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- Fast Fivers
- Higher Degrees in Electronics

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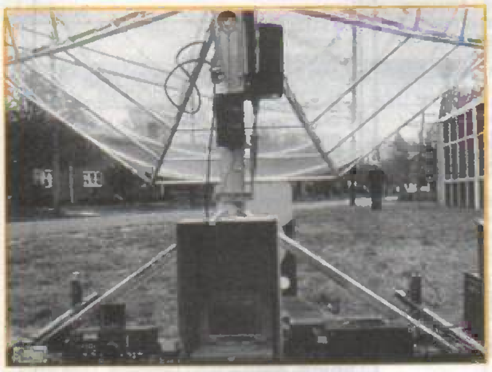
Vol 26 Issue: 9 15 August 1997 £2.50
USA $4.95

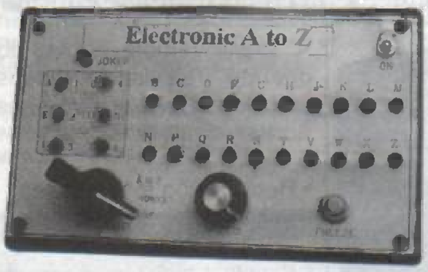
Contents

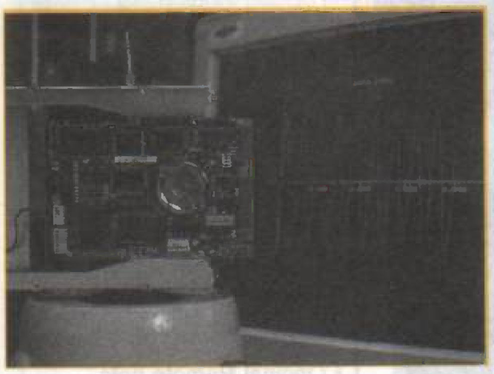
Volume 26 No.9

& Features & Projects

Next Issue 12th September 1997







Sorry - Part 2 of Speed Control in DC Motors and Part 2 of the Valve Characteristic Tester have had to be held over this month. We'll aim get them in the next issue.

Regulars

DIGITAL MULTIMETERS

CM2300 DIGITAL MULTIMETER

FEATURES:
- 3.5 LCD DISPLAY
- HEIGHT 12mm
- MAX READING 1999
- HV INDICATION FOR HIGH VOLTAGE
- SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
- ALL RANGES OVERLOAD PROTECTED
- 10A DC CURRENT TEST,
- DC VOLTAGE 2V/20V/200V/500V,
- AC VOLTAGE 200/500V
- DC CURRENT 200mA
- RESISTANCE 2kΩ /20kΩ /200kΩ /2MΩ
- SUPPLIED WITH TEST PROBES

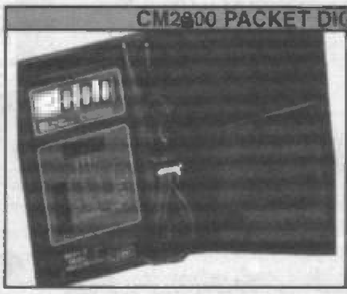
ORDER CODE: CM2300
PRICE: 975p

CM2400T DIGITAL MULTIMETER WITH TEMP MEASUREMENT

FEATURES:
- 3.5LCD DISPLAY
- HEIGHT 12mm
- MAXIMUM READING 1999
- 10A DC CURRENT TEST
- DC VOLTAGE 200mV/2V/20V/200V/1000V
- AC VOLATE 200/750V,
- DC CURRENT 0.2mA/200mA/20mA/200mA/20A
- RESISTANCE 200Ω /2KΩ /20KΩ /200KΩ /2MΩ
- SUPPLIED WITH TEST PROBES
- TEMPERATURE MEASUREMENT
- CONTINUITY TEST
- DIODE TEST & CONTINUITY CHECK
- ALL RANGES OVERLOAD PROTECTED

ORDER CODE: CM2400T
PRICE: 1450p

CM2900 PACKET DIGITAL MULTIMETER



FEATURES:
- 3.5 LCD DISPLAY
- COMPACT AND LIGHTWEIGHT POCKET SIZE
- MAXIMUM READING 1999
- DC CURRENT 7 RESISTANCE OVERLOAD PROTECTED
- SLIDE SWITCHES FOR FUNCTION AND RANGE OPERATION
- SUPPLIED IN WALLET WITH TEST PROBES
- DC VOLTAGE 2V/20V/200V/500V
- AC VOLTAGE 200V/500V
- DC CURRENT 200mA
- RESISTANCE 2KΩ /20KΩ /200KΩ /2MΩ

ORDER CODE: CM2900
PRICE1150p

CM2700 AUTORANGING DIGITAL MULTIMETER

FEATURES:
- 3.75 LCD DISPLAY WITH DECIMAL POINT
- 33 SEGMENT BARGRAPH DISPLAY
- OVERRANGE INDICATION
- ROTARY SWITCH FOR FUNCTION SELECTION
- AUTO POWER OFF (APPROX 15 mins)
- AUTO POLARITY WITH INDICATION
- DIODE TEST & CONTINUITY TEST WITH BUZZER
- ALL RANGES OVERLOAD PROTECTED
- LOW BATTERY INDICATION
- SUPPLIED WITH TEST PROBES
- DC VOLTAGE: 320mV/3.2V/32V/320V/600V
- AC VOLTAGE: 320mV/3.2V/32V/320V600V
- DC CURRENT A: 320µA/3200µA/32mA/320mA/10A
- AC CURRENT A: 320µA/3200µA/32mA/320mA/10A
- RESISTANCE: 320Ω/3.2KΩ/32KΩ/320KΩ/3.2MΩ/32MΩ

ORDER CODE: CM2700
PRICE: 4050p

CM3230 DIGITAL CAPACITANCE METER

FEATURES:
- 3.5 LCD DISPLAY
- HEIGHT 18mm
- MAXIMUM READING 1999
- CAPACITANCE 9 RANGES FROM 200pF-20000µF
- MEASURING FROM 1pF - 20000µF
- SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
- ZERO ADJUST KNOB

ORDER CODE: CM3230
PRICE: 3950p

CM3900A DIGITAL MULTIMETER

FEATURES:
- LARGE LCD DISPLAY
- HEIGHT 18mm
- MASIMUM READING 1999 + UNIT
- SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
- AUTO POWER OFF (APPROX 15 min)
- DIODE TEST FUNCTION
- ALL RANGES OVERLOAD PROTECTED
- SUPPLIED WITH TEST PROBES
- DC VOLTAGE: 200mV/2V/20V/200V 700V ACCURACY ±0.5%
- AC VOLTAGE: 200mV/2V/20V/200V/700V
- DC CURRENT A: 200µA/20mA/200mA/2A/20A
- AC CURRENT A: 200µA/20mA/200mA/2A/20A
- RESISTANCE : 200Ω/2kΩ/200kΩ/2MΩ/20MΩ/200MΩ

ORDER CODE: CM3900A
PRICE: 2900p

CM3920 DIGITALMETER WITH TEMP MEASUREMENT

FEATURES:
- TEMPERATURE MEASUREMENT
- DIODE & TRANSISTOR HFE TEST
- LARGE LCD DISPLAY
- HEIGHT 18mm
- MAXIMUM READING 1999 + UNIT
- SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
- AUTO POWER OFF (APPROX 15 mins)
- DIODE TESWT FUNCTION
- ALL RANGES OVERLOAD PROTECTED
- SUPPLIED WITH TEST PROBES
- DC VOLTAGE: 200mV/2V/20V/200V/1000V ACCURACY ±0.5%
- AC VOLTAGE: 200mV/2V/20V/200V/700V
- DC CURRENT 2mA/20mA/200mA/20A
- AC CURRENT A: 200mA/20A
- RESISTANCE : 200Ω/2KΩ/200kΩ/2MΩ/20MΩ/200MΩ
- CAPACITANCE: 2nF/20nF/200nF/2µF/20µF

ORDER CODE: CM3920
PRICE: 4100p

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A single remote control to operate Television, Videos and Satellite Receivers. Plus Auxilary Options!!

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- Simple 4 digit setup routine
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- Code Search Facility
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- Original Remote note required

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Price: 1450P + VAT

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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	SATRSU19

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,	SATPSU2
SS9210, SS9220	
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-II.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

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

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

****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	625P
BUZ45A	800P
BUZ50B	500P
BU53A	800P
BUZ71	75P
BUZ71AF	100P
BUZ72A	100P
BUZ72AF	100P
BUZ73A	150P
BUZ76A	110P
BUZ80	200P
BUZ60AF	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	55P
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	90P
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
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2N4923	30P
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2N5462	45P
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2N5680	55P
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2N6099	45P
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2N6109	40P
2N6211	400P
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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

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

ETI News...

16-bit microcontroller with on-chip flash memory

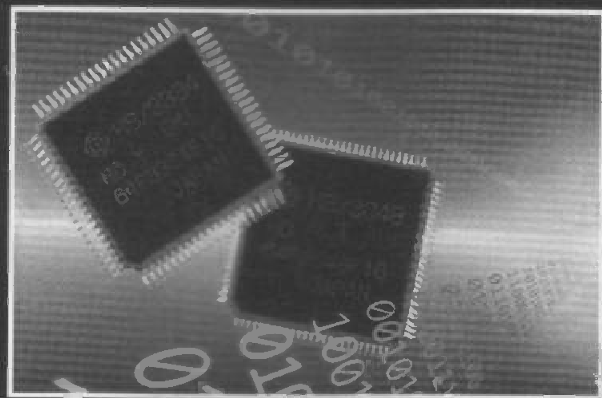
Hitachi has extended its range of F-ZTAT microcontrollers with on-chip flash memory with its first 16-bit device. Based on the H8/300H CPU core with a 125 nanosecond instruction cycle, the new H8/3048 has 128 Kbytes of flash memory, system support functions and a mix of peripherals.

The on-chip flash memory enables engineers to reprogram the microcontroller in the system, avoiding the need to remove and replace the device for software changes. Manufacturers can also build uncommitted production units and program the flash memory just before delivery. This can be used, for example, to set different languages in units destined for different countries. The flash memory also allows units to be reprogrammed in the field in incorporate new standards or product upgrades.

The H8/300H CPU core has 32-bit internal architecture with sixteen 16-bit general purpose registers and a concise instruction set designed for speed. Other on-chip functions include up to 4 Kbytes of ram, a 16-bit integrated timer unit, a programmable timing pattern controller, a watchdog timer, two serial comms interfaces, an 8-channel, 10-bit A/D converter, a 2-channel, 8-bit DAC, 78 I/O pins, a DMA controller and a refresh controller. The H8/3048 series is supported by development software and a low-cost evaluation kit including a development board with the device, a flash programming board and software, a GNU C compiler and C debugger, a Windows debugger and a CD-ROM with full documentation and tutorials.

The H8/3048 is also available with prom or masked rom memory.

For further information contact Vince Pitt, Hitachi Europe Ltd., Whitebrook Park, Lower Cookham Rd., Maidenhead, Berks SL6 8YA. Tel. 01628 585163 Fax 01628 585160.



MODSMODSMODSMODSMODSMODS

Issue 2 1997 Low Cost Digital Frequency Meter. In figure 2, D2 1N4148 should be the other way round. In figure 3, R15 should appear between X1 and pin 15 of IC1. Figure 4, the component layout, is correct.

Computer AutoSwitcher Issue 5 1997 In the bottom left hand corner of figure 2, a connection is shown between the neutral line and the 0 tap of T1 secondary. The connection should be between the 0 tap and the earth line immediately above it on the diagram. The PCB, and the component overlay shown in figure 3, are correct. *A sheet listing the published MODS from the September 1996 issue of ETI onwards is available from Nexus House (see page 74) for an SAE or International Reply postal coupon.*

Eprommer Eprom Programmer (Issue 7 1997). In figure 9 on page 55, the component labelled C15 should be IC13, the 317LP voltage regulator, with three connections, not two as marked. The tracks and pads on the PCB foils are correct. In figure 6, page 54, the two "blank" pads just to the left of R3 are for an extra 10 nF spike-precaution capacitor between pin 28 of the eprom socket and ground. The references to figure 6 (the main component overlay) and figure 8 (case construction) are a little scrambled, but fortunately the two diagrams are not easily confused. In figure 6, the through holes are marked by single pads with a black dot, not by an X as in the text.

PCB supplies for hobbyists

Etch-Tech Boards, PCB manufacturers specialising low volume PCB manufacture and services for hobbyists, have expanded by introducing a range of PC-based PCB design packages, as well as traditional artwork preparation materials. This means, says Etch-Tech, that they can offer a total PCB service to hobbyists who want to make their own boards, from the supply of PCB software and artwork materials, through to artwork generation and PCB manufacture.

For more information, write to Etch-Tech Boards, PO Box 1566, Salisbury, Wilts SP1 3XX.

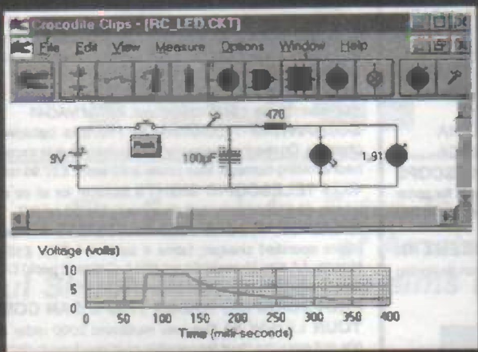
Antique Wireless 155

The Antique Wireless Newsheet is out and about again. Editor Tudor Gwilliam-Rees, formerly of The Vintage Wireless Co. Ltd., is publishing news of manuals, magazines and service data from Savoy Hill Publications, 50 Middon St., Bideford, The Little White Town, North Devon EX39 2EQ. Tel/Fax 01237 424280.

Subscriptions are UK £5 for 12 issues, overseas £7.00 for 12 issues. Recognised clubs, magazines and societies, please write and enquire.

ETI ELECTRONICS TODAY INTERNATIONAL News...

Crocodile migrates to Windows and Mac



Crocodile Clips circuit simulation software, widely used in UK schools for National Curriculum courses in Science and Technology, is now available for Apple Macintosh computers, and for Windows running on PCs.

Users can design and test their own circuits on screen with a range of components, in effect providing a software-based breadboarding system before real components are brought into use. Packages are also available to allow the user to import Crocodile Clips circuits and use them to design PCB layouts.

The makers of Crocodile Clips believe that the software, which has proved useful in schools and industrial training, is also useful to constructors designing and making their own projects and PCBs.

Demonstration versions are available from the web site www.crocodile-clips.com/education/ or by calling 0131 226 1511.

Police get one-touch computer comms in-car

Police in Lincolnshire are putting into action a county-wide installation of mobile data terminals with satellite-based location detection. This will allow the Force to pinpoint the exact location of their patrol cars, and allow Police Officers to access the Police National Computer from patrol cars.

The system, designed for Lincolnshire Police by systems integrators APD Communications of Aylesbury and Havant-based data storage and networking manufacturers Xyratex in partnership, will provide officers in up to 120 vehicles with direct live connection to central criminal records and car registration details, via purpose-designed ruggedised personal computers.

Superintendent Duncan Gerrard of Lincolnshire Police said, "Not only do officers have effortless access to key data on suspect vehicles and their drivers, but they can obtain this information directly from the PNC, within seconds, combined with direct despatch to incidents from the command and control system, linked to a full GIS mapping system. This speeds up their throughput, and dramatically decreases the number of voice request for information to the control centre, freeing up those operators to deal with other urgent requirements."

The in-car Mobile Data Terminal, deisgned and made by Xyratex, is a full-spec portable comuter capable or running all standard PC DOS and Windows-based applications. The Police units also have a new manoeuvrable LCD 7.4 in touch-screen mounted on the vehicle dashboard. The touch screen allows single-touch commands for one-man police vehicles, and can be angled to prevent visibility to others. The system has been rigorously tested to make sure that it is shock-proof, rugged and able to withstand extremes of temperature.

Tony Waddington, Special Accounts Manager at APD Communications, who designed the system, said, "This is the first operation system in the UK which offers fully-integrated mobile data and vehicle location to a police force by utilising their own existing private mobile radio network."

For more information contact Damion D'Souza at Xyratex Tel. 01705 486363 or Greg Wale at APD Communications Tel. 01296 435831.

GAS HOBS Standard domestic units, new and boxed, 3 burner, household gas, brown. Bargain at just £12.95 ref BAR316

INFRA RED FILM 6" square piece of flexible infra red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infra red output only using standard light bulbs Easily cut to shape. 6" square £15 ref IRF2

HYDROGEN FUEL CELL PLANS Loads of information on hydrogen storage and production. Practical plans to build a Hydrogen fuel cell (good workshop facilities required) £8 set ref FCP1

STIRLING ENGINE PLANS Interesting information pack covering all aspects of Stirling engines, pictures of home made engines made from an aerosol can running on a candle! £12 ref STIR2

12V OPERATED SMOKE BOMBS Type 3 is a 12v trigger and 3 smoke cannisters, each cannister will fill a room in a very short space of time! £14.99 ref SB3. Type 2 is 20 smaller cannisters (suitable for simulated equipment fires etc) and 1 trigger module for £29 ref SB2 Type 1 is a 12v trigger and 20 large cannisters £49 ref SB1

HI POWER ZENON VARIABLE STROBES Useful 12v PCB fitted with hi power strobe tube and control electronics and speed control potentiometer. Perfect for interesting projects etc 70x55mm 12vdc operation. £6 ea ref FLS1, pack of 10 £49 ref FLS2

NEW GEIGER COUNTERS IN STOCK Hand held unit with LCD screen, auto ranging, low battery alarm, audible 'click' output. New and guaranteed. £129 ref GE1

RUSSIAN BORDER GUARD BINOCULARS £1799 Probably the best binoculars in the world! ring for colour brochure.

RUSSIAN MULTIBAND WORLD COMMUNICATIONS RECEIVER. Exceptional coverage of 9 wave bands, (5 short, 1 LW, 1FM, 1MW) internal ferrite and external telescopic aerials, mains/battery. £45 ref VEGA

NEW LASER POINTERS 4.5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm. £29 ref DEC49

HOW TO PRODUCE 35 BOTTLES OF WHISKY FROM A SACK OF POTATOES Comprehensive 270 page book covers all aspects of spirit production from everyday materials. Includes construction details of simple stills etc. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of up to 800 metres and a 3 days use from a PP3 this is our top selling bug! less than 1" square and a 10m voice pickup range. £28 Ref LOT102

BUILD YOU OWN WINDFARM FROM SCRAP New publication gives step by step guide to building wind generators and propellors. Armed with this publication and a good local scrap yard could make you self sufficient in electricity! £12 ref LOT81

PC KEYBOARDS PS2 connector, top quality suitable for all 286/386/486 etc £10 ref PCKB. 10 for £65.

NEW LOW COST VEHICLE TRACKING TRANSMITTER KIT £29 range 1.5-5 miles, 5,000 hours on AA batteries, transmits info on car direction, left and right turns, start and stop information. Works with any good FM radio. £29 ref LOT101a

HIGH SECURITY ELECTRIC DOOR LOCKS Complete brand new Italian lock and latch assembly with both Yale type lock (keys inc) and 12v operated deadlock. £10 ref LOT99

***NEW HIGH POWER WIRELESS VIDEO AND AUDIO BUG KIT 1/2 MILE RANGE** Transmits video and audio signals from a minature CCTV camera (included) to any standard television! Supplied with telescopic aerial. £169

CCTV PAN AND TILT KIT Motorize your CCTV camera with this simple 12vdc kit. 2 hermentically sealed DC linear servo motors 5mm threaded output 5 secs stop to stop, can be stopped anywhere, 10mm travel, powerful. £12 ref LOT125

CCTV CAMERA MODULES 46X70X29mm, 30 grams, 12v 100mA, auto electronic shutter, 3.6mm F2 lens, CCIR, 512x492 pixels, video output is 1v p-p (75 ohm). Works directly into a scart or video input on a tv or video. IR sensitive. £79.95 ref EF137.

IR LAMP KIT Suitable for the above camera, enables the camera to be used in total darkness! £6 ref EF138

UK SCANNING DIRECTORY As supplied to Police, MOD, M15 and GCHQ! coverers everything from secret government frequencies, eye in the sky, prisons, military aviation etc £18.50 ref SCANB

INFRA RED POWERBEAM Handheld battery powered lamp, 4 inch reflector, gives out powerful pure infrared light! perfect for CCTV use, nightsights etc. £29 ref PB1.

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser , X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front &earwaveguides,

1.1"x2.7"x4.6" fits on sun visor or dash £149 ref

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS

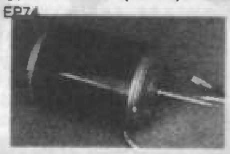
Could be adapted for laser listener, long range communications etc Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignment. 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. Each unit has two gallium Arsenide injection lasers. 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. £199 for one. Ref LOT4.

NEW LOW PRICED COMPUTER/WORKSHOP/HI-FI RCB UNITS Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends it by 750mm), fitted in less than 10 seconds, reset/test button, 10A rating. £6.99 each ref LOT5, Or a pack of 10 at £49.90 ref LOT6. If you want a box of 100 you can have one for £250!

TWO CHANNEL FULL FUNCTION B GRADE RADIO CONTROLLED CARS From World famous manufacturer these are returns so they will need attention (usually physical damage) cheap way of buying TX and RX plus servos etc for new projects etc. £12 each sold as seen ref LOT2.

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleads, designed to read standard credit cards! complete with control elctronics PCB and manual covering everything you could want to know about whats hidden in that magnetic strip on your card! just £9.95 ref BAR31

WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC. Also included is the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74



HIGH POWER DC MOTORS, PERMANENT MAGNET 12 - 24v operation, probably about 1/4 horse power, body measures 100m x 75mm with a 60mm x 5mm output shaft with a machined flat on it. Fixing is simple using the two threaded bolts protruding from the front of the motor 4mm x 12mm). These motors are perfect for model engineering etc they may even be suitable as a cycle motor? We expect high demand so if you would like one or think you may require one in the future place your order today! £22 ref MOT4 10 pack £185 ref MOT5B

ELECTRONIC SPEED CONTROLLER KIT For the above motor is £19 ref MAG17. Save £5 if you buy them both together, 1 motor plus speed controller rrp is £41, offer price £36 ref MOT5A

RUSSIAN 900X MAGNIFICATION ZOOM MICROSCOPE metal construction, built in light, mirror etc. Russian shrimp farm!, group viewing screen, lots of accessories. £29 ref ANAYLT.

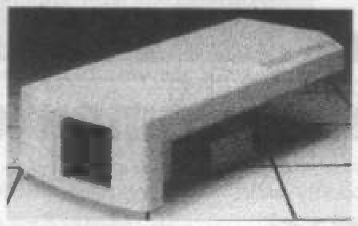
AA NICAD PACK Pack of 4 tagged AA nicads £2.99 ref BAR34

RUSSIAN NIGHTSIGHTS Model TZS4 with infra red illuminator, views up to 75 metres in full darkness in infrared mode, 150m range, 45mm lens, 13 deg angle of view, focussing range 1.5m to infinity. 2 AA batteries required. 950g weight. £199 ref BAR61. 1 years warranty

LIQUID CRYSTAL DISPLAYS Bargain prices,
20 character 2 line, 83x19mm £3.99 ref SMC2024A
16 character 4 line, 62x25mm £5.99 ref SMC1640A

TAL-1, 110MM NEWTONIAN REFLECTOR TELESCOPE Russian. Superb astronomical 'scope, everything you need for some serious star gazing! up to 169x magnification. Send or fax for further information.20kg, 885x800x1650mm ref TAL-1, £249

YOUR HOME COULD BE SELF SUFFICENT IN ELECTRICITY Comprehensive plans with loads of info on designing systems, panels, control electronics etc £7 ref PV1



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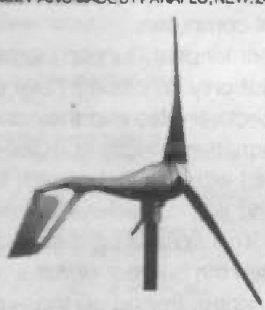

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SETI and the AMATEUR RADIO Astronomer

The Search for Extra-Terrestrial Intelligence is now in the hands of Amateur Radio astronomers.

H Paul Shuch describes the aims and the sky-search activities of the SETI League

The electromagnetic Search for Extra-Terrestrial Intelligence (SETI) has been the subject of considerable interest and attention within the amateur radio astronomy community, ever since the United States Congress terminated the NASA SETI program in 1993. I am going to discuss the more tangible aspects of amateur SETI, emphasising the similarities and differences between a SETI station and a typical radio telescope. It will become clear that amateur radio astronomers already possess much of the equipment and expertise necessary to mount a scientifically credible SETI effort. Just as optical astronomers are responsible for the discovery of most comets, the amateur radio astronomer should be in an ideal position to be the first to detect coherent signals from distant, technologically developed civilisations.

Early SETI

The notion of humankind's uniqueness in the universe had been challenged by philosophers since before Copernican times. Nevertheless, it is only within the twentieth century that the existence of other technologically advanced civilisations in space has become a possibility accepted within the scientific establishment, and far more recently still that the feasibility of detecting such other civilisations has entered mainstream thinking.

The first scientific paper seriously contemplating surveying nearby stars for intelligently directed microwave signals, *Searching for Interstellar Communications* by Cocconi and Morrison was published in 1959 (*Nature* 184 pp 844-846, 19 September 1959). Unbeknownst to the authors, as they were writing their pivotal paper, a young radio astronomer was preparing to perform the very experiment that they were describing. That scientist, Dr. Frank Drake, launched his Project Ozma search from the National Radio Astronomy Observatory (NRAO) facility at Green Bank, WV in 1960, ushering in the era of modern SETI.

Project Ozma must be considered the very first SETI study: it surveyed two nearby sun-like stars, for just a few weeks, at just one frequency, and detected no extra-terrestrial intelligent signals. Nevertheless, Ozma served as a model for dozens of later SETI projects.

The world's first SETI meeting was convened at Green Bank by Dr. Drake in 1961. As the agenda for that conference, Drake drafted an equation for estimating the number of possible communicative technologies in the cosmos. The Drake Equation is today the primary probabilistic tool whereby SETI scientists assess their prospects of success. Drake himself considers it a way of quantifying our ignorance. The exact equation is worthy of a chapter of its own, and in fact whole books have been written about it. Suffice it to say that its seven factors encompass cosmology, planetology, atmospheric science, evolutionary biology, psychology, technology, and sociology. Thus SETI is possibly the most interdisciplinary of all sciences.

In the nearly four decades between that first meeting and today, of the order of fifty different SETI projects have been conducted around the world, with frequency coverage extending throughout the microwave, millimetre-wave, and optical spectra. These searches have been attempted by Government agencies, educational institutions, non-profit scientific organisations, and, more recently, by amateurs.

Although no definitive proof of extraterrestrial intelligence has yet been received, SETI has achieved scores of tantalising hints that such signals might indeed exist. Many candidate signals have been attributed to terrestrial, aircraft and satellite interference, others to equipment malfunction and natural astrophysical phenomena, but a few defy explanation. Since these signals have failed to repeat or otherwise eluded our attempts at verification, we can draw no conclusion save that there is much to be learned about the universe we inhabit.

The Sky Survey — Amateur SETI's Rightful Role

Before its funding was terminated by Congress in 1993 NASA's SETI program consisted of two distinct but complementary research elements: a targeted search of nearby sun-like stars, and an all-sky survey for interesting signals of unknown origin. The former, which involves aiming at likely candidate stars for long periods of time, is well suited to large, steerable dishes with their narrow beam-widths and high sensitivities. If we guess right as to which stars constitute likely candidates, the targeted search will provide us with the greatest likelihood of immediate

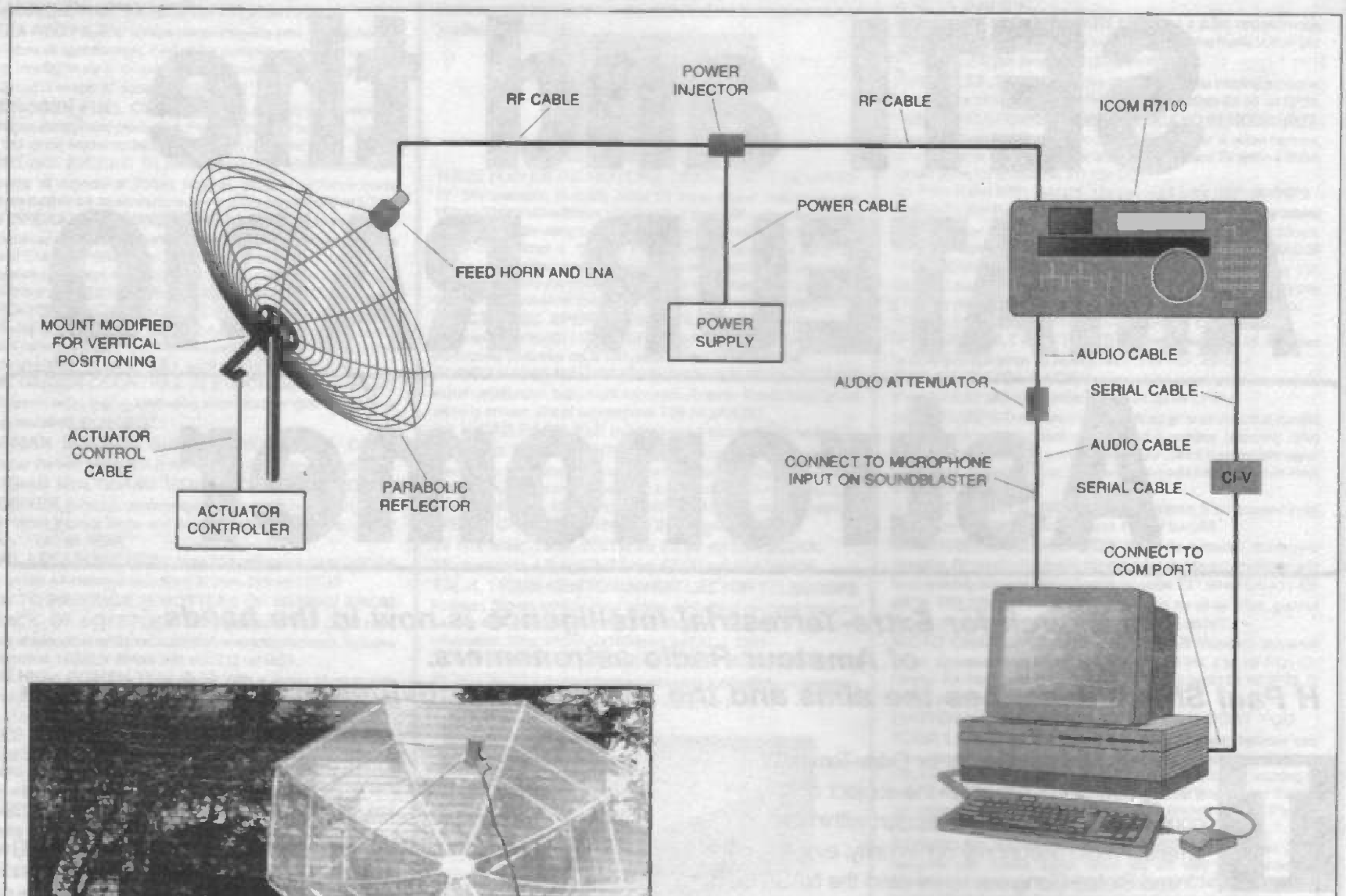

Figure 1: block diagram of a typical amateur SETI station, by SETI league member Daniel B Fox

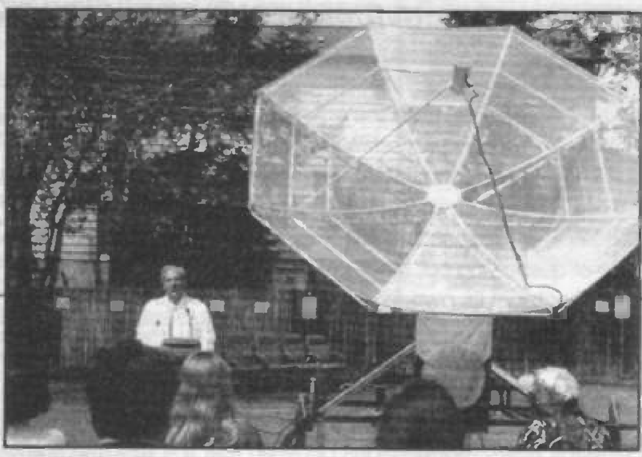

Figure 2: SETI League life member Orville Greene welcomes members and guests to the Project Argus launch in April 1996, featuring the Project Argus SETI station described in this article. (Photo: Gerry Fleming)

success. But since only a limited number of relatively nearby candidate stars is known to us, concentrating our search in their direction may cause us to miss an equally good star of which we happen to be unaware.

