ETI

ELECTRONICS TODAY INTERNATIONAL

COMPUTER RADIO CONTROL FOR THE HOME

THIS MONTH: THE RADIO CONTROL SYSTEM

DIGITAL SIGNAL PROCESSING

RIDE THE DIGITAL WAVE OF THE FUTURE

TOTAL HARMONIC DISTORTION METER

HIGH QUALITY NOTCH FILTER AND AUDIO MILLI-VOLTMETER

MKII AUTO CHECKER

AUDIBLE AND VISUAL LOW VOLTAGE TESTING AROUND THE HOME AND CAR

PLUS

GCSE GROUNDING: SOUND SWITCHER

TUNEFUL TRIFLE

ALPHANUMERIC MORSE TOUCHKEY

FOR ENTHUSIASTS BY ENTHUSIASTS
NEXUS

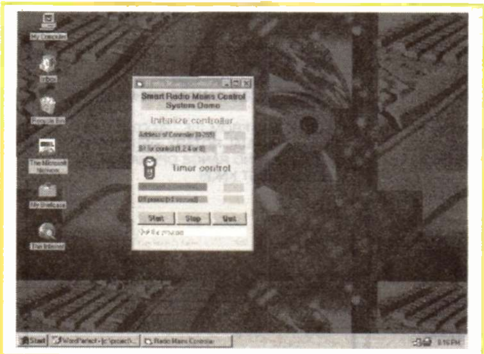
Vol 26 Issue: 11 10 October 1997 £2.50
USA $4.95

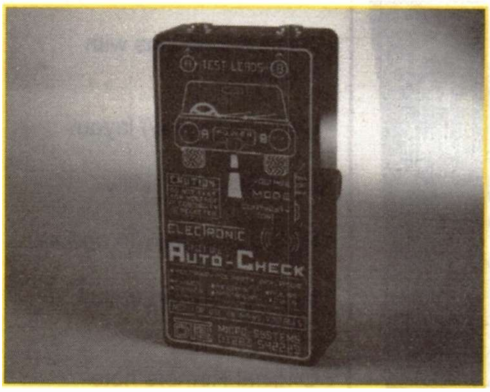
Contents

Volume 26 No.11

& Features Projects

Next Issue 7th November 1997





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

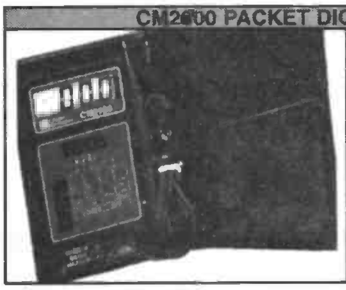
ORDER CODE: CM2300
PRICE: 975p

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

8 Way Preprogrammed Universal Remote Control

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

- Replaces up to 8 remotes with one
- Simple 4 digit setup routine
- Controls 1000's of models
- Teletext functions with Fastext
- Clear (large key) layout
- Code Search Facility
- Stylish and easy to operate
- Replace broken or lost remotes
- Original Remote note required

Order Code: 8 WAY
Price: 1450P + VAT

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Access & Visa Card accepted
WE STOCK TV AND VIDEO SPARES, JAPANESE TRANSISTORS AND TDA SERIES. PLEASE RING US FOR FURTHER INFORMATION.

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
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BC557	7P
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BC560	8P
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BC639	20P
BC640	20P
BCY33	200P
BCY34	200P
BCY70	16P
BCY71	16P
BCY72	16P
BD115	30P
BD124P	50P
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BD643	50P
BD645	50P

PART	PRICE
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BDX67C	275P
BDX71	70P
BDX77	175P
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BDX88C	150P
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BDW93	50P
BDW94	50P
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BDY56	225P
BDY58	500P
BDY90	125P
BDY92	100P
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BF167	30P
BF181	18P
BF183	20P
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BF225	30P
BF240	16P
BF245	25P
BF254	15P
BF255	12P
BF256	18P
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BF455	12P
BF458	19P
BF462	50P
BF471	28P
BF472	28P
BF479	30P
BF494	16P
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BF595	16P
BF596	16P
BF615	30P
BF617	30P
BF760	4OP
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
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BU226	120P
BU312	90P
BU325	55P
BU326A	75P
BU406	60P
BU406D	85P
BU407	55P
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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
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BU505DF	90P
BU506	100P
BU506D	70P
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BU526	75P
BU536	100P
BU546	125P
BU603	125P
BU606D	225P
BU608D	120P
BU626	120P
BU705	130P
BU706DF	175P
BU706F	150P
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BU801	70P
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BU826	120P
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BU903	110P
BU910	80P
BU912	100P
BU920	100P
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BU930	130P
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BUH15D	250P
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BUH517	275P
BUH517D	175P
BUH715	425P
BUV93	375P
BUK444/500B	200P
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BUK455/600B	200P
BUK456/	200P
BUW81A	150P
BUR51	1900P
BUR52	1900P
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BUS12A	200P
BUS14A	500P
BUS23	225P
BUS48A	175P
BUT11A	55P
BUT11AF	55P
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BUT76A	80P
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BUX42	200P
BUX47A	200P

