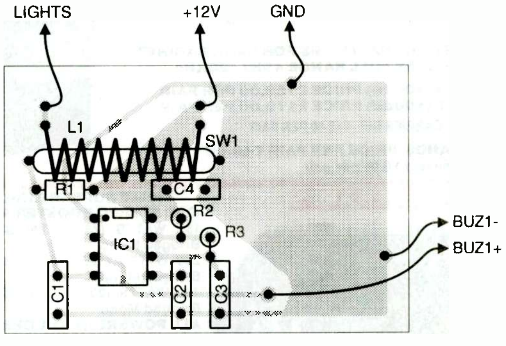


Figure 3: the component layout

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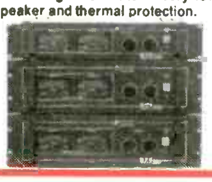

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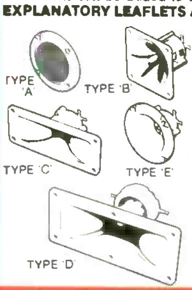

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OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
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OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
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OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE £259.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

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RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB. **PRICE £46.71 + £3.50 P&P**

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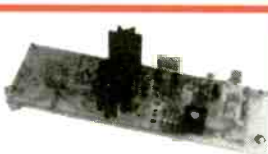

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Cut each end of the coil wire to a length of 20mm approximately. Gently scrape off the insulation from the ends using a blunt knife blade or sandpaper. Do not use a sharp blade because the wire may be nicked and will then break at that point sooner or later. Solder the reed switch and coil wires to the PCB in the positions indicated ("C" for the ends of the coil and "RS" for those of the reed switch). Note that the reed switch should be left standing about 5mm above the panel (see photograph).

Solder 5cm pieces of stranded connecting wire to the points labelled "lights", "+12V", and "gnd". Bend the "lights" and "+12V" wires over the short pieces of track leading to the coil connections. Solder them in position so that the wire provides a re-enforcement. This will ensure that the tracks can carry the current for both bulbs without problems. Complete construction of the circuit panel by inserting IC1 into its socket taking care over the orientation.

Adjustment and testing

The circuit panel may be housed in any small plastic box which can accommodate it. Drill a hole in the side for the wires from the PCB to pass through. Drill two small holes and mount the 3-section piece of screw terminal block on the side. Pass the wires leading from the PCB through the hole and, shortening them as necessary, connect them to the terminal block leaving some slack inside. Keep a check on which wire is which and label the terminal block accordingly.

Think about how the PCB will be secured in the box. However, do not attach it permanently yet since it may have to be removed to enable the number of turns on the coil to be adjusted. The PCB may possibly be attached using adhesive fixing pads. Alternatively, a small hole may be drilled in the large copper land area (above the buzzer position) to accept a nylon nut and bolt. If this method is to be used, a short stand-off insulator or plastic washer will be needed under the circuit panel. This will keep the soldered connections on the underside clear of the base of the box. If this is not done, the PCB could be placed under strain when fixing it down and it might crack.

Installing

Decide on a suitable place for the unit so that the buzzer will be heard without difficulty by the driver. A 9V battery may be used to make the circuit operate and this would be helpful in finding a good site. The positive and negative battery terminals should be connected to the "+12V" and "gnd" positions respectively on the terminal block. Note that the buzzer will be a little louder when operated from the 12V supply. Check that it can still be heard with the engine running. Now decide on a suitable position on the dashboard for on-off switch, SW2. This should be a proper auto-type switch with a rating of 5A minimum.

Attention may now be given to the external details. Locate the wire leading from the car wiring harness to the brake light terminal on the drawbar socket. The conventional colour for this wire is red. Cut it at a convenient point and extend the free ends to reach the chosen position for the unit. Use proper auto-type wire of adequate rating and make the joints using "snap lock" connectors which are available from any car accessory store. Where the wires need to pass through a hole in metal, a rubber grommet must be used. The end leading to the drawbar socket should be connected to the "lights" position on the terminal block. The other end, which will be live when the brake pedal is pressed, should be connected to one of the switch terminals. The other side of the switch should be connected to the "+12V" terminal on the unit. The "gnd" connection should be taken to a convenient nearby earth point.

PARTS LIST for the Brake Light Tester

Resistors

R1	100k
R2	10k
R3	2M2

Capacitors

All metallised polyester with 5mm pin spacing

C1, C3	100n
C2	10n
C4	220n

Semiconductors

IC1	NE555N

Miscellaneous

SW1	Reed switch - 20mm body length x 3.2mm diameter approx.
SW2	Auto-type on-off switch. 5A rating minimum
L1	22 swg (0.71mm) enamelled copper wire
BUZ1	Miniature piezo buzzer

2A screw terminal block - 3 sections required.
8-pin dil socket;
plastic box for project; small hardware.
Auto-type wire,
snap lock connectors.

All components for the Brake Light Checker are available from Maplin.

Finishing off

Do not connect up the trailer yet. Switch on S2 and the ignition (if necessary). Press the brake pedal. The buzzer should sound. If it does not, there is a circuit fault and this must be investigated before proceeding.

If all is well, plug in the trailer. With both trailer lamps working the buzzer should remain silent. Remove one of the bulbs to simulate failure and operate the brakes again. The buzzer should now sound. If the buzzer fails to work with one bulb connected, it will be necessary to remove a turn or two from the coil. With care, this may be done without de-soldering the reed switch. If the buzzer sounds with both bulbs working, it will be necessary to remove the reed switch from the PCB and wind a new coil with more turns on it. However, this is unlikely. Check operation with the engine running since then the current rises slightly.

Measure the position of the buzzer and drill a hole in the lid of the box to correspond. This should be a little larger than the hole in the top of the buzzer itself. Secure the PCB inside the box and check that it cannot move in service. Fit the lid. Mount the completed unit in position and check for correct operation.

Final note

Always remember to switch on the circuit before a period of towing. This should be made part of the routine such as immediately after the plug has been inserted in the drawbar socket.

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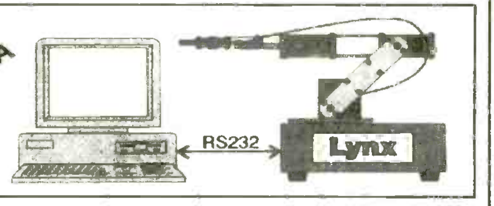

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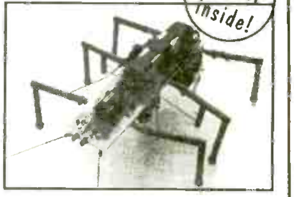

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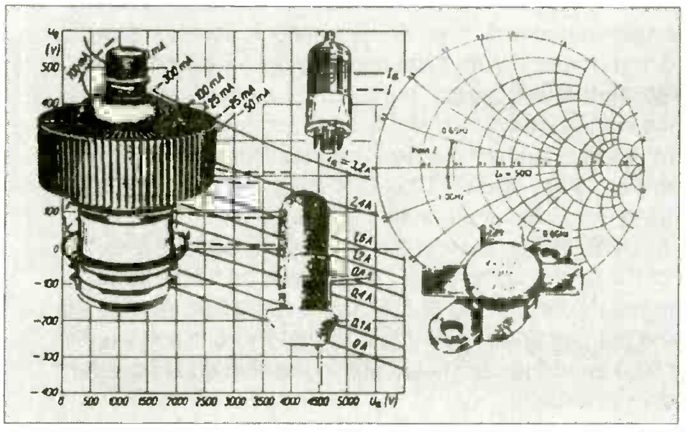

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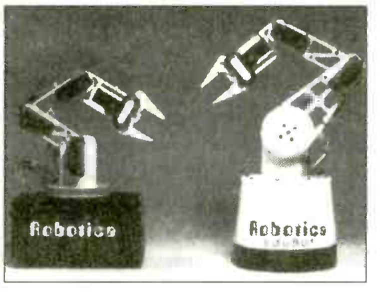

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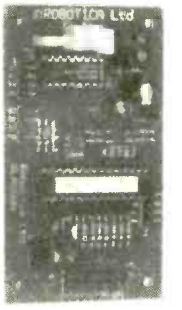

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Practically Speaking

BY TERRY BALBIRNIE

This month we go back for a refresher on Ohm's Law

This month we continue with some calculations used in electronics. We shall look at Ohm's Law and how it may be used during the testing and development of circuits. Ohm's Law is probably the most important calculation in this type of work. Even if your maths is very rusty, it is worth learning to use it because you cannot get very far without it.

Ohm is where a volt lives

Suppose you wish to know how much current is flowing through a resistor in some circuit. You may, for example, wish to know that the current is not too high and draining the battery too quickly. One method would be to disconnect one end of the resistor from the circuit panel and connect a multitester set to a current range between the free ends. This would give a direct result but it would be very inconvenient to do. A better approach would be to connect the multitester set to a voltage range across the resistor. From a knowledge of the value of the resistor (using the colour code) you could use Ohm's Law to calculate the current flowing through it.

This method does not require any de-soldering and re-soldering and so is much quicker to carry out.

Two out of three

Ohm's Law is a way of finding either the current, the voltage or the resistance by knowing the other two. It is expressed mathematically in the following three ways. The appropriate one is then used, depending on whether it is the current (I), the voltage (V) or the resistance (R) that you wish to know.

To find the current I (as in the above example) we use:
I = V/R
This means *current equals voltage divided by resistance.*

If we wish to find V we use:
V = I x R
Which means *voltage equals current multiplied by resistance.*

If we wish to find R we use:
R = V/I
Which means *resistance equals voltage divided by current.*

You can then work out the result using a calculator or, if the numbers are easy, in your head.

You must remember that the current must be expressed in amps (not milliamps or microamps), voltage in volts (not millivolts or microvolts) and resistance in ohms (not kilohms or megohms). You will therefore need to convert any milliamps into amps, kilohms into ohms and so on (Practically Speaking deal with this last time).

Examples

A resistor having a value 2R is found to have a voltage of 12V across it. The current flowing through it will therefore be 12 divided by 2 or 6A.

A resistor of value 8R has a voltage of 2V across it. The current flowing through it will be 2 divided by 8 or 0.25A. Note that here it is vital to divide 2 by 8 and not 8 by 2.

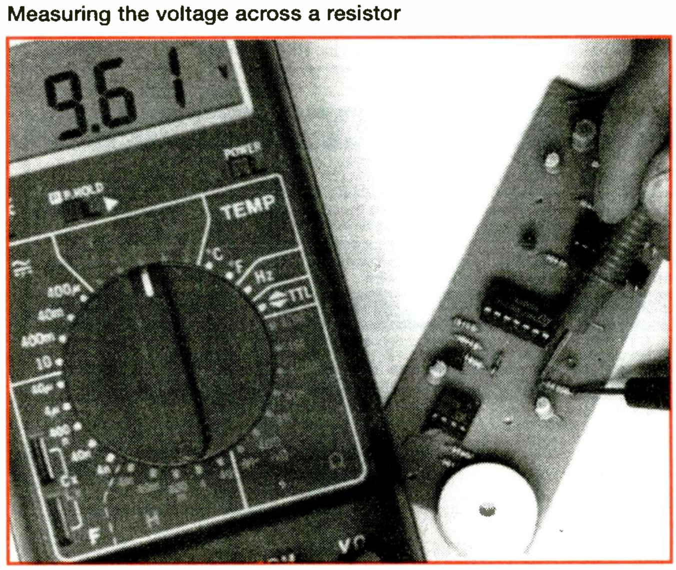
A resistor having a value of 4.7k has a current of 4mA flowing through it. The voltage across it will then be 0.004 multiplied by 4700 (having been converted into amps and ohms respectively) giving 18.8V

A resistor is found to have a voltage of 16.8V across it. The current flowing is 2.5mA. The value of the resistor is then 16.8 divided by 0.0025 or 6720 ohms.

Note: if the resistance is left in kilohms and the current in milliamps, the calculations work without conversion. It will also work where the resistance is in megohms and the current in microamps.

There is no problem measuring the voltage across a resistor when it is connected to the supply direct. However, most circuits are more complex and involve other resistors which appear in series with the one in question. In such situations, it is important for the meter itself to have a much higher resistance than that of the other resistors. This is because a negligible current must flow through the meter. If this were not so, it would seriously affect the result. A digital multitester generally has a resistance (usually called the impedance for reasons which will not be entered into here) of 10M or so and this will usually enable it to measure the voltage very accurately.

Measuring the voltage across a resistor



Higher Education in electronics

SPECIAL

If you are looking to go on to higher education in Electronics or Computer Science, this is the season to make up your mind what, where and how.

If you are one of ETI's younger, and maybe newer, readers you may be thinking about higher education, and whether to turn your main interest into a career.

You may not be studying electronics at school. The trend in recent years, especially in state schools in the UK, has been away from a few people doing electronics at GCSE level and towards everyone taking National Curriculum Design and Technology, and Science, both of which inlcude some electronics.

The lack of a specialised electronics course at GCSE or 'A' level is not a barrier to higher study in electronics, engineering or computer science, especially if you are already an active hobbyist reading and building projects. There are numerous courses open to students with no specialist qualifications, and as many colleges also run introductory or foundation courses leading to degree study in electronics and engineering, you can go all the way if you are willing to dedicate the time and effort.

Not long before time of writing, a major semiconductor manufacturer opening new plant in the UK and expressing confidence in British design expertise nonetheless expressed concern about the lack of students studying Physics at school - an important requisite for high-level design work. But it is possible to make up study in these areas during Higher Education - something that engineering students may want to look into as they choose their courses.

To get a clearer idea about what qualifications you might need to work in a certain area of electronics, or, perhaps, what kind of employment your study could lead to, the first step is your school careers officer. They should be able to give a broad view of what kind of employers are looking for electronics and engineering qualifications. Following this, it is worth finding out which colleges run the kind of courses you want to pursue - some reference works are listed at the end of this article - and writing or phoning for prospectuses as soon as possible. This will not only give you an overview of what the college teaches, and the kind of course modules you can take, but some prospectuses give information about which areas of industry your study can lead to.

Once you are forming your ideas, it can be thought-provoking to identify companies that employ technicians, engineers and designers and writing to (or phoning) their personnel departments with a general enquiry asking what kind of qualifications they are looking for. With large companies it may be more appropriate to write. With smaller companies, you are more likely to get a response if you (or someone in your family) makes a phone call. Make it clear that you are only looking for information and not fishing for a job. Take notes and try to keep calls short and to the point; all companies, especially small ones, avoid "time wasters". Of course, if you are lucky (or unlucky, depending on your view) you may get through to a boss who loves to tell people about the business. Possibly more than you ever knew there was to know!

Your school will introduce you to UCAS (Universities and Colleges Admissions Service), but if you are not at school, you can write after August 1 of the year you wish to enter college to UCAS, PO Box 28, Cheltenham, Gloucester GL50 3SA. You can also get assistance from your local Careers Office - look in your local phone book under, for instance, Careers Services. There are professional Careers Guidance companies, but look for local authority-run Careers Offices which will see you without charge.