An all-sky survey, on the other hand makes no *a priori* assumptions as to the most likely direction to explore. The sky survey attempts to sweep out the entire sky which can be seen from a given location. No antenna tracking is required, since it is the entire sky, rather than individual stars, which we seek to scan. While targeted search antennas must be constantly moved, sky survey radio telescopes are operated in meridian transit, or drift-scan mode, in which it is the Earth's rotation which turns them.

NASA's late targeted search has been resurrected by the non-profit California-based SETI Institute. Their *Project Phoenix* effort employs some of the world's finest radio telescopes, aiming them sequentially at promising targets from a catalogue of nearby sun-like stars. But since large antennas have quite narrow beam-width, they see only a small portion of the sky at a given time. To sweep out the whole sky with such large antennas would consume inordinate amounts of time. A sky survey effort, by contrast to a targeted search, would be better performed with antennas of moderate size.

Smaller antennas can see more sky within their beam patterns, but have correspondingly less gain. We achieve reasonable sensitivities through A digital signal processing, but the antennas need to remain fixed on their targets for relatively long integration times. Fortunately, when used in meridian transit mode, small antennas, with their relatively wide beam-widths, provide us with far greater signal acquisition time than do the larger antennas typically used for targeted searches.

The sky survey approach seems ideally suited to the community of amateur radio astronomers desiring to pursue SETI. The non-profit, membership-supported SETI League, Inc. has designed and initiated just such a sky survey. A grass-roots effort which will ultimately grow to thousands of amateur radio telescopes world-wide, the SETI League's *Project Argus* sky survey was initiated in April of 1996. When fully deployed early in the next century, it will provide (for the first time ever) real time full-sky coverage, looking in all directions at once, across all four pi steradians of space.

Selecting the magic frequency

Our Earth is currently surrounded by a sphere of microwave radiation roughly fifty light years in radius, which is readily detectable over interstellar distances utilising technology such as is today available to amateur radio astronomers. This radiation, emanating primarily from our planet's UHF TV transmitters and long range search radars, would mark our planet as inhabited to any similar technological society within fifty light years. Within that range are found hundreds of stars, tens of which are sufficiently sun-like to probably host one or more habitable planets.

The distance over which we are detectable is limited only by the time since we first began transmitting sufficiently strong signals in the appropriate frequency range. Fifty years from now, we will be detectable out to 100 light years distance. At that point our signals will have engulfed thousands of stars, including hundreds of potential life sites. With every successive doubling of elapsed time (out to 1,000 years or so), the number of civilisations which our radiation signature can potentially reach goes up by a factor of eight. Sooner or later, our signals may well reach a distant radio telescope.

SETI hypothesises that other technological civilisations are similarly surrounded by a detectable sphere of microwave radiation, the radius of which will be limited only by the length of time such civilisations have possessed sufficiently advanced radio technology. We depend upon our ability to intercept and recognise (though not necessarily decode) such a radiation signature to achieve the existence proof of other intelligent civilisations which SETI seeks.

The problem with seeking incidental radiation is that the unknown factors exceed the known. We can only guess as to where physically to point our antennas, when to listen, and on what frequency. The time dimension is resolved by starting to look now, and continuing until we detect something noteworthy. A large enough number of co-ordinated stations, effectively looking in all directions at once, resolves the pointing uncertainty. And we can narrow the search space in the frequency dimension by recognising the range of frequencies which are least attenuated by planetary atmospheres and the interstellar medium. This, however, leaves us with most of the microwave spectrum, and much of the optical, as likely frequencies.

Since there are no "wrong" frequencies to search, The SETI League has avoided establishing a policy of dictating search frequencies to *Project Argus* participants. One person's guess is as good as another's, so whatever frequency at which you can assemble a workable radio telescope is fair game. Amateur radio astronomers have long explored the 406 MHz, 610 MHz, 1.42 GHz and 10.6 GHz radio astronomy bands, and I can think of no good reason why they should not pursue SETI in those spectral regions as well.

The foregoing, however, applies only to the problem of scanning for incidental radiation from the distant civilisation. What if another intelligent race were making a deliberate, concerted attempt to signal its presence to its interstellar neighbours? Is there a particular frequency, or range of frequencies, which would be self-evident to the receiving civilisation? Can we narrow the search space?

Cocconi and Morrison thought so when they published their 1959 *Nature* article. They reasoned that 1420.405 MHz, the precession frequency of neutral hydrogen atoms, was a good place to start looking for deliberately beamed interstellar beacons. This frequency, which falls in the quietest part of the radio spectrum, is marked for all to see, by nature herself There is nothing geocentric about hydrogen radiation; perhaps, they reasoned, selecting it for interstellar communication is a mark of intelligence, in and of itself

Drake had arrived at the same conclusion independently, and indeed monitored a narrow band of frequencies encompassing the hydrogen line (also known as H1) during his *Project Ozma* search. Today, nearly four decades later, the hydrogen line region still looks like a good bet to many SETI professionals.

Fortunately for amateur SETI, much amateur and professional radio astronomy already goes on at the hydrogen line. Equipment for use at this frequency is abundantly available, and much of it can be readily adapted to SETI use. There are indeed other likely "magic frequencies" which are being scanned for signals of possible intelligent extraterrestrial origin, and once again, one person's guess is as valid as another's. Nevertheless, many of the world's amateur radio astronomers are already scanning the hydrogen line for natural astrophysical phenomena, and it's a small step to make their receivers search for artificial signals as well. The following sections discuss the hardware, software, and human considerations of amateur SETI.

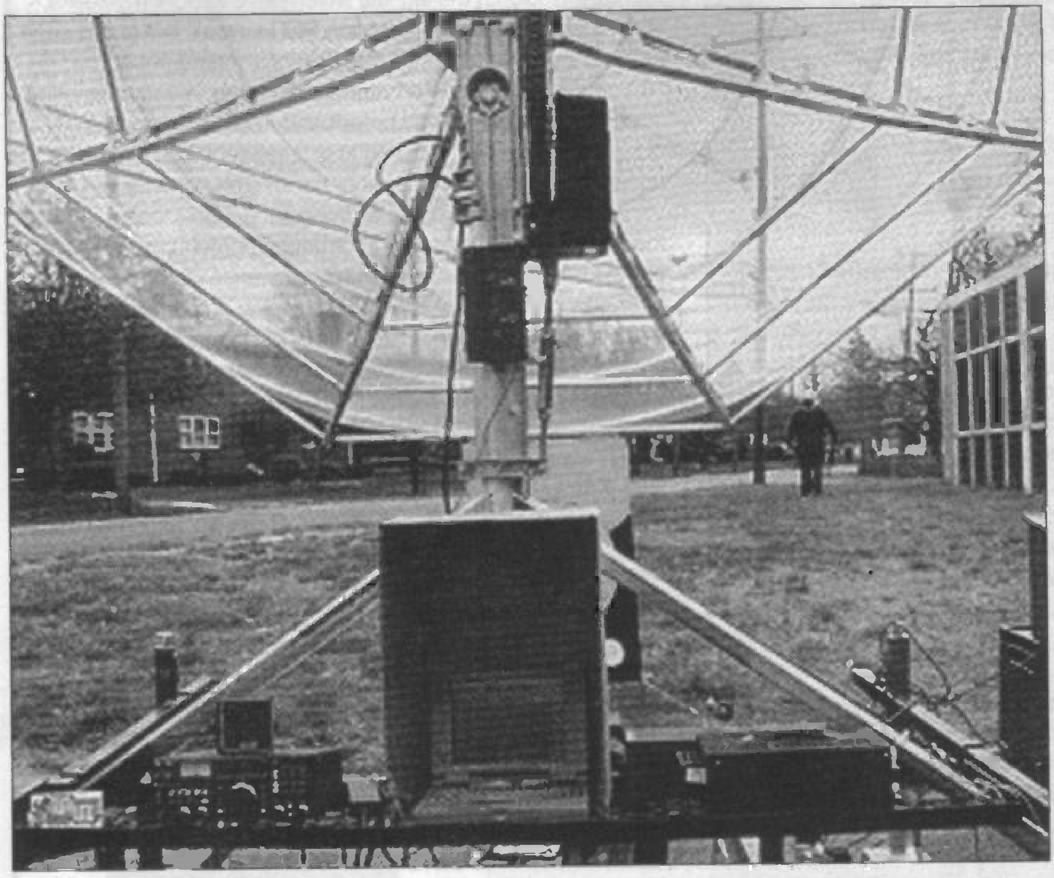

Figure 3: The business end of the first Project Argus radiotelescope. The VDU is showing a hydrogen line weak signal source (visible in the photo) for system testing. The Icom 7000 receiver, and a multimedia laptop computer for digital signal processing are also part of the station. (Photo: Gerry Fleming)

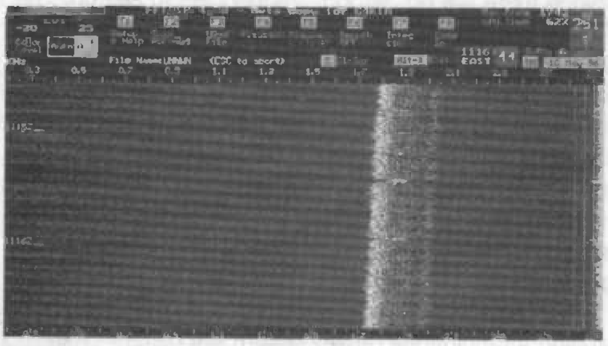

Figure 4: An anomalous signal detected by SETI League members Trevor Unsworth and Ken Chattenton at 1472.5 MHz using a home-made 3.5 metre dish. The signal exhibited digital modulation, with a 270Hz bandwidth. Its Doppler shift of -25 Hz/min marks it as RFI from a low earth orbit (LEO) satellite. Though clearly not of extra-terrestrial origin, this signal gave Project Argus its first real workout, testing both the sensitivity of our receiving stations, and our ability to recognise terrestrial and satellite interference. (Image by Trevor Unsworth G0ECP, by permission.)

What is The Drake equation?

Is there a way to estimate the number of technologically advanced civilisations that might exist in our Galaxy? While working at the National Radio Astronomy Observatory in Green Bank, West Virginia, Dr. Frank Drake conceived a means to mathematically estimate the number of worlds that might harbour beings with technology sufficient to communicate across the vast gulfs of interstellar space. The Drake Equation, as it came to be known, was formulated in 1961 and is generally accepted by the scientific community.

$$N = R^* fp\ ne\ fl\ fi\ fc\ L$$

where

ïN = The number of communicative civilisations ïR* = The rate of formation of suitable stars (stars such as our Sun) ïfp = The fraction of those stars with planets. (Current evidence indicates that planetary systems may be common for stars like the Sun.) ïne = The number of Earth-like worlds per planetary system ïfl = The fraction of those Earth-like planets where life actually develops ïfi = The fraction of life sites where intelligence develops ïfc = The fraction of communicative planets (those on which electromagnetic communications technology develops) ïL = The "lifetime" of communicating civilisations.

Frank Drake's own current solution to the Drake Equation estimates 10,000 communicative civilisations in the Milky Way. Dr. Drake, who serves on the SETI League's advisory board, has personally endorsed SETI's planned all-sky survey.

Quoted by permission of Steve Ford, WB8IMY, from QST, August 1995, page 38.

SETI with a radio telescope

"I already own a sensitive radio telescope," many an amateur radio astronomer has noted. "Why can't I use it for SETI?" The short answer is, you canl. An antenna and preamplifier adequate for radio astronomy might potentially detect intelligent signals from space. To achieve this adequate sensitivity, we design the preamplifier circuitry so as to generate minimal device and thermal noise.. And we design the antenna so as to minimise the noise contributions of our warm planet, instead responding primarily to the cold sky above. Most any successful radio telescope meets these conditions. But for SETI, we also need to pay special attention to the receiver, and the post-detection hardware and/or software, if we are to maximise our admittedly slim chances of success. This section will deal with receiver considerations. Signal processing is addressed in the section which follows.

Any amateur (or professional) radio astronomer pointing a sufficiently sensitive radio telescope at the sky will encounter a wide variety of naturally occurring radio phenomena. Prominent among these will be solar radiation, or sun noise, which spans the spectrum. All stars emit this broadband signal, though it will be most pronounced, and most easily detected, from our nearest stellar neighbour. In addition to solar noise, Hi radiation emanates from the roughly one hydrogen atom found per cubic centimetre of interstellar space. While concentrated at the 21 cm (1420 MHz) line, it is Doppler shifted both up and down in frequency by the random motion of the interstellar medium.

Though hydrogen dominates all of space, countless other atoms and molecules, both inorganic and organic, permeate the interstellar medium, and many emit characteristic signals which are similarly Doppler shifted across the spectrum. These natural emissions, the signals which radio astronomy seeks, are present in receivers pursuing SETI as well, but in this case represent not signals at all, but potential interference.

Fortunately, all known natural radio phenomena emanating from space are inherently broadband in nature, none being narrower than a few hundred kHz. Intelligently generated microwave signals, on the other hand, are characterised by their relative spectral purity or coherence, and (depending upon their modulation mode and information content) might be very narrow band indeed. So spectral coherence is one of the hallmarks of artificiality which SETI seeks, and which helps us to distinguish between a SETI signal and natural "noise."

Most microwave receivers used for classical radio astronomy tend to be relatively broadband. If the signal energy we seek represents a natural astrophysical phenomenon (which we can expect to occupy a broad slice of spectrum), then it makes good sense to employ broadband receivers, so as to intercept as much as possible of the signal energy. Such is not the case for SETI.

Narrow band "bins"

SETI tends to utilise extremely narrow-band receivers {only at the post-detection level. That is, our radio frequency (rf) circuitry might scan wide spectral expanses, but we process the received signals in some way, into very narrow channels or "bins", in search of artificial phenomena. These bins tend to be tens of Hertz to tenths of Hertz wide. This has significant implications if we try to adapt existing (presumably broadband) radio telescopes to SETI.

We could, for example, modify any superheterodyne radio astronomy receiver for narrow-band reception, simply by adding a narrow if (intermediate frequency) filter. But unless the

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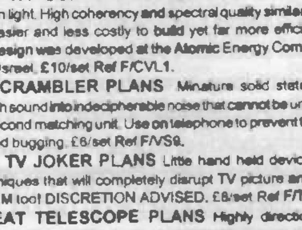

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ELECTRIC MAN PLANS, SHOCK PEOPLE WITH THE TOUCH OF YOUR HAND! £5/set Ref F/EMA1.

PARABOLIC DISH MICROPHONE PLANS Listen to distant sounds and voices, open windows, sound sources in 'hard to get' or hostile premises. Uses satellite technology to gather distant sounds and focus them to our ultra sensitive electronics. Plans also show an optional wireless link system. £8/set ref F/PM5

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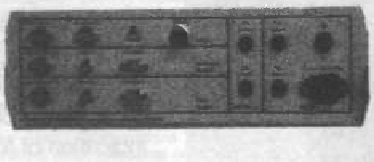
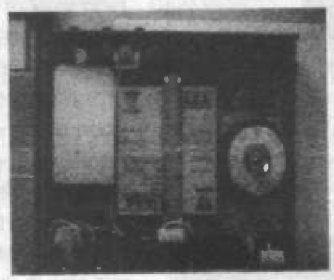
MEGA LED DISPLAYS PCB fitted with 5 seven segment displays each measuring 55 x 38mm. £5 ref LED5.

MOD TRANSMITTING VALVES 5J180E £80 ref LOT112

SWITCHED MODE PSU'S 244 watt, +5 32A, +12 6A, -5 0.2A, -12 0.2A. There is also an optional 3.3v 25A rail available. 120/240v I/P. Cased, 175x90x145mm. IEC inlet Suitable for PC use (6 d/drive connectors 1 m/board). £15 ref LOT135





VIDEO PROCESSOR UNITS?/6v 10AH BATTS/24V 8A TX Not too sure what the function of these units is but they certainly make good strippers! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear, inside 2 x 6v 10AH sealed lead acid batts, pcb's and a 8A? 24v toroidial transformer (mains in). sold as seen, may have one or two broken knobs etc due to poor storage. £15.99 ref VP2

MINI FM TRANSMITTER KIT Very high gain preamp, supplied complete with FET electret microphone. Designed to cover 88-108 Mhz but easily changed to cover 63-130 Mhz. Works with a common 9v (PP3) battery. 0.2W RF. £9 Ref 1001.

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3 CHANNEL SOUND TO LIGHT KIT Wireless system, mains operated, separate sensitivity adjustment for each channel, 1,200 w power handling, microphone included. £17 Ref 1014.

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By using our phone box, you get everything you need to convert any standard telephone into a coinbox telephone. You simply open the box, plug your telephone into a connector inside and then plug the coinbox lead into your telephone socket, it's that simple! There are one or two catches however,

Catch one is that the lock and hinges my be damaged/broken, this doesn't really matter because you could replace the hinges easily and change the lock or you could refit the front panel onto a box of your own choosing.

Catch two is that the three coinslots accept £1, 50p and 10p's this is fine except that the 10p slot is for the older 10p piece so you would need to glue a small piece of plastic across the bottom of the slot on the inside to reduce the hole size. Full programming instructions are included with every coinbox Bargain price £4.99 ref CBT1

4 WATT FM TRANSMITTER KIT Small but powerful FM transmitter, 3 RF stages, microphone and audio preamp included. £24 Ref 1028.

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Minature adjustable timers, 4 pole c/o output 3A 240v,

HY1230S, 12vDC adjustable from 0-30 secs. £4.99
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BUGGING TAPE RECORDER Small voice activated recorder, uses micro cassette complete with headphones. £28.99 ref MAR29P1.

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COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC. £12.00 REF: MAG8P2.

VENUS FLYTRAP KIT Grow your own carnivorous plant with this simple kit £3 ref EF34.

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12.

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

ELECTRONIC ACCUPUNCTURE KIT Builds into an electronic version instead of needles! good to experiment with. £9 ref 7P30

SHOCKING COIL KIT Build this little battery operated device into all sorts of things, also gets worms out of the ground! £9 ref 7P36.

HIGH POWER CATAPULTS Hinged arm brace for stability, tempered steel yoke, super strength latex power bands. Departure speed of ammunition is in excess of 200 miles per hour! Range of over 200 metres! £8.99 ref R/9.

COMPAQ POWER SUPPLIES WITH 12V DC FANS Ex equipment psu's, some ok some not but worth it for the fan alone! probably about 300 watt PC unit with IEC input. £3.50 each ref CQ1

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MEGA LED DISPLAYS Build your self a clock or something with these mega 7 seg displays 55mm high, 38mm wide. 5 on a pcb for just £4.99 ref LOT16 or a bumper pack of 50 displays for just £29 ref LOT17.

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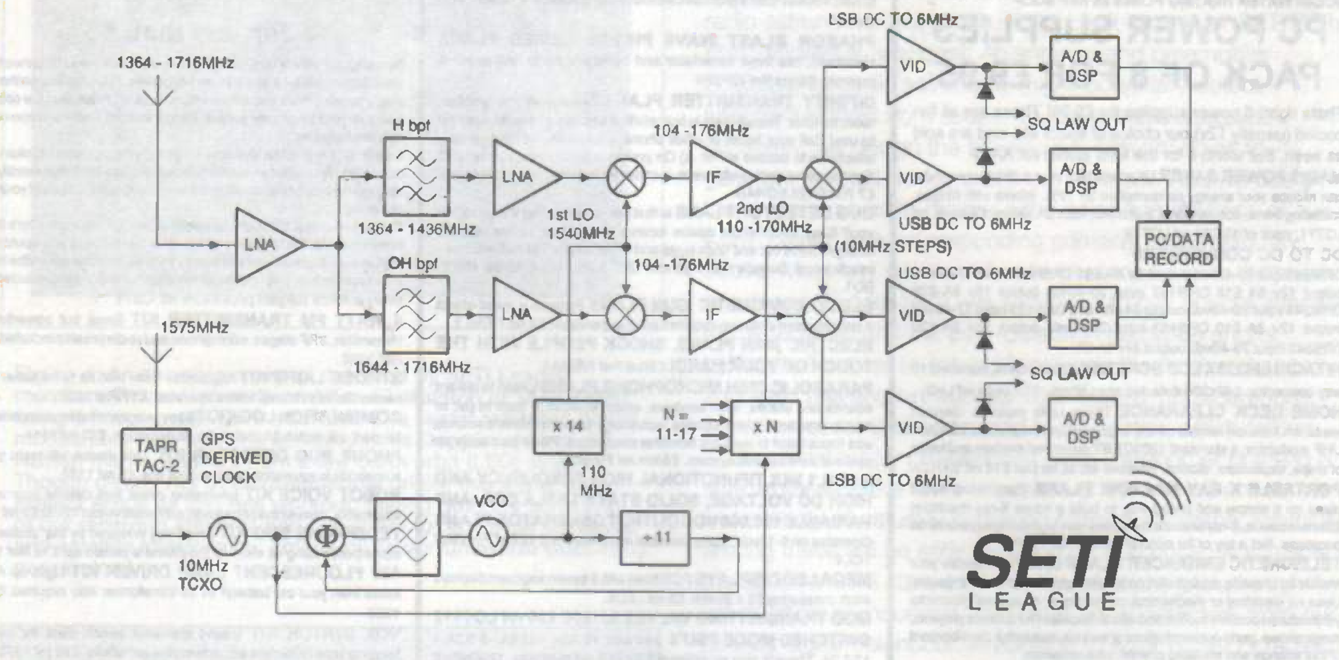

Figure 5: sample block diagram: the Mini-Meta spectral and temporal analysis receiver, a typical SETI receiver

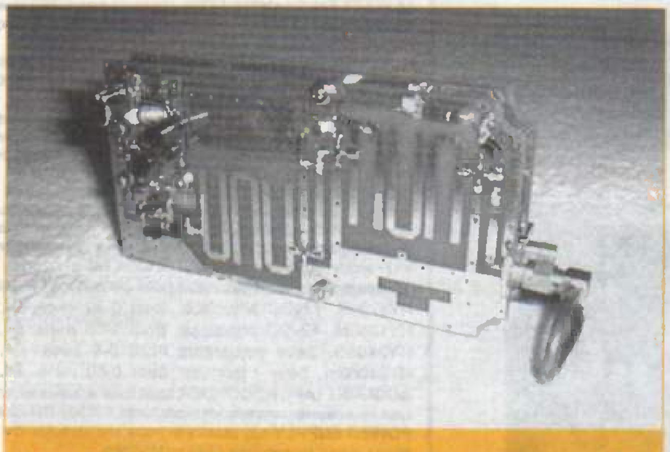

Figure 6: the new SETI League hydrogen line (1420 MHz) to 2-meter (144 MHz) downconverter, first demonstrated at the Annual Meeting in March 1997. At the Southeastern VHF Conference two weeks later, the prototype measured in at 1.85 dB noise figure and 49 dB conversion gain. This converter gives over 50 dB image rejection and 30 dB spurious rejection and will be offered in kit form by Down East Microwave (See References)

LO (local oscillator) used to downconvert the incoming signal frequency is sufficiently stable, the signal may not stay within the if passband long enough to process. Thus the radio astronomy receivers which hold most promise for SETI applications will be those with crystal-controlled LO chains. And to reduce thermal drift, an oven-stabilised crystal is highly desirable. (See also figure 5.)

Many of the more capable microwave receivers employ digital frequency synthesis of the local oscillator frequency. Synthesisers generally provide us with ample frequency stability, in that they involve phase-locking a free-running oscillator to a highly regulated, temperature-controlled crystal reference oscillator. Unfortunately, all but the most sophisticated synthesisers suffer from marginal spectral purity. This is because synthesisers tend to generate a plethora of phase-noise sidebands only a few tens of dB weaker than the desired LO frequency.

Phase noise limits the SETI receiver's ultimate sensitivity, by adding noise prior to the detector. But it has an additional detrimental effect, in that noisy LOs might generate spurious receiver responses, giving us multiple opportunities for a false indication of a coherent signal where none is in fact present. A high level of falsing can be expected for SETI anyway, due to the polluted nature of our planet's Mr environment. Why complicate the situation with receiver-generated false hits? It is probably better to avoid synthesised receivers, unless they have been designed for the lowest possible phase noise.

Another LO concern deals with long-term stability. In order to maximise the sensitivity of a SETI receiver, it might be necessary to integrate the signal (in either hardware or software) for many minutes. The LO must hold still so that the received signal remains in the bin width for the entire integration period. All but the most carefully designed oscillator circuits will exhibit excessive long-term drift.

In summary, radio telescope receivers may prove useful for SETI, with modification. A narrower bandwidth if filter is usually called for, and it is often necessary to employ an external, crystal-controlled and temperature regulated LO chain exhibiting the very highest possible frequency stability, and the very lowest possible phase noise. Such an LO is the most critical element of a suitable SETI receiver.

Signal processing considerations

OK, so we've come up with a radio telescope which employs an acceptable LO, ample if filtering, and adequate sensitivity to recover the weakest of signals. We're still not done. We now need to process the recovered signals into narrow bins, and identify within them those signals which might emanate from distant technological civilisations.

The earliest SETI receivers employed filter-bank technology. That is, the if was split into multiple filters, each with a bandwidth of a few kHz, on adjacent frequencies. Each filter drove its own square-law detector circuit, and any signal which appeared at the output of one filter channel, but not the adjacent ones, was considered narrow enough in bandwidth to

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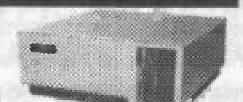

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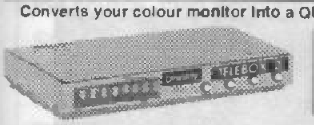

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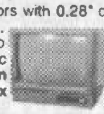

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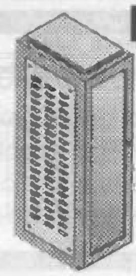

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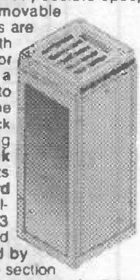

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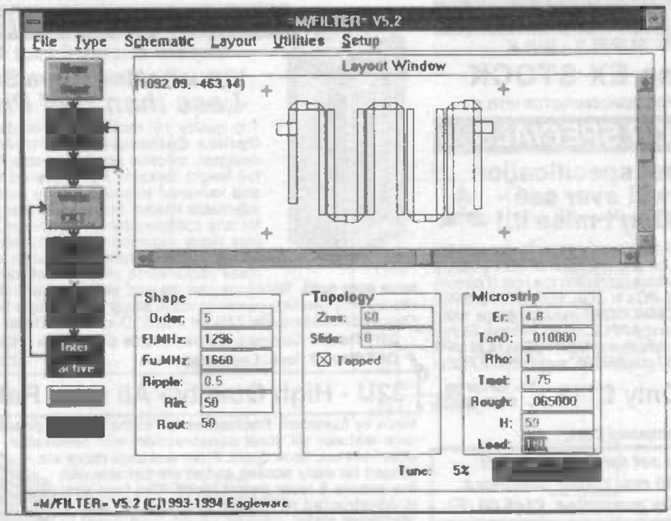

Figure 7: a design simulation of a type of microwave bandpass filter suitable for SETI use. (Compare this with figure 6)

constitute a SETI candidate. This is the very scheme employed at the Ohio State University Radio Observatory in 1977, when the so-called "Wow!" signal (the most tantalising SETI candidate signal to date), was detected.

Fortunately, our technology has advanced significantly since then. Today the favoured tool for SETI signal analysis is digital signal processing (9SP), employing computers executing fast Fourier transform (FFT) algorithms. Implementing such techniques in custom, dedicated DSP microcircuits, the SETI research community has for some time concentrated on developing sophisticated multi-channel spectrum analysers (MCSAs) capable of scanning millions of bins, over hundreds of megahertz of spectrum, in real time. The current state of the art in MCSA technology is probably BETA, developed at Harvard University by physicist Dr. Paul Horowitz, with funding from the Planetary Society and other private and corporate donors. BETA now analyses several hundred million bins, each less than one Hertz wide. Such technology is, unfortunately, well beyond the reach of the amateur SETI community at present. But we can learn from it, and emulate it on a small scale.

Personal computer technology today makes it possible for the amateur radio astronomer to scan thousands of bins, over tens of kilohertz, at virtually negligible cost. The audio output from a SETI receiver must first be digitised for signal analysis, and this is accomplished in any of a number of inexpensive computer sound cards. SETI League members have developed a variety of shareware FFT programs to sort this audio output into bins, and display the results on the computer monitor as histograms, waterfall displays, or any number of alternative formats.

Early amateur SETI systems are digitising a 12.5 kHz audio bandwidth, and applying DSP software to break it down into 1024 individual bins, each about 12 Hz wide. It remains to be seen whether these values are optimal, but the beauty of the PC-driven DSP approach is that the search parameters are readily changed in software. As faster personal computers and more advanced sound cards become available, it becomes possible to reduce the width of individual bins, increase the total number of bins scanned, or increase the bandwidth of the audio spectrum which is being monitored.

Since sensitivity of radio telescopes increases with the square root of integration time, small-aperture amateur instruments generally time-average a very large number of observations to achieve reasonable performance. Long integration would similarly improve the sensitivity of amateur SETI systems, but with a complication. We are observing the heavens from a rotating platform, which imposes on all received signals a characteristic Doppler shift related to the Earth's motion. Depending on frequency and declination angle, this Doppler shift can be ten to hundreds of Hertz during the time it takes a signal to transit the antenna's beamwidth. For wideband radio telescopes, the Doppler shift is minute compared to the signal bandwidth, hence we can integrate for the entire transit time. Narrow-band SETI receivers, on the other hand, are integration-limited by Doppler to the time it takes the signal to drift between bins. Given, for example, a 10 Hz bin width, and a Doppler rate due to the Earth's rotation of 10 Hz/min, we would be limited to only one minute integration periods. Beyond that, the signal would find itself in the next bin of the digital signal processor. This Doppler phenomenon significantly limits the maximum integration time we can utilise, hence the maximum sensitivity we can achieve.

There is a partial solution to the above problem. The same computer which performs signal analysis can compute the Doppler rate, as a function of the frequency scanned and the co-ordinates of the antenna. Many microwave receivers can be tuned if the receiver's local oscillator is properly chirped (that is, tuned slowly in frequency) at exactly the Doppler rate, the effects of the Earth's rotation can be nullified, and longer integration becomes possible.

Unfortunately, chirping the receiver's LO only compensates for the rotation of our own planet. A valid SETI signal would most likely be emanating from a similarly rotating planet, which would impose a Doppler shift on the transmitter which we can in no way predict. It is hypothesised that any civilisation producing a deliberately beamed interstellar beacon would solve the problem for us, by drifting their transmitter's frequency so as to compensate for their own Doppler. However, we can expect no such assistance in the case of intercepting a civilisation's leakage radiation, hence our practical integration times are likely to be limited.

Dr. H. Paul Shuch attempts to measure sun noise with a portable radio telescope. This system serves as a test-bed for the hardware and software to be used for the Project Argus all-sky survey. The actual antennas used for SETI are much larger.

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Software is currently under development to automate the signal analysis and verification process, by alerting the operator (and through the Internet, other SETI participants) when a signal meets a set of user-programmed criteria. Terrestrial and satellite interference have already generated false alarms for our early participants. But through the application of artificial intelligence (AI) techniques, it is expected that the system will ultimately learn from its false detections, so that in time, it will only respond to those signals which represent the most viable candidates for SETI success.

Assembling a prototype system

Let's start by defining the minimum equipment necessary to do a credible job at microwave SETI, as depicted in the typical system block diagram developed by SETI League member Dan Fox (figure 1). You will want to acquire, at a minimum, a dish antenna and feed horn, a low-noise preamplifier, a microwave receiver, and a suitable computer running some kind of digital signal processing software. A number of useful accessories will round out the SETI station. There are sections in the SETI League Technical Manual corresponding to each of these areas, but the choices are so diverse as to boggle the mind. Is there anything we can do to narrow things down a bit?

In fact, there is. I can tell you exactly what hardware and software I used in the first *Project Argus* station at SETI League headquarters. I didn't go with the least expensive choices in each category, or necessarily the best. I opted for expediency in order to get a station on the air in time for our April 21, 1996 launch ceremonies and, yes, I cut a few corners in the process. You probably won't want to duplicate my station exactly as I implemented it, but at least this will give you a starting point. As more stations come on the air, better solutions to the problems of amateur SETI will make themselves known. Some of these will come from you, and I hope you'll share them with your fellow League members.