PART	PRICE
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BUX81	160P
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BUX85	50P
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BUZ83	200P
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IRF120	225P
IRF130	475P
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IRF230	550P
IRF240	425P
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IRF330	600P
IRF340	325P
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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
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IRF9540	300P
IRF9541	200P
IRF9610	150P
IRF9620	150P
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IRF9640	375P
IRFD9220	100P
IRFBC30	200P
IRFBC40	400P
IRFP140	250P
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IRFP240	300P
IRFP250	400P
IRFP350	325P
IRFP450	400P
IRFP460	775P
IRFP9140	1450P
IRFP9240	500P
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IRFZ20	65P
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MJE13007	100P
MJE13009	100P
MJE15028	200P
MJE15029	200P
MJE15030	250P
MJE15031	400P
MJE18004	125P
MJF18004	175P
MJF18204	350P
MPSA05	15P
MPSA06	15P
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MPSA13	15P

PART	PRICE
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MR510	35P
MR856	36P
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OC36	250P
OC45	50P
OC200	180P
R2008B	100P
R2010B	100P
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S2000AF	175P
S2055A	175P
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S2800M	72P
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2N918	30P
2N930	18P
2N1131	28P
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2N1304	350P
2N1305	225P
2N1613	24P
2N1711	24P
2N1893	30P
2N2102	50P
2N2218A	24P
2N2219	24P
2N2221	23P
2N2222	23P
2N2243	40P
2N2369	15P
2N2484	15P
2N2646	40P
2N2894	50P
2N2904	20P
2N2905	20P
2N2906	18P
2N2907	18P
2N3019	28P
2N3053	18P
2N3054	40P
2N3055	38P
2N3055H	50P
2N3439	40P
2N3440	45P
2N3441	175P
2N3442	85P

PART	PRICE
2N3553	100P
2N3585	650P
2N3702	9P
2N3703	9P
2N3704	9P
2N3705	9P
2N3706	9P
2N3707	9P
2N3710	12P
2N3711	12P
2N3771	85P
2N3772	90P
2N3773	100P
2N3792	150P
2N3799	18P
2N3819	29P
2N3820	70P
2N3823	40P
2N3866	110P
2N3903	11P
2N3906	11P
2N3924	375P
2N3958	375P
2N4031	25P
2N4033	25P
2N4036	29P
2N4220	175P
2N4347	130P
2N4391	60P
2N4392	50P
2N4393	55P
2N4399	200P
2N4401	12P
2N4403	12P
2N4416	120P
2N4420	75P
2N4427	75P
2N4920	50P
2N4922	30P
2N4923	30P
2N5038	175P
2N5061	20P
2N5088	20P
2N5109	100P
2N5116	175P
2N5154	150P
2N5160	600P
2N5179	40P
2N5192	50P
2N5241	500P
2N5245	45P
2N5294	30P
2N5296	30P
2N5320	50P
2N5322	55P
2N5401	10P
2N5416	40P
2N5448	12P
2N5457	45P
2N5458	55P
2N5460	55P
2N5461	75P
2N5462	45P
2N5484	55P
2N5551	12P
2N5671	350P
2N5672	400P
2N5680	55P
2N5884	175P
2N5886	325P
2N6031	250P
2N6049	55P
2N6059	150P
2N6098	50P
2N6099	45P
2N6107	40P
2N6109	40P
2N6211	400P
2N6248	150P
2N6284	250P
2N6287	225P
2N6292	40P
2N6385	120P
2N6403	160P
2N6427	25P
2N6476	250P
2N6488	90P
2N6491	90P
2N6547	300P
2N6609	375P
2N6660	375P
2N6675	175P
2N6678	225P
4N35	50P