Looking for a college

Higher education colleges offer a variety of courses distinct to each college, from foundation courses and GCSEs up to degree level and beyond. Which you are looking for depends on your qualifications and experience so far, the kind of work you hope to do and the amount of time you want to dedicate. Broadly, if you have 'A' levels and can study for three to four years further, you can aim for a degree course. One criticism aimed at degree courses in the past was that while the student studied all-important theory to a high level, practical experience and, particularly, experience of business and industry was often lacking. The Universities' answer was that students are expected to be bright and flexible enough to gain additional practical and business skills quickly when they go into employment. There is no substitute for practical experience on the job, but experience is not a substitute for an all-round education, either.

Photograph: CLARE ASH BA ABIPP

They need to complement each other. However, many Universities are now more conscious of the need for industrial awareness and take steps to include this. The other side of the argument is that for dedicated design engineers, an extensive grasp of mathematical engineering principles is much more important than business awareness, which they can gain in working life if they have any aptitude for it. There is much truth in this view; high-level engineering is demanding. We would say, though, that unless you are aiming for an esoteric career in academic electronics or physics, that choosing a higher education course that shows an appreciation of industry needs will give you a better grounding. There is nothing to beat having an understanding of what is actually needed by your company's customers.

Wherever you hope to enter the higher education system, find out from your likely colleges what their attitude to industry is and whether any out-placements or industrial awareness modules are included in your course. This may help you in your final choice.

Highbury College

Among the prospectuses that ETI looked at this year, Highbury College in Portsmouth offers a range of technology courses from foundation level up to pre-degree or a vocational degree equivalent. Highbury's Engineering (Electronics) BTEC GNVQ Intermediate one-year course offers a broad-based introduction to Electronic Engineering, including relevant GCSEs if required, for students with no formal applications, leading straight to working life or on to A levels or the two-year Advanced BETC GNVQ course - which itself leads the student into working life, or on to Degree or BTEC Higher National Diploma level. The BTEC HND is a two-year course offering a combination of academic and practical study in partnership with Portsmouth University, requiring five GCSEs (grade C or above) including Maths and a science, together with a relevant A or AS level pass, or the relevant BTEC Certificate or Diploma.

These are quite standard entry qualifications for Degree level, and the BTEC HNC is roughly equivalent to a Degree. A BTEC qualification is generally regarded as more vocational and less theoretically-based than a University; some employers may regard this as an advantage, but if you want to do design or research, or move into higher management you should consider entering for a degree course rather than an HNC as soon as you qualify.

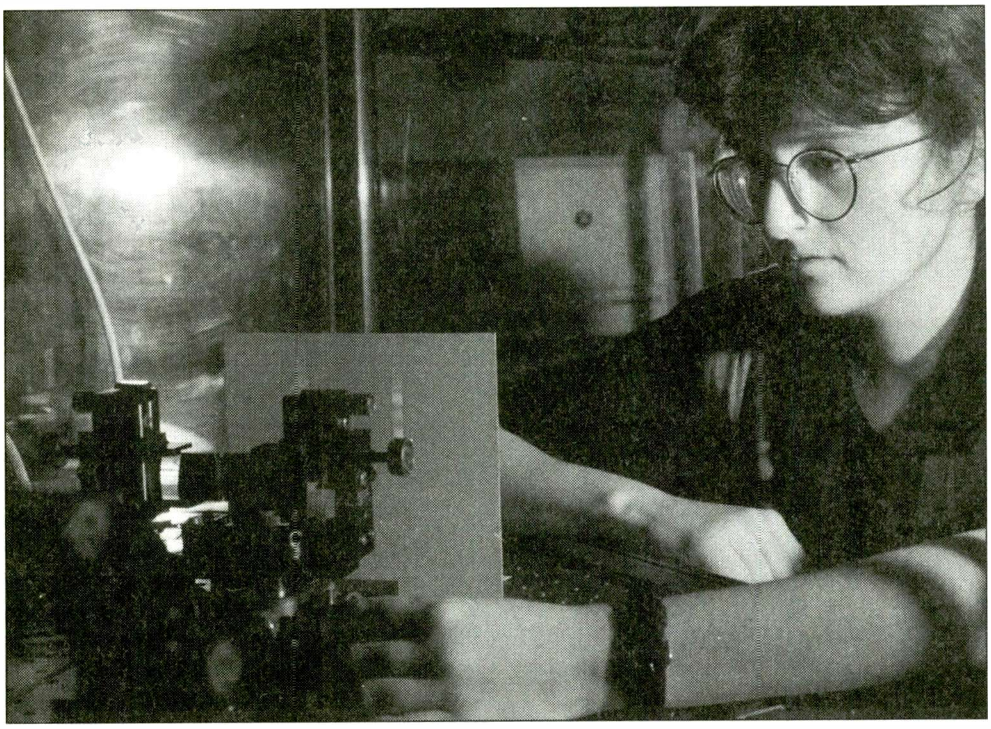
Highbury also offers a two-year BTEC National Diploma at a slightly higher level than the Advanced GNVQ as a preparation for Degree study or working life. There is also a one-year introductory course in Electronic and Microcomputer Technology for unqualified applicants as a preparation for further study or trainee posts, including the Armed Forces. There is an equivalent set of Mechanical Engineering courses, as well as more general A lever, GCSE and University Foundation courses on the same site. Another advantage of technically-based colleges like Highbury is that if you want to try your hand at video production (or journalism!), or get your hair curled by a fellow-student, you are very likely to be able to do so. There is also plenty of provision for student guidance, careers information, etc. and the college is happy for prospective students to call or visit the Student Advice Centre for advice before applying.

University of Hertfordshire

The University of Hertfordshire is based on several separate campuses in Hatfield, Hertford, St. Albans and Watford in Hertfordshire, about 50 miles north of London. The Faculty of

University of Hertfordshire

Engineering is based at the Hatfield Campus in Hatfield, and offers several BEng degrees involving electronics studies, plus two BSc degrees, and several Masters (MEng) degrees. The engineering courses aim to meet the needs of project management and creative application of technical knowledge for useful ends, and students will undertake case studies, project work and laboratory work, as well as opportunities to work in teams with students from other disciplines. Many of the courses include an opportunity to study a European language, and there are some opportunities for industrial placements and study in Europe and the USA. There are alternative routes into engineering for people without standard entry qualifications; several degrees are also offered as extended degrees with a preliminary year. The preliminary year also addresses important general topics such as teamwork. There are Electronics and Manufacturing programmes available within combined modular degrees, again for students who are not following a traditional maths and physics based route.



Electronics Engineering, Aston University

The University's BEng courses include BEng Honours Electronic Engineering, BEng Honours Communications Systems, BEng Honours Digital Systems, BEng Honours Electrical and Electronic Engineering, BEng Electrical Engineering, BEng Honours Electronic Engineering with Medical Electronics, BEng Honours Power Electronics and Control and BEng Honours Computer Aided Engineering, all of which either fully accredited by the Institution of Electrical Engineers (IEE) and lead towards Chartered Engineer status, or are accredited qualifications by the IEE. There is also a BSc Honours in Medical Electronics or Medical Electronics with German, which can lead towards Chartered Engineer status upon graduation, and a BSc Honours in Engineering Management, in combination with the University's Business School to train managers capable of handling the resources of modern manufacturing and engineering industries.

All these courses can be undertaken as an Extended Degree, and most of them have a required or (usually) optional Sandwich Year, with a paid industrial placement. A Sandwich Year provides practical experience in a real industrial environment, working with engineers, managers and technicians already case-hardened to the job and therefore with a somewhat different slant on it. Indeed, some feel that one benefit of college study is that students can acquire knowledge and experience without the pressures of commercial life - the two must in time be combined into a grasp of practical engineering.

The University of Hertfordshire also offers several computing BSc Honours degrees, mainly four-year sandwich courses, including Computer Science in Europe, currently based around German. Students learn German, do a six-month industrial placement and a year of study in Germany, and gain the Diploma Informatiker (German BSc.) as well as the UK BSc. As second language capability is now a very valuable asset in building a career, courses of this type (which tend to have a limited number of places) are much sought-after.

The faculty of Information Sciences also does a number of two-year (three years if Sandwich) HND courses in computing, which can lead to a final year degree course for students with good passes. A network of approved NVQ assessment centres at the University give students the opportunity to gain recognition in areas such as management, business administration, information technology, etc. as complementary to their degree courses.

The University encourages people who may not have traditional qualifications to enquire about routes. As with many colleges, a certain amount of advice about grants, application, how to build up qualifications for a career, and so on can be given to prospective students, especially those who are not coming from school and may not have access to this information.

Aston University

Aston University in Birmingham has a well-established reputation for mathematics and engineering, and prides itself in particular on two benefits: its heavy investment in high-quality computing facilities for all its students, with IT integrated into all degree programmes - indeed, it is proud to be able to claim that students "cannot avoid developing high-level skills in computing and information technology" - and a graduate employment "second to none", with a higher proportion of graduates finding permanent employment within six months of graduating than any other British university. There is also an emphasis on optional Sandwich programs for practical professional experience.

Aston offers BEng degree courses in Electrical and Electronic Engineering, Electronic Engineering with Management studies, ElectroMechanical Engineering, Electronic Engineering and Computer Science, Communications Engineering and Electronics combined with a Business, Language, Science or Social Science subject. These are available as three year courses, or four years with a Sandwich year. Electrical and Electronics, and ElectroMechanical also have a foundation year (STEPS) available. The first year of all the Electronics and

Electronics Engineering, Aston University

Computer Science courses cover the fundamental principles of electronics engineering, physical science and computer science, so that whatever direction the student chooses to pursue in the second year and after, a grounding across all the related disciplines is firmly in place.

Arguably, as school courses become less specialised, firm grounding early in a degree course is increasingly necessary. As far back as the 1970s, when new math courses (some of them ill-fated) were being introduced into British schools, engineering students found that any gaps in their maths could not be filled by their University courses, and they had to make up lost ground as best they could. These days, good colleges are prepared to make certain that students are properly grounded during their course. A good study record at GCSE and A level, or any parallel qualifications offered, is still necessary for degree study at most Universities, but help can often be obtained in weaker subjects.

Aston's degree courses are accredited, as should be the case with good degree courses, by the IEE or the British Computer Society, or in the case of newer courses will be submitted for approval at the relevant body's next visit to the University. Aston has a further Open Day this year on Monday 29th September. University Open Days usually take place in late April/early May and September

Other factors

When you depart on a Higher Education course, you will be spending between two and four years of your life in the neighbourhood of your college. If you are leaving your family home for this first time, this may also be your first major change of environment. College is rightly seen as a half-way house to independence, especially if you are not living on the College campus (the site where most of the teaching faculties and living accommodation are) throughout your course. Of course your choice of the right course and college and course is the most important consideration, but your choice of environment is not trivial. There are likely to be a number of good colleges offering courses that you want to follow, so look at them and consider where you would personally be happy to live. If you are not keen on outdoor pursuits, you may feel cut off on a campus deep in the country. If you are an outdoor type, you may feel equally cut off in the middle of a large city. Some people prefer to live away from the main campus (if one exists; in London, for instance, college accommodation is scattered throughout the city and suburbs); you may be expected to find your own living quarters for at least one year of your course, as there is still a shortage of college rooms. So it is a good idea to look for somewhere you will be happy to live - as long as the course takes priority.

Resources

Even small local libraries usually have reference books listing colleges and courses for the current or previous year. Some suggested sources are (usually to be found in the Reference section under Education - look under R378 and R370 for a start):

The Times Good University Guide
edited by John O'Leary (Times Books)

The Big Official UCAS Guide to University and College Entrance (Letts Study Guides with The Independent)

Which Degree 1997 - Volume 2: Engineering, Technology and Geography and *Volume 3: Science, Medicine and Mathematics*
CRAC Student Guide (Hobson's Publishing)

DOHE (Directory of Higher Education): How to Choose your Higher National Diploma Course
edited by Eric Whittington (Trotman & Co.)

Don't be daunted by the mass of information that some guides offer (the UCAS guide, in particular, is perhaps more suited to careers officers than new students), but use them to pick out the addresses and phone numbers of colleges offering courses that appeal to you, and then contact the colleges themselves for their Prospectuses, which will give you their up to date entrance requirements and other details in a format designed for students. The DOHE Guide is handy for pointing out which colleges offering HNDs also have "transfer" courses to degree level.

Next month

Next month we will be looking at some more colleges, including some Masters and other courses for postgraduates and people returning to college from working life.

To obtain prospectuses from the colleges above, contact Highbury College on 01705 283373 or write to Highbury College, Cosham, Portsmouth PO6 2SA; contact the University of Hertford on 10707 284000 or write to the University of Hertfordshire, Hatfield Campus, College Lane, Hatfield, Herts AL10 9AB; contact Aston University on 0121 359 3611 or write to Aston University, Aston Triangle, Birmingham B4 7ET (email prospectus@aston.ac.uk, Web Site http://www.aston.ac.uk.home.html

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SPEED CONTROL in DC Motors

PART ONE

When David Ponting gained possession of a high-quality reel to reel recorder, all he had to do was create a constant-speed capstan drive suitable for both sides of the Atlantic. So began the experiments to find the best control circuit.

It was a most magnificent machine and I was being given it for nothing! It seemed that no-one else even wanted to give house room to this ancient but truly beautiful Rolls Royce of a reel-to-reel tape recorder. It was in excellent condition.... except that the all-important capstan motor had burnt out. The other two motors which provide the spooling and tension functions were fine, but the capstan motor which has to turn at a very precise and constant speed under a varying load no longer existed.

The original motor was a synchronous 115 volt AC type whose speed was locked to the American mains frequency of 60 Hz.. So even if I could replace it with a new one, the tape recorder would still not operate properly in England: any recording made on it would be non-standard and could only be replayed on the same machine.

So I started to look for circuits which are designed to drive small AC or DC motors at very constant speeds. I tried electronics magazines, past and present. I searched through collections of circuits in numerous books. I found nothing. There were many circuit designs that allowed a potentiometer to control and set the speed of a motor to the required value, but I found none that then kept that speed constant as the loading on the motor changed. I began to think that I would have to fit an excessively large motor whose power would hardly notice a small varying load.

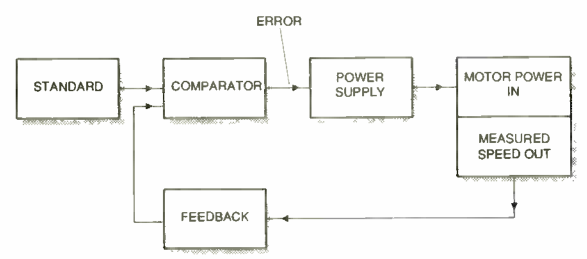

Figure 1: block diagram of a feedback loop

But surely there must be a better answer than that? I decided that if there were no tried and tested circuits available, I would have to start from scratch.

It quickly became clear that some sort of feedback loop (figure 1) was going to be required.