The headquarters station is depicted in figures 2 and 3. Though just about any surplus satellite TV dish in the 3- to 5-meter diameter range would suffice, the antenna we chose for our first system is a Paraclipse Classic 12, with horizon-to-horizon mount. This 3.7 meter diameter dish has a focal length to diameter ratio which makes it easy to illuminate with a simple cylindrical waveguide feed horn from Radio Astronomy Supplies of Atlanta. Feed efficiency is on the order of 50 percent. As the antenna is slightly under-illuminated, sidelobes and antenna noise temperature are reduced. We are exploring the possibility of adding a choke ring to this feed horn in the future, to improve both illumination efficiency and sidelobe performance. The robust Paraclipse mount and chain-drive rotor were modified for meridian transit mount with full 180 degree elevation rotation.

A SETI League-designed GaAs MMIC (gallium arsenide monolithic microwave integrated circuit) low-noise amplifier, as manufactured by Down East Microwave, is mounted directly on the feed with a male-to-male type N coaxial adapter. The next generation preamp, now in the design phase, will employ a GaAs PHEMT (pseudomorphic high electron mobility transistor) device in front of the existing MMIC stage, for a significant reduction in front-end noise. At present, no bandpass filter is being used behind the preamp, although in Mr polluted areas it might be wise to add one. Though not yet commercially available, a microstrip filter such as the one described in the Technical Manual is probably a good bet. We expect to add such a filter to our station at a later date.

Twenty-five feet of RG-8 coaxial cable, with type N connectors installed, connect the LNA to an Icom 7000 microwave receiver. (Production of this receiver has been discontinued in favour of the new model 8500. At time of writing the SEI league has not evaluated the new design, but it should perform at least as well as the model 7000 series. We had considered replacing this receiver with a homebrew downconverter driving a VHF scanner, although the Icom is performing so well that we would be hard pressed to recommend any other approach at this time. Receiver audio output is applied to the microphone input of a Texas Instruments model 560CDT multimedia laptop computer, which uses a 75 MHz Pentium CPU. In fact, much less costly computers of the 486DX variety would be perfectly acceptable, at a fraction of the price. The DSP software we are currently using is a commercial product called Spectra Plus, although any of the low-cost shareware programs listed in the Appendix are certainly worthy of consideration. We have yet to obtain suitable SETI logging software, so at present one must stare at a computer screen and evaluate the incoming signals. This is a weakness in the first Argus systems which we hope our members will help us to overcome.

It must be emphasised that this station is not the only, indeed not necessarily the best, approach to amateur SETI. It does, however, achieve all design objectives in terms of frequency coverage, stability and sensitivity. If all components are purchased new, it can be duplicated in its entirety at a cost of about $7,000 US. (Although half of that cost is tied up in the particular multimedia laptop computer we chose.) This is certainly quite a bit more than one need spend for an effective SETI station. In fact, using a more modest computer and dish, the price quickly drops in halt for no discernible difference in performance. And if one uses an existing computer, a surplus dish, and builds some of the RF hardware from kits rather than purchasing it assembled, then the basic design is duplicable for well under $1000 US. Thus, the system just described should be considered as a proof-of-concept effort, nothing more.

Search coordination and verification

The search space for SETI involves temporal, directional, and frequency dimensions, and it's probably unrealistic to expect any search to encompass all possibilities. Nevertheless, the greater the number of participants, the more frequencies and directions we can hope to monitor per unit time. Thus The SETI League has concentrated its efforts on devising a global network of thousands of participating stations. The publication of these pages constitutes a part of that effort. But an infinite network will avail us little if all members end up searching on the same frequency, in the same direction, at the same time.

As discussed in the Magic Frequencies section above, there are good arguments against dictating frequency coverage at present. Sky coverage, on the other hand, can be readily co-ordinated. If all the amateur radio telescopes being devoted to SETI are operated in meridian transit mode, then by judicious assignment of declination angles, full shy coverage becomes a feasible goal. Based upon the beam-widths typical of amateur radio telescopes, scanning all four pi steradians of sky in real time will require something on the order of 5,000 participants. This goal seems elusive, when viewed from the perspective of around 24 active stations. But The SETI League Is adopting a

Improved SETI feedhorn incorporating a scalar choke ring. The position of the choke ring along the waveguide feedhorn can be varied to optimise performance for maximum gain, or minimum noise temperature, as the user requires. The feed can be readily optimised for dishes with a wide range of focal length to diameter (F/D) ratios.

longer view. If we provide the necessary co-ordination between participant stations, we can hope to achieve full sky coverage early in the next decade.

A major concern of SETI professionals is whether amateur radio astronomers have the training and discipline to separate the electromagnetic wheat from the cosmic chaff That is, will we be fooled by astrophysical phenomena and manmade interference which might masquerade as intelligently generated extra-terrestrial signals? The concern is a valid one; even professionals are sometimes fooled by their equipment or the environment. When Frank Drake first swung his *Project Ozma* dish toward Epsilon Eridani, he was excited to be greeted by a strong, stable, clearly artificial signal. "Can it really be this easy?" he wondered. It took several days of repeat observations for Drake to figure out that he was being tantalised by manmade interference, most likely from a military aircraft or spacecraft.

Every subsequent SETI study has encountered similar false alarms. Our planet is now encased in a shell of orbiting communications and navigation platforms, all generating signals across the microwave spectrum which could easily be mistaken for interstellar communications. The Project Phoenix targeted search has received hundreds of these false alarms, and has had to employ a sophisticated follow-up detection mechanism involving the use of two widely separated radio telescopes, in order to eliminate interference from consideration The SETI League has been similarly fooled by our increasingly rf-polluted environment.

Our *Project Argus* sky survey kicked off on 21 April 1996 initially with a mere five participating stations. Less than three weeks later, on 10 May, two of our members in England reported receiving a candidate signal in the 1.4 GHz band (figure 4). Follow-on analysis indicated that the signal's Doppler shift was far too rapid to be explained by the Earth's rotation, but was consistent with that expected from a low-Earth satellite orbit. It appeared that the SETI League's search had fallen prey to what Frank Drake calls Spectral Gridlock.

Fortunately, we have a variety of tools in our arsenal to guard against such false alarms. If we employ computer-controlled receiver tuning as outlined in the previous sections, then such satellite interference as experienced in England will spread itself across several adjacent DSP bins, and be essentially ignored by the computer. But we can envision interfering signals which emulate even the Doppler signature of interstellar communications, and must take steps to guard against drawing false conclusions.

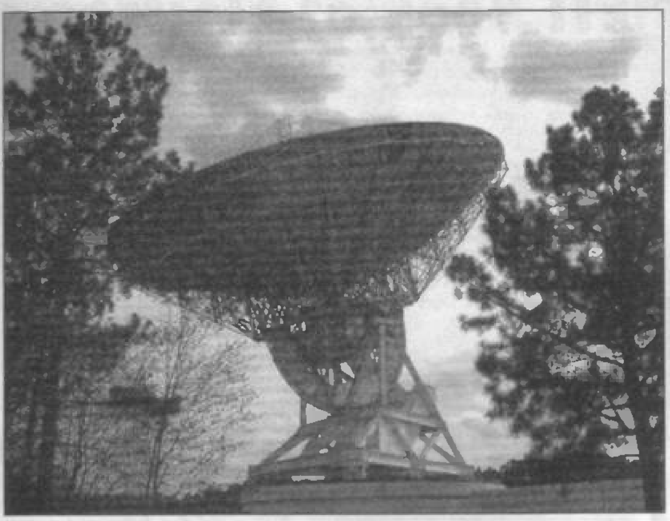
The Follow-Up Detection Device (FUDD) approach utilised by Project Phoenix, to which we alluded earlier, holds promise for amateur SETI as well. Just as the professional SETI community can pair up spatially disparate research-grade radio telescopes for signal verification, so can amateur SETI pair up two widely separated lesser telescopes. If properly co-ordinated, they can form what I call a "zeroth-order" interferometer.

The idea is for two member stations, displaced in longitude by several hundred kilometres, to both view the same celestial co-ordinates, at the same frequency, all the time. Linked through the Internet, the two stations can continually compare notes. Any signal detected by only one of the stations is deemed terrestrial interference. Any signal which fails to exhibit the precise (and readily calculable) differential Doppler signatures which a true interstellar source would generate at the two particular observing sites is dismissed as aircraft or spacecraft interference. Only if the amplitude and frequency patterns match those calculated for the two locations is a signal deemed a viable SETI candidate.

Unfortunately, in order to achieve full sky coverage by stations working in pairs, it now becomes necessary to recruit not 5,000, but rather 10,000 participants. Such numbers, though daunting, are not altogether unprecedented. The various radio amateur satellite (AMSAT) organisations, for example, boast in excess of 10,000 members worldwide. They provide, however, a service to the radio amateur community: the design, construction, launch and operation of a network of communications satellites, which permit members to better pursue their hobby. It remains to be seen whether a sufficient number of SETI enthusiasts will similarly regard the co-ordination of a global search as a service worthy of their involvement and support.

Sadly, in recent years the Search for Extra-Terrestrial Intelligence has been attacked not just in the halls of Congress, but in the electronic hobbyist press, as being a waste of time and money. There may be a grain of truth to this, especially if SETI efforts ultimately fail to achieve positive results. An important consideration of a "privatised" search, however, is that no government entity is wasting the time and money of its citizens. Rather, it is our individual members who choose to waste their own time and money, to varying degrees, for their individual purposes.

Besides, by definition, doesn't "waste of time and money" properly describe all pastimes? *(Serious scientific research undertaken in this area has concluded (I paraphrase) that life would be a waste of time and effort without the presence of personal pastimes.- Ed.)*



The SETI Institute's Project Phoenix targeted search of nearby sun-like stars resumed in May 1997, from the National Radio Astronomy Observatory, Green Bank WV. In addition to the 140 foot NRAO radio telescope, the group is employing this 100 foot dish at Georgia Tech's Woodbury Research Facility, as a follow-up detection device, or FUDD.

Conclusions

The world's amateur radio astronomers are in a unique position to make major contributions to the ongoing Search for Extra-Terrestrial Intelligence (SETI). Their radio telescopes already contain much of the hardware and software which comprises a credible SETI station. By paying careful attention to LO stability, if filtering and DSP techniques, they can achieve sensitivities adequate to detect signals of likely power level out to perhaps several hundred light years.

Our signal analysis capabilities are presently limited primarily by the power of our computers. But that's a very good place to be limited. Computer power has been roughly doubling every year for the past few decades. If the technological trend continues, within ten years our available computers will be about 1,000 times as powerful as the ones we use today. At that point, there may well be no place in the Milky Way galaxy which evades our gaze.

Lacking a concentrated, Government-sponsored SETI program, success will most likely require thousands of individual stations in a co-ordinated effort. The SETI League is one organisation willing to provide the needed co-ordination. But discipline on the part of the participants is also crucial. Fortunately, the optical astronomy community has already showed us that amateurs have the discipline necessary to make significant scientific contributions. Why should it be otherwise in the radio spectrum?

Those amateur astronomers interested in pursuing the SETI challenge are invited to join the non-profit, membership-supported SETI League, Inc. The SETI League maintains an extensive Internet presence; publishes quarterly newsletters, how-to manuals, and other technical documents; assists its members in locating equipment and software, as well as setting up their SETI stations; provides co-ordination of frequency and sky coverage; and provides a medium of communications for participants in its Project Argus all-sky survey.

Contacting SETI

Our best information contact (and membership details) are on our Web site at http://www.setileague.org/, by email from join@setileague.org. Our postal address is The SETI League Inc., PO Box 555, Little Ferry, NJ 07643, USA. Tel (Fax only) (US) 201 641 1771. H. Paul Shuch, PhD is Executive Director of The SETI League, Inc.

Within the USA you can call the League's toll-free membership hotline, 1(800) TAU-SETI.

References

The SETI League Technical Manual
(ISBN 0-9650707-2-7) Available for a $10 US contribution ($12 for foreign delivery) to The SETI League, Inc.

Equipment suppliers

These are sources for the equipment used to assemble the SETI receiving station described in this article. The list is by no means exhaustive; it merely serves to document one particular prototype system. For additional hardware and software sources, the SETI League Technical Manual, or refer to our World Wide Web site mentioned above.

Feedhorn:
1.4 GHz Cyl
Radio Astronomy Supplies, 190 Jade Cove Drive, Roswell, GA 30075, USA. Tel 770 992 4959

Antenna:
Classic 12
Paraclipse Inc., PO Box 686, Columbus, NE 68602, USA. Tel 402 563 3625 Fax 402 996 3702

Preamp:
SETI-LNA
Down East Microwave, 954 Route 519, Frenchtown, NJ 08825, USA Tel 908 996 3584 Fax 908 996 3702

Receiver:
IC-R7000, IC-R7100, IC-R8500
Icom America, 2380 116th Avenue NE, Bellevue, WA 98004, USA Tel 206 454 8155 Fax 206 454 1509.

Software:
FFTDSP
Mike Cook, 501 E Cedar Canyon Rd., Huntertown, IN 46748, USA 219 637 3399.

SETIFOX
Daniel B. Fox, 911 E Miller Dr., Bloomington, IN 47401 Tel 812 336 8238.

DSP Blaster
Brian Beezley, 3532 Linda Vista Dr., San Marcos, CA 92069, USA Tel 619 599 4962.

QST
American Radio Relay League, 225 Main Street, Newington, CT 06111, USA. Tel 860 5940200 Fax 860 594 0259 email qst@arrl.org

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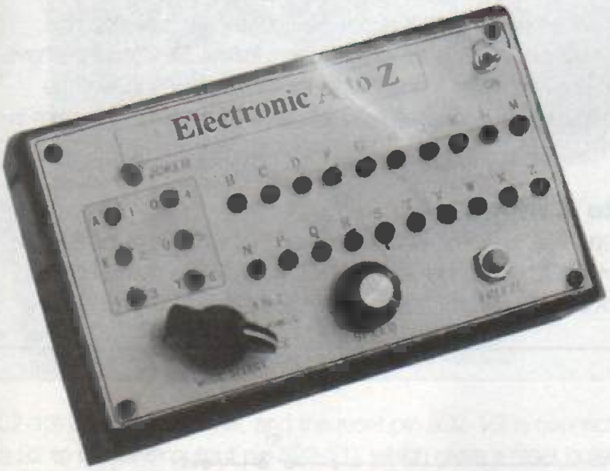
Electronic A to Z



Take a letter - any letter. Add a joker and you have a recipe for an evening of popular word games. By Roy Bebbington

Given twenty-six different letters you could write a best-seller - or a symphony for twelve letters, if you can arrange them in the right order. Perhaps this is too tall an order, but the Electronic A-Z has some more realistic mind-bending challenges to offer with its series of random letters at the touch of a button. Many popular TV quiz shows and board games call for a random selection of letters; for instance, 'Countdown', 'Catchword', 'Lexicon', Scrabble, and so on. Although a number of alphabetic characters can be electronically displayed using eye-catching 7-segment displays, it is not easy to reproduce the full alphabet in this way.

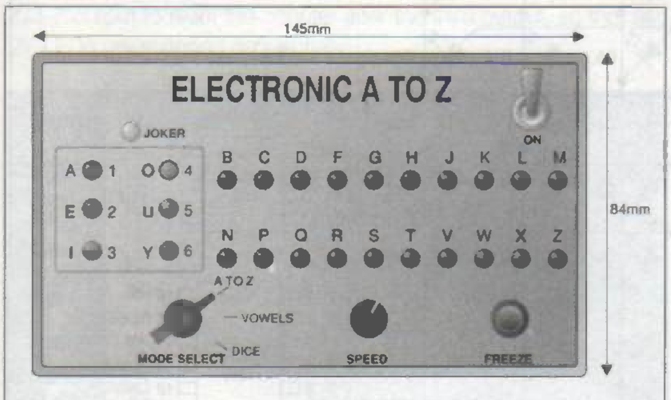


Figure 1: Electronic A to Z - the front panel layout

This project describes a simpler A to Z selector, achieved by using single LEDs, one for each letter. Figure 1 shows a suggested front panel layout. The five vowels can be selected separately, and an electronic dice (or die, to be strictly correct), is also 'thrown-in' as a bonus; it is useful in many board games and saves all that scrabbling about with conventional dice that never seem to stay on the board. Besides the 26 letters of the alphabet, a 'joker' is included, which is useful in some word games to represent any letter - like the blank tile in 'Scrabble'!

At switch-on, the display LEDs flash through the selected characters repeatedly at a rate determined by the position of the SPEED control. When the FREEZE button is pressed, the display will pause on the particular character that is being scanned at that instant. On release, the LEDs will resume flashing. The circuit consumes only 6 mA at 9 V.

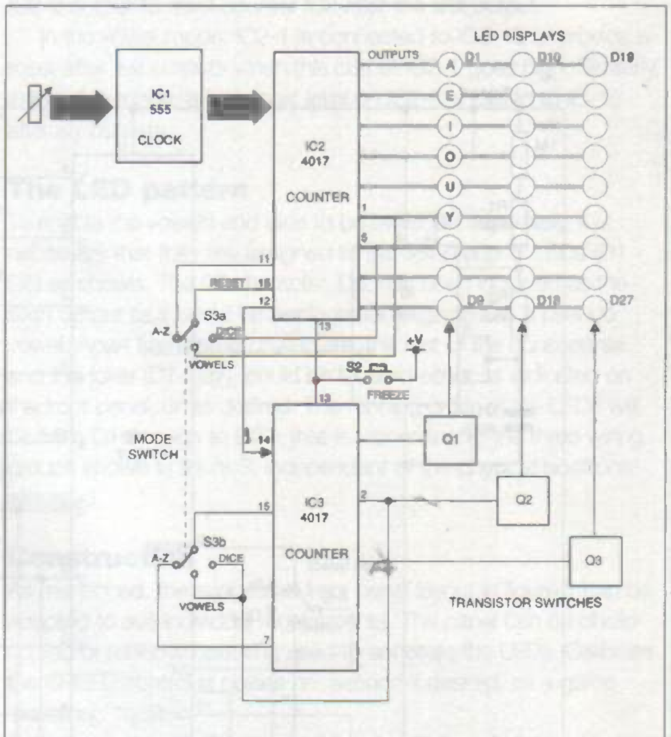


Figure 2: the block diagram

The block diagram

The block diagram (figure 2) consists basically of an oscillator providing clock pulses to a counter circuit that drives LED displays representing the alphabetic characters. The popular 555 timer and two 4017 decade counter cmos ics are used in this A to Z version to activate 27 LEDs (all 26 letters of the alphabet and the 'joker'). You are probably thinking that, mathematically, something doesn't add up if we expect to scan 27 characters from two decade counters - we don't! All 27 characters, in three groups of nine LEDs, are actually scanned by one decade counter, the second counter merely switching the groups into circuit in the correct sequence. The available characters are selected by the MODE SELECT switch S3, operating broadly as follows:

In the 'A to Z' position, all 27 LEDs, arranged in three groups of nine on the outputs of the first counter IC2, are activated to run in sequence. The second counter, IC3, clocked by the 'carry' output (pin 12), operates three transistor switches TR1-TR3 in sequence to turn on the three groups of LEDs in the right order (D1-D27). - In the 'vowel' position all 5 vowel LEDs on the first five outputs of the counter, are activated in sequence. In addition, the reset (pin

15 of IC2) is connected to the sixth output pin (IC2-1), which causes the counter to reset after the first five outputs are scanned so that only the five vowels are selectable

In the 'dice' position the link from the reset (pin 15 of IC2) is switched to the seventh output pin (IC2-5). This causes the counter to reset after the first six outputs are scanned; as the five vowels and the first consonant (Y) are also labelled 1 to 6, a dice facility is available.

The circuit

The 555 stage, IC1, provides the rectangular clock pulses to operate the counter stages, IC2 and IC3. A potentiometer RV1 has been included in the timing circuit, designated SPEED, to allow adjustment of the scan speed of the LEDs (approximately 2 to 14Hz). If the speed selected is slow, then it could be possible to anticipate and 'freeze' a letter (or number) of your choice - a useful facility for some games, especially when handicapping is needed. The timer IC1 is connected in the astable multivibrator mode and positive-going output pulses are available on output pin IC1-3. The speed is determined by the setting of RV1 and the values of R1, R2 and C1. These timing pulses are applied to input pin IC2-14 to 'clock' the counter IC2. The MODE SELECT switch S3 determines which outputs from the counter are activated and therefore which LEDs are available for display. The functions have been briefly covered in the block diagram description, but the details are now discussed with reference to the circuit diagram in figure 3.

A to Z mode

When the A to Z mode is selected on S2, the nine outputs from counter IC2 go high in sequence at a speed determined by the clock pulses. Cycling continues because the clock enable pin

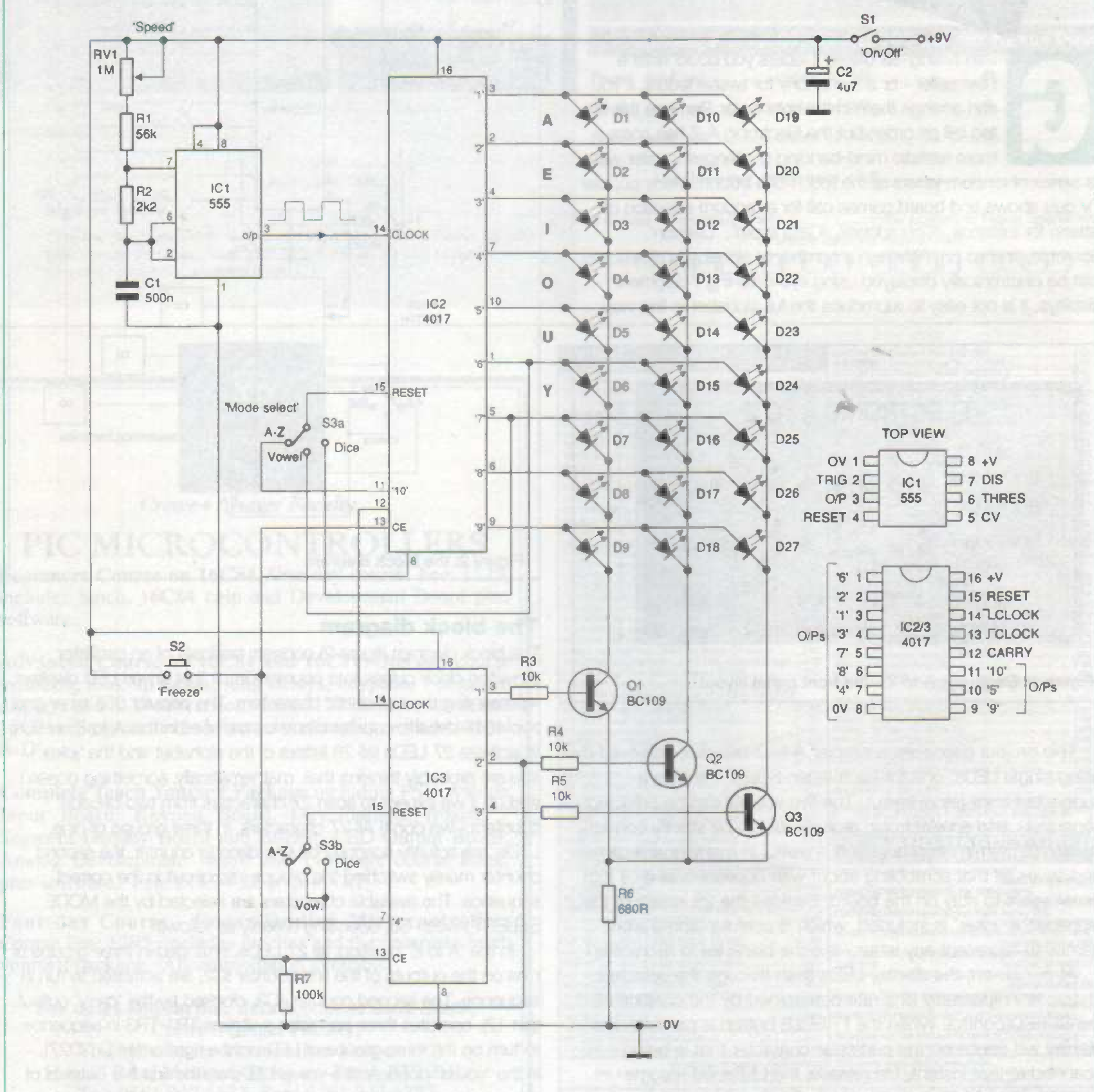
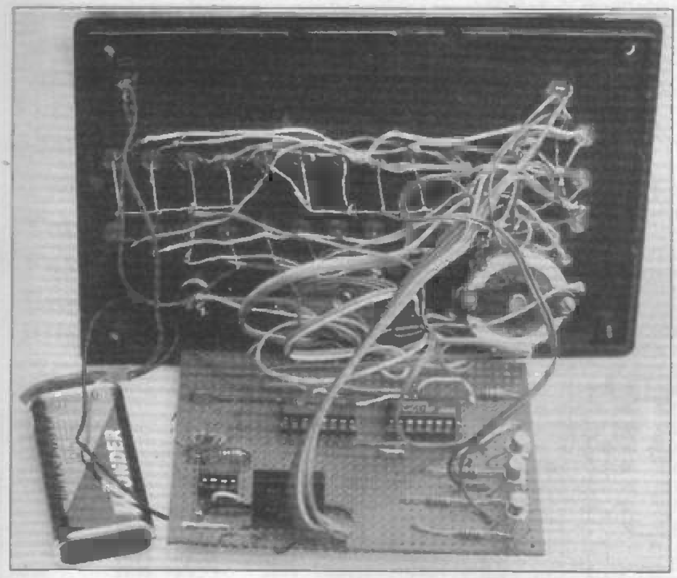


Figure 3: the circuit



(IC2-13) is held low via R7, and the reset pin (IC2-15) is connected via S2 to the tenth output pin (IC2-11), which gives a reset pulse when it goes high.

The second counter, IC3, in conjunction with the three transistor switches Q1, Q2, Q3, selects the three groups of LEDs in sequence, that is, D1-D9, D10-D18, D19-D27, to provide a continuous running display of the 27 letters in this mode. The divide-by-ten output pin (IC2-12) is used as the clock input to IC3-14 to provide three outputs (IC3-3, IC3-2, IC3-4) to switch the three transistors in sequence. These transistors provide the 0V return, via R6, to activate the three groups of LEDs. This resistor limits the current through the LEDs and also allows IC2-15 to go sufficiently high to achieve reset in the vowel and dice modes. In the A to Z position, the mode select switch S3b returns IC3-15 to IC3-7 output to reset the counter after the third output, so that all 27 LEDs are scanned sequentially.

PARTS LIST for the Electronic A-Z

Resistors

R1	56R
R2	2.2R
R3,R4,R5	10k
R6	680R
R7	100k
RV1	1M lin pot.(SPEED)

Capacitors

C1	500nF polyester
C2	24.7uF 10V radial elect

Semiconductors

IC1	NE555 timer
IC2, IC3	4017 decade counter
Q1 to Q3	BC109 or equivalent
D1 to D5	5mm green LEDs (vowels)
D6 to D26	5mm red LEDs (consonants)
D27	5mm yellow LED (joker)

Switches

S1	spst (ON/OFF)
S2	push-to-make (FREEZE)
S3	2-pole, 3-way rotary (MODE SELECT)

Miscellaneous

Suitable project box eg Maplin MB5 (145 x 95 x 57.5 mm); stripboard (36 strips x 24 holes), 9V battery (PP3); dil holders (8-pin, 2 x 16-pin), connecting wire, solder, etc.

The clock enable pins of the IC2 and IC3 are normally held to 0V by resistor R7. However, when the FREEZE pushbutton S2 is operated, +9V is applied, the clock is disabled and the LED activated at that instant is displayed, while the S2 button is held down. To guard against the 'button-jabbers', who may release S2 before the selected character has been observed, a small circuit modification is suggested. An electrolytic capacitor can be wired in parallel with resistor R7 to continue the freeze action momentarily after S2 is released. A 10uF capacitor holds the selected LED on for a further second before sequencing resumes. Obviously, this modification is effective in all modes.

Vowel/dice mode

In the vowel and dice modes, only the first group of LEDs requires to be activated so that the 5 or 6 characters (vowels or dice) can run continuously in sequence. This means that only transistor switch Q1 needs to be in circuit, so S3b now returns IC3-15 to IC3-2 output to reset counter IC3 after the first output.

In the vowel mode, IC2-1 is connected to IC2-15 to provide a reset after five outputs when this output IC2-1 goes high. Similarly, in the dice mode, a high logic level on IC2-5 is routed to IC-15 after six outputs.

The LED pattern

To enable the vowels and dice to be switched separately, it is necessary that they are assigned to the first group of LEDs (D1 - D6) as shown. The 'Y' character, D6, has been included as the sixth output as it could be useful in some games as a pseudo vowel. Apart from these characters, the rest of the consonants and the joker (D7-D27), could be labelled either as indicated on the front panel, or as desired. The running order of the LEDs will be from D1 through to D27; that is, according to the three wiring groups shown in figure 3, independent of the physical positions allocated.

Construction

As mentioned, the suggested front panel layout in figure.1 can be adapted to suit individual requirements. The panel can be photocopied or rubdown lettering used to annotate the LEDs. Calibrate the SPEED control in pulses per second if desired, as a game 'handicap' facility.

A stripboard layout (36 strips x 24 holes) is given in figure 4, which also shows the interconnections from the PCB to the 27 LEDs and the switches. Use multi-strand wire to keep these connecting links flexible. Only the component side is shown; the breaks in the copper strips on the underside are Indicated by crosses (x). Make sure that no whiskers of copper are left, and there are no excess blobs of solder to cause short-circuits. The integrated circuits should preferably be mounted In dil sockets to avoid overheating and should be retained in their original wrapping until required, that is, fitted last, to avoid the risk of damage by static charges.

Word games

Many of the popular word games are well-known, but here's a reminder of some of them and a few new suggestions for using your Electronic A to Z.

The popular TV game *Countdown* offers the random selection of a mixture of nine letters, choosing vowels and consonants to make the longest possible word with bonus points for a nine-letter word. This allows plenty of scope for variations, such as a limited word-length for children and a slower speed for capturing your favourite letters.

Catchword, on the other hand, selects three consonants that are used to form as many words as possible in a given time that

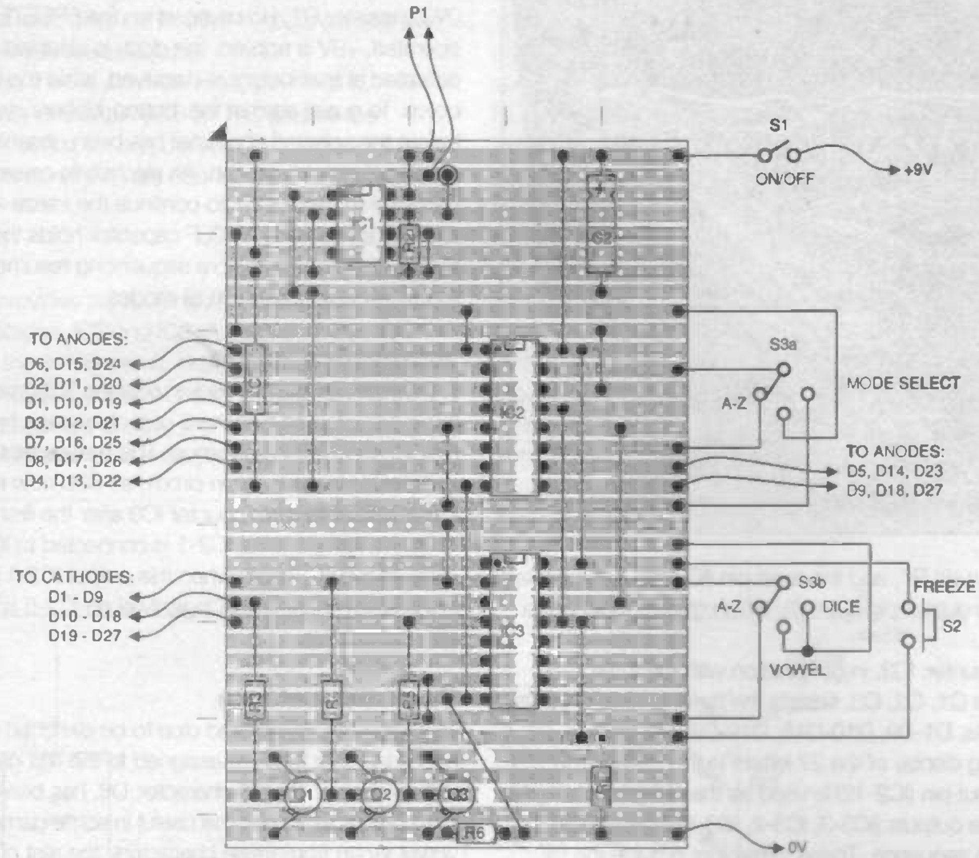
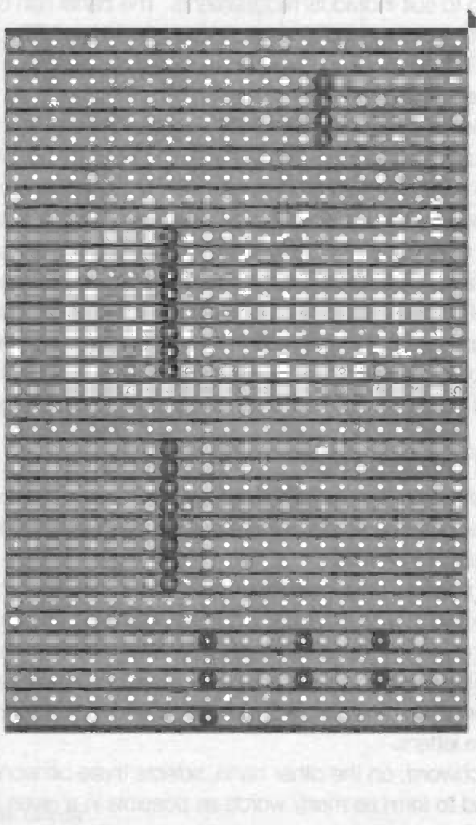


Figure 4: the stripboard layout



start with the first letter and include the other two in the given order. For example, LND could produce LINED, LOANED, LAMINATED, and so on, a bonus being given for the longest word. In this game, any vowels displayed could be ignored, but the joker could be used to advantage to stand for any desirable consonant.