RECTIFIER DIODES

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

SATELLITE POWER SUPPLY REPAIR KITS

ALBA	CODE
SAT660	SATPSU2

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

BRITISH TELECOM	CODE
SVS300	SATPSU17

BUSH	CODE
IRD150	SATPSU12
IRD155	SATPSU19

CHURCHILL	CODE
D3MAC DECODER	SATPSU7

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

FERGUSON	CODE
SRD 5, SRD16	SATPSU1
SRV1	SATPSU2
SRDE4	SATPSU11

FINLUX	CODE
SR5700	SATPSU12

GOODMANS	CODE
ST700	SATPSU1

GRUNDIG	CODE
STR1	SATPSU1
GIRD200, FIRD3000	SATPSU2

MANHATTAN	CODE
850, 950	SATPSU1

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

MIMTEC	CODE
SOPRENSON TYPE PSU ONLY	SATPSU15

NETWORK	CODE
9000, 9200	SATPSU2

NOKIA	CODE
SAT1500	SATPSU2

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

PHILIPS	CODE
STU802/05M	SATPSU1
STU801	SATPSU2

THOMSON	CODE
SRS4	SATPSU2

TOSHIBA	CODE
SAT99, TU-SDU200	SATPSU1

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

PACE SATELLITE TUNERS

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

PACE SWITCH MODE TRANSFORMERS

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

SATMETER

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

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

LED INDICATOR: VERTICAL/HORIZONTAL
POWER AMPLIFIER: 18 DB

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

ORDER CODE: TOOL 22 PRICE: 8500p

SATELLITE LNB'S

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

FUSES

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

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

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

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

PART	PRICE
8156	300p
8224	240p
8226	240p
8250	750p
8251	200p
8253	160p
8257	220p
8271	340p
8279	270p
8283	400p
8284	440p
8287	260p
8288	650p
82C206PLCC	500p
8748	700p
8755	800p
8T26	95p
8T28	110p
CMOS IC's	
4000	13p
4001	13p
4002	13p
4006	34p
4007	13p
4009	20p
4010	21p
4011	13p
4012	13p
4013	19p
4014	32p
4016	18p
4018	30p
4019	28p
4020	33p
4021	36p
4022	36p
4023	13p
4024	25p
4025	13p
4026	60p
4027	18p
4028	29p
4029	34p
4030	17p
4032	52p
4033	60p
4034	76p
4035	42p
4038	46p
4040	30p
4041	36p
4042	30p
4043	36p
4045	72p
4046	42p
4047	45p
4048	26p
4049	18p
4050	20p
4051	38p
4052	35p
4053	35p
4054	53p
4055	52p
4056	52p
4060	40p
4063	52p
4066	20p
4067	120p
4068	13p
4069	13p
4070	13p
4071	13p
4072	13p
4073	13p

PART	PRICE
4075	13p
4076	42p
4077	13p
4078	13p
4081	13p
4082	13p
4085	36p
4086	30p
4089	75p
4093	18p
4094	44p
4094	58p
4098	50p
4099	42p
4501	26p
4502	36p
4504	35p
4505	80p
4506	58p
4507	30p
4508	67p
4510	32p
4511	30p
4512	38p
4514	65p
4515	65p
4516	36p
4517	100p
4518	36p
4519	28p
4520	36p
4521	86p
4526	38p
4527	41p
4528	38p
4529	65p
4532	48p
4553	140p
4555	29p
4556	36p
4557	140p
4583	60p
4584	30p
4585	40p
40103	120p
40105	140p
40106	35p
40107	50p
40110	170p
40114	180p
40160	55p
40161	55p
40174	48p
40192	48p
40193	48p
40194	58p
40257	120p
74 SERIES	
7400	20p
7401	16p
7402	18p
7403	20p
7404	35p
7405	10p
7406	30p
7407	30p
7408	25p
7409	20p
7413	30p
7414	45p
7416	32p
7417	32p
7420	20p
7421	25p
7425	15p