The feedback loop

The speed of the motor has to be measured in some way, and that measurement has to be compared with a speed standard. For example, suppose we want a motor to rotate at exactly 1000 revolutions per minute. We switch the motor on, count the number of revolutions the motor is actually making, and then compare this with the required 1000. If the measured figure is 999 or smaller, we can use the difference from 1000 to speed the motor up; but if the measurement is 1001 or larger, we can use the error to slow it down. If the revolution counter is measuring exactly 1000, we can turn the power to the motor off and not turn it on again until the speed drops to 999. We could arrange that the motor is braked if the speed exceeds 1000, but in practice loading and friction will automatically provide braking. So the power to the motor can be off both when the speed is exactly 1000 and when it is higher.

Having got that far in my thinking, I began to look around for what motors are available and soon discovered an advertisement which offered a DC motor with a fitted 'tach' (tachometer). In addition, the advertisement said that the motor operated from 6 to 21 volts, with a speed of 2900 rpm at 12 volts (300mA) and 5300 rpm at 21 volts (380mA). This told me that without any control circuit, the speed of this motor when unloaded depended directly on its supply voltage.

I responded to the advertisement and, when my motor arrived, I found that there were four connectors, two to power the motor and two which were the output of the 'tach'. Initially I was not sure what this output would be, and so I looked at it on an

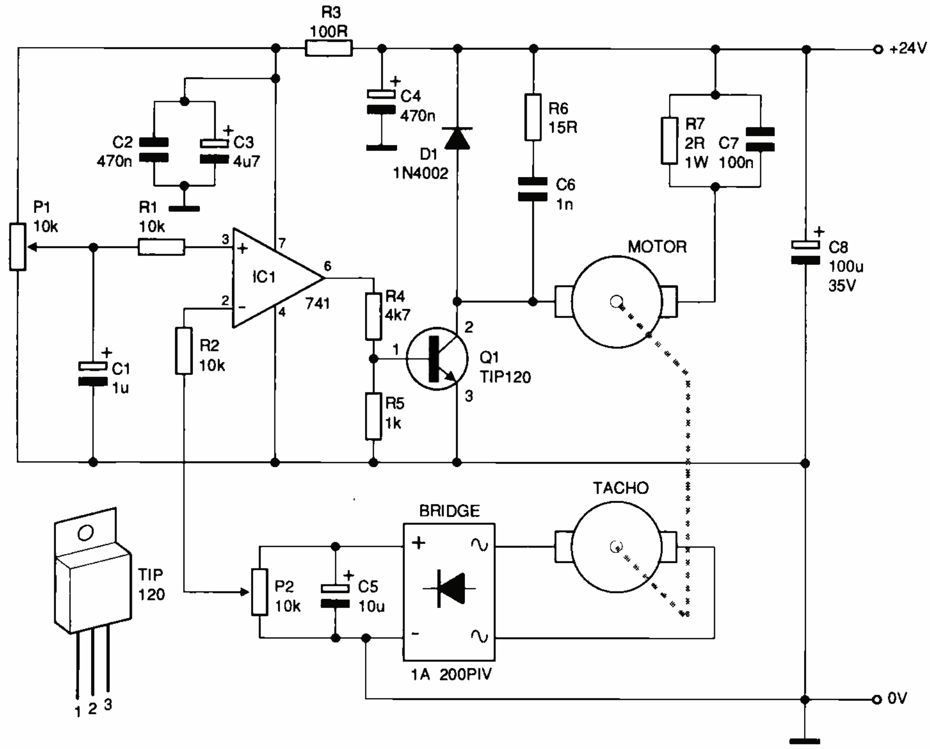

Figure 2: the first control circuit

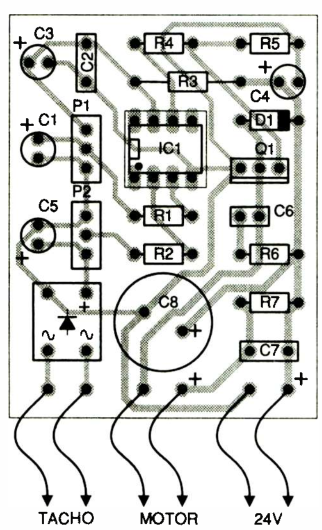

Figure 2a: the component layout for the first control circuit

oscilloscope. As I had suspected, it was a very regular sine wave whose peak-to-peak voltage was completely independent and floating with respect to the power supplying the motor. Clearly this tach was just a small AC generator driven directly by the shaft of the motor. The original advertisement had included the additional information that "the tach produced approximately 3.15 volts per 1000 rpm". I was able to confirm this experimentally when I found that at 1000 rpm the output of the tach was 3.2 volts rms.

Much more important than the value of this voltage is the fact that as the speed of the motor increased, the peak-to-peak AC tach voltage increased as well. Clearly the size of this voltage is a measure of the speed of the motor.

So, if the tach voltage can somehow be compared to a fixed voltage which represents the required speed, our aim of a motor which rotates at constant velocity under varying loads is achieved. This led me to my first useable control circuit (figure 2 is the circuit and figure 2a is the component layout for this board).

How it Works

As connected, the output of ICl, an ordinary LM 741 op-amp, is high (within a couple of volts of 24) as soon as the power to the circuit is applied Consequently Ql is switched on via R4 and the motor starts to turn, drawing its power via R7.

Driven by the motor, the tach starts to generate an increasing AC voltage. This is rectified by the bridge, smoothed by C5 and reaches pin 2 of IC1 via P2 and R2. At pin 3 of 1C2 is a fixed voltage set by P1.

Eventually, if the 24 volt supply is great enough, the motor will spin so fast that the rectified and smoothed DC from the tach into pin 2 of ICl will exceed the set voltage into pin 3. When that happens, the output at pin 6 will go low (within a couple of volts of zero), Tl will switch off, and the motor will start to slow down until the voltage at pin 2 drops below that at pin 3 when the whole process repeats itself.

In effect, the motor is supplied by pulses of power resulting in its rotating at constant speed even when the loading on the motor changes. When that happens, the pulses just get longer, supplying the motor with greater power. The final speed of the motor can be controlled either by adjusting P1 or P2, or both.

R3, C2, C3 and C4 de-couple the supply to the motor from that to the control circuit. R7 is a 1-watt current limiting resistor, and should be of a higher wattage if the current to the motor exceeds 1 amp. R6, CG and C7 limit the electronic noise produced by all switching circuits similar to this. Dl is an important component as, with a highly inductive load like a motor, every time the power to the motor is switched off, a

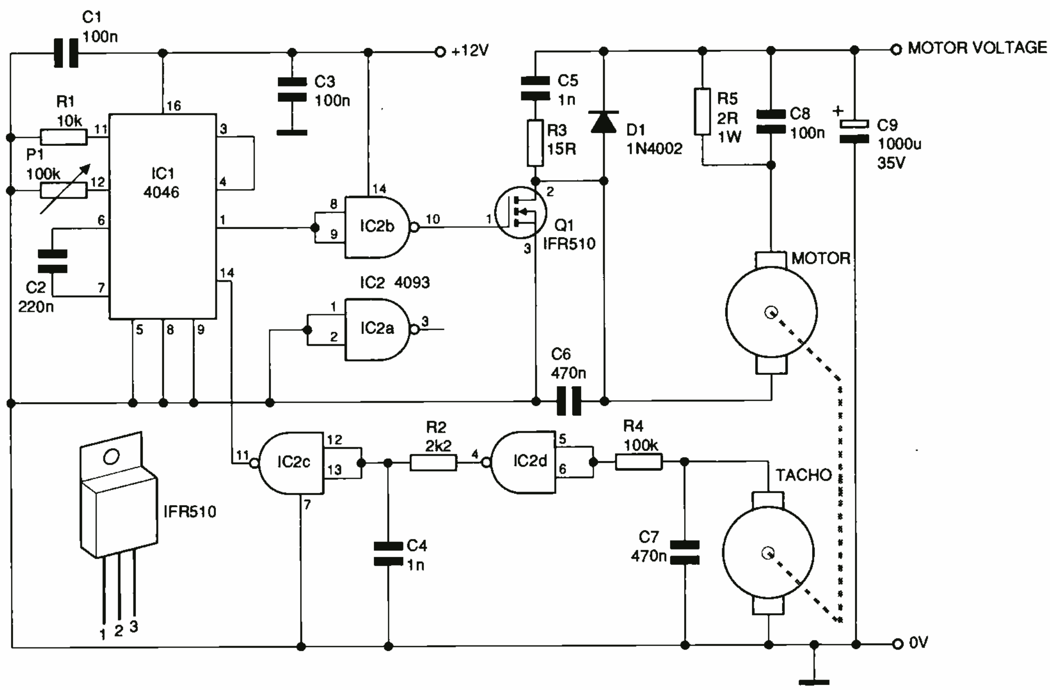

Figure 3: the 4046 circuit

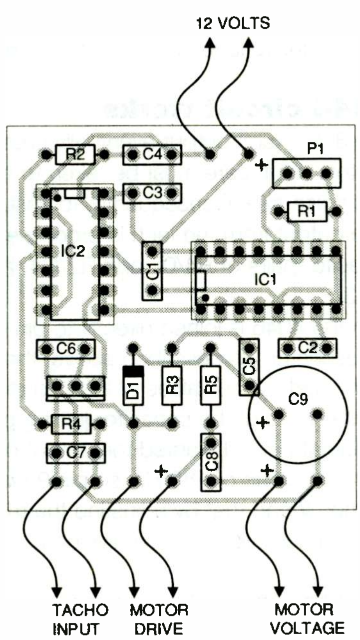

Figure 3a: the component layout for the 4046 circuit

reverse voltage is generated in the motor's windings, which would destroy the transistor if the diode were not there to clamp this voltage to the 24 volt rail.

Success and the first problem

Using this rather straightforward circuit, a very stable and relatively constant rotational speed can be achieved. For the tape recorder I was trying to restore, transporting the tape at the standard speed of 7.5 inches per second required the motor to rotate at 1800 rpm. Using this circuit, I could set the motor to 1800 rpm when it was unloaded (200 mA), and the rotational speed was only reduced by 8 rpm when the motor was heavily loaded and close to stalling (greater than 1 amp). Further, driving the motor by this pulse method (which is called pulse-width modulation, or PWM), ensures that the motor starts readily, has a high torque as it starts to rotate, and continues to provide that high torque when it reaches its constant speed.

So this motor, driven by the above circuit, seemed to meet all my requirements for constant speed. But I quickly discovered that there was one major problem: if the motor was run for an extended period of time, its speed increased away from that set by the standard. In practice, starting from cold at a set 1800 rpm, the speed had increased to 1910 rpm after running for about an hour or so.

The reason for this is annoying but interesting. The current passing through the main windings causes the motor to warm up. This results in the windings of the tach coils also becoming warmer. When copper is heated, its resistance increases and the result is that the output voltage of the tach decreases. Consequently, the motor speeds up to produce a voltage to match the "standard". If the motor could be cooled so that it never became warmer, this circuit would provide the necessary accuracy to run a tape recorder. As it is, someone with perfect pitch would be only too well aware that the key of music played on the machine would increase in pitch by about a semi-tone after running for half an hour. However, if your need for (relatively) constant velocity is met by a motor whose speed variation is no more than about +6 percent after running for an hour and then remains more or less constant, the above circuit is for you. Unfortunately it was not sufficiently accurate for me.

So it was back to the drawing board.

AC frequency

It had occurred to me when first checking the tach on my motor that not only did the rms voltage increase as the motor's speed increased, but so did the *frequency* of the AC signal. To

PARTS LIST for the experimental DC Motor Control circuits

Figure 2

'P1','P2'	10k
R1,2	10k
R3	100R
R4	4k7
R5	1k
R6	15R
R7	2R 1 watt
C1	1uF electro
C2	470n
C3	4u7 electro
C4	470n electro
C5	10u electro
C6	1n
C7	100n
C8	1000u 35V electro
D1	1N4002
Q1	TIP120
1C1	741
Bridge	1A 200PIV

Figure 3

R1	10k
R2,4	2k2
R3	15R
R5	2R 1 watt
P1	100k
C1,3,8	100n
C2	220n
C4	100k
C5	1n
C6,7	470n
C9	1000u 35V
D1	1N4002
Q1	IFR510
IC1	4046
IC2	4093

Figure 5

R1	2k2
R2	1M
R3	1k
R4	15R
R5	2R 1 watt
R6	220R
R7	1k3
R8	2k
C1	100p
C2	5 - 25p
C3	1u tantalum
C4	100n
C5,9	100n
C6,7	1n
C8	470n
C10	1000u 16V electro
D1	1N4002
Q1	IFR510
IC1	4060
IC2	4017
IC3	4077
IC4	7812
IC5	LM317
XTAL	1.8432 MHz

date I had concentrated on the voltage increase because the comparison of two voltages is so much easier than the comparison of two frequencies. But the latter clearly became the route I was going to have to take since, unlike voltage at a given speed, the frequency of the tach output was independent of the temperature of the motor's windings.

By experiment I found that at a speed of 1800 rpm, the frequency of the AC output from the tach was (coincidentally) 180 Hz.. Now I had to consider what I should use as a comparator and how I should obtain an adjustable frequency which would become my standard.

It was at that point that I remembered that I had recently done some work on a little used but useful 4000 series CMOS chip, the 4046. This IC is generally employed as the basis for a phase-locked loop, a not-so-dissimilar function to what I wanted.

The 4046 effectively includes two independent exclusive-or gates, both having pins 3 and 14 as common inputs and pins 1, 2 and 13 as outputs. Now both exclusive-or and exclusive-nor gates can be thought of as frequency comparators. Consider the two-input, exclusive-nor gate: when both inputs are the same, the output is high, ie when the frequency and phase of each signal into the inputs are identical, the output is high; as soon as there is any difference between the two inputs, the output is low more often than it is high. It seemed like a promising start.

In addition, the 4046 has an on-board voltage-controlled oscillator, a VCO. With a couple of resistors and a single capacitor, a varying voltage into pin 9 will reappear at pin 4 as a corresponding variable frequency. I found that you get a similar effect if you fix the input voltage and vary one of the resistors.

How the 4046 circuit works

Looking at figure 3, the tach output eventually enters the 4046 at pin 14. Using this input, care must be taken to ensure that the signal here is noise-free. Consequently, to ensure a clean square wave, the output from the tach is processed through the two resistor/capacitor pairs of R4/07 and R2/C4, and the two gates, N4 and N3.

Input pin 3 on the 4046 is joined directly to pin 4, the output of the on-board oscillator. As described above, the frequency of this VCO is determined by the values of the two resistors into pins 11 and 12, the value of the capacitor joining pins 6 and 7, and the DC voltage at pin 9. I wanted the output of the VCO to have the relatively low value of 180 Hz, so pin 9 was held at zero volts and I then found that by adjusting the resistance of P1 at pin 12, I could achieve an output frequency of 180 Hz at pin 4.