Another game is called *Well-known Initials*. A pair of letters can be selected in the A-Z mode to see whether contestants can conjure up famous, or infamous, initials of people in history, films, music, TV, sport, etc. For example, Winston Churchill, Mickey Mouse, Russ Abbot, Andy Cole.

The game *Word Chain* consists of selecting a sequence of letters in the A-Z mode, which are written down by the contestants. Like the proverbial typewriting monkeys, this chain of letters will mostly produce jibberish, but occasionally a word will be formed. A contestant scores points if a word is spotted before the next letter is selected.

In *Wordsmith*, the skill is to make as many words as possible from six or seven letters chosen at random. It will be necessary to select a couple of vowels if none is forthcoming from the A-Z mode. As an elegant variation, one of the consonants may be chosen as the key letter, which must occur in all the words.

Finally, don't forget the pencil and paper game of *Categories* where, starting with a chosen letter, lists are made by each contestant of such categories as a girl's name, boy's name, town, county, country, animal, flower, fish, TV star, and sport. The difference is that with the Electronic A to Z, a different starting letter can be randomly selected for each category. Players score 2 for a suitable category name not duplicated by any other player, and one if another player (or more) shares the same answer.

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SSM2015P	£12.32
SSM2017P	£3.38
SSM2131P	£4.19
SSM2141P	£4.21
SSM2142P	£6.16
SSM2143P	£3.78
TBA120S	£0.90
TBA800	£0.70
TBA810S	£0.64
TBA820M	£0.40
TDA1170S	£2.48
TDA2002	£1.04
TDA2004	£3.11
TDA2030	£1.18
TDA2050V	£3.12

TDA2611A	£1.88
TDA2822A	£1.68
TED3718DP	£5.03
TEA5115	£3.11
TL061CP	£0.35
TL062CP	£0.60
TL064CN	£0.72
TL071CP	£0.39
TL072CP	£0.38
TL074CN	£0.50
TL081	£0.33
TL082CP	£0.54
TL084CN	£0.50
TL494CN	£1.46
TL7705ACP	£1.62
TLC271	£0.54
TLC272	£0.88
TMP01FP	£5.60
ULN2003	£0.52
ULN2004A	£0.48
ULN2803	£0.90
ULN2804A	£1.64
ULN2806	£1.20
XR2206	£5.37
ZN414Z	£1.16
ZN416E	£1.99
EPROM's	
2716	£4.74
2732	£4.84
2764-25	£4.20
27C64-25	£3.44
27C010	£5.74
27128-20	£4.08
27C128-20	£4.08
27256-20	£4.85
27C256-20	£3.68
27C512	£3.42
RAM	
4164-15	£1.90
6116-10	£1.53
6264-10	£3.16
41256-10	£2.80
62256-10	£4.22
511000-8	£8.54
514256-8	£6.80
A/D Converters	
Data Acquisition	
AD420AN	£25.38
AD557JN	£8.75
AD574AJN	£18.48
AD775JN	£18.48
AD7226KN	£25.69
AD7528JN	£7.04
AD7545AKN	£14.04
AD7828KN	£20.33
ICL7109CPL	£7.75
TLC549IP	£3.04
ZN425E	£5.94
ZN426E	£3.13
ZN427E	£9.25
ZN428E	£5.94
ZN448E	£7.34
Microcontrollers	
PIC16C54A-04	£3.07
PIC16C71-04	£4.88
PIC16C84-04	£5.92
PHONE FOR OTHER DEVICES	
Voltage Regulators	
7805	£0.35
7808	£0.50
7812	£0.38
7815	£0.38
78L05	£0.23
78L08	£0.23
78L12	£0.23
78L15	£0.24
78L24	£0.39
78S05	£0.70
78S12	£0.70
78S15	£0.98
7905	£0.40
7912	£0.30
7915	£0.38
7924	£0.38
79L05	£0.23
79L12	£0.23
79L15	£0.28
79L24	£0.30
ADM666AN	£3.44
L200CV	£1.30
L296	£6.87
L387A	£3.24
LM2940CT	£2.30
LM317T	£0.50
LM323K	£2.84
LM334Z	£1.35
LM337T	£0.68
LM338K	£5.52
LM723	£0.29
LP2950CZ	£2.70
REF01CP	£3.44
REF02CP	£4.66
REF12Z	£1.28
REF195GP	£4.72
REF25Z	£1.24
REF50Z	£1.22
TL431CP	£0.45
ZN423	£1.55
ZN458B	£1.89
Diodes	
1N914	£0.06
1N916	£0.06
1N4001	£0.06
1N4002	£0.07
1N4003	£0.07
1N4004	£0.07
1N4005	£0.07
1N4006	£0.08
1N4007	£0.08
1N4148	£0.05
1N4149	£0.06
1N5400	£0.09
1N5401	£0.09
1N5402	£0.10
1N5404	£0.11
1N5406	£0.12
1N5407	£0.14
1N5408	£0.15
BA157	£0.10
BA158	£0.10
BA159	£0.10

BAT85	£0.17
BY126	£0.13
BY127	£0.18
BY133	£0.10
OA47	£0.24
OA90	£0.07
OA91	£0.10
OA200	£0.56
OA202	£0.29
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400mW	£0.08
1.3W	£0.14
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1.5A 50V	£0.19
1.5A 200V	£0.20
1.5A 400V	£0.22
1.5A 600V	£0.22
1.5A 800V	£0.27
1.5A 1kV	£0.24
3A 200V	£0.36
3A 400V	£0.40
3A 600V	£0.33
6A 200V	£0.70
6A 800V	£0.59
10A 400V	£1.39
25A 200V	£1.68
25A 600V	£1.80
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C106D	£0.36
PO102AA	£0.30
TIC116D	£0.66
TIC126D	£0.77
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ZO105DA	£0.42
TIC206D	£0.65
TIC226D	£0.94
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TIC236D	£0.96
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2N1711	£0.26
2N1893	£0.29
2N2218A	£0.28
2N2219A	£0.25
2N2222A	£0.18
2N2646	£1.12
2N2904A	£0.25
2N2905A	£0.25
2N2907	£0.20
2N2907A	£0.20
2N2926	£0.16
2N3053	£0.27
2N3054	£0.85
2N3055	£0.58
2N3439	£0.62
2N3440	£0.50
2N3702	£0.09
2N3703	£0.10
2N3704	£0.10
2N3705	£0.10
2N3706	£0.10
2N3771	£1.44
2N3772	£1.51
2N3773	£1.70
2N3819	£0.42
2N3820	£0.66
2N3904	£0.10
2N3905	£0.10
2N3906	£0.10
2N4036	£0.34
2N5245	£0.80
2N5296	£0.57
2N5321	£0.57
2N5322	£0.57
2N5401	£0.11
2N5551	£0.11
2N6107	£0.60
2N6491	£1.58
2SB548	£0.30
2SD1730	£1.44

AC126	£0.44
AC127	£0.50
AC128	£0.40
AC187	£0.48
AC188	£0.48
ACY17	£3.84
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AD161	£0.92
AD162	£0.92
BC107	£0.16
BC107B	£0.17
BC108	£0.14
BC108B	£0.16
BC108C	£0.15
BC109	£0.17
BC109C	£0.19
BC114	£0.19
BC115	£0.41
BC116	£0.41
BC118	£0.41
BC132	£0.36
BC134	£0.36
BC135	£0.36
BC140	£0.25
BC141	£0.27
BC142	£0.31
BC143	£0.34
BC149	£0.21
BC154	£0.36
BC157	£0.12
BC159	£0.17
BC160	£0.28
BC170	£0.16
BC170B	£0.16
BC171	£0.11
BC171B	£0.16
BC172	£0.13
BC172B	£0.13
BC177	£0.18
BC178	£0.18
BC179	£0.18
BC179A	£0.17
BC182	£0.11
BC182A	£0.11
BC182B	£0.12
BC182L	£0.08
BC182LB	£0.08
BC183	£0.08
BC183L	£0.08
BC183LB	£0.08
BC184	£0.08
BC184L	£0.08
BC186	£0.33
BC204C	£0.72
BC206B	£0.72
BC208	£0.72
BC209A	£0.72
BC212	£0.08
BC212L	£0.08
BC212LB	£0.08
BC213	£0.08
BC213B	£0.08
BC213LC	£0.08
BC214	£0.08
BC214L	£0.08
BC225	£0.15
BC237B	£0.09
BC238B	£0.09
BC238C	£0.09
BC239C	£0.10
BC250A	£0.10
BC252	£0.13
BC261B	£0.30
BC262B	£0.24
BC267B	£0.30
BC307	£0.10
BC308	£0.10
BC319C	£0.13
BC327	£0.10
BC327-25	£0.10
BC328	£0.10
BC328-16	£0.10
BC337	£0.10
BC337-25	£0.12

BC338	£0.10
BC338-25	£0.10
BC348B	£0.14
BC357	£0.25
BC393	£0.73
BC441	£0.40
BC461	£0.46
BC463	£0.29
BC478	£0.32
BC479	£0.32
BC516	£0.21
BC517	£0.17
BC527	£0.20
BC528	£0.20
BC537	£0.20
BC546B	£0.08
BC546C	£0.08
BC547B	£0.09
BC547C	£0.09
BC548C	£0.08
BC549C	£0.10
BC550C	£0.10
BC556A	£0.08
BC557B	£0.08
BC557C	£0.08
BC558C	£0.08
BC559C	£0.08
BC560A	£0.08
BC560B	£0.09
BC637	£0.21
BC638	£0.21
BC639	£0.21
BC640	£0.13
BCY70	£0.22
BCY71	£0.20
BCY72	£0.20
BD124P	£6.86
BD135	£0.21
BD136	£0.21
BD137	£0.23
BD138	£0.23
BD139	£0.25
BD140	£0.25
BD150C	£0.82
BD165	£0.42
BD166	£0.35
BD187	£0.39
BD201	£0.40
BD202	£0.40
BD203	£0.40
BD204	£0.40
BD222	£0.58
BD225	£0.42
BD232	£0.50
BD237	£0.50
BD238	£0.44
BD240C	£0.37
BD243B	£0.50
BD244A	£0.53
BD244C	£0.53
BD245C	£1.18
BD246	£1.18
BD246C	£1.18
BD283	£0.61
BD284	£0.61
BD400	£0.79
BD441	£0.40
BD442	£0.37
BD534	£0.47
BD535	£0.50
BD536	£0.65
BD581	£0.65
BD597	£0.92
BD646	£0.52
BD648	£0.52
BD650	£0.53
BD707	£0.42
BD708	£1.04
BD807	£0.80
BDX32	£1.78
BDX33C	£0.56
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BF180	£0.31
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BF194	£0.31
BF194B	£0.19
BF195	£0.19
BF244	£0.35
BF244B	£0.40
BF244C	£0.35
BF257	£0.33
BF259	£0.33
BF337	£0.40
BF355	£0.38
BF423	£0.13
BF451	£0.19
BF459	£0.33
BF469	£0.36
BFX29	£0.29
BFX84	£0.31
BFX85	£0.32
BFY50	£0.30
BFY51	£0.25
BFY52	£0.28
BS107	£0.21
BS170	£0.23
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BU205	£1.41
BU208A	£1.24
BU326A	£1.40
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MJ11015	£2.45
MJ11016	£2.56
MJE340	£0.40
MJE350	£0.48
MPSA05	£0.14
MPSA06	£0.11
MPSA13	£0.12
MPSA42	£0.17
MRF475	£7.28
TIP29C	£0.31
TIP30C	£0.37
TIP31C	£0.41
TIP32C	£0.41
TIP33C	£0.72
TIP41A	£0.44
TIP42C	£0.52
TIP47	£0.48
TIP48	£0.62
TIP50	£0.53
TIP121	£0.45
TIP122	£0.48
TIP125	£0.46
TIP127	£0.40
TIP132	£0.46
TIP137	£0.56
TIP142	£1.30
TIP147	£1.12
TIP2955	£0.97
TIP3055	£0.70
VN10KM	£0.48
ZTX300	£0.16
ZTX500	£0.16

SAMEDAY DESPATCH

Quality Components

No Minimum Order Value

Electrolytic Radial

µF	16v	25v	40v	63v	100v
0.47	—	—	—	£0.05	—
1.0	—	—	—	£0.05	£0.05
2.2	—	—	—	£0.05	—
4.7	—	—	£0.05	£0.05	£0.05
10	£0.05	£0.05	£0.05	£0.05	£0.09
22	£0.05	£0.05	£0.05	£0.07	£0.11
33	£0.05	—	£0.05	—	—
47	£0.05	£0.05	£0.07	£0.10	£0.19
100	£0.06	£0.06	£0.10	£0.13	£0.26
220	£0.08	£0.09	£0.13	£0.25	—
330	£0.09	—	£0.19	—	—
470	£0.12	£0.17	£0.24	£0.33	—
1000	£0.15	£0.33	£0.34	—	—
2200	£0.27	£0.55	£0.70	—	—
3300	—	£0.94	—	—	—
4700	£0.67	£1.05	—	—	—

Electrolytic Axial

µF	16v	25v	40v	63v	100v	250v	450v
0.47	—	—	—	—	—	—	—
1.0	—	—	—	£0.13	—	—	£0.22
2.2	—	—	—	£0.13	—	—	£0.30
4.7	—	—	—	£0.13	—	—	£0.41
10	£0.12	—	£0.12	£0.13	£0.17	£0.40	£0.51
22	£0.12	£0.13	£0.14	£0.15	£0.21	£0.52	£1.06
33	—	—	—	—	—	—	—
47	£0.13	£0.13	£0.15	£0.19	£0.32	£0.57	—
100	£0.14	£0.16	£0.19	£0.26	£0.44	—	—
220	£0.19	£0.20	£0.27	£0.39	£0.48	—	—
330	—	—	—	—	—	—	—
470	£0.24	£0.28	£0.43	£0.53	—	—	—
1000	£0.33	£0.43	£0.59	£1.08	—	—	—
2200	£0.53	£0.66	£1.11	£1.55	—	—	—
3300	—	—	—	—	—	—	—
4700	£0.86	£1.11	—	—	—	—	—

Ceramic Mini Disc
1.0,1.2,1.5,1.8,2.2,2.7,3.3,3.9,4.7,5.7,6.8,8.2

1.0pF to 22nF 100V	£0.06
47nF & 100nF 50V	£0.07

Also in stock - Mylar Film. MKT, Boxed & Dipped Polyester. Tantalum. Sub-miniature, low Leakage & 105°C Radials

Dipped Ceramic Multilayer
10,22.33,47 and multiples.

10pF to 100nF 100V	£0.10
220nF 100V	£0.14
330nF 100V	£0.16
470nF 100V	£0.22
1.0µF 100V	£0.29

Full Technical Specification available

Resistors - Please State Value Required

¼W Carbon Film 5%	E12 Series	1Ω-10M	£0.02 Each, £0.60 per 100
¼W Metal Film 1%	E24 Series	10Ω-1M	£0.04 Each, £1.72 per 100
½W Carbon Film 5%	E12 Series	1Ω-10M	£0.02 Each, £0.95 per 100
1W Carbon Film 5%	E12 Series	1Ω0-10M	£0.07 Each, £3.90 per 100
2W Carbon Film 5%	E12 Series	1Ω0-10M	£0.12 Each, £5.99 per 100
2.5W Wirewound 5%	E12 Series	0Ω1-220Ω	£0.23 Each

per 100 of one value only

Preset Resistors - Please State Value Required

Enclosed, 10mm Square Horz / Vert.	100Ω - 1M0 0.15W	£0.15 Each
Skeleton, 10mm Dia. Horz / Vert.	100Ω - 1M0 0.1W	£0.11 Each
Sub-min, 6mm Dia, Horzontal	E3 200Ω-1M0 0.1W	£0.19 Each
Multiturn, 10mm Square, Top Adjust.	E3 100Ω-1M0 0.5W	£1.00 Each
Multiturn, 19mm Long, End Adjust.	E3 50Ω-2M0 0.5W	£0.64 Each

Potentiometers - Please State Value Required

Single Gang - ¼" Shaft, 25mm Dia.	470Ω-2M2 Linear	£0.49 Each
Single Gang - ¼" Shaft, 25mm Dia.	4k7,10k,47k,100k,1M,2M2 Log	£0.49 Each
Dual Gang - ¼" Shaft, 20mm Dia.	1K0-2M2 Linear	£1.62 Each
Dual Gang - ¼" Shaft, 20mm Dia.	1K0-2M2 Logarithmic	£1.71 Each
Switched - ¼" Shaft, 20mm Dia.	1K0-2M2 Linear	£1.56 Each
Switched - ¼" Shaft, 20mm Dia.	1K0-2M2 Logarithmic	£1.69 Each
PCB Mount, Splined Shaft, 16mm Dia.	470Ω-1M0 Linear	£0.42 Each
PCB Mount, Splined Shaft, 16mm Dia.	470Ω,4k7,100k,1M0 Log	£0.42 Each
Dual PCB, Splined Shaft, 16mm Dia.	10k,50k100k,500k Linear	£0.85 Each
Dual PCB, Splined Shaft, 16mm Dia.	10k,50k,100k,500k Logarithmic	£0.85 Each

ORDERING INFORMATION - Carriage £1.25+Vat, Prices Exclude Vat (17½%), Add Carriage & Vat to all orders. Payment with Order. PO/Cheques payable to ESR Electronic Components. **ALL** Credit Card Orders Accepted. **NO** Credit Card Surcharges. Trade discount for Schools & Colleges.

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Cossor 3102 – 60MHz Dual Channel	£250
Gould 1602 – 20MHz D.S.O. with printer (cursors)	£1150
Gould OS 245A/250/255/300/3000/3351/4000	from £125
Hameg 203/203-5 – 20MHz – Dual Channel	from £150
Hewlett Packard 180A/180C/181A/182C	from £200
Hewlett Packard 1740A, 1741A, 1744A, 100MHz dual ch	from £350
Hewlett Packard 54100D – 1GHz Digitizing	£2995
Hewlett Packard 54602A – 150MHz – 4 channel	£1750
Hitachi V650F – 60MHz Dual Channel	£350
Hitachi V152F/V302B/V302F/V353F/V550B/V650F	from £125
Intron 2020 – 20MHz Digital Storage (NEW)	£650
Iwatsu SS 5710/SS 5702 – 20MHz	from £125
Kikusui COS 6100 – 100MHz, 5 Channel, 12 Trace	£475
Kikusui 5100 – 100MHz – Dual Channel	£350
Meguro – MSO 1270A – 20MHz Digital Storage (NEW)	£650
National VP5703A – 100MHz – Digital Storage	£750
Nicolet 310 – L.F. D.S.O. with twin Disc Drive	£550
Nicolet 3091 – L.F. D.S.O.	£900
Lecroy 9450A – 300MHz/400 Ms/s D.S.O. 2 ch	£2250
Philips PM 3211/PM 3212/PM 3214/PM 3217/PM 3234/PM 3240/PM 3243/PM 3244/PM 3261/PM 3262/PM 3263/PM 3540	from £125
Philips PM 3295A – 400MHz Dual Channel	£1750
Philips PM 3335 – 50 MHz/20Ms/s D.S.O. 2 ch	£1500
Tektronix 434 – 25MHz – 2 Channel Analogue Storage	£250
Tektronix 454 – 150MHz – 2 Channel	£400
Tektronix 468 – 100MHz D.S.O.	£750
Tektronix TDS 520 – 500 Mhz/500Ms/s D.S.O. 2 Ch	£4000
Tektronix 2213 – 60MHz Dual Channel	£425
Tektronix 2235 – 60MHz Dual trace	£450
Tektronix 2235 – 100MHz Dual trace	£800
Tektronix 2335 – Dual trace 100MHz (portable)	£750
Tektronix 2225 – 50MHz dual ch	£450
Tektronix 2440 – 300 MHz/500 Ms/s D.S.O. 2 Ch	£4250
Tektronix 455 – 50MHz Dual Channel	£350
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Tektronix 465/465B – 100MHz dual ch	from £350
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Tektronix 7313, 7603, 7613, 7623, 7633, 100MHz 4 ch	from £300
Tektronix 7704 – 250MHz 4 ch	from £650
Tektronix 7904 – 500MHz	from £850
Tektronix 7934 – 500MHz with storage	from £1000
Trio CS-1022 – 20MHz – Dual Channel	£125

Other scopes available too

SPECIAL OFFER

HITACHI V212 – 20MHZ DUAL TRACE	£180
HITACHI V222 – 20 MHZ DUAL TRACE + ALTERNATE MAGNIFY	£200

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Advantest 4131 – 10KHz – 3.5GHz (G.P.I.B.)	£4500
Advantest 4131B – 10KHz – 3.5GHz	£4750
Advantest 4133B – 10KHz – 20GHz (60GHz with external mixers) + Ext. Keyboard	£7250
Ando AC8211 – Spectrum Analyser 1.7GHz	£2950
Eaton/Alltech 757 – 10KHz – 22GHz	£2750
Hewlett Packard 3580A – 5Hz-50KHz	£995
Hewlett Packard 182T with 8559A (10MHz – 21GHz)	£3750
Hewlett Packard 35601A – Spectrum Analyser Interface	£1000
Hewlett Packard 141T + 8552B + 8555A – (10MHz – 18GHz)	£1600
Hewlett Packard 3562A Dual Channel Dynamic Sig. Analyser	£7500
Hewlett Packard 8505A – Network Analyser 500KHz – 1300MHz	£3950
Hewlett Packard 853A + 8558B – 0.1 to 1500MHz	£3250
Hewlett Packard 182T + 8558B – 0.1 to 1500MHz	£2750
Hewlett Packard 8565A – 0.01 – 22GHz	£3750
Hewlett Packard 8754A – Network Analyser 4-1300MHz	£2500
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Marconi 2370 – 110MHz	£995
Marconi 2371 – 30KHz – 2000MHz	£1250
Meguro MSA 4901 – 1-300GHz (AS NEW)	£1995
Meguro MSA 4912 – 1-1GHz (AS NEW)	£3000
Polrad 641-1 – 10MHz – 18GHz	£1500
Rohde & Schwarz – SWOB 5 Polyskop 0.1 – 1300MHz	£2500
Takeda Riken 4132 – 1.0GHz Spectrum Analyser	£2750
Tektronix 7L18 with mainframe (1.5-60GHz with external mixers)	£2000

MISCELLANEOUS

Adret 740A – 100KHz – 1120MHz Synthesised Signal Generator	£2000
ANRITSU ME 462B DF/3 Transmission Analyser	£3000
Danbridge JP30A – 30KV Insulation Tester	£1500
Anritsu MG642A Pulse Pattern Generator	£1500
Dranetz 626 – AC/DC – Multifunction Analyser	£850
EIP 331 – Frequency counter 18GHz	£700
Farnell AP70-30 Power Supply (0-70v/30A) Auto Ranging	£750
Farnell TSV-70 MKII Power Supply (70V – 5A or 35V – 10A)	£200
Farnell DSG-1 Synthesised Signal Generator	£125
Flure 5100A – Calibrator	£2500
Flure 5100B – Calibrator	£3500
Gigatronics 8541 – Universal Power Meter	£1500
Guildline 9152 – T12 Battery Standard Cell	£550
Helden 1107 – 30V – 10A Programmable Power Supply (IEEE)	£650
Hewlett Packard 331A – Distortion Analyser	£300
Hewlett Packard 333A – Distortion Analyser	£300
Hewlett Packard 3314A – Function Generator	£2250
Hewlett Packard 3336C – Synthesised Signal Generator (10Hz – 21MHz)	£1000
Hewlett Packard 3437A System voltmeter	£350
Hewlett Packard 3456A Digital voltmeter	£850
Hewlett Packard 3438A Digital multimeter	£200
Hewlett Packard 3560A Dual Ch. Dynamic Signal Analyser	£3750
Hewlett Packard 3711A/3712A/3791B/3793B Microwave Link Analyser	£2250
Hewlett Packard 3776A – PCM Terminal Test Set	£POA
Hewlett Packard 3325A – 21MHz Synthesiser/Function Gen	£1500
Hewlett Packard 3488A – HP – 1B Switch control unit (various Plug-ins available)	£650
Hewlett Packard 334A – Distortion Analyser	£300
Hewlett Packard 3455A 6½ Digit M/Meter (Autocal)	£750
Hewlett Packard 3478A – Multimeter (5½ Digit) + HP – 1B	£550
Hewlett Packard 3776A – PCM Terminal Test Set	£POA
Hewlett Packard 3779A/3779C – Primary Mux Analyser	from £600
Hewlett Packard 436A + Sensor	from £1000
Hewlett Packard 4275A – LCR Meter (Multi-Frequency)	£3950
Hewlett Packard 4338A – Millionmeter (As New)	£2000
Hewlett Packard 4342A 'Q' Meter	£995
Hewlett Packard 4952A – Protocol Analyser (with interfaces)	£2500
Hewlett Packard 4953A – Protocol Analyser	£2750
Hewlett Packard 432A – Power Meter (with 478A Sensor)	£275
Hewlett Packard 435A or B Power Meter (with 8481A/8484A)	from £750
Hewlett Packard 4271B – L.C.R. Meter (Digital)	£900
Hewlett Packard 4278A – 1KHz/1MHz Capacitance Meter	£3750
Hewlett Packard 4279A – 1MHz C-V Meter	£6500
Hewlett Packard 4948A – (TIMS) Transmission Impairment M/Set	£2000
Hewlett Packard 4927A – Lan Protocol Analyser	£2000
Hewlett Packard 5420A Digital Signal Analyser	£350
Hewlett Packard 5335A – 200MHz High Performance Systems Counter	£600
Hewlett Packard 5314A – (NEW) 100MHz Universal Counter	£250
Hewlett Packard 5183 – Waveform Recorder	£2250
Hewlett Packard 5238A Frequency Counter 100MHz	£250
Hewlett Packard 5370A – 100MHz Universal Timer/Counter	£450
Hewlett Packard 5384A – 225 MHz Frequency Counter	£950
Hewlett Packard 5385A Frequency Counter – 1GHz – (HP1B) with OPTS 001/003/004/005	£995
Hewlett Packard 6031A – 1000W Autoranging p.s.u. (20v - 120A)	£1550
Hewlett Packard 6034 – 60V – 10A System Power Supply	£1500
Hewlett Packard 6253A Power Supply 20V – 3A Twin	£200
Hewlett Packard 6255A Power supply 40V – 1.5A Twin	£200
Hewlett Packard 6266B Power Supply 40V – 5A	£220
Hewlett Packard 6271B Power supply 60V – 3A	£225
Hewlett Packard 6034A – 0-60V – 10A System P.S.U.	£1500
Hewlett Packard 7475A – 6 Pen Plotter	£250
Hewlett Packard 7550A – 8 Pen Plotter A3/A4	£450

HEWLETT PACKARD 6261B
Power Supply 20V-50A £450 ***Discount for Quantities***

Hewlett Packard 8349B – Microwave Broad Band Amplifier	£3500
Hewlett Packard 8355A – Millimeter – Wave source Module 33-50GHz	£4250
Hewlett Packard 8015A – 50MHz Pulse Generator	£750
Hewlett Packard 8405A – Vector Voltmeter	£500
Hewlett Packard 8165A – 50MHz Programmable Signal Source	£1650
Hewlett Packard 8350B – Sweep Oscillator Mainframe (various Plug-ins available) extra	£2650
Hewlett Packard 8152A – Optical Average Power Meter	£1250
Hewlett Packard 8158B – Optical Attenuator (OPTS 002 + 011)	£1100
Hewlett Packard 8180A – Data Generator	£1500
Hewlett Packard 8182A – Data Analyser	£1500
Hewlett Packard 83554A – Wave Source Module 26.5 to 40GHz	£3500
Hewlett Packard 8620C Sweep oscillator mainframe	£400
Hewlett Packard 8684A 5.4GHz to 12.5GHz Sig-Gen	£2750
Hewlett Packard 8620C Sweep oscillator mainframe	from £250
Hewlett Packard 8656B – Synthesised Signal Generator	£2950
Hewlett Packard 8750A Storage normaliser	£375
Hewlett Packard 8756A – Scaler Network Analyser	£2000
Hewlett Packard 8757A – Scaler Network Analyser	£2750
Hewlett Packard 8903A – Audio Analyser (20Hz – 100KHz)	£2600
Hewlett Packard 8958A – Cellular Radio Interface	£4000
Hewlett Packard 8901A – Modulation Analyser	£3400
Hewlett Packard 8920A – R/F Comms Test Set	£6000
Hewlett Packard P382A Variable Attenuator	£250
Hewlett Packard 1630D – Logic Analyser (43 Channels)	£650
Hewlett Packard 16500A – Fitted with 16510A/16515A/16530A/16531A – Logic Analyser	£4000
Hewlett Packard 11729B – Carrier Noise Test Set	£2000
Krohn-Hite 2200 Lin/Log Sweep Generator	£995
Krohn-Hite 4024A Oscillator	£250
Krohn-Hite 5200 Sweep. Function Generator	£350
Krohn-Hite 6500 Phase Meter	£250
Marconi 2019 – 80KHz – 1040MHz Synthesised Sig. Gen	£1850
Marconi 2019A – 80KHz – 1040MHz – Synthesised Signal Generator	£1950
Marconi 2022A – 10KHz – 1GHz AM/FM Signal Generator	£2000
Marconi 2432A 500MHz digital freq. meter	£200
Marconi 2610 – True RMS Voltmeter	£850
Marconi 2871 Data Comms Analyser	£1000
Marconi 2955 – Radio Comms Test Set	£3000
Marconi 2950A – Radio Comms Test Set with Cellular Adaptor	£3500
Marconi 6960 – Power Meter & Sensor	from £950
Marconi 6960A – Power Meter & Sensor	from £1050
Philips PM 5167MHz function gen.	£400
Philips 5190 L.F. Synthesiser (G.P.I.B).	£800
Philips PM5519 – TV Pattern Generator	£350
Philips PM5667 – Vectorscope	£500
Philips PM5716 – 50MHz Pulse Generator	£525
Philips PM6652 – 1.5GHz Programmable High Resolution Timer/Counter	£900
Philips PM6670 – 120MHz High Resolution Universal Counter	£350
Philips PM6673 – 120MHz High Resolution Universal Counter	£430
Prema 4000 – 6 ½ Digit Multimeter (NEW)	£450
Racal 1992 – 1.3GHz Frequency Counter	£800
Racal Dana 9081/9082 Synth. sig. gen. 520MHz	from £500
Racal Dana 9084 Synth. sig. gen. 104MHz	£450
Racal Dana 9303 R/F Level Meter & Head	£650
Racal Dana 9917 UHF frequency meter 560MHz	£175
Racal Dana 9302A R/F multivoltmeter (new version)	£375
Racal Dana 9082 Synthesised am/fm sig gen (520MHz)	£500
Racal 9301A – True RMS R/F Multivoltmeter	£300
Racal 9921 – 3GHz Frequency Counter	£450
Rohde & Schwarz LFM2 – 60MHz Group Delay Sweep Gen	£1600
Rohde & Schwarz SMFP2 – 1GHz Radio Comms T/set	£2500
Rohde & Schwarz UPSF2 – Video Noise Meter	£1400
Rohde & Schwarz URE – RMS Voltmeter (10Hz-25MHz)	£500
Rohde & Schwarz Scud Radio Code Test Set	£300
Rohde & Schwarz SUF 2 Noise Generator	£300
Rohde & Schwarz UPGS – Psophometer	£150
Rohde & Schwarz SMDU – 15MHz to 525MHz Signal Gen (FM & AM)	£500
Schaffner NSG 203A Line Voltage Variation Simulator	£950
Schaffner NSG 222A Interference Simulator	£850
Schaffner NSG 223 Interference Generator	£850
Schaffner WSG 431 Electrostatic Discharge Simulator	£1250
Schlumberger 4923 Radio Code Test Set	£950
Schlumberger 4031 – 1GHz Radio Comms Test Set	£7000
Schlumberger 2720 1250MHz Frequency Counter	£500
Schlumberger 7060/7065/7075 Multimeters	from £350
Solartron 1250 – Freq. Response Analyser	£2500
Stanford Research DS 340 – 15MHz Synthesised Function (NEW) and arbitrary waveform generator	£1200
Systron Donner 6030 – Microwave Frequency Counter (26.5GHz)	£2500
Telequipment CT71 Curve Tracer	£250
Tektronix TM5003 + AFG 5101 Arbitrary Function Gen	£1750
Tektronix 1240 Logic Analyser	£500
Tektronix DAS9100 – Series Logic Analyser	£500
Tektronix – Plug-ins – many available such as SC504, SW503, SG502, PG508, FG504, FG503, TG501, TR503 + many more	£POA
Tektronix 577 Curve Tracer	£1150
Tektronix AM503 + TM501 + P6302 – Current Probe Amplifier	£995
Tektronix PG506 + TG501 + SG503 + TM503 – Oscilloscope Calibrator	£1995
Tektronix AA5001 & TM5006 M/F – Programmable Distortion Analyser	£2500
Tektronix 577 – Curve Tracer	£1150
Time 9811 Programmable Resistance	£600
Time 9814 Voltage Calibrator	£750
Toellner 7720 – Programmable 10MHz Function Gen (AS NEW)	£700
Valhalla Scientific – 2724 Programmable Resistance Standard	£P.O.A.
Wandel & Goltermann PCM4 (+ options)	£9950
Wayne Kerr 4210 – LCR Meter	£600
Wayne Kerr 4225 – LCR Bridge	£600
Wayne Kerr 6425 – Precision Component Analyser	£275
Wayne Kerr 8905 – Precision LCR Meter	£850
Wavetek 171 – Synthetised Function Generator	£250
Wavetek 172B Programmable Sig Source (0.0001Hz – 13MHz)	£P.O.A.
Wavetek 184 – Sweep Generator – 5MHz	£250
Wavetek 3010 – 1-1GHz Signal Generator	£1250
Wiltron 6620S – Programmable Sweep Generator (3.6 – 6.5GMz)	£650

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Higher Education in electronics

SPECIAL

Postgraduate Studies and Research

Students considering an advanced Degree in Electronics or Computing need top-level qualifications, but have a wide choice of research departments to apply to.