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

SERVICE AIDS

DESCRIPTION	VOLUME	CODE	PRICE	DESCRIPTION	VOLUME	CODE	PRICE
VIDEO HEAD CLEANER	75ML	SP01	180p	EXCEL POLISH 80	250ML	SP18	150p
VIDEO HEAD CLEANER	200ML	SP27	250p	ADHESIVE 120	400ML	SP19	190p
SWITCH CLEANER	176ML	SP02	180p	LABEL REMOVER 130	200ML	SP20	240p
SUPER 40	400ML	SP15	250p	REFURB 140	400ML	SP21	240p
SILICONE GREASE	200ML	SP03	210p	TUBE SILICON GREASE	50 GRAMMES	SP11	220p
FREEZE IT	170ML	SP04	320p	TUBE TUBE SILICON			
FREEZE IT	400ML	SP16	600p	SEALANT WHITE	75ML	SP22	280p
FOAM CLEANER	400ML	SP05	200p	TUBE SILICON SEALANT			
ANTI STATIC	200ML	SP06	190p	CLEAR	75ML	SP23	280p
AEROKLEANE	200ML	SP07	220p	TUBE HEAT SINK COMPUND	25 GRAMMES	SP12	150p
AERO DUSTER	150ML	SP08	310p	DRIVE CLEANER	200ML	SP24	150P
AERO DUSTER	400ML	SP17	550p	SCREEN CLEANER	200ML	SP25	150p
PLASTIC SEAL	200ML	SP09	250p	COMPUTER CARE KIT		SP26	2100p
GLASS CLEANER	250ML	SP10	160p	ANTI STATIC FOAM CLEANER	400ML	SP28	175p
COLDKLENE	250ML	SP13	230p	AIR DUSTER	400ML	SP29	450p

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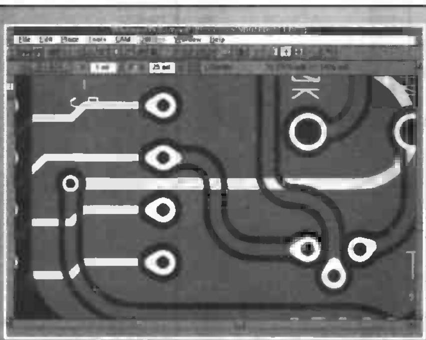
News...

OVERSEAS READERS

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

Update to WinDraft for schematic design



Ivex Design International's WinDraft CAD package for Windows will now have the capability to act as a "schematic viewer" and view any size of sheet. The facility applies to all versions, including the 100-pin capacity shareware version.

WinDraft's view mode is analogous to Microsoft's Word 6 viewer, and allows the user to view a document without having to purchase a "full" version of the software. According to Ivex, WinDraft V1.26 will give engineers the ability to distribute schematics freely in a standardised format, including over the Internet.

Features available with V1.26 include the ability to view any size of sheet created with a licensed copy of WinDraft Schematics; added printing functionality to allow x and y offsets in the print dialog box; user definable attribute fields to include in the Bill of Materials (the user can include information such as the module name, part stock number or any other attribute); an improved Library Editor to allow easier pin mobility when creating or editing parts and changed configuration to speed up use; added default module footprints of hundreds of additional parts to facilitate PCB layout; user-request to view pin numbers on power pins; revised Getting Started Guide which includes netlist information and important PCB layout information; revised on-line Help with up to date information.

WinDraft is the ideal front end for WinBoard PCB layout software. Prices range from £19.95 (including VAT) to £350 plus VAT, depending on the pin capacity. Version 1.26 is a free upgrade to existing customers.

A free shareware version of both WinDraft and WinBoard can be obtained from the Web at http://www.ivex.com by downloading wdshare.exe and wbshare.exe on the anonymous FTP service. These shareware versions are complete, fully functional programs with an 100-pin/pad limitation, and will now view any size of schematic.

For more information contact The PC Solution, 2a High Road, Leyton, London E15 2BP. Tel 0181 926 1161 Fax 0181 926 1160 email: info@The PCSol.Demon.co.uk.

Shorts

Author Bill Davies has produced a substantial first volume in a series covering all areas of applied robotics, Practical Robotics. For information about the contents, price, delivery costs etc. please contact the author at WERD Technology Inc., Unit 35B, Suite 155, 10520 Yonge St., Richman Hill, Ontario L4C 3C7, Canada. Information may also be available from CPIC Technical Books email cpic@idirect.com

The Federation of Electronics Industry has appointed a new President for 1997-1998, Barry Wood, chairman and MD of Celab Ltd., specialists in power conversion for defence, telecomms and cable TV. Speaking to the FEI annual dinner, Barry Wood said, "Well over 80 percent of the 50,000 companies in the electronics and related industries employ less than 20 people and over 95 percent less than 200 people. Successful partnerships between large and small enterprises are crucial to the economic success of national and European industry. Without innovative and flexible small firsm the industry will not prosper." IT, electronics and telecommunications is set to represent 10 percent of all

Yes, There are 5 prizes to win!