The final output from the 4046 I took from pin 1. This is essentially low when the frequency into pin 14 is less than that into pin 3, is high when the two inputs receive equal frequencies, and is mainly high when the frequency into pin 14 exceeds that into pin 3. This represents the reverse of what I wanted, hence the use of gate N2 of 1C2, used here as an inverter. Gate N1 is unused and so its inputs are tied low to prevent random switching.

The motor's power supply is switched by a mosfet transistor, type IFR 510, and the rest of the circuit around the motor helps to limit switching noise.

The positive supply to the motor's circuit is critical this should be set high enough so that the motor will speed the revolutions per minute required and there lock with the signal, but it should not be so high that the motor speeds through the locking point before it can be stabilised by the clock.

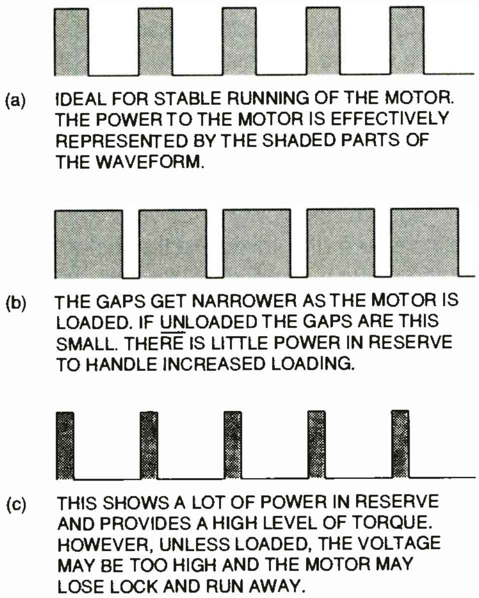

Figure 4: waveforms into pin1 of the mosfet transistor IFR510

Referring to Figure four, section (a) shows the ideal waveform into pin 1 of the mosfet when the motor speed is firmly locked to the clock frequency. The shaded part of the waveform is a representation of the power driving the motor. If you provide mechanical loading of the motor, you will see (section (b) that the shaded areas will increase in size horizontally, showing that the motor is working harder to hold its speed constant.

The same effect will occur if you just reduce the voltage to the speed-locked motor. Now the waveform will again look like Section (b) but there will be a smaller amount of potential power to cope with any increased loading. Indeed, as loading increases, the gaps may narrow until they disappear altogether and the motor may stall.

If the voltage applied to the motor is too high, Section (c), there is a greatly increased reserve of power, but if the shaded areas become too narrow, the motor may again become unstable, lose lock and speed up out of control.

The circuit in figure 3 meets many of the requirements I had for a replacement motor for my tape recorder. Unfortunately, the clock frequency in this circuit is very dependent on the stability of the 12 volt supply to the control circuit, and a 7812 voltage regulator chip was not quite stable and constant enough for my very high quality tape recorder. A more accurate clock seemed to imply some sort of crystal drive.

How the crystal drive circuit works

The clock is built around the 4060, a chip which not only permits the design of a crystal-driven oscillator, but also has a number of pins which allow the repeated division-by-two of the crystal's fundamental frequency, down to a level more useful for this application. When connected as shown in the diagram, the

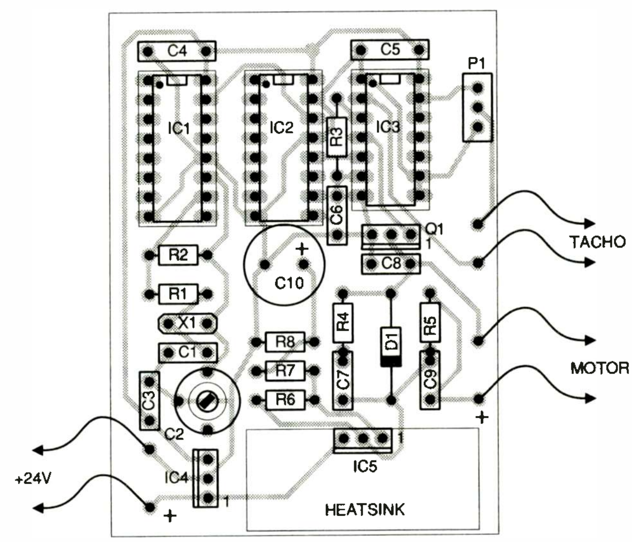

Figure 5a: the component layout of the crystal drive circuit.

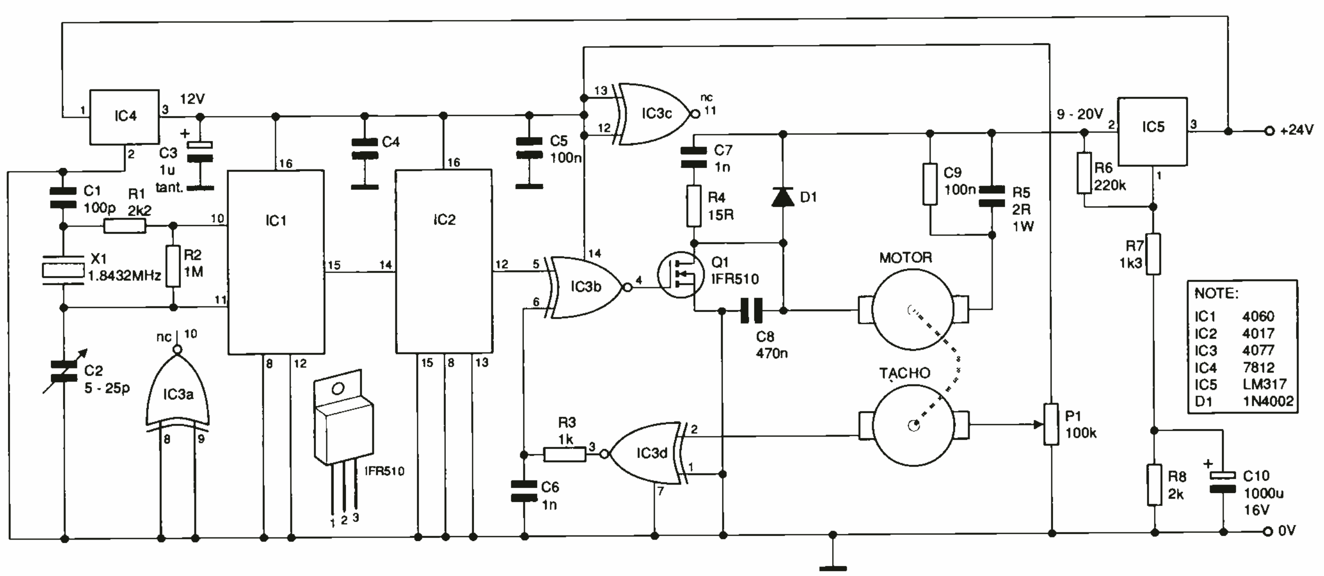

Figure 5: the crystal drive circuit

4060 produces a 1800 Hz signal at pin 15. This is derived from the fundamental of the 1.8432 megahertz crystal by dividing it by 2 to the power of b.

The next IC in the chain is the 4017, used here as a decade divider. Consequently, the 1800 Hz. signal applied to the clock input at pin 14 is divided by 10 and emerges from pin 12 as a frequency of 180 Hz..

Clearly I did not chose this particular crystal at random. Knowing that I wanted a final frequency of 180 Hz and that divisions by 2 and 10 are easy, I worked backwards to try and find a suitable one. Only a small amount of trial and error was required to arrive at a fundamental of 1.8432 MHz. for which crystals are easily available.

Using this circuit does produce a very accurate and stable clock, but it also means that changes in the clock frequency, and hence variation of the "standard", are only possible by division.

An understanding of the workings of the rest of this circuit largely follows previous explanations. However there are perhaps one or two points which should be made.

The clock function of the previously used 4046 chip is no longer required, and so this IC is replaced by a 4077 which has four exclusive-nor gates on board. One of these, N2, is used as the comparator. These gates are more tolerant of noise at inputs than those of the 4046, but they do require a very exact 50 percent duty cycle (that is, equal high and low states in the waveform). Consequently, one side of the tach is joined to P1 which allows exact adjustment to 50 percent of the final waveform into pin 6 of N2. Gate N4 and the low pass filter R3/C6 square off the tach's sine wave and eliminate any spikes which might be present.

The rest of the circuit is similar to the previous one except that figure five does show how the two voltages are produced: 12 volts for the control circuit and eventually 20 volts to drive the motor. I say *eventually* 20 volts, because that is what the output voltage is when a total resistance of 3k3 (R7 + R8) is connected between pin 1 of the variable voltage regulator, LM 317, and earth. But the inclusion of C9, a 1000 microfarad capacitor, means that on the first application of 24 volts to the input of LM 317, the initial output from pin 2 will be about 9 volts and will rise relatively slowly to 20 volts as C9 charges. This gradual increase in the voltage to the motor's drive circuit ensures that the motor will speed up gradually, allowing it to lock at the required speed and not race through that point. Incidentally, there is never any doubt when the shaft speed is locked: the motor will maintain constant rotation against powerful attempts to load the motor.

Care must be exercised in the construction and setting up of this circuit since mains hum can be a problem. Motor jitter can also be present as a result of comparing two similar frequencies which may "beat" together. However, the final circuit shown as figure five meets all the requirements for a constant speed motor to run my tape recorder.

But wouldn't it be nice if as well as a tape speed of 7.5 inches per second, I could also record and play tapes at other standard speeds?

In a following article I want to look at a motor with a different kind of tach, develop a circuit which uses as the standard clock the frequency of the mains (either 50 or 60 Hz. at the flick of a switch) and which allows the tape recorder to run at 3.75 and 15 inches per second as well as at 7.5 ips.

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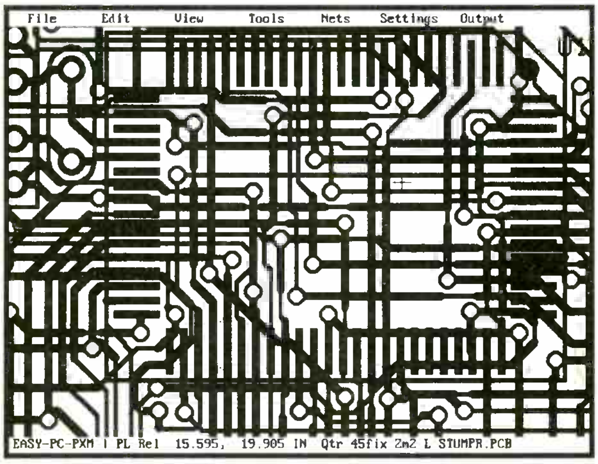

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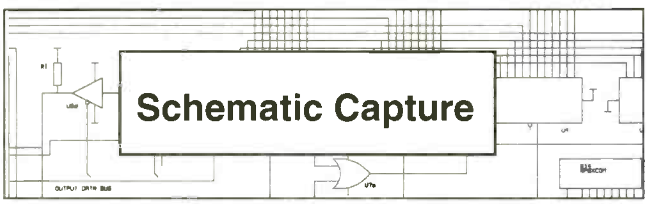

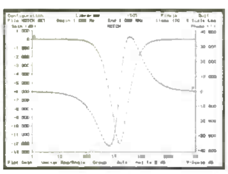

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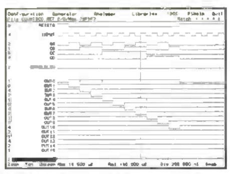

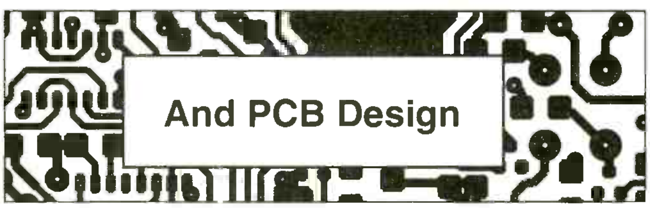

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VALVE CHARACTERISTIC Tester

PART 1

Peter Kenyon's valve tester assists in checking the essential characteristics of most types of electronic valve, and making up matched pairs.

The increasing popularity of valves in new designs for audio amplifiers, pre-amplifiers and filters is creating the need for appropriate test equipment. This article describes a small portable unit (figure 1) which, with the aid of information from data sheets and other sources, enables the essential characteristics of most types of electronic valve to be obtained. Where two or more valves of the same type have to be matched, this unit provides a fast and convenient method.

Valves which use the most popular bases, B7G, B9A and 10 (International Octal) are catered for. The less common base types can be accommodated by constructing an adapter to be plugged into the 10 socket.

The specification of the Valve Characteristic Tester is as follows:

Anode voltage (Va): 75 to 300 volts at up to 100mA
Screen grid voltage (Vg2): Equal to Va and up to 200 volts less than Va at up to 25mA
Control grid (Vg1): 0 to -6l volts
Heater voltage (Vh): 1.4 volts fixed and 4.0 to 20 volts continuously adjustable at up to 2.5A

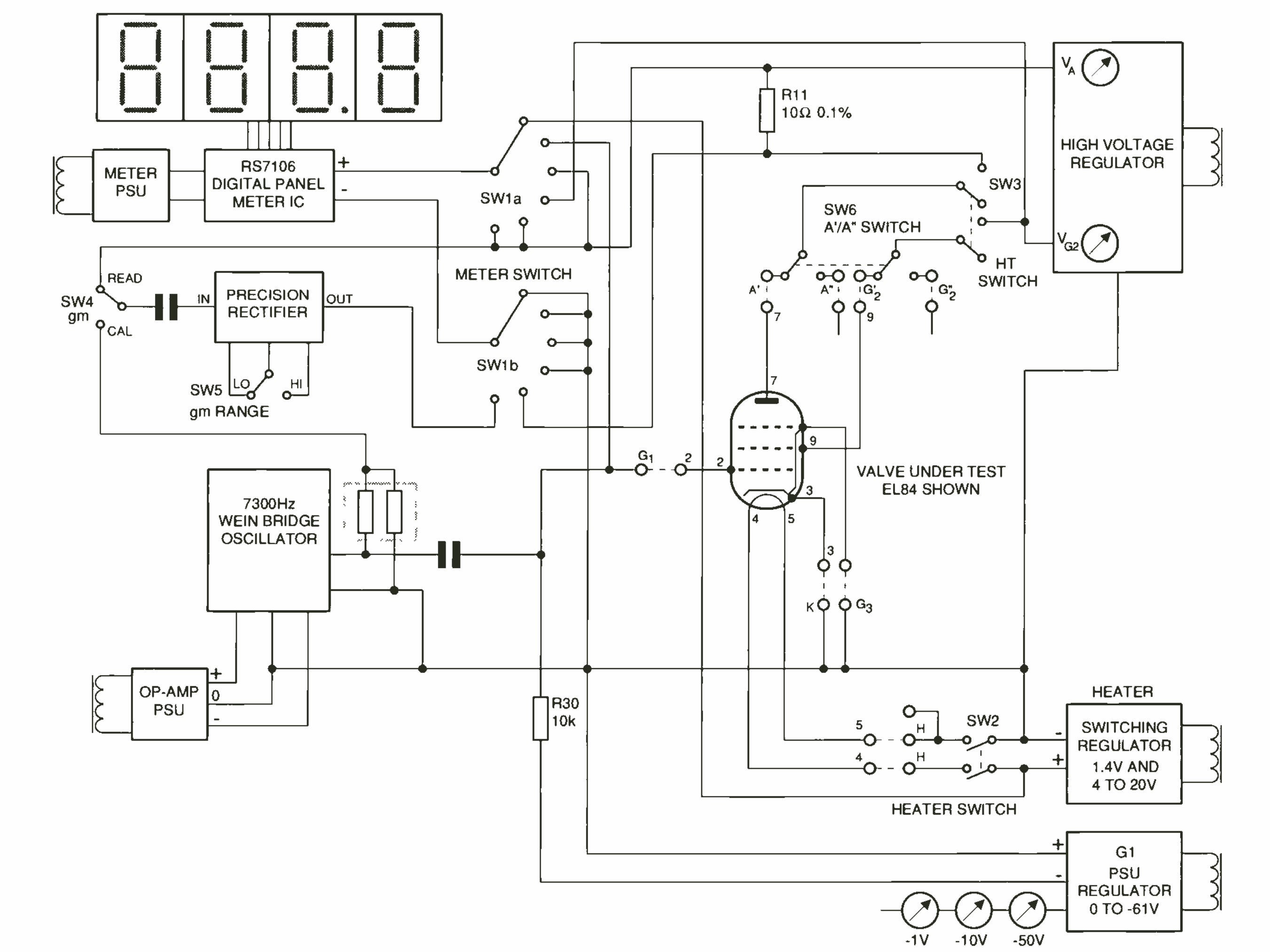


Figure 1: the Valve Characteristic Tester: system diagram

Readout of voltages, currents and mutual conductance (gm) is by a 34-digit LCD digital panel meter (DPM). Each of the set voltages can be read on the DPM before being applied to the valve under test.