In our last issue, this feature had a look at some of the courses for students of electronics engineering and computer science up to Degree level.

It's well know that the number of students taking college courses has risen over the last couple of decades as formal quaiifications have become important to employers. Some people blame this effect on lower academic standards (on one hand) and insufficient on-the-job training by industry (especially the lack of apprenticeships) on the other hand. A revival of apprenticeships, and the arrival of NVQs (National Vocational Qualifications) in recent years are beginning to address the latter criticism. But the trend to more higher education has seen a sharp rise in the number of postgraduate students - people with degrees or equivalent higher qualifications opting to continue or return to their studies at an even higher level - in the last five years.

One reason for this has been the difficult employment situation in the UK over the economic recession period of the early 90s - which has by no means entirely passed away. Many already well-qualified and/or experienced people found themselves in a situation where their best option was to return to higher education for one, two or three years in the hope of making themselves more competitive in a difficult job market, or simply of using their time constructively. Many students emerging from first degree courses were in the same position, and so more of those with good results (and access to some financial resources) decided to continue their studies and research.

UK graduates can generally obtain a grant for one or two years of further accredited vocational training, but it is less easy to get financial help for Masters or Research studies. Some colleges have a limited number of scholarships or bursaries to help students in some subjects, usually those with strong industrial links, but in general postgraduates doing a Masters or Research degree will have to find most or all of their own finance. More higher degree students, for instance, take regular paid work throughout their degrees, in the American style, than do undergraduate students, who are still often actively discouraged from working while studying, for obvious reasons. Once at Postgraduate level, not only is it acknowledged that the student is likely to be beyond resources often available to younger people (like financial help from parents), but the older student is expected to have sufficient experience of study be ready to balance research with some other obligations. Many working people are also studying, but on a part time basis. Full time research does not mix with heavy work obligations, so the postgraduate student must be ready to take our further student loans, or have other resources.

Anyone thinking of studying for a further degree is advised to look carefully at where their studies could apply to industry, and what industrial and commercial support there is for their field within the colleges they are applying to. Strong links with the "outside world" are valuable to everyone concerned, both during study and research, and when the student enters a commercial environment full-time.

Imperial College, London

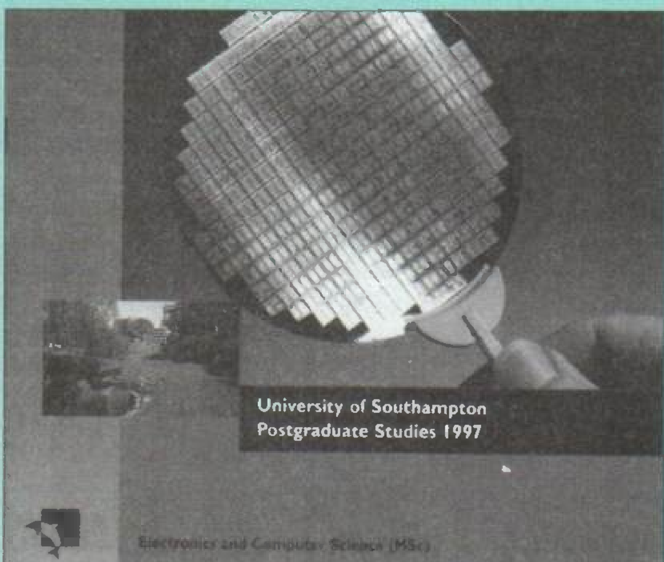
Imperial College of Science, Technology and Medicine is one of the best-known specialist colleges in the United Kingdom. The reputation - and the staff - of the college is international, and Imperial has had strong links both with industry and government from its earliest days in the late 19th and early 20th century. Imperial is part of London University. Like Oxford and Cambridge, the individual colleges of the University are known simply by their "college" names, but unlike Oxford and Cambridge, where the colleges are mainly accommodation and tutoring establishments, sharing many academic resources and departments, London colleges are complete establishments each with its own departments or faculties.

Imperial College's Department of Electrical and Electronic Engineering offers postgraduate education through both taught courses - leading to an MSc degree of the University of London and the Diploma of the Imperial College (DIC) - and research programmes, leading to the DIC, MPhil (Master of Philosophy) or PhD (Doctor of Philosophy). The MSc courses on Communications and Signal Processing, and Control Systems, are both currently accepted by the Engineering and Physical Sciences Research Council as suitable for tenure of its Advanced Course Studentships. The course on Physical Sciences and Engineering in Medicine is run with the Centre of Biological and Medical Systems, and is taught by their staff; the course in Semiconductor Science and Technology is run by the department jointly with the Departments of Materials and of Physics. There are two new MSc courses, in Analogue and Digital Integrated Circuit Design, and in Power Engineering: Control and Optimisation. These are all 12-month full-time courses requiring a first or good second class Honours degree in Electrical Engineering, or an equivalent to qualify for entry.

Research in the Department is conducted through a number of sections. In outline, the current sections include Analogue and digital circuit design; Biomedical systems engineering; Control and instrumentation; Digital communication; Energy and electromagnetics; Information engineering; Intelligent communications systems; Neural systems engineering; Optical and semiconductor devices, Signal processing; Solid state electronics and Thin films. Full details of the current programmes can be obtained from the Department, which produces a detailed Research Report. The normal qualification for research training is a First or Upper Second Class Honours Degree in Electrical Engineering.

The Department of Computing offers two full-time courses, both leading to an MSc degree of the University of London and/or the Diploma of the Imperial College. These are Computing Science (primarily a conversion course for graduates without computing) and Advanced Computing, training in IT research which also acts as an introduction to research degree study in the Department. Research in the Department is based in two centres, IC Parc, and Imperial College/Fujitsu Parallel Computing European Research Centre.

The research sections are Advanced Language and Architectures; Applied Systems and Decision Support; Distributed Software Engineering; Logic and Automated Reasoning; Logic Programming; and Theory and Formal Method. The booklet Postgraduate Study In Computing describes the options in more detail and can be obtained from the Assistant Registrar (Admissions).



The University of Southampton

The Department of Electronics at the University of Southampton was established in 1947, the first in any UK university, and combined with the Department of Computer Studies in 1986 to form the Department of Electronics and Computer Science as part of a major expansion in Information Technology - at a time when IT was beginning to gain public notice - within the University. It is the largest department of its kind in the UK, with over 50 academic staff and teaching and research covering every aspect of electronics and computer science, including the fabrication of integrated circuits, parallel processing and computer systems, signal processing, program and algorithm design. Alone among universities, Southampton was chosen by the Engineering and Physical Sciences Research Council (EPSRC) to host a microelectronics fabrication facility, that also provides advice and fabrication facilities to industry and other academic institutions.

Southampton also hosts the Institute of Transducer Technology, a Transputer Support Centre and an Interdisciplinary Research Centre (IRC) concerned with optoelectronic technology. An unusual feature of the Department of Electronics and Computer Science is that it is a department within the Faculty of Engineering and Applied Science. They are separate from the Department of Electrical Engineering and the Faculty of Mathematical Studies, which in many universities are the location for studying electronics and computer science respectively. Here, electronics is taught as a discipline in its own right, and Computer Science is taught from the standpoint of software engineering with a strong emphasis on working software systems. There is a greater degree of specialisation available. The Department also has close links with industry, with a number of engineers from industry providing specialist teaching to support courses from a commercial viewpoint.

The Department runs advanced MSc courses in four areas: Microelectronics Systems Design, Radio Frequency Communication Systems, Instrumentation and Transducers, and Optical Fibre Communications. The basic courses take one year to cover, and may be studied full-time or part-time (over two years). The normal entry requirement is a Second Class Honours Degree in an appropriate subject (normally physics, maths, engineering (including electronic) or computer science, although the University will look at applicants with other applicable qualifications (for instance, the Engineering Council Part 2 examination) and/or experience. The department issues pre-course reading lists to applicants to make sure that they are up to speed if they are accepted for a course, and specifically warns against expecting to undertake part-time employment to support themselves while attending a full-time course. The college, like most institutions of higher education, will also advise on possible sources of grants and other funding, but prospective students must remember that grants and scholarships for higher studies are the exception, rather than the rule, for students who do not already have industrial sponsorship.

Research at Southampton is organised into research groups usually consisting of academic staff, fully time research staff (usually with industrial experience) and research students. As

they succinctly describe it: "The normal method of progress is for a supervisor in the first year to tell you what to do, in the second year you discuss the project together, while in the third eyar to tell your supervisor what he or she is doing!". Initially research students are registered for a Master of Philosophy degree. After 12 to 18 months and a successful thesis, this can be re-registered as a PhD (Doctor of Philosophy, the highest standard degree qualification level) which is normally expected to take three years to complete.

The current Research Groups in the department include Communications (digital cellular mobile systems), Design Automation (simulation, synthesis and testing techniques underlying CAD systems); Concurrent Computation (parallel processing) and Image Speech and Intelligent Systems (ISIS). These are only a sample of the research groups currently in progress.

De Montfort University, Leicester

De Montfort University offers MPhil (1-2 years full-time, 2-4 years part-time) and PhD (2-3 years full-time, 3-5 years part-time) qualifications, with the option to register for MPhil with the possibility of transfer to PhD after 18 months. Research at the University is conducted in partnership with, or on behalf of, large and small industrial and commercial concerns, as well as public sector organisations. The development of European and international links allows research to be carried on with organisations outside the UK through European initiatives such as BRITE/EURAM.

The University's recently opened Science and Engineering Research Centre (SERCentre) currently supports the work of several research units, and assists the carrying-on of multi-disciplinary and cross-disciplinary research among the teams. Separately, a Research Unit exists to carry out the administration for registered research degree students throughout the university.

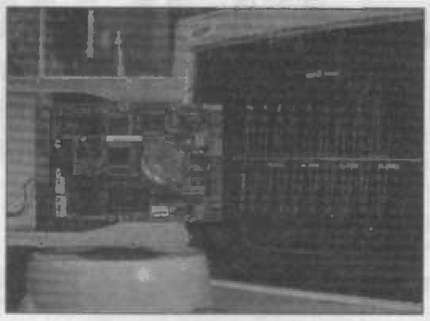
There are a number of research schools that may have courses of interest to people with a background in electronics, computing or physics, including Applied Sciences, Computing Sciences, Engineering and Manufacture (which includes the department of Electronics and Electrical Engineering) and the Science and Engineering Research Centre (SERCentre). The School of Applied Sciences, for instance, has the Solid State Research Centre, dealing with cross-disciplinary Physical and Materials Science Research. Computing Sciences supports research programmes in computing, information systems, mathematical sciences and medical statistics. The Department of Electronics and Electrical Engineering, in collaboration with engineering giant Lucas, the Rutherford Appleton Laboratory, and Daresbury (part of the Engineering and Phusical Sciences Research Council) is one of the leading institutions in microengineering. A number of the research activities are interdisciplinary and the research groups have a commitment to applied and strategic research.

The Science and Engineering Research Centre includes research groups in Emerging Technologies (microelectronics), water software systems, computer imaging, communication networks and systems engineering. There are also a number of MSc programmes offered in the University.

What research?

Students moving on from first degrees to higher degrees will need to think carefully about whether they want to go more deeply (that you are going in deeply goes without saying) into the area they are interested in, or whether they are more

Below: An electrodynamic shaker is shown being used to identify mechanical resonances in a disk drive. (Neville Miles LRPS)



interested in pursuing interdisciplinary aspects. Some colleges and research groups concentrate more on one than the other. It is normally safe to assume that all research groups have contacts with industry and interests outside the academic sphere, but you may want to know more about which industries and bodies are involved with the area you are interested in.

Nearly all research activity is sponsored by industry or government bodies, except in the rarer cases where the college is its own sponsor. There is not a completely open choice of areas in which to research. Certain research programmes are taking place at any time, and it is for these that the institutions are considering research applicants. A positive aspect of this is that your research should per se have practical relevance to a career path.

Some colleges routinely consider applicants with first degrees only, while others prefer PhD applicants to have obtained an MSc first, but all will consider applicants with any high-level qualifications even if these do not exactly fit their normal entrance requirements. All colleges will refer applicants to bodies who may offer grants, but the number of grants is limited. Also, the most demanding full time courses do not in practice allow for financing by working, and it would be unwise to plan on doing so.

Resources

Some of the useful books that we mentioned last month are listed below, but students already at college will find more information in their college careers advice office. The Registration departments of the colleges in question often produced more detailed literature about higher degrees for prospective students and, (where available), subject booklets provided by specific departments

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)

To obtain prospectuses from the colleges above, contact

The Assistant Registrar (Admissions), Imperial College of Science, Technology and Medicine, London SW7 2AZ. Tel 0171 589 511 Fax 0171 594 8004.

(Imperial College also publishes *Postgraduate Study in Electrical and Electronic Engineering,Research Report '95-'96'* and *Postgraduate Study in Computing.)*

The Prospectus Enquiries Office, University of Southampton, SO17 1BJ. Tel 01793 592379 Fax 01703 593037.

De Montfort University Leicester, The Gateway, Leicester LE1 9BH. Tel 0116 255 1551 FAx 0116 255 0307.

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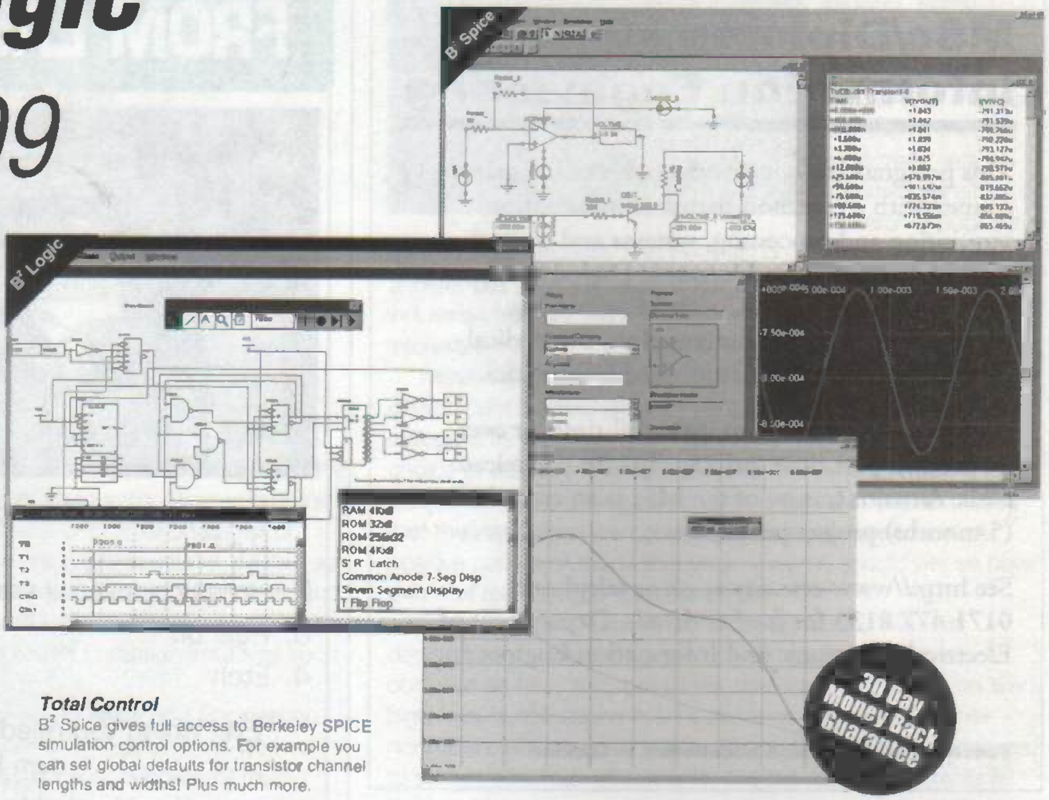

- Design and test analogue and digital circuits quickly and easily
- Incorporates a dedicated model editing package
- Fast 32 bit SPICE 3F5 engine
- Windows 3.1/95/NT
- Mac version also available
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Fully Integrated and Interactive
Build the circuit on the screen and set up the simulations by choosing options from menus and dialogues. Then run the simulation and view your results.

Flexible Visualisationof Results
In B² Spice results can be displayed in graphs, tables or directly in voltmeters and ammeters. Change from typical to worst case analysis and include the effectsof temperature on components. You can customise everything, right down to the colour of an individual trace so you see just what you need. B²Spice and B² Logic let you export data to other applications.

Versatility
A plethora of components include resistors, capacitors, inductors, mutual inductors / transformers, controlled sources, bipolar junction transistors, zener diodes, power MESFETs, JFETs, MOSFETs, voltage regulators, operational amplifiers, opto-couplers, voltage comparators, quartz crystals, IBIS I/O buffers and switching matrix connectors and much more ***All devices and model parameters can be edited to suit your needs.*** Implement hierarchical circuits in your designs quickly and easily

No Limits
With B²Spice and B² Logic there is no limit on the number of components in the circuit.

Models
There are literally thousands of them... The complete Berkeley SPICE model library as well as commercial libraries from manufacturers such as, **Motorola, Texas Instruments, Burr-Brown, Maxim, National Semi, APEX Comlinear, AMP, Elantec, Linear Tech,** and many more. Included with B²Spice is a full model and symbol editing package so you can create, import and edit custom models.

Commands
B² Spice supports AC frequency sweep, DC operating point, transient analysis, fast fourier Noise, sensitivity distortion, Tf small signal transfer.

Simulation Options
Added facility for sub-circuits (macro-models).
You can set all simulation options.
Allows you to set initial conditions at all nodes.
Allows you to set initial guess at nodes for simulation.
Allows "not given" state for all values.

Total Control
B² Spice gives full access to Berkeley SPICE simulation control options. For example you can set global defaults for transistor channel lengths and widths! Plus much more.

Waveform Analysis
Display and compare multiple response curves in a single graph at the same time. B²Spice simulation results can be selectively displayed and analysed graphically and in numerical format as well as exported to other applications. All of B²Spice and B² Logic's display capabilities are completely flexible.

Devices & Stimulus for Simulation
In B² Spice sinusoidal, constant, periodic pulse, exponential, single frequencyFM, AM, DC voltage, AC voltage, VCO, Vcc, piecewise linear, exponential, polynomial /arbitrary source, voltage-controlled voltage, voltage-controlled current, current-controlled voltage, current-controlled current, Lossy and ideal transmission line, MESFET uniform RC, current and voltage switches are all available.

Cross Probing
Cross probing allows you to display waveform results simply by marking pins, wires and devices on the circuit drawing. Monitor results while the simulation is in progress then plot analogue results on linear or log scales.

Graphs
In B² Spice analogue traces may be displayed as raw voltages and current values or further processed using arithmetic expressions, functions and Fast Fourier Transforms.High quality graphs let you see just what you need to, clearly and easilyYou can also display multiple simulations in one graph. Multiple graphs can then be aligned and compared.

Data Analysis
Position detection with mouse for data points. Import and export data to and from other industry standard SPICE programs. B² Spice supports Polar, Smith and Nyquist charts.

Digital Options.
B² Logic is completely flexible. Set up ROM, RAM and PLA to your own requirements. Shrink a whole circuit to a block and use it as a component in a new design. Run the simulations in real time or step by step. Customise rise and fall time of all components. Results displayed in a logic analyser or table. Select parts from all major logic families. Create your own custom libraries. Create and run pre-programmed simulations.

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Digitally Controlled Power Supply

Robert Penfold's power supply with PIC-controlled stability will not suddenly provide a high voltage on switch-on if you forget to readjust it

When using a variable voltage bench power supply unit you need to take due care to avoid the classic mistake of connecting the supply to your latest circuit, switching on, and then discovering that your 5 volt logic circuit is being supplied with about 20 volts! Some up-market power supply units avoid this possibility by having the supply always start at its minimum output voltage at switch-on. In most cases this means that the supply always starts with zero output voltage, and therefore fails to supply any output signal at all until the user has set the required output potential.

Although this feature is normally only found on expensive digital bench power supply units, it can be included on relatively low cost power supplies. In fact it does not require the use of digital electronics and can be provided using an analogue circuit. However, it is difficult to obtain really good stability using an analogue design which has to rely on a capacitor "remembering" the set output voltage. Even using the highest quality components together with the usual precautions such as earth rings does not guarantee good results. Over a period of time the output voltage will change slightly, and over a period of hours if it is likely to change quite radically.

For a reasonably simple power supply that will start from zero and provide good stability, it is necessary to use some basic digital electronics. This power supply unit has a simple digital control circuit that is basically just a PIC microcontroller that acts if as a form of up/down binary counter. At switch-on the counter it is set at zero which in turn sets the output potential at zero. The output voltage is controlled via four pushbutton switches, and two of these enable the output potential to be increased. The difference between the two is that one changes the voltage quite rapidly while the other gives a much slower change in the output voltage. Using the "fast" button enables the user to rapidly set an approximation of the required output potential, and the "slow" button is then used to set precisely the required voltage. The other two pushbutton switches provide the same basic function but enable the output voltage to be reduced.

The output voltage range of the supply is zero to 20 volts with a maximum output current of 1.4 amps. The output voltage can actually be set as high as 25 volts, but at output potentials of more than about 20 volts the maximum output current is less than 1.4 amps. The maximum output current is typically only about 250 milliamps with the output at 25 volts. The circuit is protected against overloads by output current limiting that prevents the output current from exceeding more than about 1.8 amps even with a short circuit on the output. When testing low current circuits the current limiting can be set to a lower level of about 180 milliamps. An analogue voltmeter monitors the output voltage so that the required output potential can be set, and this also provides a warning if an overload should occur. The output noise is less than 500uV at most output voltages and currents, and the output regulation is extremely good.

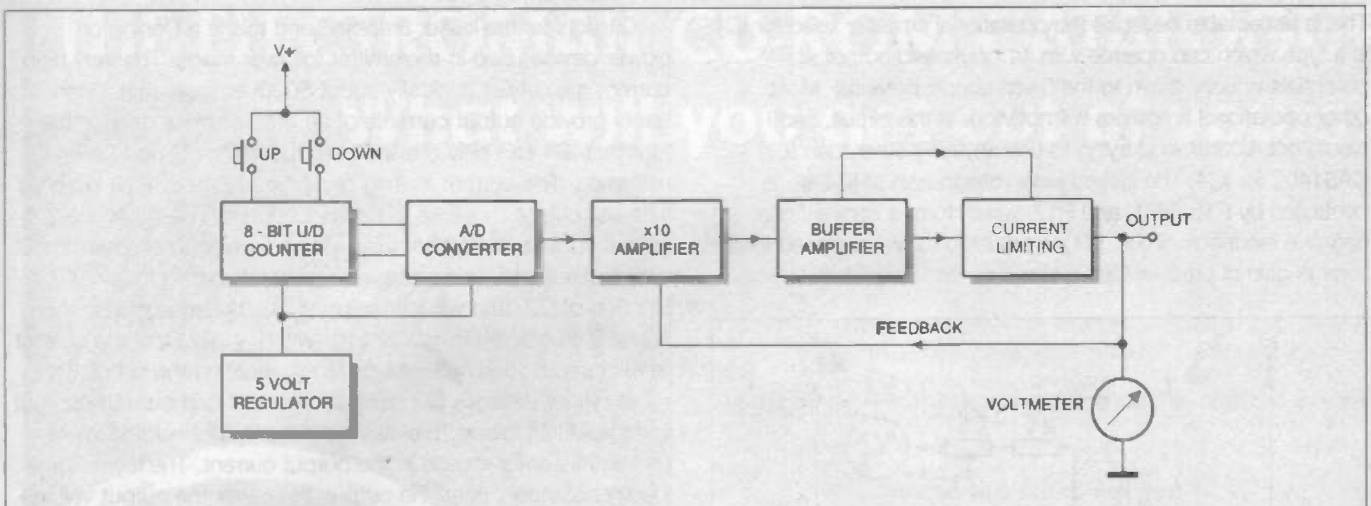


Figure 1: the block diagram for the Digitally Controlled PSU

System Operation

The hardware is greatly simplified by the use of a PIC processor to provide the basic up/down counter function. The block diagram of figure 1 shows the basic arrangement used in this power supply unit. A digital to analogue converter is fed with the eight-bit output from the PIC processor and it provides an output voltage that is equal to 10 millivolts (0.01 volts) per lsb. The maximum count from an eight-bit counter is 255 (decimal), but in this case we require the count to go no higher than 250 so the maximum output voltage is 2.5 volts. After amplification by a factor of 10, this provides an output voltage range of 0 to 25 volts with a resolution of 0.1 volts. The PIC software is used to restrict the count to no more than 250. The counter and converter stages are power from the main 30 volt supply via a 5 volt regulator, but the rest of the circuit is powered from the unregulated 30 volt supply.

A buffer amplifier at the output of the x10 amplifier enables the circuit to handle high output currents, but a standard current limiting circuit pulls the output voltage lower if an excessive output current is detected. This limits the output current to a safe level even with a short-circuit across the output terminals. The negative feedback loop to the x10 amplifier is taken from the output of the circuit so that the feedback compensates for the voltage drops through the buffer amplifier and current limiting circuit. An analogue voltmeter is used to monitor the output potential, and enables the output voltage to be set with good accuracy.

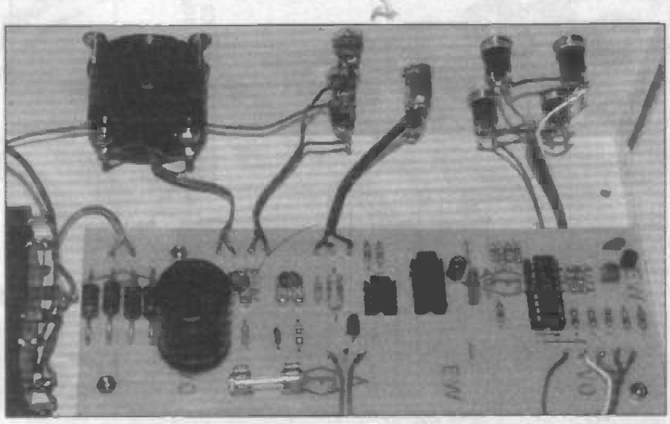
Circuit Operation

Figure 2 shows the main circuit diagram for the Digitally Controlled PSU, but the circuit for the unregulated supply generator is shown separately in figure 3. Taking figure 2 first, IC1 is the PIC processor, and this is a 16C84-04. This is the 4MHz version of the chip, and in this circuit it is used with a C - R clock generator that has R1 and C1 as the discrete timing components. These set the clock frequency at about 14 to 15kHz, but the exact clock frequency is not critical in this application. The C - R clock mode is therefore perfectly adequate.

Port A of IC1 is set as inputs and used to read the four pushbutton switches (S1 to S4). These inputs are normally taken low by pull-down resistors R2 to R5, but operating on of the pushbutton switches takes its respective input high. Port B is an eight-bit type, and it is used to drive the digital to analogue converter. There is a minor problem in that the Port B lines default to the input mode at switch-on, and there is a short delay before the program sets them as outputs. During this time they tend to drift high, producing a brief output signal at 25.5 volts. This could obviously prove fatal for any low voltage circuit connected to the output of the unit at switch-on. Resistors R6 to R13 act as pull-down resistors on IC1's outputs, and these ensure that the outputs remain low while the program goes through its setting up routine.

The analogue to digital converter is a Ferranti ZN426E (IC2), and this has a built-in precision voltage generator. IC2 requires discrete load resistor R14 and decoupling capacitor C2, but is otherwise self-contained. IC3 is a low power monolithic voltage regulator which provides a stabilised 5 volt supply to the counter and converter circuits. Series resistor R16 is used at the Input to IC3 to reduce its input voltage. This helps to keep the dissipation in IC3 down to an acceptable level, and ensures that it is not fed with an excessive input voltage.

IC4 acts as the x10 amplifier, and this is almost a standard non-Inverting mode amplifier circuit. It only differs from the standard configuration In that no negative supply rail is used.



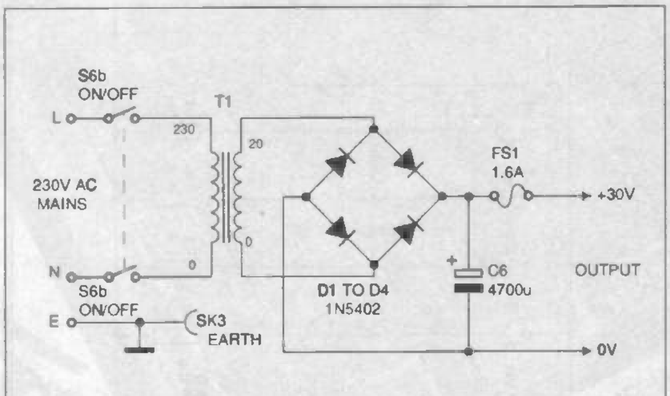


Figure 3: the circuit diagram for the rectifier and smoothing stages of the unit

This is acceptable because the operational amplifier used for IC4 is a type which can operate with its inputs and output at potentials virtually down to the 0 volt supply potential. Most other operational amplifiers will not work in this circuit, and I would not recommend trying to use anything other than a CA3140E for IC4. The closed loop voltage gain of IC4 is controlled by R15, VR1, and R17, which form a conventional negative feedback circuit. VR1 is adjusted to give a closed loop voltage gain of precisely ten.