But np prizes for spotting that we only printed one question last month, instead of the three questions needed to enter our RD Research/B2Sprice competition. Technical details: it was right when it left our end of the phone lines, and different when it came out at the other end, burying the all-important questions under the answer coupon.

The three questions are:

Question 1 What is the latest SPICE ENGINE used in B2 Spice V2?

Question 2: Which university developed it?

Question 3: What does SPICE stand for?

The competition is open to purchasers of ETI Issue 10 1997 (last month's issue) who are not empolyees of Nexus Special Interest Ltd. or RD Research. Please send your entries on the coupon in Issue 10, or a neat copy of it, to: Spice Competition, ETI Magazine, Nexus Special Interests, Nexus House, Boundary Way, Hemel Hempstead, Herts HP2 7ST. Terms are as published in ETI issue 10 1997, and the final date for entries has been extended to October 30th 1997.

ETI ELECTRONICS TODAY INTERNATIONAL News...

Electrical recycling charges up in Yorkshire

Businesses in Yorkshire have been invited to attend two seminars on electronic waste in Hull and Bradford in September as part of a trial collecting project to target the region's share of the 6 million or so pieces of electronic waste discarded annually in the UK. Equipment like computers, printers, telephones, fax machines and monitors contain valuable materials and components which can be collected for reuse and recycling.

The seminars were arranged by Save Waste and Prosper (SWAP) in conjunction with Leeds Environment Business Forum, Bradford Business and Environment Forum and the Humber Resource Efficiency Centre, with attendance by representatives from the Industry Council for Electronics Recycling and the Corporation of London. The main theme was a survey carried out by SWAP which revealed widespread uncertainty in local companies about how to dispose of obsolete electronic and electrical equipment. The 200 Leeds companies surveyed tackled the problem in a variety of ways from long-term storage, donation to schools, selling off to staff and disposal with general waste. Leeds-based collection company Silver Lining Ltd. began a trial collection service in July, to continue till January 1998 in the Leeds, Bradford and Humber areas. Considerable interest is expected from businesses that do not yet know about the scheme.

Few businesses know that they can pay to have specifically electronic waste removed; some items, such as nicad batteries, should by law be disposed of (by businesses) through specialist commercial waste collection, not via normal rubbish collection.

The seminars are part of a project funded by Cleanaway Ltd. through the Landfill Tax mechanism, which was one of the first to gain support in this way. Support has also come from the Government Office for Yorkshire and Humber.

Businesses that have electronic waste they want collected can contact the organisations listed below - please note that companies will be charged for collection according to the amount and weight of waste.

Paul Twiddy at Business Link Bradford tel. 01274 751399; John Frank at Leeds Environmental Business Forum, tel. 0113 2470000; Terry Lander, Humber Resource Efficiency Centre, tel. 01482 228580.

For further information, contact Elaine Kerrell or Rebecca Shannan at Save Waste and Prosper Ltd., tel. 0113 243 8777 fax 0113 234 4222.

Reclaim and recovery gathers pace in Scotland

A new electronics recycling plant is being opened at the Dumfries site of R Frazier Reclamation, Scotland's Waste, Electrical and Electronic Equipment (WEEE) Recycler. R Frazier Reclamation specialises in the recycling of computers, telecoms and office equipment, including the reclamation of components and parts, and the recycling of materials.

MD Gary Griffiths said, "The purpose-built recycling plant has been designed to process electrical and electronics equipment and related plastics. Sophisticated mechanical separation equipment will reduce electronic parts such as computer boards to small particles, enabling separation of metals from plastics and other materials more effectively than existing processes. The recovered material will them be recycled into new products." He also adds, "R Frazier's asset management approach maximises revenue earning potential as re-used equipment earns more than recycled material."

The company acknowledges openly (not all reclaiming operations do this) that a proportion of waste electronics will be recovered and resold for reuse in its original function. Product handling by the company is prioritised on the basis of re-use, reclaiming components and materials recycling. Trained operators sort incoming equipment to identify any products that can be sold for re-use. The remainder is dismantled and reusable components recovered for re-sale. Hazardous parts such as capacitors, VDUs and batteries are safely disposed of. The company states that security-sensitive equipment is guaranteed destruction - a reassurance that may be necessary as companies frequently forget to clean or overwrite company information on hard disks before parting with their obsolete computers. All products will be tracked and clients will receive reports on how and where materials end up.