Double valves can be tested one half at a time by means of the A'/A" switch.

Principle of operation

To obtain valve parameters, the voltage developed across a precision 100ohm resistor is measured by the DPM. The 100ohm resistor is interposed in the anode circuit of the valve. Mutual conductance is measured by applying a 7300Hz sine wave to g1 of the valve. The resulting ac voltage developed across the lOohm resistor is then measured, and gives a direct reading of gm in mA per volt (mA/V).

The DPM switch positions, starting from the anticlockwise position, lead the user logically from setting voltages to making measurements.

Operation is in the following order:

Vh	Set heater voltage
Vg1	Set control grid voltage
Va	Set anode voltage
Vg2	Set screen grid voltage
Ia	Measure anode current
gm	Measure mutual conductance. A READ/CAL switch is included with this function.

The layout of the main PCB and heater regulator PCB are shown in figure 14 and figure 15 with the Parts List near the end of this article.

Pin assignment

Pin connections to the valve are made by plugging 2mm plugs on short leads into sockets designated h (heater), k (cathode), g1 (control grid), g2 (screen grid), g3 (suppressor grid or beam plate) and a (anode). In most manufactured valve testers, these connections have been made with thumbwheel switches. So that size and cost can be kept low in this design, the plug and socket arrangement was thought preferable.

For optimum safety, it is recommended that a Residual Current Device (RCD) be used with this unit. The Valve Characteristic Tester is a mains powered, high voltage project, recommended for experienced mains constructors.

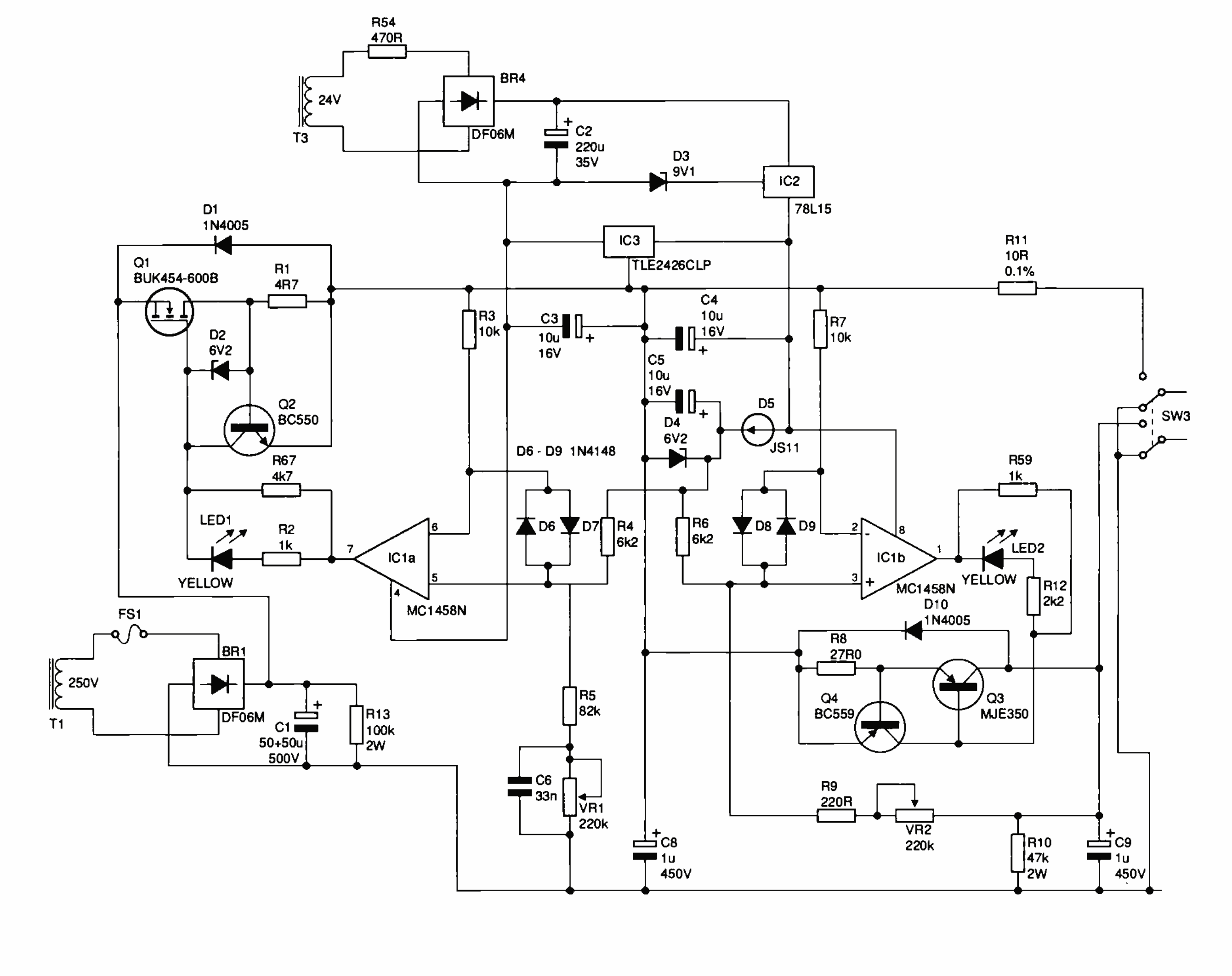


Figure 2: the HT supply circuits

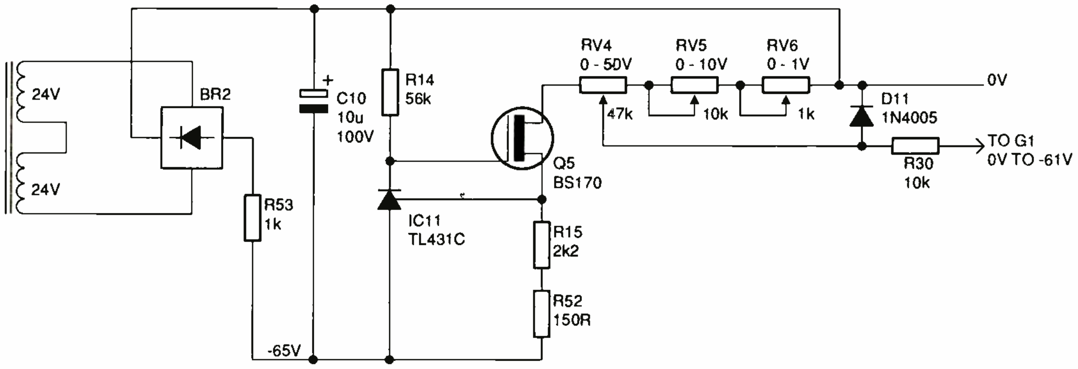


Figure 3: the G1 negative supply circuit

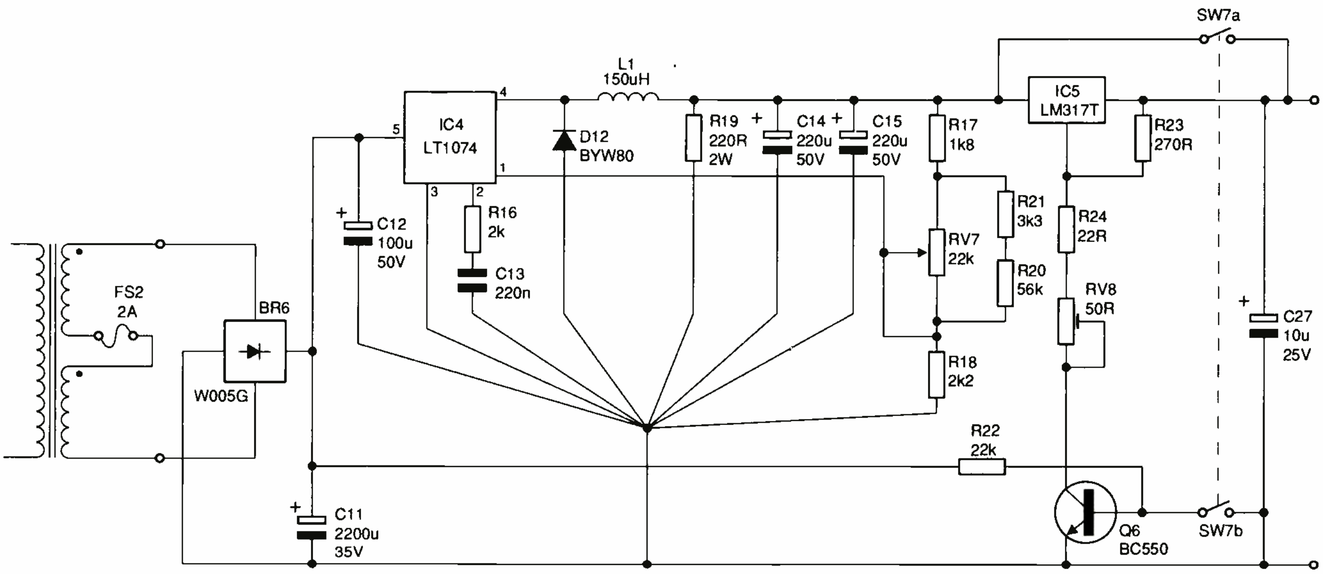


Figure 4: the heater regulator circuit

HT Supplies

250 vac from T1 is rectified by BR1 and smoothed by C1 (figure 2). It is very important that C1 and the other high-voltage capacitors used in this design are NOT substituted by lower-voltage capacitors. A lower voltage capacitor here would fail, very likely causing permanent damage to the equipment. It is recommended that the part numbers specified or an exact equivalent are used. This is a high-voltage circuit and must be treated as such.

Q1 is the pass transistor, controlled by IC1a. In this regulator the op-amps are "floating" at Va. Their +l2 volt and -l2 volt supplies are derived from a single 24vac transformer winding. This is rectified by BR4, regulated by 1C2 and the mid rail is derived by 1C3, a TLE2426CLP. This device is basically an op-amp and voltage divider in one three-pin package. Its use obviates the need for centre tapped windings.

Zener diode D4 provides a reference for IC1a and IC1b and is +6.2 volts with respect to (wrt) Va. IC1a, in normal op-amp fashion, will act to keep a zero voltage difference between its two inputs. Since R4 is 6k2, 1mA will flow through it and R5 and VR1 in series. IC1a will therefore drive the gate of Q1 to maintain 1mA in R5 and VR1. The output voltage at C8 is then proportional to VR1+R5 and is 1 volt per 1k. D2 gives over-voltage protection for Q1 gate. When output current exceeds l00mA, 0.7V is developed across R1, turning on Q2 and robbing voltage from Q1 gate. The resulting current through Q2 lights LED1 to indicate that an over-current condition exists. This regulator sets the required anode voltage.

If a lower voltage is required for Vg2, VR2 is rotated anticlockwise. As with IC1a, IC1b will maintain a zero voltage difference between its two inputs. 1mA will flow through R9, VR2 and R10 in series to 0V. This type of regulator requires this 1mA to flow under all load conditions. For the lowest voltage likely to be set, a value of 47k is chosen for the minimum load. This regulator will maintain