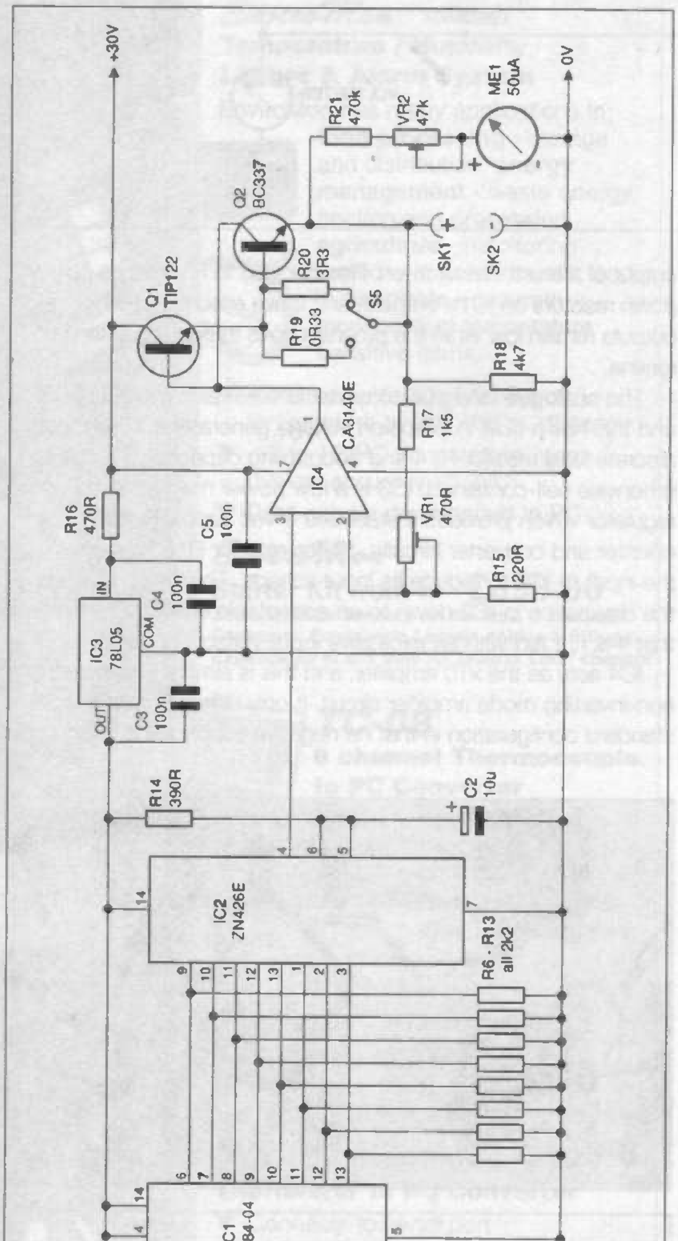


Figure 2: the main circuit diagram for the Digitally Controlled PSU

Q1 acts as the buffer amplifier, and this is a Darlington power device used in the emitter follower mode. The very high current gain of Q1 (typically about 5000) ensures that it can easily provide output currents of an amp or more despite the fact that IC4 can only provide output currents of up to a few milliamps. The current limiting circuit uses R19 or R20 in series with the output to sense the output current. The larger the output current, the higher the voltage developed across the selected resistor. This voltage is fed to the base-emitter junction of Q2, and will forward bias Q2. Voltages of less than about 0.6 volts are insufficient to switch on Q2, and the current limiting circuit then has no significant affect on the circuit.

At higher voltages Q2 starts to conduct and pulls the output voltage of IC4 lower. This also pulls the output voltage lower, and resists any increase in the output current. The lower the load resistance across the output, the lower the output voltage is pulled. Even with a short circuit across the output, the output current will be kept at a safe level, and the output potential will be reduced to virtually zero. With R19 switched into circuit the output current is limited to around 1.8 to 1.9 amps. This is low enough to ensure that the circuit is not damaged in the short term, but it is high enough to ensure that the maximum output current of 1.4 amps can be delivered without the current limiting starting to operate. The higher value of R20 gives a lower limit current of around 180 to 190 milliamps.

R18 is the output load resistor, and it ensures that the output current is always high enough to keep the output circuitry functioning properly. ME1 is used in a simple analogue voltmeter circuit that has a full scale voltage of 25 volts. VR2 is set to give the voltmeter the correct sensitivity.

The basic 30 volt supply is provided by the circuit of figure 3, and this is a conventional full-wave circuit having bridge rectification provided by D1 to D4. C6 is the smoothing circuit, and fuse FS1 protects this circuit if a fault should occur in the control and regulator circuitry. A separate earth socket (SK3) is provided so that either output rail can be earthed, or the unit can be used as a "floating" supply with neither output rail earthed. However, for safety reasons the chassis of the unit must be permanently (and reliably) earthed to the mains earth lead.

Software

The PIC software first sets up port B as eight outputs, and leaves port A as four inputs. A value of 0 is written to port B initially so that all eight outputs are set low, and zero volts is produced at the output of the unit. The program then goes into a loop which reads port A and tests each bit in turn. The programs loops until it detects that an input line has gone high (one of the pushbutton switches has been operated), and it then goes to the appropriate one of four subroutines.

Two of these subroutines increment the value stored in the COUNT register, and then output the new value to port B. However, a check is made first to determine whether the count has reached 0xFA (250 decimal). The subroutine is aborted if this value has been reached. Both subroutines finish with a delay loop, but one provides a much longer delay than the other. This gives the fast and slow increments of the output voltage, but note that both routines provide full resolution and differ only in their rate of change. Basically similar routines are used to decrement the output voltage, but these check to see if the count has reached zero, and abort the subroutines if it has. Again these two routines only differ in the length of the delay provided at the end of the routines.

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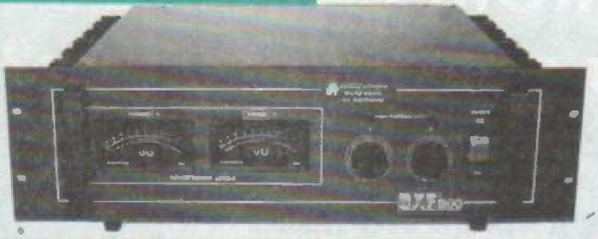

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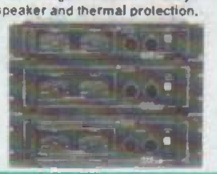

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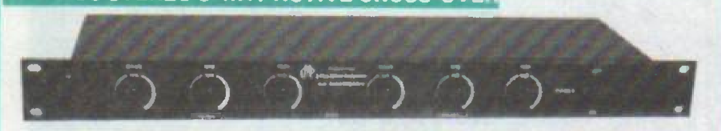

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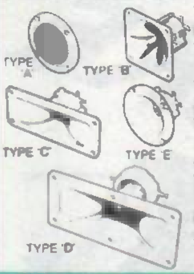

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Construction

Details of the printed circuit board are provided in figure 4. Although this project is not particularly difficult to construct, there are a number of points that are worthy of note. One of these is simply that this is a mains powered project, and as such it is not suitable for beginners. The mains supply is potentially lethal, and only those with the appropriate experience should undertake projects that connect to the mains.

The 16C84-04 (IC1) and CA3140E (IC4) are both MOS devices, and as such they require the normal anti-static handling precautions. Use holders for both devices, but do not plug them into circuit until the unit is in other respects finished. They should be supplied in some form of protective packing, and they should be left in this until it is time for them to be fitted in the holders. Try to touch their pins as little as possible when fitting these components into the holders, and keep them well away from any known sources of static electricity. The ZN426E used for IC2 is not a MOS input device, but it is not particularly cheap either, so it is also advisable to use a holder for this component as well.

Smoothing capacitor C6 will only fit onto the printed circuit board if it is a modern type such as the Maplin "HC Series Snap-In Radial Electrolytic" used on the prototype. It is possible to use a large "can" type electrolytic, but it would have to be fixed on the case using a suitable mounting clip, and then hard wired to the circuit board. Make absolutely certain that rectifiers D1 to D4 are fitted with the correct polarity, as mistakes here could cause costly damage. They could even be dangerous.

As ever with mains projects, take particular care and seek assistance from an experienced constructor if you yourself do not have mains construction experience.

Fuse FS1 is mounted on the printed circuit board by way of two 20 millimetre fuse clips (Maplin "Type 1" or similar). Alternatively, FS1 can be fitted in a panel mounting fuse-holder fitted on the rear panel of the case and hard wired to the printed circuit board. Do not overlook any of the link-wires. There are five of them, including one immediately above IC1, and one immediately below IC2.

Power transistor Q1 has to dissipate quite large amounts of power when the supply is used with low output voltages and high output currents. This results in the generation of a fair amount of heat, and Q1 will quickly be destroyed unless it is mounted on a substantial heatsink. The cheapest option is to mount Q1 on the metal case which then acts as a large heatsink. If the unit is likely to be used for long periods to supply low voltages and high currents, it would be advisable to fit a large heatsink having a rating of about 1.8 degrees per watt or less to the rear panel of the case. Q1 is then mounted on this, and hard wired to the circuit board via leads which pass through holes drilled in the heatsink and the rear panel of the case.

Whether Q1 is mounted on a heatsink or direct onto the case, it must be insulated from the heatsink and (or) case using a TO220 insulating kit. This consists of a thin mica or plastic washer which fits between Q1 and the heatsink or case, and a plastic bush which fits over the M3 or 6BA mounting bolt. The washer insulates Q1 from the case/heatsink, and the bush insulates Q1 from the mounting bolt (which is not insulated from the case). The side view of figure 5 shows how everything fits together. Make sure that the hole for the mounting bolt is properly deburred, because the thin washer is easily pierced. Once Q1 is in place,

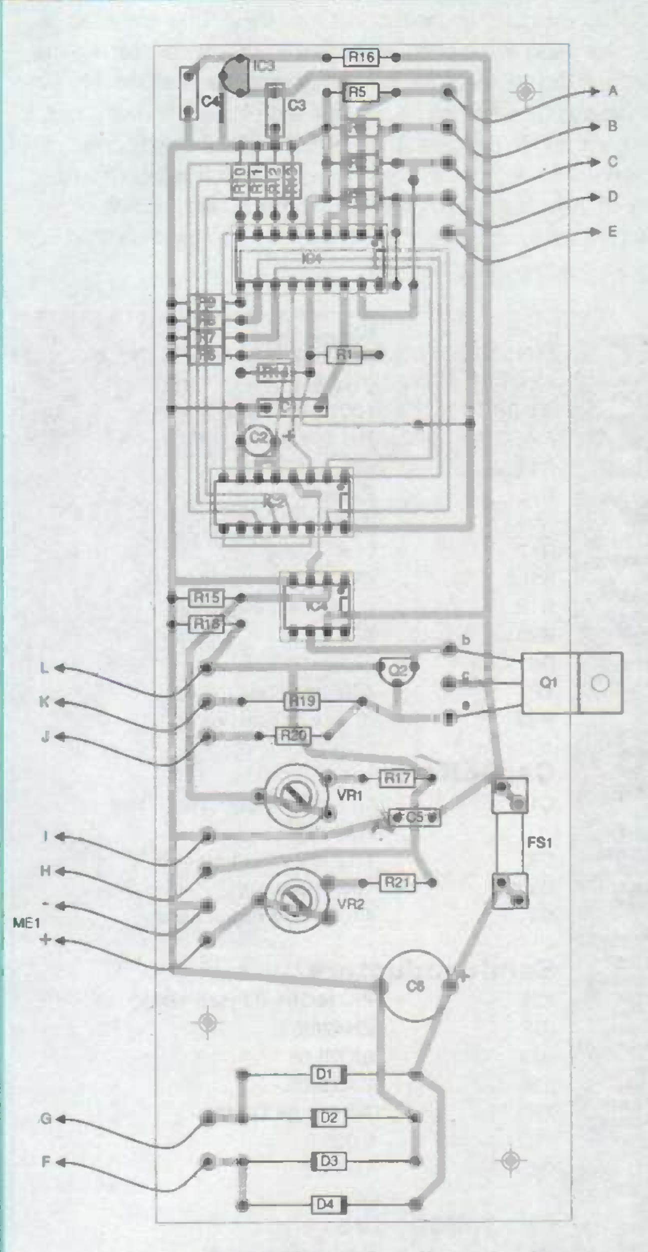


Figure 4: the component overlay for the PCB

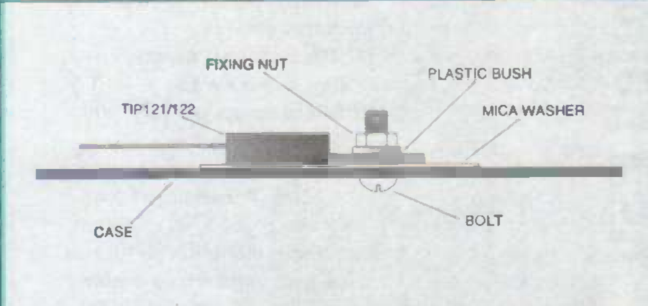


Figure 5: a TO220 insulating kit is used to insulate Q1 from the case/heatsink

use a continuity checker to ensure that it is properly insulated from the case. A break in the insulation could result in a short-circuit on the unregulated 30 volt supply, but FS1 should "blow" and prevent any major damage if this should occur.

As this project is mains powered it must be housed in a metal case, and it is essential that the case is earthed to the mains earth lead. A soldertag fitted on one of T1's mounting bolts provides a strong and reliable chassis connection point. A metal instrument case about 250 millimetres wide and at least 75 millimetres high should comfortably accommodate everything. T1 is mounted on the base panel of the case, as far to the right as possible, so that there is sufficient space for the printed circuit board to its left. The printed circuit board can be mount using plastic stand-offs, or it can be bolted to the case. If it is bolted in place, use spacers at least 6 millimetres long to hold the underside of the board well clear of the metal case. A hole for the mains lead is drilled in the rear panel of the case near to T1, and this hole must be fitted with a grommet to protect the cable.

PARTS LIST for the Digitally Controlled PSU

Resistors (All 0.6W 1 percent metal film unless noted)

R1-R5	10k (5 off)
R6-R13	2k2 (8 off)
R14	390R
R15	220R
R16	470R
R17	1k5
R18	4k7
R19	0R33 2.5W (see text)
R20	3R3
R21	470k
VR1	470R min hor preset
VR2	470k min hor preset

Capacitors

C1	1n5 polyester, 7.5mm lead spacing
C2	10u 25V radial elect
C3,4,5	100n ceramic
C6	4700u 35V radial elect

Semiconductors

IC1	PIC16C84-04 (see text)
IC2	ZN426E
IC3	uA78L05
IC4	CA3140E
TR1	TIP121 or TIP122
TR2	BC337
D1 - D4	1N5402

Miscellaneous

SK1	Red 4mm socket
SK2	Black 4mm socket
SK3	Green 4mm socket
S1 - S4	Non-locking push-to-make switches
S5	SPDT min toggle switch
S6	Rotary mains switch
T1	Standard mains primary, 20V 2.25A secondary
ME1	50uA moving coil panel meter
FS1	1.6A 20mm "quickblow" fuse

Metal instrument case about 250 x 150 x 75mm, printed circuit board, 18-pin dil holder, 14-pin dil holder, 8-pin dil holder, pair of 20mm fuse-clips, mains lead and plug, TO220 insulating kit, wire, solder, etc.

The front panel layout is not critical, but try to use one that is reasonably neat and practical. The only minor difficulty when fitting the components on the front panel is that the meter requires a large circular cut-out. For a normal 60 x 45 millimetre component a cut-out some 38 millimetres in diameter is required. This can be cut using an Abrafile, fretsaw, coping saw, miniature round file, etc., but it is advisable to cut just inside the perimeter of the required cut-out. The hole can then be enlarged to precisely the required size using a half round file. Alternatively, most DIY superstores now stock a device which is simply called a "hole cutter" (but is also known as a "tank cutter"). This is used in a brace, and can be set to produce a wide range of hole sizes. This tool produces reasonably neat and almost instant results.

Details of the hard wiring are provided in figure 6, which is used in conjunction with figure 4. The mains transformer (T1) should have a 20 volt secondary voltage and a current rating of at least 2.25 volts (a rating of at least 50VA). The modern trend is for mains transformers to have twin secondary windings which can be wired in series or in parallel. In this case either twin 10 volt secondaries wired in series, or two 20 volt secondary windings connected in parallel are required. In practice the only option is likely to be two 20 volt secondary windings connected in parallel, and this is the method of connection shown in figure 6. Note that parallel connection of secondary windings should only be used with transformers that are designed to be used in this manner. With other transformers it could result in one winding driving a large current through the other winding.

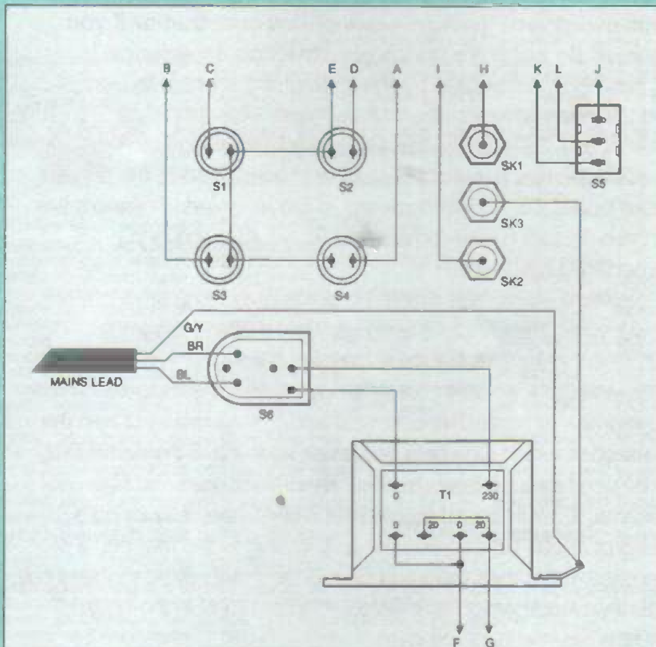
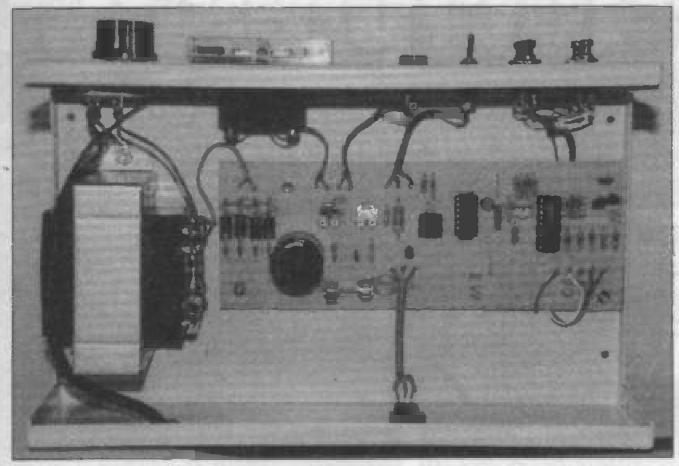


Figure 6: details of the hard wiring

Adjustment

With a mains powered project such as this it is essential to thoroughly check all the wiring before connecting the unit to the mains and switching on. Once you are sure everything is as it should be, set VR1 and VR2 at roughly middle settings and then switch the unit on. Initially the meter should indicate zero volts, but by operating the four pushbutton switches it should be possible to vary the output voltage. If there is any sign of a malfunction, switch off at once, disconnect the unit from the mains, and recheck the wiring, etc.

In order to give VR1 the correct setting, use a multimeter to measure the output voltage, and use the pushbutton switches to set the unit for maximum output potential. Then adjust VR1 for an



output voltage of 25 volts. Next VR2 is adjusted to give a reading of 25 volts on ME1, and the unit is then ready for use. The 0 to 50 scale on ME1 is easily converted into a voltage reading, but you might prefer to recalibrate the meter's scale. With most modern panel meters the front simply unclips, and removing two small screws then frees the scale plate. The existing numbers can then be carefully scraped off or painted over so that new figures can be added using rub-on transfers. Alternatively, the new figures can added immediately above the existing ones.

```
;*************************************************************
;Digitally Controlled PSU Program
;*************************************************************
;
STATUS      EQU     03
Z           EQU     02
BDIR        EQU     06
PORTA       EQU     05
PORTB       EQU     06
STORE       EQU     0C
COUNT       EQU     0D
DELAY       EQU     0F
        BSF     STATUS,5;Select page 1
        CLRW
        MOVWF   BDIR        ;Sets Port B as outputs
        BCF     STATUS,5 ;Select page 0
        CLRF    PORTB       ;Sets Port B to zero
        CLRF    COUNT       ;Sets count at zero
LOOP    MOVF    PORTA,0 ;Read Port A
        MOVWF   STORE       ;Store result
        BTFSC   STORE,0     ;Reads S1
        CALL    FASTUP
        BTFSC   STORE,1     ;Reads S2
        CALL    SLOWUP
        BTFSC   STORE,2     ;Reads S3
        CALL    FASTDOWN
        BTFSC   STORE,3     ;Reads S4
        CALL    SLDOWN
        GOTO    LOOP
FASTUP          MOVF    COUNT,0
        BCF     STATUS,Z
        XORLW   0xFA        ;Limits count to 250
        BTFSC   STATUS,Z
        RETURN
        INCF    COUNT,1
        MOVF    COUNT,0
        MOVWF   PORTB
        MOVLW   50
        MOVWF   DELAY
DELOOP          NOP
        DECFSZ  DELAY,1
        GOTO    DELOOP
        RETURN
SLOWUP          MOVF    COUNT,0
        BCF     STATUS,Z
        XORLW   0xFA        ;Limits count to 250
        BTFSC   STATUS,Z
        RETURN
        INCF    COUNT,1
        MOVF    COUNT,0
        MOVWF   PORTB
        MOVLW   0xFF
        MOVWF   DELAY
DELOOP2         NOP
        NOP
        NOP
        NOP
        DECFSZ  DELAY,1
        GOTO    DELOOP2
        RETURN
FASTDOWN BCF            STATUS,Z
        MOVF    COUNT,0
        BTFSC   STATUS,Z ;Aborts if count at zero
        RETURN
        DECF    COUNT,1
        MOVF    COUNT,0
        MOVWF   PORTB
        MOVLW   50
        MOVWF   DELAY
DELOOP3         NOP
        DECFSZ  DELAY,1
        GOTO    DELOOP3
        RETURN
SLDOWN          BCF     STATUS,Z
        MOVF    COUNT,0
        BTFSC   STATUS,Z ;Aborts if count at zero
        RETURN
        DECF    COUNT,1
        MOVF    COUNT,0
        MOVWF   PORTB
        MOVLW   0xFF
        MOVWF   DELAY
DELOOP4         NOP
        NOP
        NOP
        NOP
        DECFSZ  DELAY,1
        GOTO    DELOOP4
        RETURN
END
```


```
:10000000831600018600831286018D0105088C008D
:100010000C1811208C181F200C1930208C193D2031
:1000200006280D080311FA3A031908008D0A0D0875
:10003000860050308F0000008F0B1B2808000D0831
:100040000311FA3A031908008D0A0D088600FF30E3
:100050008F0000000000000000008F0B292808001E
:1000600003110D08031908008D030D088600503098
:100070008F0000008F0B3928080003110D080319A9
:1000800008008D030D088600FF308F00000000007F
:0A009000000000008F0B4628080056
:00000001FF
```

64K Eprom EMULATOR

Following out popular ETI Eprommer in Issue 7, Keith Wardill has produced a matching eprom emulator

It is useful when developing software for a new design to be able to modify and then test the software quickly. One way to do this is with an Eprom Emulator. This is a block of random access memory (ram) which can be loaded with program data from a host computer and connected to the target circuit under development, where it acts as read only memory (rom). This allows software to be written and compiled on a host computer, downloaded to the emulator and tested in the development circuit before finally burning the software into the eprom.

This Eprom Emulator connects to a host computer serial port from which the program data under development can be downloaded into the emulator. The emulator has a second interface to the target system, so that the development system can only read the emulator memory, and therefore 'sees' the emulator as an eprom. The emulator memory is 64bytes in size, so will emulate standard 27XX series eproms up to type 27512.

There is not room to reproduce all the relevant software here, but a disk is available (see end of article), and some constructors will be able to work on their own adaptations.

Operating protocol

1The emulator is designed so that when it receives a data byte from the host computer, it will answer with a data byte. Thus, in LOAD mode, the program data is sent to the emulator and written into the emulator memory. Then the emulator will 'echo' the same byte to the host computer, as a prompt to send the next byte. In READ mode, it is possible to read the contents of the emulator memory back to the host computer. To do this, a dummy byte is sent to the emulator to prompt it to read a byte of data from memory and transmit it to the host computer.

After a byte has been sent to the emulator, the Emulator Address Counter is incremented. If the RESET switch is pressed to zero the Address Counter before starting, then, by repeatedly sending data, the Emulator memory can be stepped

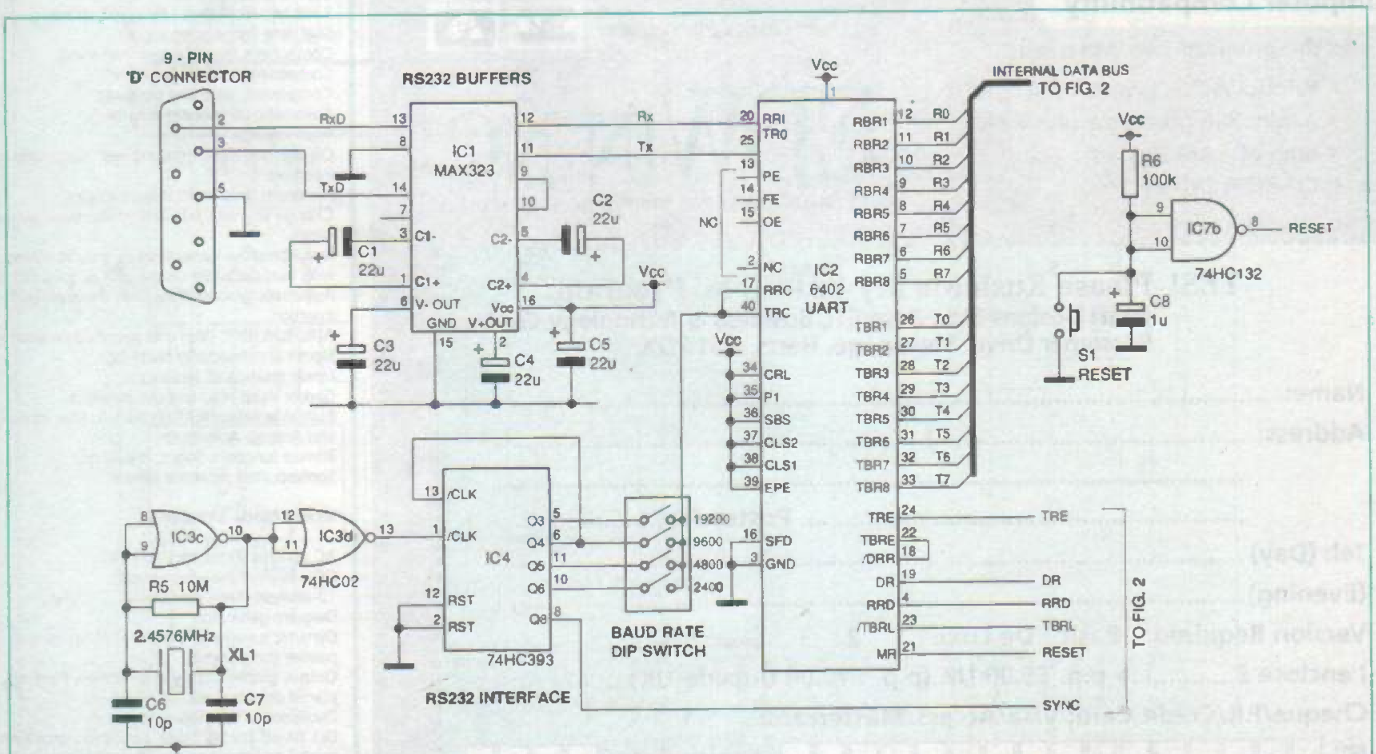


Figure 1: Eprom emulator serial interface

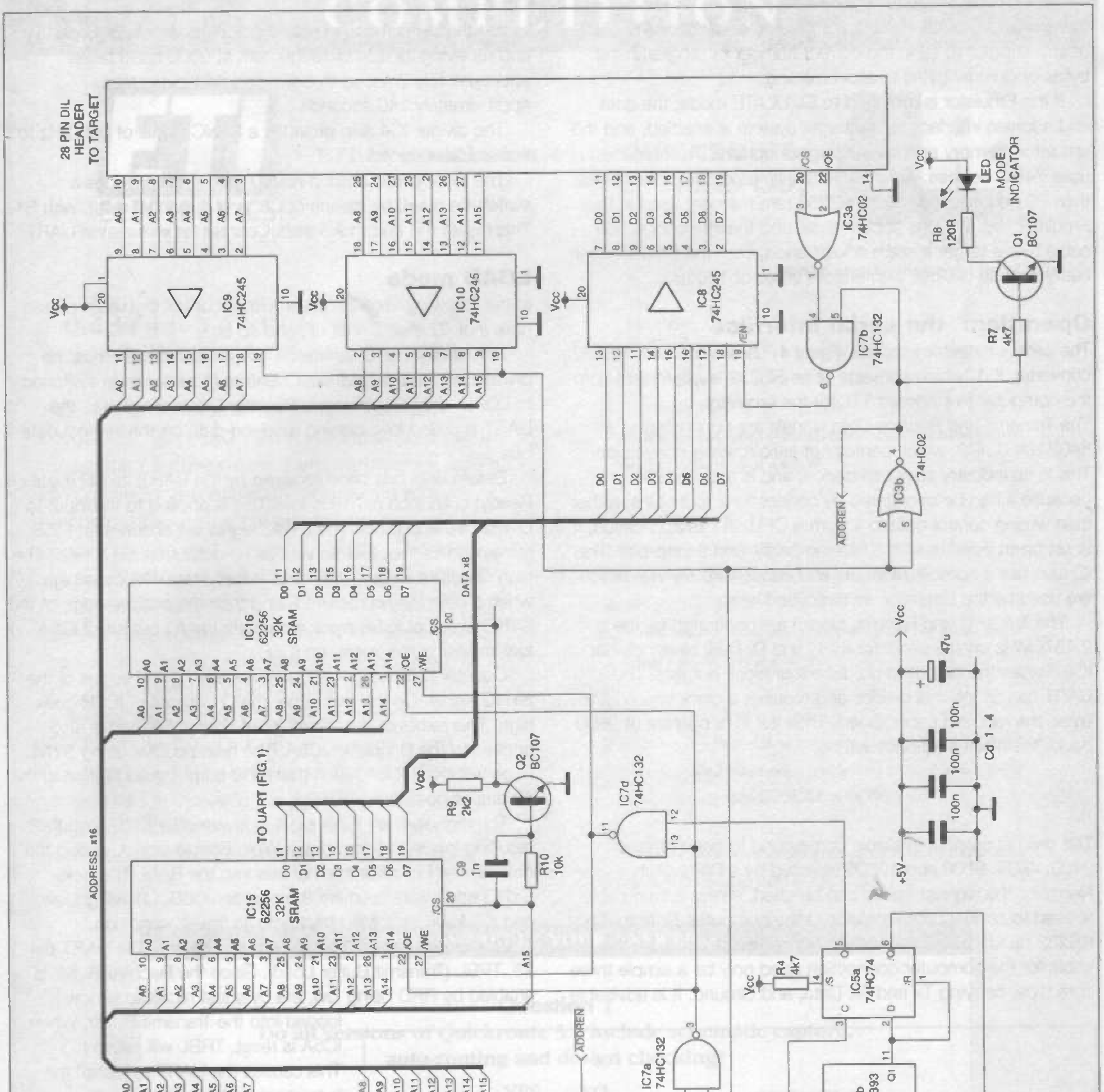


Figure 2: Eprom emulator control

through and programmed or read. It is the responsibility of the host computer to send the correct number of programming bytes or dummy bytes to allow reading.