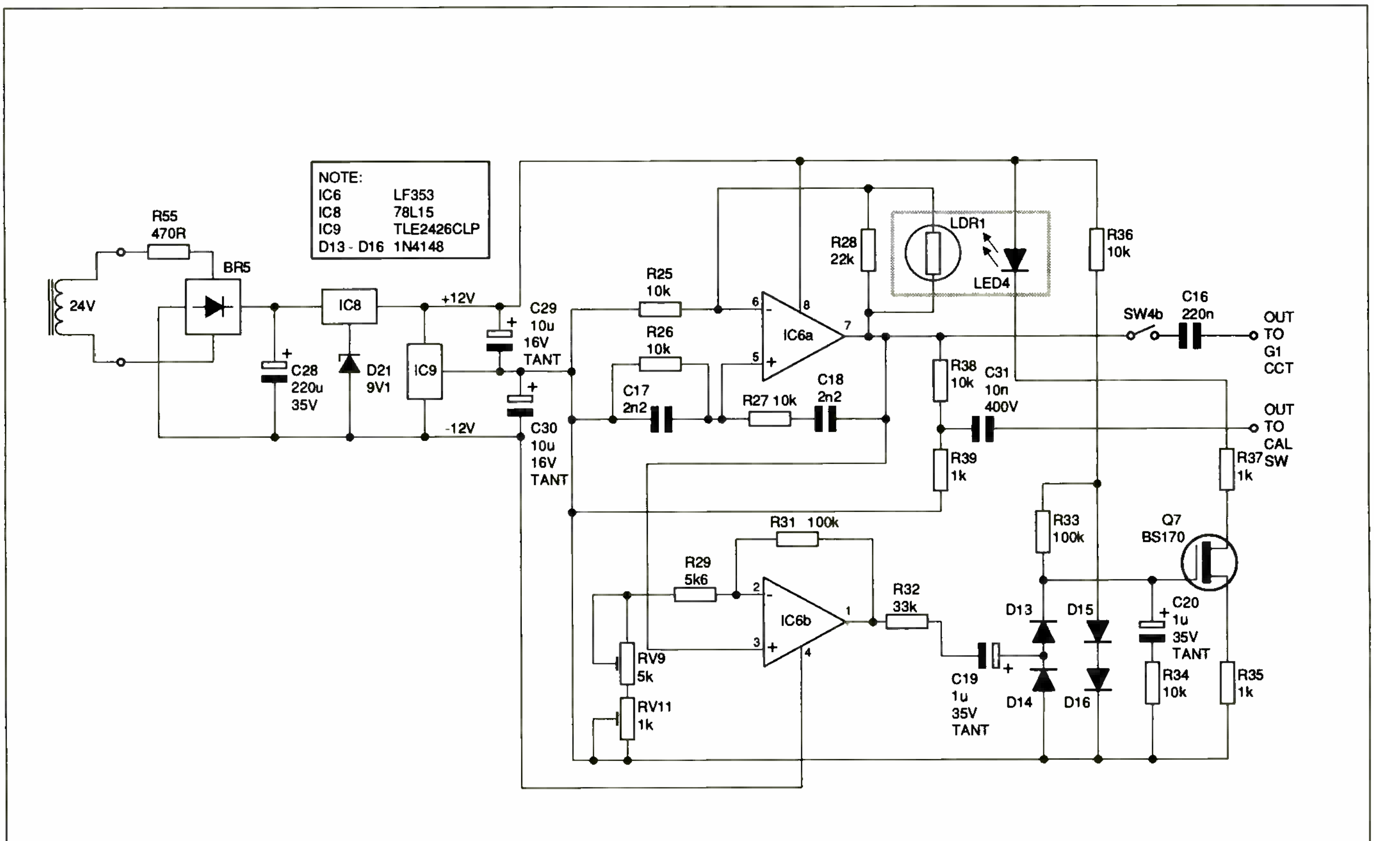


Figure 5: the oscillator circuit

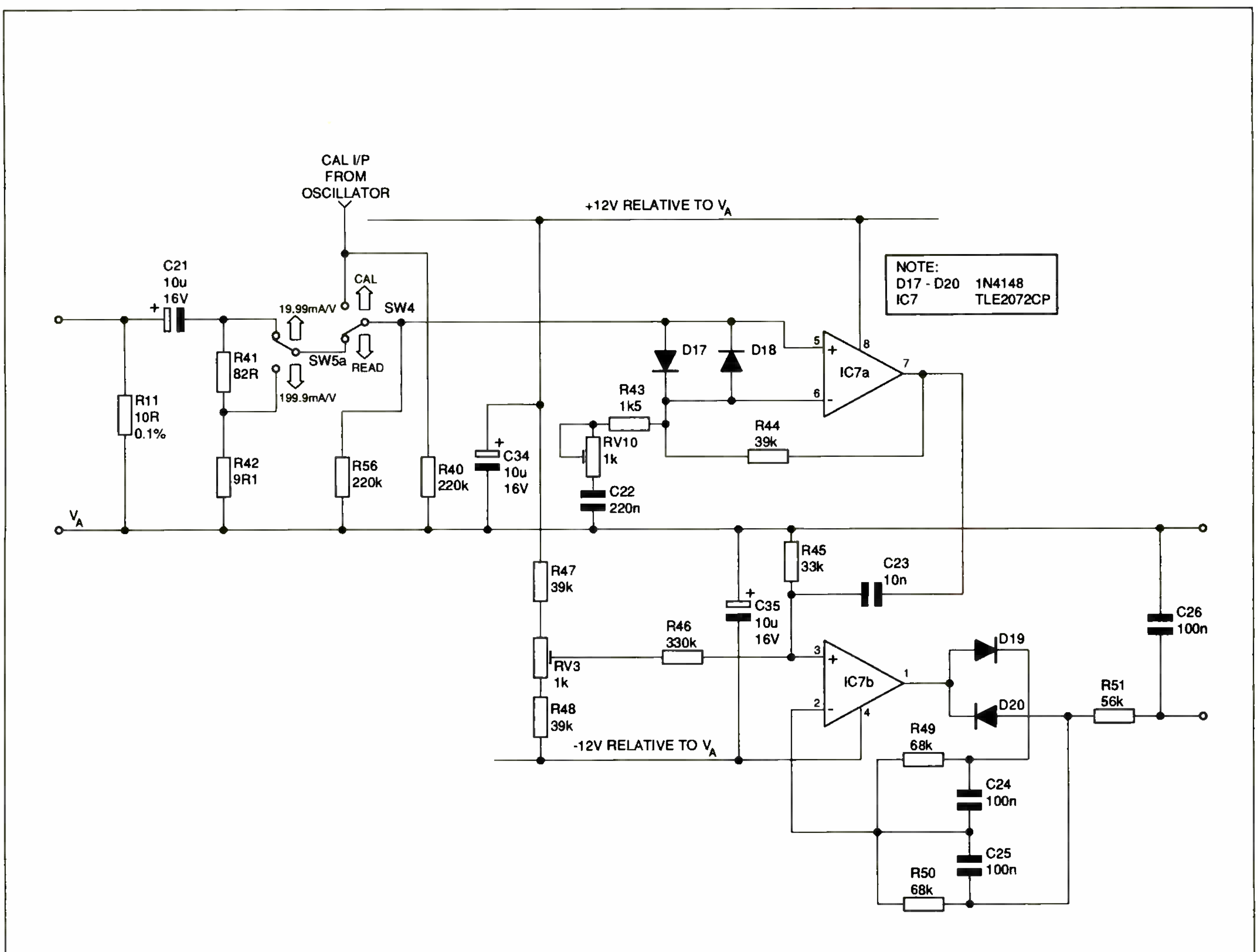
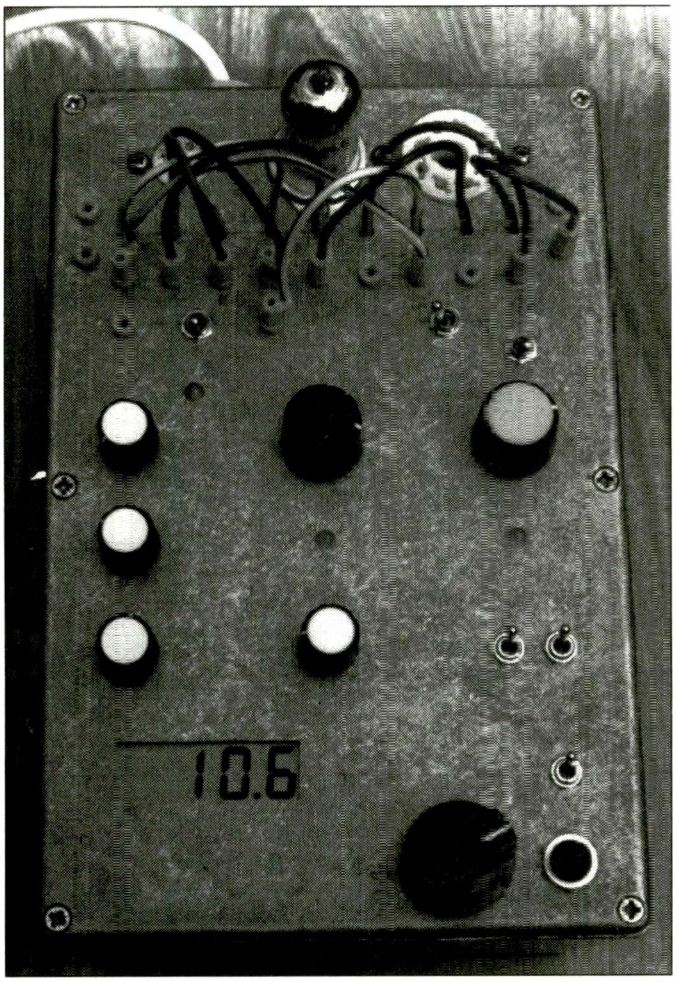


Figure 6: the precision rectifier circuit



The top panel with a valve in test

the same voltage difference between its input and output. Vg2 will therefore track Va regardless of the voltage set for Va, with the proviso that at least 1mA flows through VR2. Q4 limits the current through Q3 to about 25mA by robbing base current from Q3, lighting LED2 to show overload. Add a small flat heatsink 25mm by 15mm to Q3 to help heat dispersion.

Control grid negative bias supply

In the g1 negative bias supply (figure 3), 48vac is rectified by BR2 and smoothed by C10. The programmable zener TL431C (1C7) adjusts the current into its cathode to maintain 2.5V at its control pin. From I = E/R, a current of 1.064mA flows in R15 and R52. Q5 is in common gate mode, and this same current therefore flows in VR4, VR5 and VR6. Since this is a constant current, the voltage at the wiper of VR4 (47k) will change with the settings of both VR5 and VR6. Thus, up to 1 volt can be added by VR6 (1k) and up to 10 volts can be added by VR5 (10k). D11 protects against flashover or other leakage in the valve under test.

Heater regulator

To minimise power dissipation, IC4, an LT1074CT switching regulator is used (figure 4). However, when 1.4 volts is required for battery valves, IC4 is a pre-regulator and IC5 (LM317T) brings the output down to 1.4 volts, preset with VR8. VR7 is a 22k pot with integral DPST switch. In the "off" position, Q6 is biased on via R22 into saturation giving 1.4 volts at the output. When VR7 is rotated to the "on" position, contact 'a' bypasses IC5 and contact 'b' removes bias from Q6, thus isolating IC5 from the 0V rail and

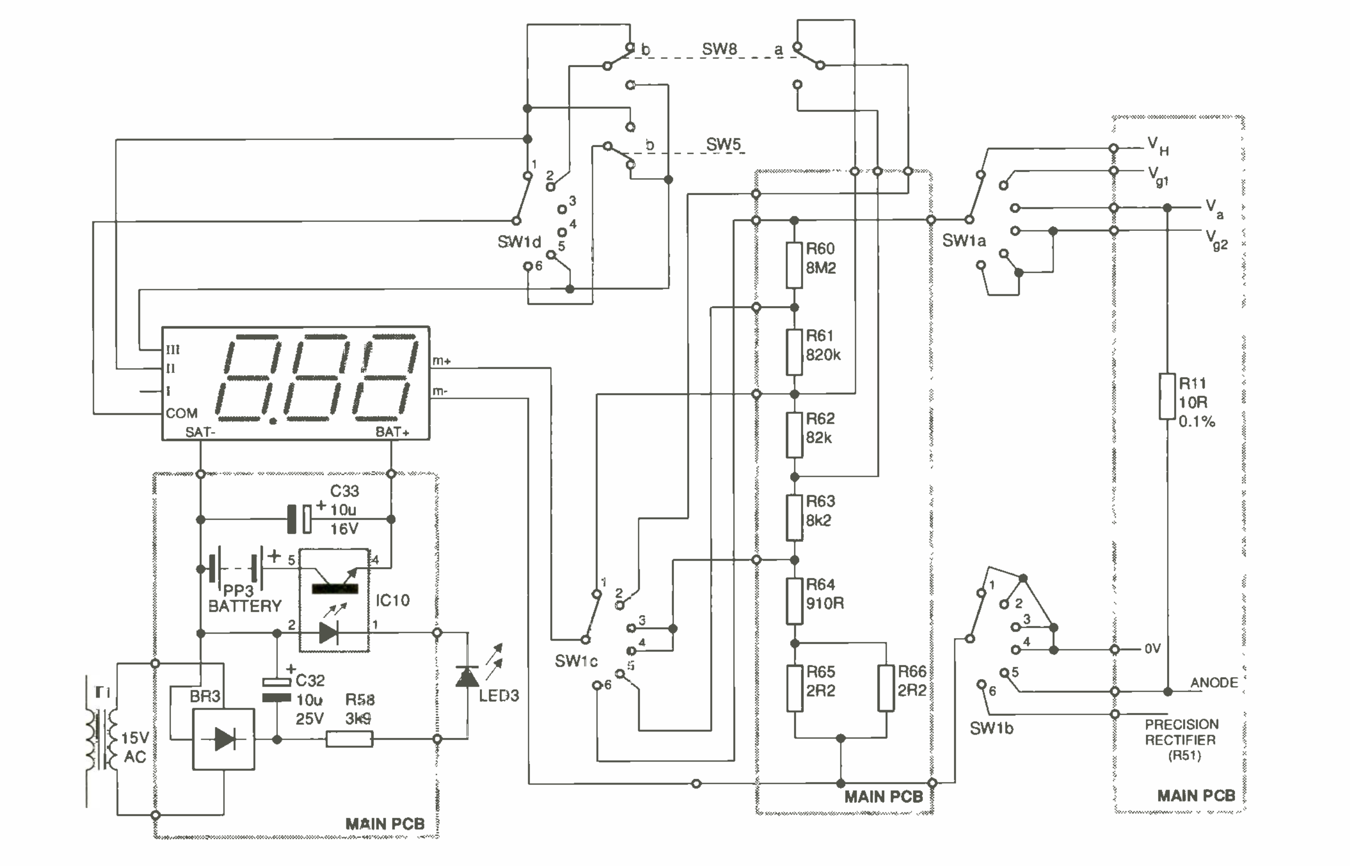


Figure 7: the DPM and function switch circuits

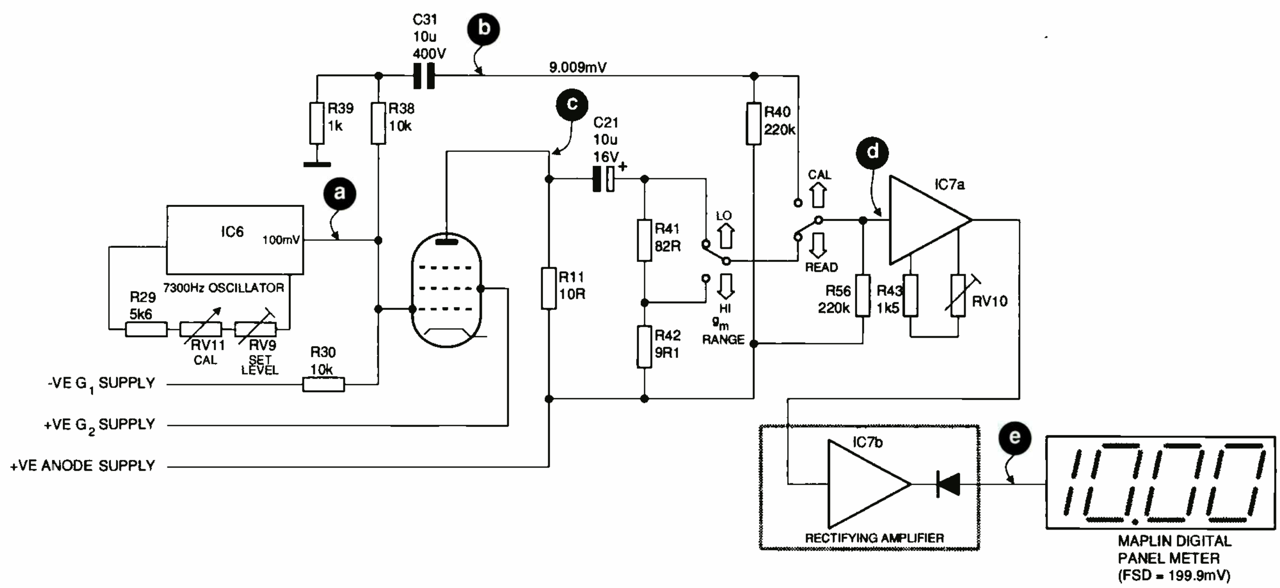


Figure 8: the calibration diagram

preventing damaging currents from flowing into its output. The heater voltage is now continuously adjustable from 4.0 volts up to 20 volts.

The oscillator

The oscillator (figure 5) is a Wien bridge type, amplitude stabilisation being provided by a light dependent resistor illuminated by an LED. The output signal at IC6a is amplified by IC6b and rectified by D13 and D14 to provide a dc control voltage at Q7 gate. The resulting current through LED4 illuminates LDR1 to control the negative feedback loop of IC6a. D15 and D16 provide forward bias for Q7 and simultaneously give temperature compensation. The change in output voltage is less than 2 percent for a temperature change of 15 degreesC. The preset VR9 sets the output level, while VR11 is the front panel CALIBRATE control.

Range switching

To measure ac volts a precision rectifier (figure 6), IC7, converts the ac signal across Rh to dc for measurement by the DPM. Since IC7 is only used in the anode circuit of the valve under test, it is powered by the same supply as IC1 and is, therefore, at Va above 0 volts. VR10 presets the gain of the precision rectifier.

A Maplin module (Catalogue reference GW01B) is used as the basis of the measurement system. This uses the ICL7106 dual ramp digital panel meter ic. SW1a and SW1b switch between the various measurement points in the valve tester. SW1c switches ranges while SW1d selects the appropriate decimal point. See figure 7.

A high pass filter comprising C21 and R41/R42 couples the signal voltage to IC7a. SW5 selects "gm HI" or "gm LO" for two ranges of mutual conductance. The "LO" range is likely to be the most commonly used range. SW4 is the "CAL/READ" switch. VR3 is an offset adjustment for the op-amp so that the DPM will read zero when no signal is present. To simplify the wiring, the negative output from the precision rectifier is measured by the DPM.

Power for the DPM is obtained from a PP3 9V battery. A 15vac winding on T1 provides current for the opto-isolator IC12 and LED3 in series, IC10 acting as the on/off switch for the DPM. Since the DPM module current consumption is less than 1mA, an alkaline battery life of at least 500 hours can be expected.

Calibration

Referring to the calibration diagram, figure 8, consider the hypothetical valve under test (VUT) to have a mutual conductance, gm, of 10mA per volt. A signal at the control grid, g1, of 100mV will develop an ac voltage of:

$$E = (0.1 \times 10\text{mA/V}) \times Ra$$

where Ra is the combined value of R11 and R41 + R42 in parallel, 9.011ohms. Therefore, E equals 9.011mV. (Remember that measurement of dc current is developed across R11 alone, while measurement of ac current is developed across R11 and R41 + R42 in parallel.)

This voltage of 9.011mV is raised in level by IC7a and peak rectified by IC7b to read 100mV on the DPM. The decimal point is positioned to show 10.00.

Theoretically we could use our hypothetical valve to calibrate the Valve Tester, but since such a device does not exist, we use a combination of resistors to do the job. Thus, R38, R39 with R40 and R56 in parallel simulate the hypothetical valve.

To calibrate the Valve Tester, SW4 is moved to the "CAL" position and the front panel control VR11 is adjusted for a reading of 10.00 on the DPM. Switch SW4 back to "READ" and a real life valve can be measured.

Next month

In the second and final part of this project in the next issue, we will print the construction details, wiring, Parts List and pcb layouts for the Valve Characteristic Tester.

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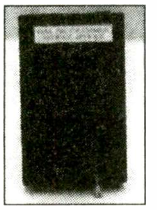

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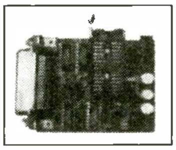

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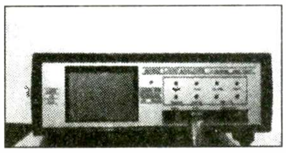

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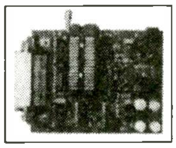

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Fast Fivers

Adaptable, affordable - handy circuits for around £5. By Owen Bishop

4. Process Timer

In many instances, the Old Technology has advantages that we did not appreciate at the time. We took them for granted. And often these advantages have not been carried forward into the New Technology. Take the hour-glass, for example. It may have been cumbersome and not all that precise, but it had one big advantage. At a glance you could tell (near enough) how much of the hour had elapsed (lower bulb) and how much time there was still to run (upper bulb). Doing the same thing with a digital watch involves a load of mental arithmetic, which is prone to error if you are timing a telephone call and need to concentrate on the conversation.

This project is the New Technology equivalent of the hour-glass, with the added advantage of being able to time up to three consecutive stages of a process. It can time a multistage process lasting for half-an-hour or so and, provided that you are willing to go beyond the £5 limit, you can increase the number of stages to seven, or even more. The design is flexible, allowing stages to be set to different lengths, and there is scope for variety in the LED display.

How it works

The circuit consists of two parts, a ramp generator or integrator (top left in figure1) and an array of comparators driving LEDs (right in figure 1). The circuit employs a single ic, a TL064CN, which contains four operational amplifiers. One of the op amps is used for the ramp generator and the other three are used as comparators. The ramp generator is based on the principle of the building up of charge on a capacitor. As current flows into a capacitor, the charge increases and so does the voltage - it ramps upward. When a capacitor is charged from a fixed voltage source, the amount of current (and hence the charge) flowing into the capacitor depends on the voltage difference between the fixed source and the voltage across the capacitor. This difference becomes less and less as the capacitor charges, so current gradually falls and the rate of ramping decreases. A varying ramp rate is not usually suitable for timing purposes, but there are ways to produce a constant ramp. This circuit relies on the fact that when the op amp is connected as in figure 1 its inverting (-) input acts as a virtual ground. This is because an op amp acts to keep both its inputs at the same potential, and the non-inverting (+) input here is connected directly to the 0V (ground) line. Thus, whatever charge there may be on the capacitor C1, point A in figure 1 stays at 0V. Current reaches A from the network to the left. This consists of a Zener diode ZD1 wired so as to produce a constant voltage (3.9V) across R2 and VR1. We tap off a very low voltage (say 30mV) by adjusting VR1. This too is constant. If one end of R3 is at 30mV, and the other at 0V, a constant current flows through R3 and this current is equal to 0.030/10000000 = 3nA.

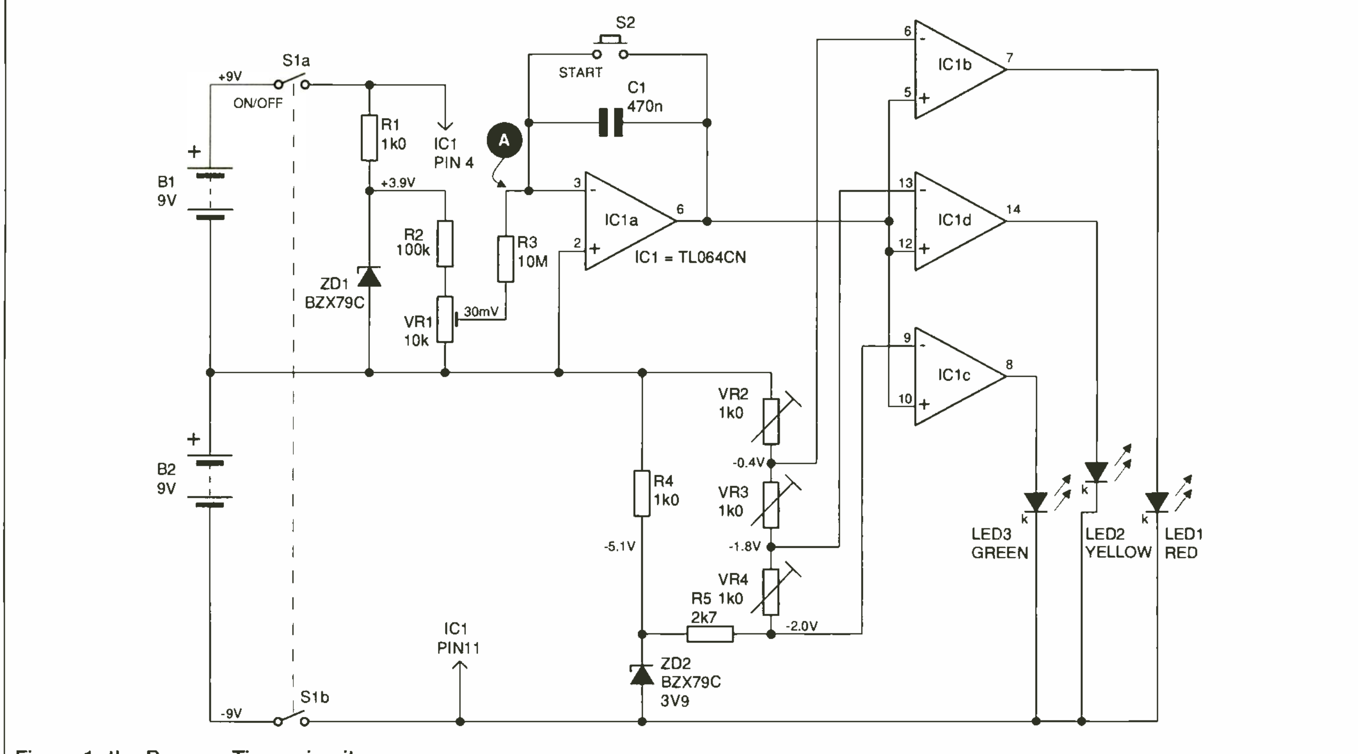


Figure 1: the Process Timer circuit

The current flowing arriving at A must go somewhere. Not much of it can enter the opamp because the opamp has FET inputs with an input resistance of about 10(the the power of 12) ohms, that is, a million megohms. So the current flows into the capacitor and begins to charge it. But opint A must stay at 0V. To make it possible for C1 to accept the charge, the potential at its other terminal must go down. As current enters the capacitor and a potential difference develops between its terminals, the output of the opamp goes negative by just the right amount to hold A at 0V. A constant current of 3nA carries charge into C1 at the rate of 3nC per second. For a capacitor, capacitance C, charge q, the voltage across its is V=q/C. Thus the voltage across Cq increases by 3 nanocoulombs/470 nanofarads = 6.38mV per second, or approximately 0.4V per minute. Putting it the other way round, the voltage output of IC1 falls by 0.4V per minute. This is the basis of the timing. A beneficial feature of this circuit is that quite long times are obtainable when using a capacitor of relatively small value. This is an advantage over circuits that require large-value electrolytic capacitors, which not only vary widely from their nominal values but also change in value with use and as they age.

The output of IC1 is fed to the (+) inputs of three op amps wired as comparators. A resistor chain consisting of VR5 and three preset resistors provides a series of voltages with which to compare the ramping-down output from IC1. The voltage across the chain is fixed at -5.1V by another 3.9V Zener diode, ZD2. The values used for R5 and VR2 to VR4 depend on the total process time and the times of the individual stages. It is as well to calculate these before you build the project as you may need different values for any or all of these. We will illustrate the calculations by taking an example of a telephone call timer. Suppose we want a total period of 5 minutes, subdivided into three periods, of lengths 1, 3.5 and 0.5 min. The first period is for indicating a reasonable limit for trunk calls. The middle period allows extra time for local calls. The final 0.5 min is the period for closing down the conversation prior to hanging up. It is a warning that time is nearly up. Maximum call time is 5 min.

PARTS LIST for the Process Timer

Resistors

(0.25W, 5% tolerance or better; variable resistors are all miniature horizontal presets)

R1, R4	1k
R2	100k
R3	10M
R5	2.7k (for 5-min period)
VR1	10k
VR2 to VR4	1k (or other values as required)

Capacitor

C1	470nF, metallised polyester, 100V

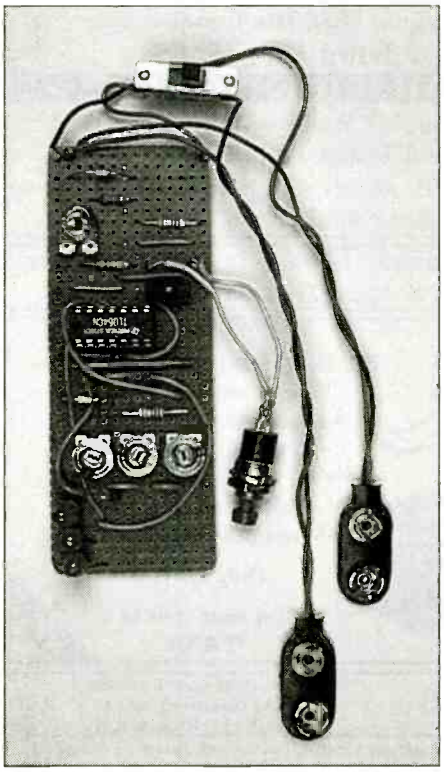
Semiconductors

ZD1, ZD2	Zener diode, BZX79C, 3.9V
LED1 to LED3	Light-emitting diodes
IC1	TL064CN fet input quad op amp

Miscellaneous

S1	2-pole single throw switch
S2	Push-to-make push-button

Stripboard (98mm x 40mm, 15 strips x 38 holes), 1mm terminal pins (5 off), PP3 battery clips (2 off), 14-pin dil ic socket.