If the Emulator is switched to EMULATE mode, the data and address interface to the target system is enabled, and the emulator memory acts as the target's eprom. The interface uses 74HC devices, which have rise times of the order of less than 20 nanoseconds. If the 62256 ram memory used in the Emulator has a 100ns access time, and the interconnection cable to the target system is kept short, then the Emulator can easily replace devices with access times of 120 ns.

Operation: the serial interface

The serial computer interface (figure 1) uses a MAX232 RS232 converter, IC1, which converts serial RS232 levels to and from the computer to standard TTL for the emulator.
The Transmit and Receive Data signals are connected to a 6402 UART, IC2, which carries out serial/parallel conversion. This is an industry standard device, and is easy to use because it can be configured by connections to its pins, rather than writing control data to it from a CPU. In this application, it is set up to operate with 8 bits, no parity, and 2 stop bits. This IC also has a number of status and handshake signals, which are used by the Emulator, as described later.

The Transmit and Receive clocks are generated by the 2.4576MHz crystal oscillator IC3C and D. Dual binary divider IC4 divides the output to produce four clock outputs. The UART has an internal divider, and requires a clock which is 16 times the required baud speed. Thus if it is to operate at 9600 baud, the clock frequency will be:

$$16 \times 9600 = 153600 \text{ Hz.}$$

The divided outputs available correspond to baud rates of 2400, 4800, 9600 and 19200 selected by a DIP switch. Normally, the highest speed can be used, unless a long cable is used to connect the emulator to the computer. Note that no RS232 handshakes, software or hardware are used, so the cable for the computer connection need only be a simple three core type, carrying Tx and Rx Data, and Ground. It is advisable to use the highest speed practical, because sending one byte and receiving its acknowledgement at 9600 baud takes approximately 2ms, so to download 64 Kbytes takes approximately 140 seconds.

The divider IC4 also provides a SYNC signal of 9600 Hz to the emulator control.

The reset circuit around NAND gate IC7B provides a switch-on reset, by means of C8, and a manual reset, with S1. This resets the eprom Address Counter, as well as the UART.

LOAD mode

In the following sections on emulator control (figure 2), please note that /Q means 'not Q', and so on.

Before any LOAD operation, the RESET button must be pressed to set the Address Counters to zero. When switched to LOAD, the RRD (Receive Register Disable) signal to the UART is pulled low, placing received data on the internal data bus.

Before data has been received by the UART, its DR (Data Ready) output on pin 19 is low. This is applied to the input to D-Type flip-flop IC5B. The SYNC signal will ensure that IC5B remains in its 'reset' state with its /Q output on pin 8 high. The high Q output keeps IC6B in its 'reset' state. DR goes high when a data byte is received, and the next positive edge of the SYNC signal at IC5B clock input sets the /Q output of IC5A low, releasing the 'reset' on IC6B.

Counter IC6B can now count negative going edges of the SYNC signal. On the first edge, the Q1 output of IC6B goes high. This removes the 'reset' input from IC5A, and is also applied to the D input of IC5A. The next positive going SYNC edge will clock IC5A, such that its Q output goes high, and the /Q output goes low.

The high level on IC5A pin 5 is inverted by IC7D, and the resulting low signal provides a Write Enable signal, writing the data on the Emulator internal bus into the RAM. The next SYNC edge will increment the counter IC6B, Q1 will go low, and IC5A will be forced back into its 'reset' condition.

The low /Q output from IC5A is fed back to the UART pin 23, TRBL (Transmit Buffer Load). Since the Receive Buffer is enabled by RRD being low, the byte just received is now loaded into the Transmit Buffer. When IC5A is reset, TRBL will return high. This causes the UART to 'echo' the byte received back to the host computer, which may then transmit the next byte. When the data byte is loaded into the UART Transmit Buffer, the UART outputs TRE (Transmit Register Empty). This goes low when the byte is loaded, and is used to clock the Address Counters IC11 and IC12. TRE will return high after the byte has been transmitted.

Study of the timing diagram figure 4, will make this operation clear.

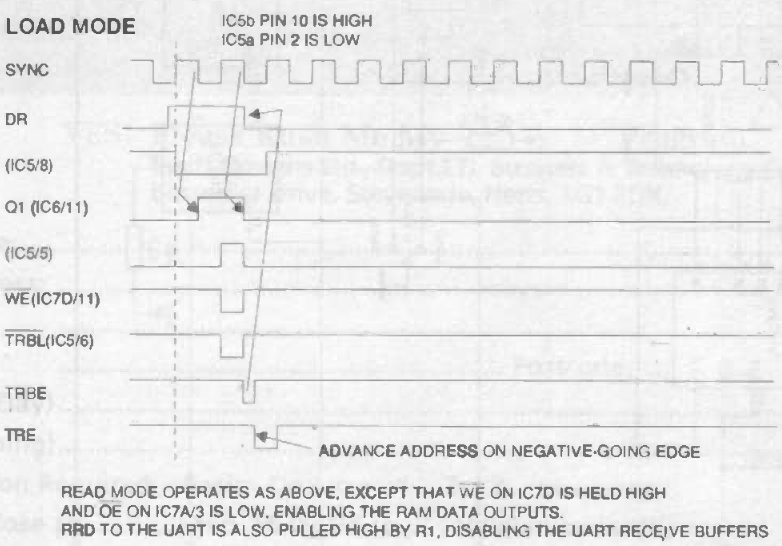


Figure 4: the timing diagrams

READ mode.

Before any READ operation, the RESET button must be pressed to set the Address Counters to zero. If the Emulator is switched to READ the inputs to IC7A are held high by R1. This is connected to the UART RRD input (Receive Register Disable), forcing the

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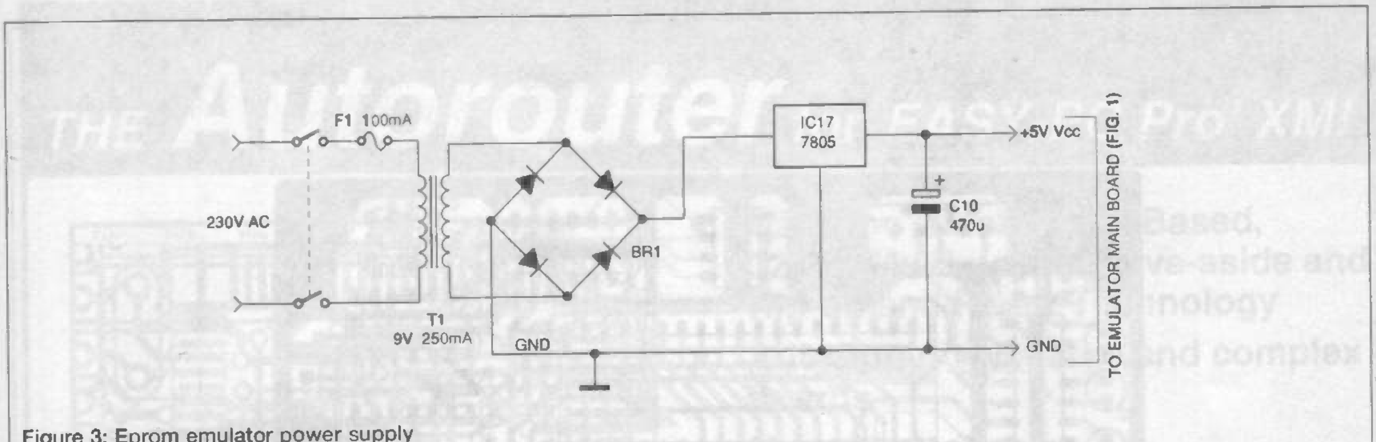


Figure 3: Eprom emulator power supply

Receive Register outputs into a high impedance state and disconnecting them from the Emulator internal data bus. The low output from IC7A is applied to the rams as Output Enable, so the ram data is placed on the internal data bus. This low output is also applied to IC7D pin 13. This forces the output of IC7D high, preventing any Write Enable signal reaching the rams.

If now a data byte is received by the UART, DR again goes high, and the same sequence takes place as for LOAD, except no data is written to the rams. However, the data echoed by the UART is the ram data, rather than the byte just received. The Address Counters are incremented by TRE as described above, so by sending 'dummy' bytes, the host computer can read the entire ram memory.

EMULATE Mode

If the emulator is switched to EMULATE mode, the output of IC3B goes high. This forces the 74HC541 Address Buffers IC12 and IC14 into high impedance state, disconnecting the internal Address Counters from the ram. The Target Address Buffers IC9 and IC10 are enabled, so now the rams are addressed from the Target circuit. Similarly, Target Data Buffer IC8 is enabled, allowing the ram data to be read by the Target when the appropriate Chip Select and Output Enable Signals are received by IC3A. The emulator is connected to the Target Circuit by means of a flat cable about 30cm long fitted with a 28 pin DIL Header. This DIL Header plugs into the socket on the target Circuit which will eventually accommodate the eprom. A led is driven by the buffer enable signal via TR1, coming on when the emulator is in EMULATE mode.

Power Supply

The power supply (figure 3) uses a straightforward bridge rectifier with capacitor smoothing to produce a stabillsed +5V supply via IC12 for the logic. Please note that this is a mains device. Seek assistance if you have little mains experience.

Mechanical construction

General construction is shown in figure 5. The PCB layout shown is double-sided: normally this requires through-hole plating to connect from one side of the board to the other. This is virtually impossible to do if you make the board yourself (as I do), and it is expensive if you have it made. To get round this, some of the 'through' connections are made by soldering the ic sockets on both sides of the PCB. It is strongly recommended that good quality turned-pin Ic sockets be used. These stand slightly clear of the PCB when fitted, and it is possible with a steady hand to solder to pads on the component side of the board under these sockets, and on the 'copper' side of the board, thereby creating a through connection. (See figure 6). Be warned: a steady hand, good eye, and small, hot soldering iron is essential for this. It is possible to do without the ic sockets, and solder directly to the pins of the ics, but this is not recommended, because testing and replacement becomes extremely difficult once the chip is soldered in, and could result in mechanical damage.

There are also a number of through connections made by wire links soldered on both sides of the PCB and also a number of the resistors and capacitors are soldered on both

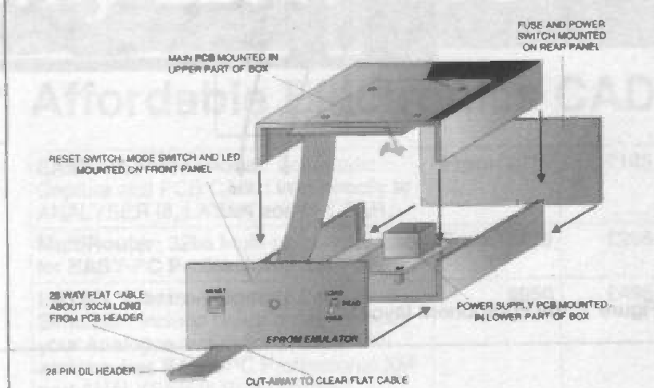


Figure 5: Eprom emulator general construction

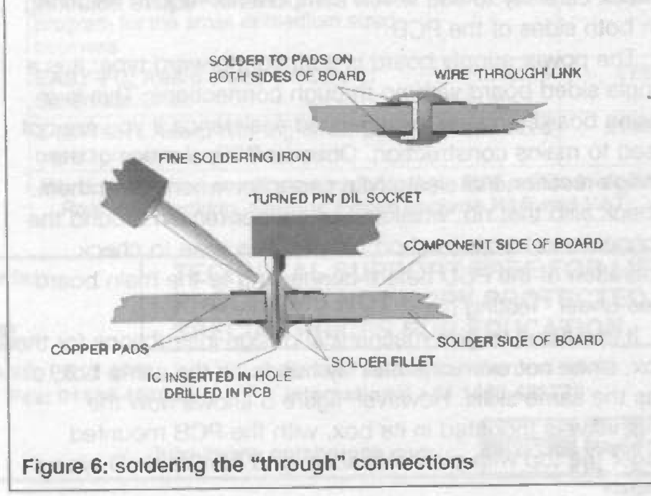


Figure 6: soldering the "through" connections

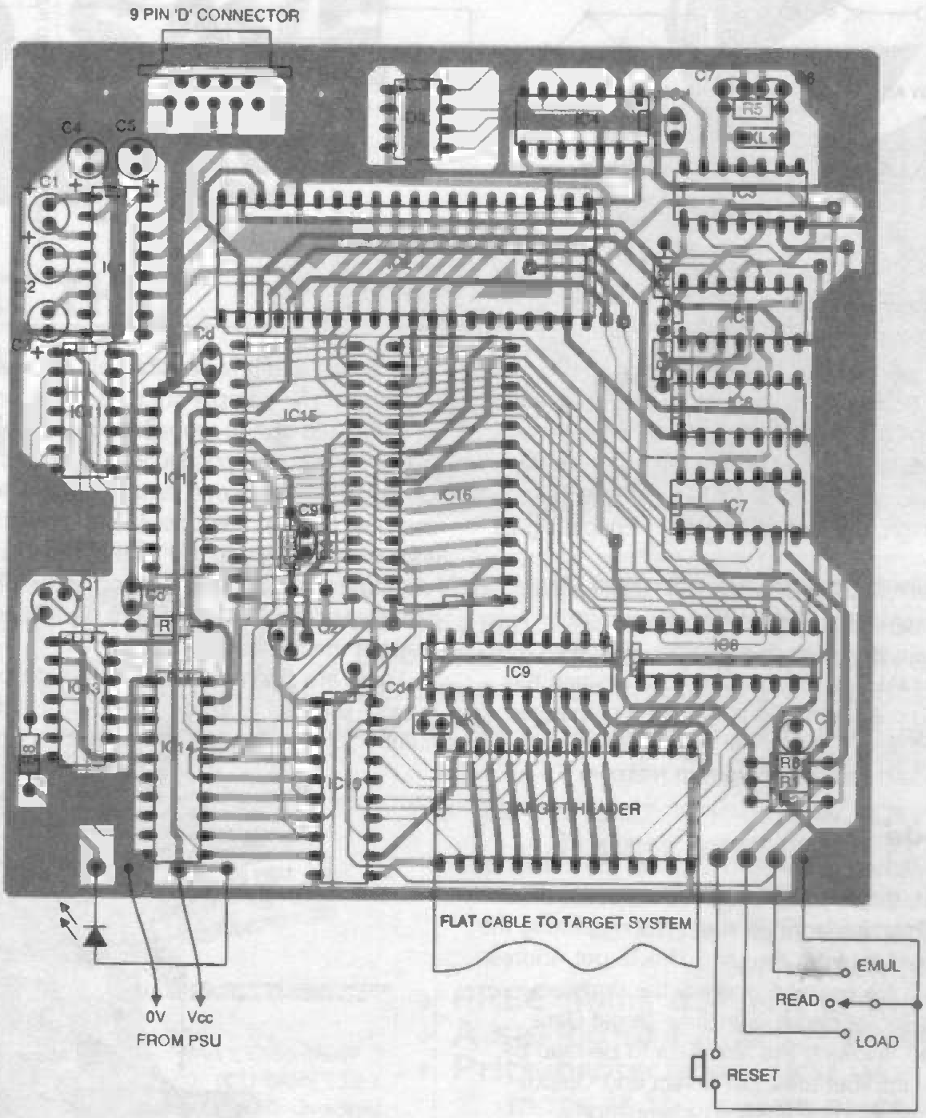


Figure 7: the component layout

sides. The through links are shown on figure 7, the component layout, by an 'X'. Fit all these links first, because some must go under ic sockets, followed in sequence by the other components, the ic sockets, and the crystal. A small blob of glue gives added security for the crystal XL1. Check carefully to see which components require soldering on both sides of the PCB.

The power supply board is a straightforward type: it is a single sided board with no through connections. This is a mains board, so seek experienced assistance if you are not used to mains construction. Observe the polarities of the bridge rectifier and electrolytic capacitor when fitting them. Check also that no 'whiskers' of copper remain around the connections to cause short circuits. It is wise to check operation of the PSU before connecting to the main board (see under 'Testing').

It is difficult to give mechanical design instructions for the box, since not everyone can lay hands on the same box, or has the same skills. However, figure 5 shows how the original was mounted in its box, with the PCB mounted under the top with plastic spacers and the 9 pole D-type RS232 connector protruding through a hole cut in the rear panel. If you have problems finding plastic spacers, short pieces cut from a plastic ballpoint pen barrel are ideal. The interface cable between the emulator and the target consists of a piece of flat cable about 30 cm long, fitted with a 28 pin DIL Header at each end (note carefully which is pin 1). One end of this is plugged into the Target Interface socket on the main PCB, and the other is fed out of the box via a small slot cut into the edge of the front panel. It can then be plugged into the target circuit, again observing the correct orientation. The length of this cable should be kept as short as is reasonable, to prevent noise pickup affecting operation.

The Reset Switch, Mode Switch and Mode LED are mounted on the front panel, connected to the PCB with short lengths of multicore wire. I used a piece of flat cable, as this keeps things tidy. The power switch and fuse are mounted on the rear panel, and the power cable is routed through a notch cut in the edge of the rear panel.

The PSU was bolted into the base of the box, again using short M3 bolts and plastic spacers.

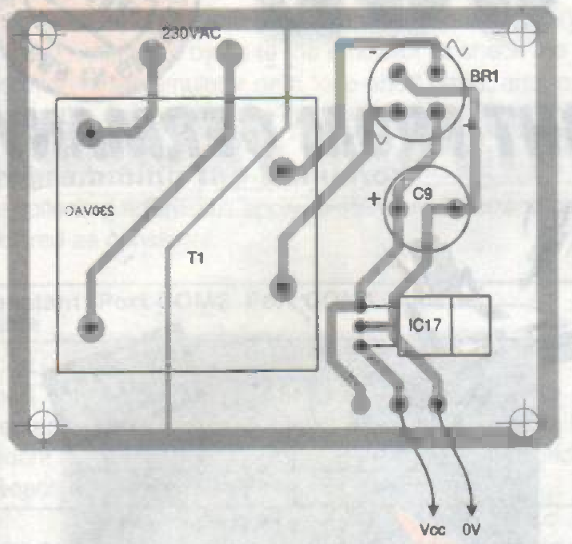


Figure 8: the power supply component layout

Testing

Connect 230V ac to the PSU, and switch on, taking great care not to touch the high voltage points - 230V ac is lethal! Seek experienced assistance with building and testing if you are not used to constructing with mains power.

With a voltmeter, check that the +5V supply is available. If this appears OK, switch off, connect the main PCB without inserting the ICs, and switch back on. Check that +5V is available on the appropriate pin of any ic socket. If not, switch off and look for the probable short-circuit on the main PCB.

When all is well, insert the ics. If you have access to an oscilloscope, then the oscillator can be checked, and the baud rate divisor. If the UART is not fitted, then a link can be fitted between pins 24 and 17 of the UART socket. This connects a clock signal to the Address Counters, which can be checked for correct operation at the ram sockets.

Conclusion

The Emulator is not restricted to use on an IBM compatible PC. There is no reason why it should not be used on any machine with a serial port, providing the user can produce the appropriate software. I have tested the prototype with an Atari ST machine, as well as 386/486/Pentium-based PCs running at various speeds.

The software.

Because the Emulator responds to a byte, and returns a byte, it is not possible just to use a simple terminal program and transmit a data file to the Emulator. The software must be able to check that each byte has been received and acted on by getting a response. The original software was written in QBasic supplied with the later versions of DOS. The problem here is that it is not possible to compile an executable program, although it can be done with the stand-alone versions of QBasic. The full QBasic listing is too long to reproduce here. However, two annotated listings are given: these show how to download data to the emulator, and how to read data. These are very much 'bare-bones'

PARTS LIST for the Eprom Emulator

Resistors

(0.25 watt 5 percent)

R1, R2, R3, R4, R7	4k7
R5	10M
R6	100k
R8	120R
R9	2k2
R10	10k

Capacitors

C1, C2...	
...C3, C4, C5	22uF/35V radial electro AT56L
C6, C7	10pF ceramic WX44X
C8	1uF/63V radial electro AT73Q
C9	1nF ceramic WX68Y
C10	470uF/25V radial electro AT51F
Cd 1-3	100nF polyester DT98G
Cd 4	47uF/16V radial electro AT39N

Semiconductors

IC1	Max 232CPE FD92A
IC2	6402 UART QQ04E
IC3	74HC02 Quad 2 I/P NOR UB01B
IC4, IC6...	
...IC11, IC13	74HC393 dual binary divider AE60Q
IC5	74HC74 dual 'D'-Type flipflop UB19V
IC7	74HC132 quad 2 I/P NAND Schmitt UB00A (if difficult to obtain, use 74HC00)
IC8, IC9, IC10	74HC245 octal bus transceiver UB67X
IC12, IC14	74HC541 octal bus driver UB93B
IC15, IC16	62256 32K x 8 bit static ram UH40T
Q1, Q2	BC107 QB31Jj
IC17	L78M05CV QL28F
BR1	Bridge rectifier 50V/1A, Type W005 AQ94C
XL1	2.4576 MHz crystal FY81C

Miscellaneous

T1	Transformer 230Vac/12Vac - 250mA YN14Q
F1	Chassis mount fuse holder 100mA RX96E
S1 Reset switch	Momentary push to make FF98G
Power switch	2 pole on-off FH04E
Mode switch	1 pole/3 position FH01B
Serial connector	9 pin 'D' type plug PCB mounting FG66W
Baud rate switch	4-pole DIP switch JH08J
14 pin ic sockets	(7 off) Use 'turned pin' type FJ64U
16 pin ic socket	(1 off) FJ65U
20 pin ic sockets	(5 off) FD90X
28 pin ic socket	(1 off) FJ68Y
40 pin ic sockets	(2 off) FJ69A
28 pin ic header	(2 off) JP40T
28-way flat cable about 30 - 40 cms	
Box (HxWxD) 6.5 x 13 x 13 cms	

All part number given are for Maplin, PO Box 3, Rayleigh, Essex SS6 8L. Tel. 01702 554161. Most parts are widely available.

listings: you are encouraged to expand these and write your own software: it really is not difficult. An executable program in Visual Basic 3 for use with Windows 3.1 or Windows 95 has been developed, and a small application which sends a selected number of bytes to the emulator to check the operation of the emulator on a 'one-shot' basis, and to confirm the operation of the Address Counter

Programming the Emulator

The following addresses apply to standard PCs, and can be declared as constants.

Constant Name	Port COM2	Port COM1	Function
txport	&H2F8	&H3F8	Tx Buffer
rxport	&H2F8	&H3F8	Rx Buffer
intenreg	&H2F9	&H3F9	Interrupt Enable Reg.
intident	&H2FA	&H3FA	Interrupt Identification
linecont	&H2FB	&H3FB	Line Control

In the following description the actual program instructions generally come first, and the remarks in the listings themselves are preceded by 'a single quote. &HFF is the QBasic convention for showing hexadecimal data, in this case hex FF. The following variables must be initialised in your program:

```
workfile[percent]   integer containing the active
                      filenumber.
byte[percent]       integer containing the databyte.
workfile$             string variable containing
                      the name of a file.
counter&            long integer used as an index.
emulatorsize&       size of the EPROM in use in bytes
available = 4       interrupt bit mask for RxData
```

Port Setup.

Before using the emulator, your program should set up the PC port to be used to match the UART settings. This requires a divisor to be loaded to set the baud rate (in this case, 9600 baud), and the appropriate stop bits, parity and handshakes must be set:

```
OUT linecont, &H80    set up baud rate: enable baud rate
                        divisors
OUT txport, &HC       baud rate division
                        (1843200/baudrate x 16 = &H0C)
OUT intenreg, &H0
OUT linecont, 3       no parity, 1 stop bit, 8 bits/char,
                        no handshakes
OUT intenreg, 1       enable data available interrupt
```

Writing data to the emulator from file

This assumes that a file of data exists to be written to the emulator.

```
counter& = 1          'initialize the counter
OPEN workfile$ FOR BINARY AS workfile[percent]    'Now
                      loop until all the data is read from
                      file and sent to Emulator.

do
  GET workfile[percent], counter, byte[percent]
                      'QBASIC reads 2 bytes from file
                      byte[percent] = byte[percent] AND
                      &HFF   'so reduce it to 1 byte
  OUT txport, byte[percent]        'then send it to the
                                    Emulator
'now wait until the Emulator echoes the data

do                            'wait for 'data available' interrupt
  TIMER ON   'switch timeout watchdog on
  ready = INP(intident) AND available
  LOOP UNTIL (ready = available)
  TIMER OFF  'exit when data received

  counter& = counter& + 1        'increment the counter
                                  loop until counter& [right arrow]
                                  emulatorsize&    'and loop if not
                                  completed
close workfile[percent]   'close the file when finished
```

Reading data from Emulator to file

If data is received by the PC, it sets a bit in the Interrupt Identification Register. The read process enters a loop until this bit is set, then reads the waiting byte of data and writes it to file.

```
  counter& = 1   'initialise the counter
  OPEN workfile$ FOR RANDOM AS workfile[percent] LEN
                 = 1
  FIELD #workfile[percent], 1 AS databyte$
'Now loop until all data read from Emulator and written to
file.

do
  OUT txport, &HFF   'prompt Emulator to return data
  DO   'loop until 'data available' interrupt occurs.
                              TIMER ON   'switch timeout
watchdog on
                              ready = INP(intident) AND available
  LOOP UNTIL (ready = available)
  TIMER OFF   'exit loop when data received
  rxbyte[percent] = INP(rxport)   'then read returned data
  LSET databyte$ = LEFT$(MKI$(rxbyte[percent]), 1)
                              'convert number to a 1-char string
  PUT #workfile[percent]   'and put it in the file
  counter& = counter& + 1   'increment the counter
                              loop until counter& [right arrow]
                              emulatorsize&   'and loop if not
                              completed
close workfile[percent]   'close the file when finished
```

Any data may be sent to the emulator as a prompt in read mode (I used FF). It may also be worth noting that if the emulator fails to return a byte for any reason, this routine will stay in the loop forever waiting for data. You should include a check on the timer value, and exit after a short period, noting this is a Timeout Error. The remainder of the program is left up to you.

Software

A disk containing the Eprommer software is available from ETI advertisers Forest Electronic Developments, 10 Holmehurst Ave., Christchurch, Dorset BH23 5PQ, priced £5 inclusive of post and packing. A kit may be available in the future - please enquire at FED at the address above.

ELECTRONIC Door Chimes

An adjustable modern replacement for the traditional ding-dong. By Terry Balbirnie

When operated, this circuit will make a sound very similar to that of a traditional set of metallic door chimes. However, there are several advantages in using this, compared with the old electromagnetic variety. This unit can be used as a replacement for a failing set of chimes, or for a new installation. The continuous standby current requirement is only 150uA so a pair of AA size cells will be sufficient to operate the circuit for at least one year in normal use.

The chimes unit is built in a small plastic box. This contains the circuit panel, batteries and a small loudspeaker. On the front is a matrix of holes for the sound to pass through. The speaker provides enough sound to be heard around the average house. However, it is possible to connect an additional "repeat" speaker so that the chimes may be heard in, say, a workshop or garage. It may also be useful to fit an additional speaker in the lounge so that the sound can be heard above that of the TV.

Hold off

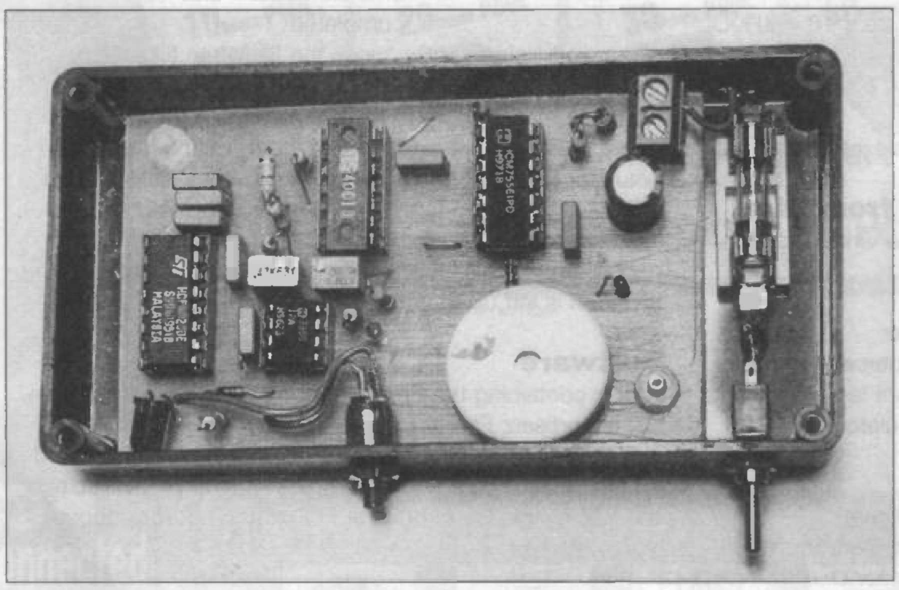
With the traditional type of door chimes, the "dong" is delayed until the bell push is released. Some people, especially children, keep the button pressed to give a prolonged "ding". With this unit, two regular "ding-dongs" will be given however the bell push is used. Also, after operation the circuit will be inhibited for a preset time so that it cannot work again for up to 1 minute. This prevents multiple operations which some people like to give in an effort to attract your attention but which usually prove annoying. There is provision, however, for those people who prefer to allow more than one operation (so that friends and family members can announce their arrival by a pre-arranged code of "ding-dongs").

A significant advantage of this circuit is that, in use, the bell push carries a current of only a few microamps. In traditional chimes, a large current - some 1A or more - flows through the bell push and its associated wiring. Any high resistance due to an excessive length of wire or poor contact will result in the chimes not working. Bell pushes are prone to moisture entering the body and causing corrosion of the contacts resulting in a significant resistance when they "make". This leads to unreliable or intermittent operation. With this unit, the low current means that operation is much less affected by the condition of the contacts or the length of interconnecting wire.

Preset controls on the circuit panel allow the unit to be customised so that it provides a quality of sound according to the user's preference. It is fun to experiment with these at the end. A further preset control sets the hold-off time between 2 and 60 seconds approximately.

Traditional arrangements

At this point it seems appropriate to give a quick description of a conventional door chimes arrangement. The unit itself consists of a solenoid (coil of insulated copper wire) wrapped on an insulating tube and a moveable soft iron core. The core is able to slide into the tube and is held loosely in its rest position with a spring (not shown) - see figure 1. There are two metal bars attached to rubber mountings - one on each side of the coil. These are normally kept out of contact with the core. They are tuned to emit certain sound frequencies (musical notes). When struck in turn, the chimes therefore emit the characteristic ding-dong tone associated with these units. Musicians would say that they sound in thirds. The rubber mountings prevent the sound from decaying too quickly when the bars are sounding.



When the bell push is operated, current flows from a battery or mains transformer via the bell push contacts through the coil. A magnetic field in produced by the coil and this pulls the core into the tube. However, it tends to overshoot the central position due to its inertia and the left-hand end strikes the smaller metal bar. This therefore emits the higher of the two musical notes (the

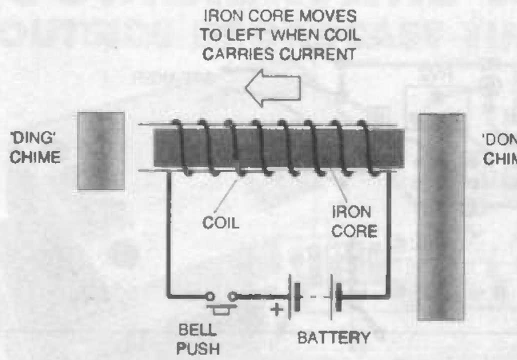


Figure 1: traditional electromagnetic door chimes

"ding"). It then centralises and takes up a position in the coil out of contact with either metal bar. When the bell push is released, the magnetic field collapses and the iron core is returned by the spring. However, as before, it tends to overshoot and strikes the lower-frequency (larger) bar (the "dong") before returning to its rest position. It makes no difference whether ac or dc is used since either a steady or alternating magnetic field will be generated in the coil and the core will be pulled inside the tube whichever is used

The chief disadvantage of such a mechanical system is the large current requirement of the solenoid. Thus, for battery operation, the cells will need to be of the heavy-duty type (eg C or D size alkaline cells) and will not give a very long period of service when used several times per day. There is a second disadvantage that, after a long period of use, the core sometimes sticks and the unit works intermittently or not at all.

How it works

The complete circuit for the Electronic Door Chimes unit is shown in figure 2. The nominal 3V supply is derived from two 1.5V cells which comprise battery B1. There is no on-off switch since there seems to be no reason why the unit should ever be switched off. IC2 is a dedicated "chimes" device, while IC1 is a timer ic configured as a monostable. This latter component provides the "hold off" aspect of the circuit. Ignore this for the moment. When IC2 pin 1 is made high momentarily its output, pin 5, gives two "ding-dong" signals with a short space between. If pin 1 is maintained in a high condition, the signals will be repeated indefinitely. The output is of a low level so it is amplified by feeding it into the base of npn transistor Q1. This, in conjunction with pnp transistor, Q2 forms a high gain amplifier. The boosted signal then flows through loudspeaker, LS1. While pin 1 is left unconnected it assumes a low state and the significance of this will be seen presently.

The parallel arrangements of resistors and capacitors connected between IC2 pins 2 and 3 and the 0V line also the resistance appearing between pins 6 and 7 determine the operating characteristics of the circuit. Each of these is made variable by means of the presets RV2, RV3 and RV4, and these will be adjusted at the end of construction to produce a tone which suits the user's requirements.

Monostable

The monostable circuit based on IC1 operates in the following way. When triggered by a low pulse applied to pin 2, the output (pin 3) goes high for some preset time then reverts to low. The bell push connected between pin 2 and the 0V line provides the necessary low state when operated. No matter how it is pressed, the monostable will be triggered and the output will go high for the preset time. This time depends on the values of R2, RV1 and C2 and RV1 is used to adjust it as required at the end. Once triggered, a high state will be transferred momentarily via capacitor C3 to IC2 input, pin 1. The loudspeaker will therefore emit the chimes sound as described previously. However, while the monostable is active and pin 3 remains high, further operations of the bell push will have no effect. Eventually, IC1 times out and pin 3 reverts to low. Capacitor C3 then discharges very quickly since both sides of it (connected to IC1 pin 3 and IC2 pin 10) are in a low state. The circuit then becomes active again and ready to respond to further operations of the bell push. IC2 pin 2 is kept normally high through resistor R1 and this prevents false triggering. Capacitor C1 bypasses ac signals which tend to be induced in long runs of bell-push wiring from nearby mains equipment. Without this there could also be a tendency to false triggering.

The chimes ic is designed to operate from a nominal 3V dc supply such as will be provided by a pair of AA size cells. This is

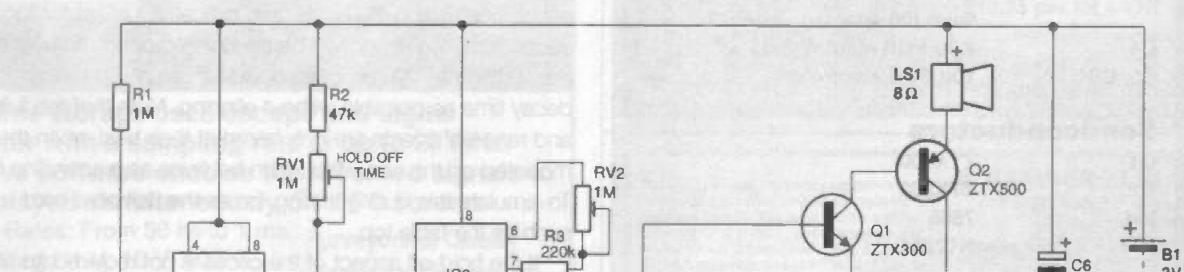


Figure 2: the circuit of the electronic door chimes

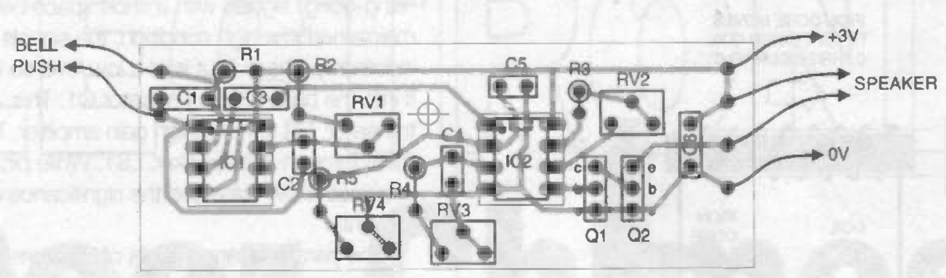


Figure 3: the component overlay

also suitable for operating IC1. Do not use a higher voltage than this because the maximum allowed supply voltage for IC2 is 3.3V. Do not under any circumstances attempt to operate this circuit from a mains transformer.

Construction

The PCB component layout is shown in figure 3. Begin by drilling the fixing hole and soldering the two ic sockets in position. Follow with all capacitors and resistors (including presets RV1 to RV4). Solder the two transistors noting which is which and taking care over their orientation - the flat faces should be adjacent to one another. Solder 10cm pieces of stranded connecting wire to the two sets of pads labelled "speaker" and "bell push". Solder the positive (red) PP3-type battery connector wire to the pad labelled "+3V" and the negative one to the 0V pad (if the battery holder is of that type - otherwise solder pieces of wire for its solder tags). Adjust the wipers of RV2, RV3 and RV4 to approximately mid-position and RV1 fully clockwise as viewed from the top edge of the PCB (for minimum hold-off time).

PARTS LIST for the Electronic Door Chimes

Resistors

R1	1M
R2	47k
R3	220k
R4	470k
RV1, RV2	1M
RV3, RV4	470k

Capacitors

C1	100n min. metallised polyester, 5mm pin spacing
C2	47u PCB electrolytic
C3	220n min. metallised polyester, 5mm pin spacing - see text
C4	2.2u PCB electrolytic
C5, C6	10u PCB electrolytic

Semiconductors

Q1	ZTX300
Q2	ZTX500
IC1	7555
IC2	HT2811

Miscellaneous

LS1	Miniature 8 ohm loudspeaker diameter 66 mm approx
B1	2 x AA alkaline cells and holder

8-pin dil sockets (2 off), PP3-type battery connector (if required); 2-section piece of 2A screw terminal block. Plastic box size: 138 x 76 x 25 mm internal.

The HT2811 ic is available from Maplin, as are all other components for the chimes unit.

The positions of the PCB, speaker and cell holder are shown in the photograph. Note that everything is mounted on the lid section of the box. If using the specified case, the PCB will be a close fit and cannot rotate even though only one fixing hole is used. Drill this hole through the plastic but do not attach the PCB yet. Drill the hole for the bell push wires and a matrix of holes in the lid for the sound to pass out from the speaker. Drill a hole in the rear to secure the unit to the wall. Attach the speaker itself using a little quick-setting epoxy resin adhesive around the rim. When the adhesive has hardened, attach the circuit panel using a short insulating spacer on the bolt shank and solder the speaker leads in position. Secure the battery holder using adhesive fixing pads and connect it to the circuit.

Testing

Insert two AA size alkaline cells in the holder. Since capacitor C1 begins in a discharged condition, it sometimes triggers IC1 as the supply is established. There may therefore be two "ding-dongs" emitted by the speaker. Check that the circuit may be operated by touching the two "bell push" wires together for an instant. Wait for a second or two between operations to be sure that the monostable has timed out. If this only sometimes works, raise the value of C3 slightly. This should not be necessary and the specified value (220n) was found to give reliable results in the prototype unit. Check the effect of RV2 adjustment. Basically, this sets the rate at which the "ding-dong" is delivered. By varying it, the pitch and speed of the sound may be changed from a slow deep tone to a fast high-pitched one. This is rather like changing the speed of the record in an old (analogue) record player. Adjust it according to personal taste.

Experiment with the effects of RV3 and RV4. RV4 sets the time taken for the signal to decay and RV3 sets the quality of the sound. Adjust these in conjunction with RV2 for the best overall effect. The setting of RV4 is fairly critical. If it is set for too long a decay time, the sound will be suddenly clipped at the end. Once the setting of RV2 has been decided, adjust RV4 for as long a decay time as possible without clipping. Note that the full volume and range of effects are only heard at their best when the unit is mounted on the wall which then behaves as a sounding board. To simulate this during testing, press the unit on a hard surface such as the table top.

If the hold-off aspect of the circuit is not required (to allow multiple operations), leave RV1 as it is. If, however, some degree of inhibition is needed, set it accordingly. If an additional speaker is fitted, connect it in series with the first one. Each will sound only a little less loudly than with one. Use a similar speaker to that in the main unit and mount it in a suitable box.

Wire up the bell push to the unit using light-duty twin wire. Note that an illuminated bell push is not suitable - a standard type must be used. The illuminated type has a filament bulb connected in parallel with the contacts and this would maintain IC1 pin 2 in a low condition.

Fast Fivers

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

5. A musical booby trap

The idea for this 'Fiver' came from a Victorian port decanter which is an heirloom in our family. Instead of locking up the port and sherry in a tantalus, the decanter is left on the sideboard protected by a booby trap. Whether it was actually thought of as a booby trap in the days of Queen Victoria we do not know, but there have always been boobies and there have always been traps, even if the combined term had not then been invented. The port decanter, beautifully engraved, has its base shaped into a dome, to provide a groove to catch the lees which precipitate with age (this was before the days of lees-free supermarket port). But the dome has another purpose. Beneath it is concealed a musical box triggered by a small brass knob projecting downward from the base of the decanter. When the decanter is in its proper place on the sideboard the knob is pressed upward by the weight of the decanter and prevents the musical box from working. However, when an unwary person lifts up the decanter to sample the contents, the pressure on the knob is released and the music sounds loudly. It is no good hastily replacing the decanter for, once started, the tune is played through to its end, leaving the embarrassed booby to 'face the music'.

This project uses a UM66 music ic to provide the tune, and a timer ic to turn on the power for long enough to let the tune play once through. Once the circuit has been triggered, the melody plays all the way toits end, even if the pilferer replaces the booby-trapped object. The circuit is adaptable to a wide range of applications, which we leave to the reader's imagination and ingenuity.

How it works

The music ic (IC2) is one of a series available with different pre-programmed tunes ranging from 'Twinkle twinkle little star' to 'White Christmas'. The one in our prototype plays 'Love me tender' which is no longer in the catalogue, so perhaps, like the Victorian decanter, it is a collector's piece. This is connected in the drain circuit of a 2N7000 mosfet, actually a package containing a Darlington-connected pair of mosfets for greater gain. The gate of the mosfet is connected to the output of a 7555 cmos timer ic, wired as a monostable. Normally the output of the 7555 (pin 3) has a low (0V) output. Its trigger input (pin 2) is normally kept high (+3V) by the button or switch S1 being held closed. If S1 is opened, even for an instant, the voltage at pin 2 is pulled low by R1, triggering the ic into action. Its output swings sharply high and stays high for a period of time determined by the value of R2 and C1. What happens is that the voltage across C1 is detected by internal circuits connected to pin 6. In the untriggered state this is held at one third of the supply voltage (at 1V, in this circuit). Surplus current flowing through R2 is diverted into pin 7 and through the ic to ground. When the ic is triggered and the output goes high, current is no longer allowed to flow into pin 7. It flows to C1 and the charge on C1 gradually increases. This continues until the charge on C1 reaches two-thirds of the supply (that is, 2V). This voltage is sensed by pin 6, and the output is switched low. At the same time current flows again though pin 7, rapidly reducing the charge on C1 to 1V once more. Thus the length of time that the output is high depends on how long it takes to charge the capacitor from 1V to 2V. This depends on the resistance R of R2 and the capacitance C of C1. The formula is:

$$t = 1.1RC$$

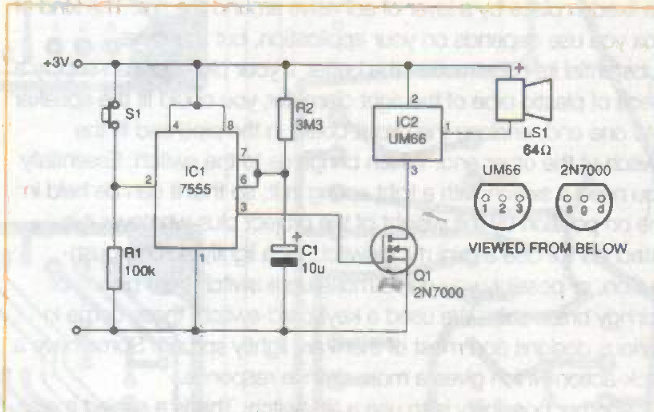


Figure 1: the circuit of the musical booby-trap

t is in seconds, R in ohms and C in farads. In this project we need to give the music ic time to complete its tune. Ours required 30 seconds and, with the values shown in figure 1:

$$t = 1.1 \times 3.3 \times 10^6 \times 10 \times 10^{-6} = 36.3 \text{ seconds}$$

One of the good features of the 555 and 7555 timer ics is that the timing depends on charging from 1/3 of supply to 2/3 of supply. It is independent of the actual voltage of the supply. If the battery goes a little flat this does not affect the timing.

When it is in the resting or quiescent state (waiting to trap the unwary), the only current used is that flowing through R1 and the small amount going through the timer. These total only 60uA, so a small battery of two AAA alkaline cells lasts several months.

Construction

There are two points to consider before you begin. One is the mounting of the loudspeaker. We used one of the smallest available low-cost speakers, but a larger one can be used. Smaller types are obtainable from suppliers specialising in surface-mount devices. To obtain a reasonably loud sound it is essential that the speaker is mounted firmly on a baffle. The function of a baffle is to prevent the sound waves emitted from the back of the speaker coming round and cancelling out the sound waves emitted from the front. In practical terms, the speaker needs to be mounted in an aperture cut in a box or enclosure. Small speakers can usually be fixed in place by a layer of adhesive around the rim. The kind of box you use depends on your application, but the more substantial its construction the better. If your plumber can supply a piece of plastic pipe of the right diameter, you could fit the speaker into one end, enclose the circuit board in the pipe and fit the switch at the other end. Which brings us to the switch. Essentially, you need a switch with a light spring in it, so that it can be held in the on position by the weight of the project plus whatever it is attached to. Use a mini microswitch, or a lightly sprung push-button, or possibly you could make up a switch from pieces of springy brass strip. We used a keyboard-switch; these come in various designs and most of them are lightly sprung. Some have a click-action which gives a more definite response.

Another possibility is to use a tilt-switch. This is a sealed metal tube containing two wire electrodes and a small quantity of mercury. When it is the upright position the mercury rests in contact with the electrodes and completes the circuit. When the switch is tilted, even by as little as 10 degrees, contact is broken and the circuit is triggered. Another version of this is the vibration switch (though this is more expensive and will take the cost of the project above the £5 limit). This is normally open when still but closes with any vibrations. To use this you will need to alter the switching circuit as shown in figure 3. This way of connecting the switch can be used for any other kind of switch which is normally open and closes when disturbed.

The circuit is assembled on a small scrap of stripboard, stuck to the bottom of the battery box with double-sided adhesive foam strip. You could alternatively use a resin such as Araldite. The layout is compact so as to make it easier to fit the device into a restricted space. It you have any particular application in mind, you may need to adapt the layout to a differently shaped board.

First cut the strips beneath the board at E4, F3, G5 and D10-G10, as shown in figure 2. Assemble the timing circuit (IC1, R1, R2, S1), connecting the positive side of the switch to the pin at A1. Use a multimeter to test the output at pin 3. This is normally 0V but rises to 3V for just over 30 seconds when triggered. Next assemble the remainder of the circuit, connecting the positive side of LS1 to the pin at A1. Note that IC2 faces the opposite way to Q1. When we assembled the prototype we put IC2 the wrong way round. It still produced a tune with the correct beat but the notes were in a strangely minor key! You might like it better than the usual rendering, but possibly the ic might burn out eventually. Assembly is now complete and the circuit should play its complete jingle every time it is triggered. If it cuts off too soon, increase the length of the timed period by increasing R2 to, say 2.7 megohms.

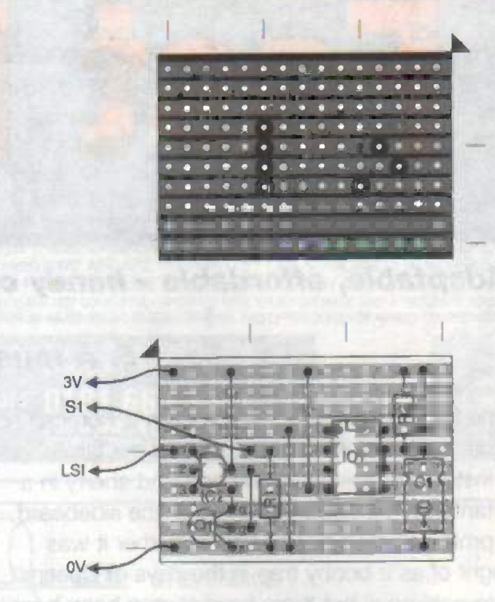


Figure 2: the stripboard layout

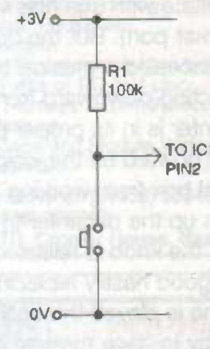


Figure 3: alternative switching, using a "normally open" switch

PARTS LIST

Resistors

R1 100 kilohm
R2 3.3 megohm

Capacitor

C1 10uF electrolytic, 16V, axial

Semiconductors

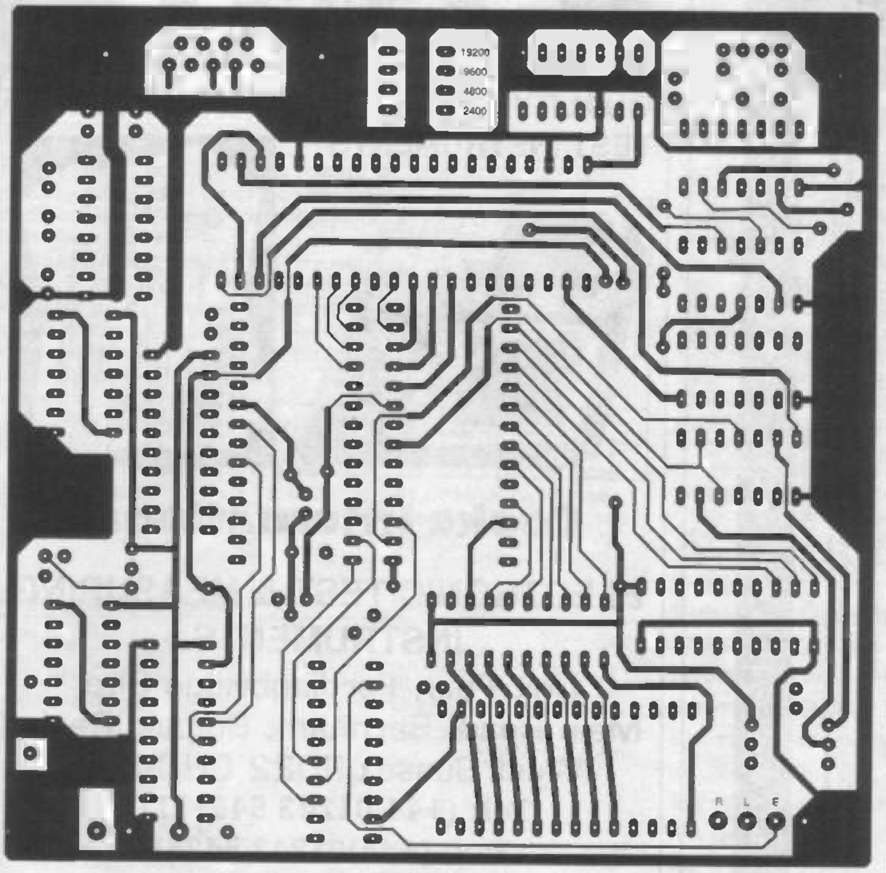
Q1 2N7000 Fetlington mosfet
IC1 7555 CMOS timer
IC2 UM66 musical ic

Miscellaneous

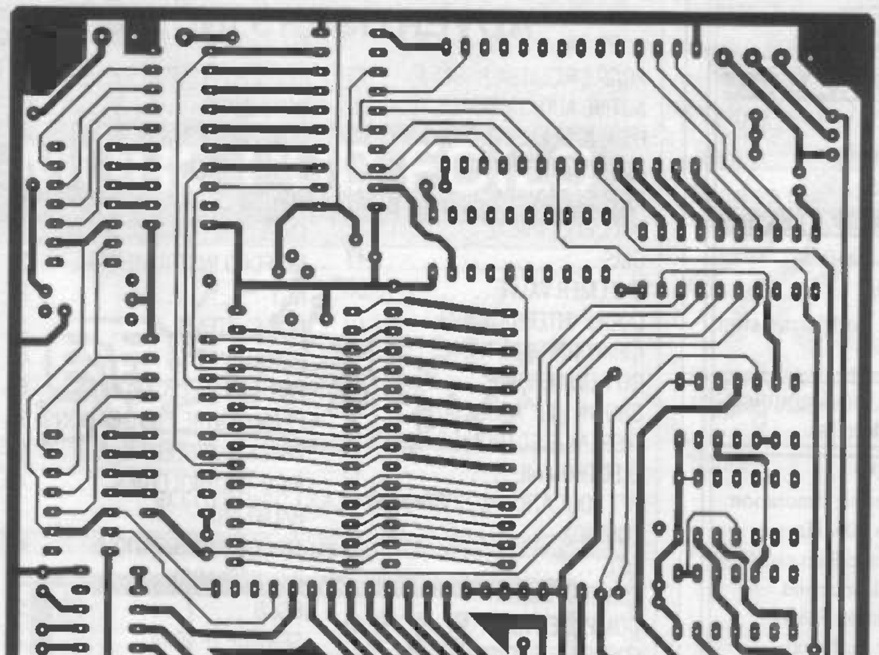
S1 Switch (see text)
LS1 Loudspeaker 64-ohm
8-pin dil ic socket, 40mm x 27m stripboard (10 strips x 15 holes); 1mm terminal pins; battery box for 2 x AAA cells.

FOILS FOR THIS ISSUE

CONTINUED ON PAGE 71

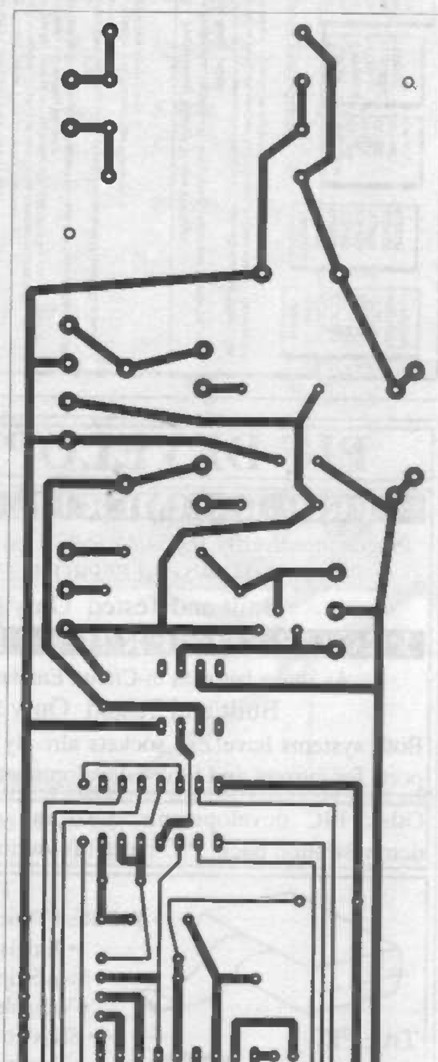


COMPONENT SIDE



SOLDER SIDE

EPROM EMULATOR: COMPONENT & SOLDER SIDES



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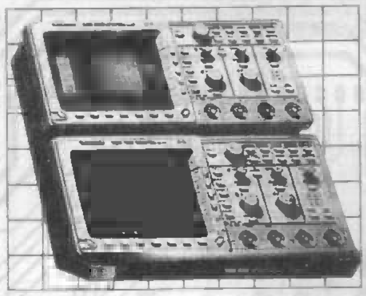

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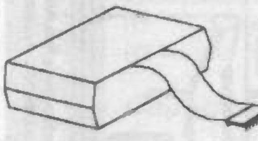

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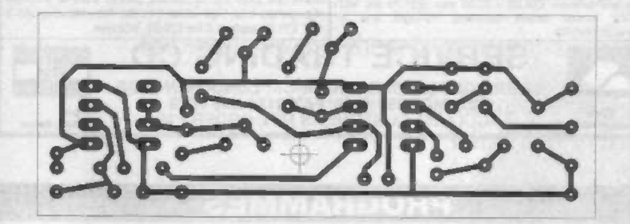

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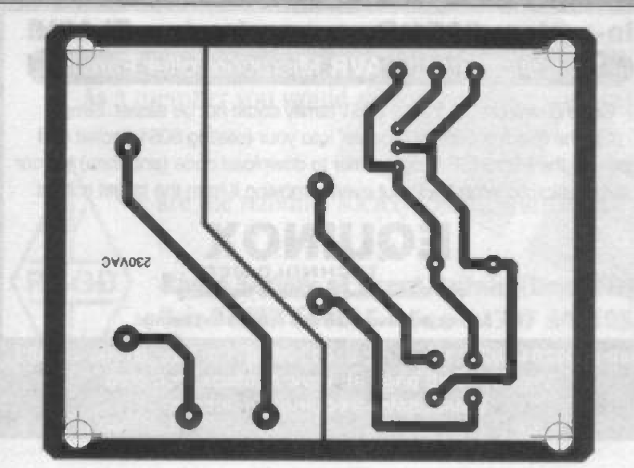

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Around the Corner

Real improvements in electronic devices continue, though as ever they are less widely reported than the latest PC software. For several years IGBTs (insulated gate bipolar transistors) have been heralded as a better type of switching device for switched mode applications. IGBTs, invented about 15 years ago and designed to carry serious wattages, can be viewed roughly as a combination of a power mosfet and a bipolar transistor. Conduction can be maintained without a continuous base current flowing, but at high currents they have a lower voltage drop than comparable power mosfets, as well as having a lower gate capacitance to charge and discharge.

IGBTs have not previously been relevant for switched mode power supplies of the most familiar type, because of their low switching speed. A year ago I recall seeing in a catalogue a switching frequency of 10 kHz heralded as fast for an IGBT. This is certainly useful for some things, but switched mode supplies used for desktop computers and applications of much larger loads run at frequencies of 50 kHz to 500 kHz.

Recently, International Rectifier have announced IGBTs with ratings up to 150kHz at 50A and 600V. Clearly these devices can now be considered for high power off-line switchers, and will probably soon see service in high power supplies, power factor correctors, and welders.

The problem with high-speed switching arises because the bipolar part of the device switches off by recombination of minority carriers in the base region. IR have found a way to reduce the carrier lifetime without the severe side effects, such as higher on-state voltage and, if lifetime-killing (as this process is now known) is taken too far, a negative resistance characteristic that makes the device useless.

Now, for off-line switched mode supplies operating below 150kHz, IGBTs can be used with a power saving - there are still higher switching losses than power mosfets, but with lower conduction losses, and requiring a much smaller chunk of silicon to achieve all this.

Nevertheless, while everything else gets smaller and smaller with every passing season, traditionalists will be happy to know that it may be a while before we see surface-mount versions of this kind of device.

Rob Bebbington MISTC

A few weeks ago I wrote to author Roy Bebbington with a minor query on a project he had submitted. Shortly afterwards, we received the news that Roy had died suddenly. Roy was a technical author before his retirement, and continued to design and build projects afterwards. He was not a young man, but from his project designs he was clearly young in spirit, and would have continued in his hobby for many more years had an untimely heart attack not carried him off. We at ETI extend our sympathy to Roy's family with the thought that his name, like the names of all dedicated designers, will be immortalised in the project collections of many ETI readers for a long time to come.

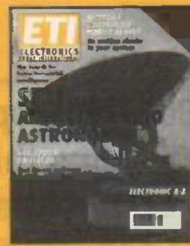
Say EEEEEE!

One of our readers in the manufacturing business kindly returned a couple of comments on Controlling DC Motors (Part one) in last month's ETI. We do not know precisely what our correspondent is experimenting with, other than the fact that it involves moving quantities of toothbrushes. Perhaps he is delivering or even testing toothbrushes. Either that, or some startling developments in electric tooth-brushing techniques have yet to reach the public ear.

Next Month...

Volume 26 no. 10 of Electronics Today International will be in your newsagent on 12th September 1997 ... Tim Savage has been working on a Mk II Auto-Checker for continuity checking around the car and house ... Pei An describes a radio digital data control system which can be used for home automation applications ... At last, Terry Balbirnie's mock alarm flasher offers a very low cost safety feature for cars ... all the regulars, and more ... PLUS Buy issue 10 of ETI and save money on your PCB packs from our Beta Layout Promotion.

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



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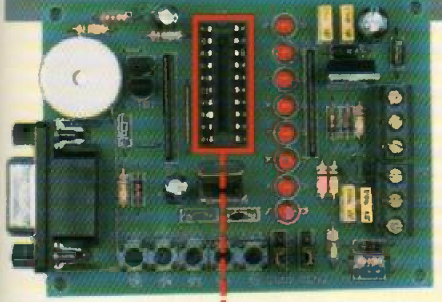
- Micro-Pro for Windows™ Programmer Interface Software
- FPGA hardware ensures future device support
- Supports most DIL devices up to 40 pins without an adaptor
- Adaptors available for many other package types

Order code: MPW-SYS £149.00 ▲

The ATMEL 8051 FLASH microcontroller family

Atmel Part Code	89C51	89C52	89C55	89S8252	89S53	89C1051	89C2051
Flash Code ROM (bytes)	4K	8K	20K	8K	12K	1K	2K
RAM (bytes)	[illegible]	256	256	256	256	64	128
EEPROM	-	-	-	2K	-	-	-
In-system re-programmable	-	-	-	YES	YES	-	-
I/O Pins	32	32	32	32	32	15	15
16-bit Timer/Counters	[illegible]	[illegible]	[illegible]	[illegible]	3	1	[illegible]
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	[illegible]	-	-
Analogue comparator	-	-	-	-	-	YES	YES
Data pointers	1	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]
Package Pins (DIL)	40	40	40	40	40	20	20

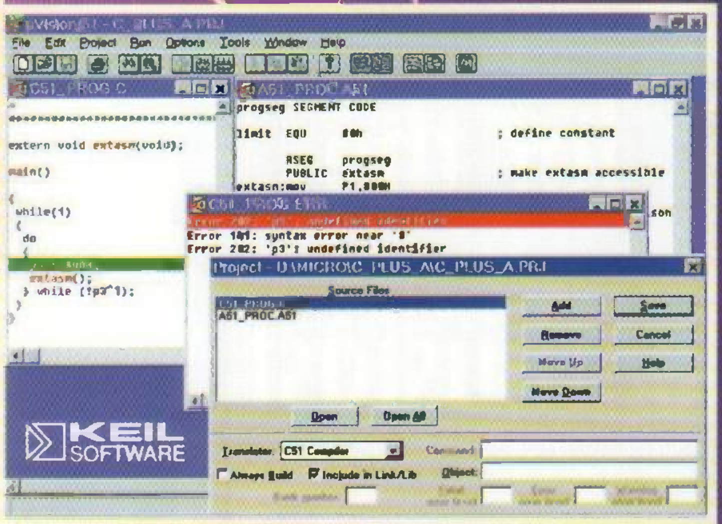
C51 Microcontroller Starter System



- ✔ Optimising C Compiler
- ✔ Macro Assembler
- ✔ Software Simulator
- ✔ Device Programmer
- ✔ Evaluation Module
- ✔ Atmel AT89C2051
- ✔ Hardware/Software Documentation

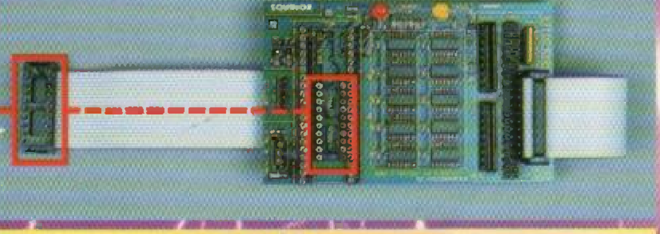
Plus FREE Atmel CD ROM data book

Order code: AT-89C-2K-ST £199.00



▲ KEIL Integrated Development Environment - C compiler + Assembler output restricted to 2K total program code.

In-Circuit Parallel Programming Adaptor



Now you can re-program the entire 89C & 89S Atmel Microcontroller families in-circuit

▲ Order code: AD-8051-ICPP £125.00 (Requires Micro-Pro Programmer to operate)

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