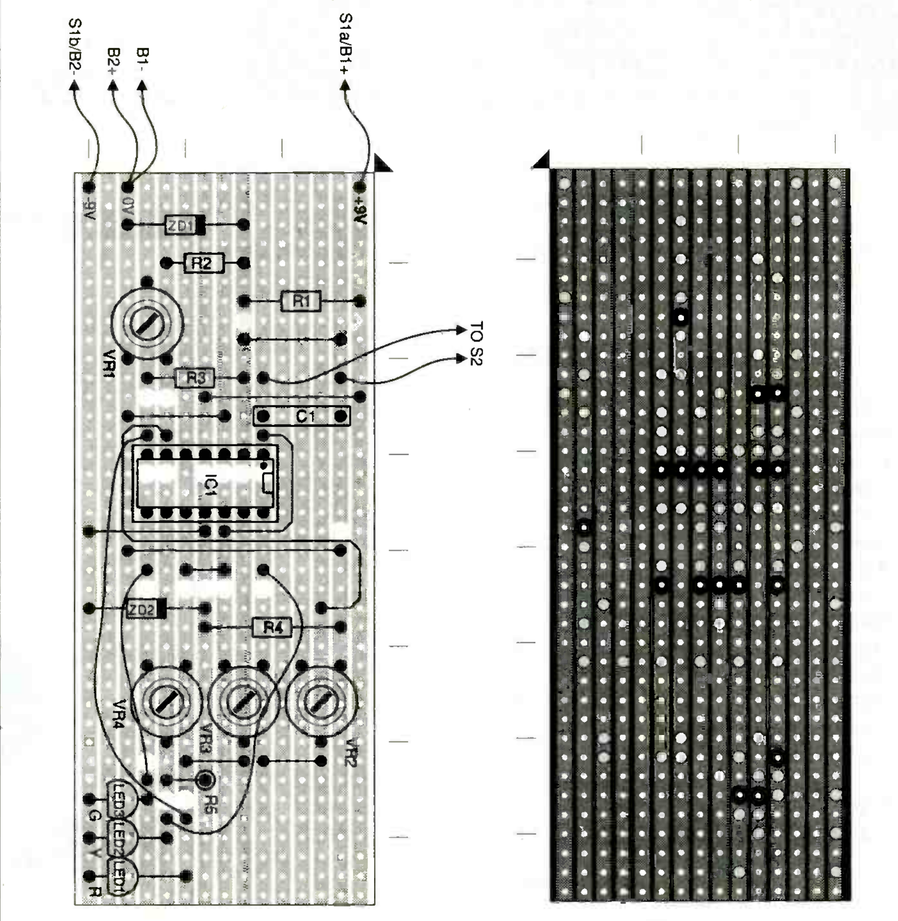


Figure 2: stripboard layout for the Process Timer

Calculations

We will assume that you have adjusted VR1 to produce a voltage of 30mV at its wiper, so obtaining a ramp down of 0.4V per minute (approximately, to make calculations easier). Pressing S2 sends the output of IC1 to 0V at 0 min. At 1 min it will have fallen to -0.4V, at 4.5 min (that is 3.5 min later) it will have reached -1.8V, and at 5 mins it is -2.0V.

Assume that the current through the chain is to be 1mA. The voltage across R5 is to be 5.1-2 = 3.1. So the value of R5 is 3.1/0.001 = 3100 ohms. For convenience use 2.7 kilohms, and let the current be 3.1/2700 = 1.15mA. If t is the required length of a period, the resistance needed is R = (time ◊ 0.4)/0.00115. For periods of 1, 3.5 and 0.5 min the required resistances are 348, 1217,and 173 ohms. If you are not too worried about exact timing, you could use fixed resistors in place of the presets. Values of 330 ohms, 1.2 kilohms and 180 ohms would do. If you use presets, you need 1kilohm or 470 ohm presets for VR2 and VR4, and a 2.2 kilohm or 4.7 kilohm preset for VR3. These are adjusted to the exact value as calculated.

For longer periods you can decrease the value of R5, or set VR1 to produce a voltage lower than 30mV and hence a slower ramp.

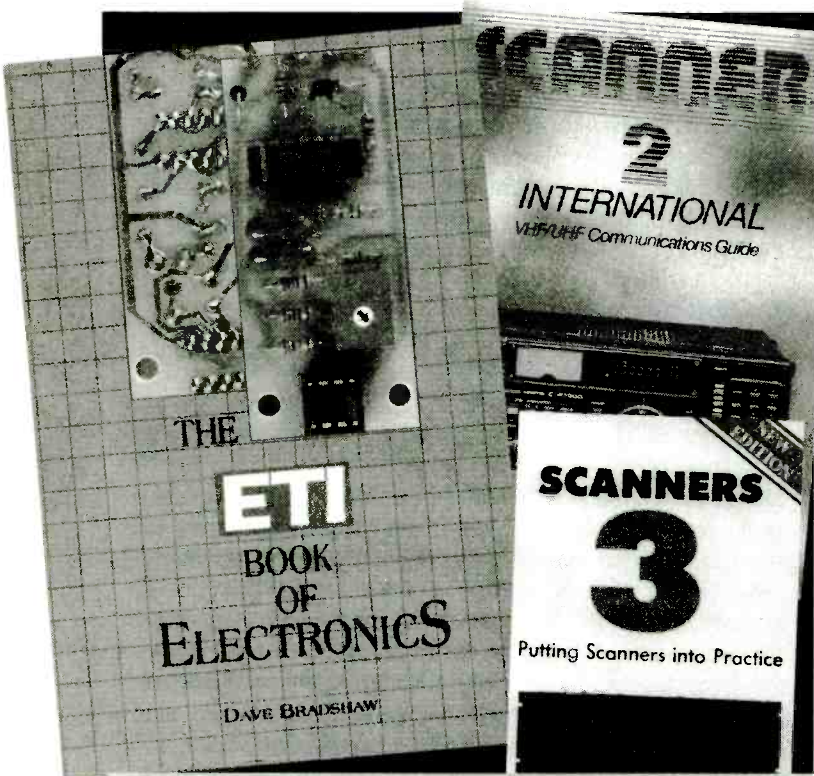
Displays

With the circuit as shown in figure 1, all three LEDs come on when S2 is pressed. LED1 goes out at the end of the first period (in the example, after 1 min). LED2 goes out at the end of the second period (after 4.5min) and LED3 goes out at the end of the third and final period (after 5 min). We used ordinary 5mm red LEDs in our prototype but you can vary this by using LEDs of different colours (red, yellow, green) or shapes. You can also use flashing LEDs. For example, if LED3 is a flashing type it effectively signals the imminent end of the process. It is also possible to wire the circuit for the reverse operation, with all LEDs off to begin with and all on at the end. Just reverse the input connections to the op amps.

Construction

Figure 2 shows the stripboard layout and connections to the main switch S1. The circuit is powered by two 9V PP3 batteries, using two battery clips . First assemble the ramp generator circuit, which includes everything on the board to the left of column 20. The ramp generator is best tested at this stage, using a meter with high-impedance input, for example a digital multimeter. A moving-coil meter will probably require too much current and give misleading low voltage values at the wiper of VR1. Check the voltage at the cathode of ZD1; it should be close to 3.9V. Measure the voltage at the wiper of VR1 and adjust VR1 to bring this to 30mV or any other value you have decided upon. Finally monitor the voltage at pin 1 of IC1. This should be 0V when S2 is pressed and released, then fall steadily at a rate close to 0.4V per minute. If you have decided upon the timing of the periods, have a seconds clock handy, press and release S2 and note the voltages (negative) as each of the period ends. These figures form the basis for calculating the resistances required in the resistor chain (see previous section).

Having decided on timings, the values of resistances and the types of LED, assemble the rest of the circuit. If you are using presets, switch off the power, connect a multimeter across each in turn and adjust each to its calculated value.



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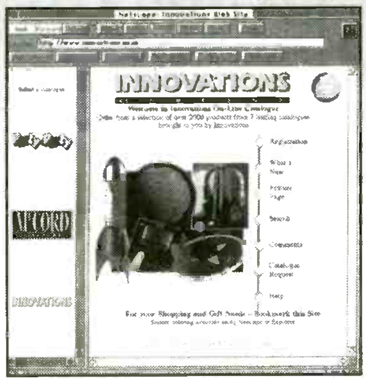

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Shorts...

Technical market research specialists Dataquest predict that the market for digital still (as opposed to video) cameras will remain firmly attached to the market for computer peripherals for at least the next three years, although it will expand to achieve nearly 6 million units by the year 2000, generating substantial sales for the digital still camera semiconductor industry. Research indicates that the higher price of digital cameras means that conventional film cameras (of which there are now a number of formats, some developing towards digital computer link-up in the future) will remain the most popular format until digital prices become more competitive. Dataquest have produced a report "Digital Still Cameras Develop into a New Semiconductor Market", which can be purchased via Tel. 0800 716089 ... **The publication** of consultation paper on the licensing of Trusted Third Parties for the provision of encryption services was announced in March by the Science and Technology Minister Ian Taylor. According to the Minister, "the proposals involve licensing TTPs who offer encryption services to the public in order to facilitate the development of electronic commerce; to protect consumers; and to preserve the ability of the intelligence and law enforcement agencies to fight serious crime and terrorism.

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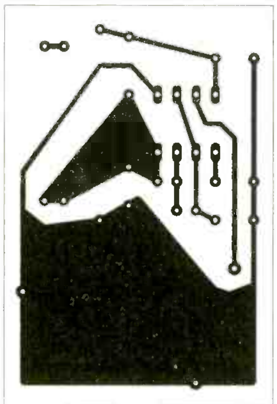

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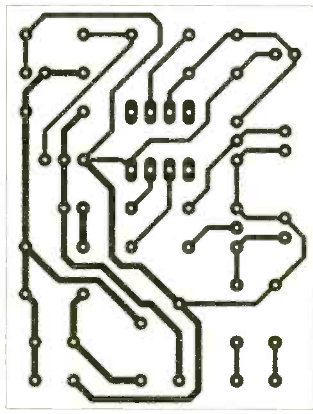

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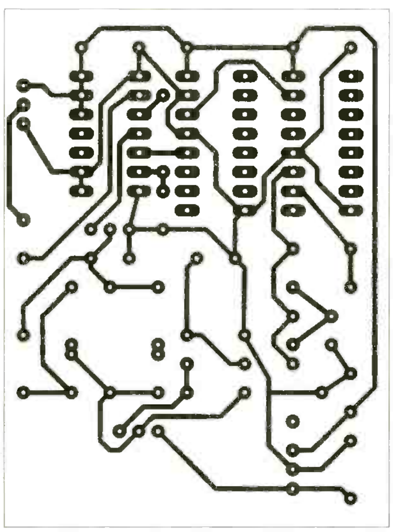

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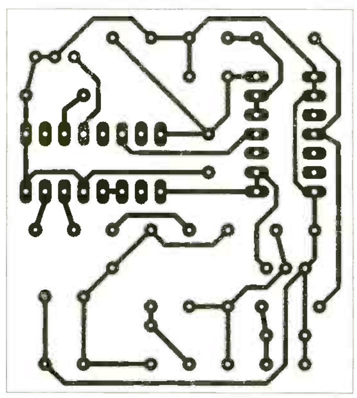

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Around the Corner

Every so often, a manufacturer can make the boast that their kit is currently the ruggedest on the streets (see News: The World's first 5 GB laptop disk drive). this leads us to wonder - how many computers are at risk? We knew someone who hit a printer once (yes: it broke. One of those £2.95 parts that costs £10 to replace.), and someone who used to thump his monitor (it made it work - right up to the day it blew up. He wasn't injured, but a colleague lost two hours' work when the circuit breaker tripped) and a technician who swears that hitting keyboards makes them work better (like the monitor, perhaps). But we have yet to meet anyone who hits computers. Even other people's computers. On trains? Maybe ...

But seriously, although for some electronics purists anything with a moving part is distinctly suspect, it is likely that rotating storage media will be with us for some time. The technological advances in hard discs should not be underestimated. Many people remember mainframe hard discs, with stacked disc packs used in a clean room environment, and storing a few hundred kilobytes if you were lucky.

The 'head crash' (now a science fiction title) used to be an ever present risk. A tiny particle, perhaps cigarette smoke, would get between the head and the disk, and trigger a destructive operation in which the head scraped the magnetic coating off the disc. This is still physically possible with modern hard discs, it doesn't happen often.

When 20 megabytes constituted a large hard disc, it was necessary to run a program to park the heads before moving the computer, to stop the heads clattering against the platter and chipping the magnetic coating off. Nowadays that is taken care of in the mechanism, and when the power is switched off the heads are moved to a safe position. More effort is made to give each new generation of disc drives improved aerodynamics for the heads and ever smoother coatings for the platter to permit closer spacing between disc and head, so that we can read and write ever smaller magnetic domains.

What does this mean for portable computers? The most obvious problem is that the heads must not chip the platter even when shock is applied while data is being written. Ideally, there should be no disruption to the data storage accuracy.

There is another less obvious problem: the platter is spinning very fast, and even a small tilt applied to it will generate strong precession forces (which can be illustrated with an ordinary gyroscope). This precession is a result of the conservation of angular momentum, so the faster the spin, the more change in angular momentum from a given tilt, and the more force. This force tries to flex the platter, and puts strain on the bearings. The whole assembly must be rigid enough so that the platter does not contact the head and use it like a lathe tool to machine pieces off.

When you consider all these factors, the production of a 5 Gigabyte hard disc (see News) for use in a portable computer is another modern marvel.

Last Month's Competition Winners

Congratulations to our RIAT competition winners from issue 6. 15 pairs of complimentary tickets to the Royal International Air Tattoo at RAF Fairford, Gloucester, in July are winging their way to the winning entries.

Next Month...

Volume 26 no. 9 of Electronics Today International will be in your newsagent on 15th August 1997 ... H. Paul Shuch will be scanning the heavens for signs of life as yet unknown ... Terry Balbirnie's mock alarm flasher offers a very low cost safety feature for cars ... We take a look at some more Electronics courses, including some postgraduate and research departments ... all the regulars, and more.

Contents are in preparation but are subject to space and availability.

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In-system re-programmable	-	-	-	YES	YES	-	-
I/O Pins	32	32	32	32	32	15	15
16-bit Timer/Counters	2	3	3	3	3	1	2
Watchdog timer	-	-	-	YES	YES	-	-
Interrupt sources	6	8	8	9	9	3	6
Serial UART (full duplex)	YES	YES	YES	YES	YES	-	YES
SPI Interface	-	-	-	YES	YES	-	-
Analogue comparator	-	-	-	-	-	YES	YES
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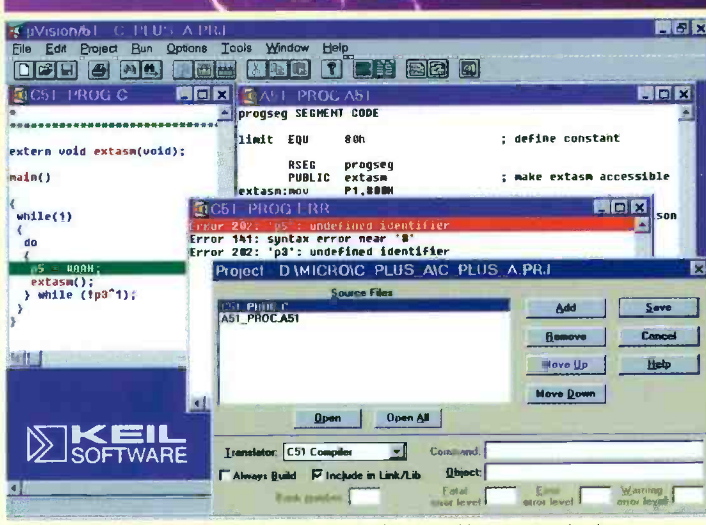

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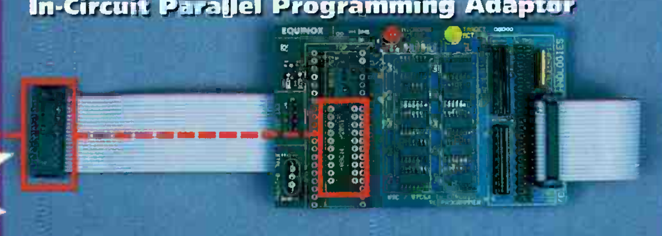

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