"This offers clients the opportunity to turn waste management costs into possible revenue in a process offering both commercial and environmental benefits", says Chairman Liam McKenna.

The company is aiming for zero landfill at the end of the process, and reckons that it has already achieved 99 percent recovery on IT products and 97 percent on telecoms products. The company aims to work with organisations to improve the commercial viability of electronic and electrical equipment recycling, rather than have such recyclable material dumped at cost into landfill.

For further details, contact Gary Griffiths or Katie Martin tel. 01387 721513.

TELNET

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Hewlett Packard 180A/180C/181A/182C ... from £200
Hewlett Packard 1740A, 1741A, 1744A, 100MHz dual ch ... from £350
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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
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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 2221 – 100MHz Digital Storage 2 Channel ... £1750
Tektronix 2221 – 60MHz Digital Storage 2 Channel ... £1500
Tektronix 2235 – 60MHz Dual trace ... £450
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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
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Hewlett Packard 141T + 8552B + 8555A – (10MHz – 18GHz) ... £1600
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MISCELLANEOUS

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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
EIP 545 – Frequency counter 18GHz ... £1500
EIP 545A – Frequency counter 18GHz ... £1600
EIP 575 – Frequency counter 18GHz ... £1750
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
Farnell ESG-1000 Synthesised Signal Generator 1GHz (as new) ... £1650
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Digital Signal Processing

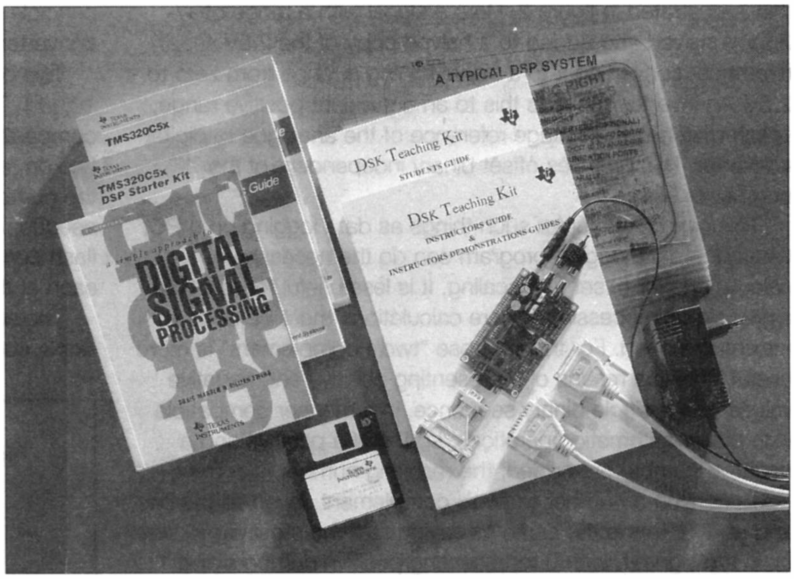
Signal processing in a chip, DSP will soon become as ubiquitous as the general purpose microprocessor.

Digital signal processing (DSP) is used in modems, amateur radio equipment, high-end sound equipment, and in many areas where you might not at first expect to find it. Although it is difficult to design a complicated DSP system, the principles on which DSP works are accessible to anyone. It is only the mathematics and coding for complex systems which present a challenge.

Apart from fashion, why should DSP be used in preference to other filtering techniques? There are many reasons, but one of the most important is that DSP can do things that are not achievable with conventional signal processing (see finite impulse response filters below), or that are too expensive or complicated to be practical with other techniques.

A DSP system is controlled by software, so that the same system can be dynamically reconfigured for different functions (for instance, for different modem speeds) or can even be self-adapting. Depending on speed of signal and the speed of the DSP system, the same DSP chip may be able to carry out several functions at once, or perhaps to control a user interface with controls and displays in addition to its real-time signal processing task. For these and other good reasons, DSP is becoming widely used.

Digital signal processing, once the signal is in digital form, requires adders, subtractors, multipliers and dividers. It also needs time delays, which can normally be provided by the use of memory.



Digitisation

In order to use a digital filtering system, the first requirement is to digitise the signal (unless, as with the data stream from a CD, it has already been digitised). In order to implement a high quality DSP function, the digitisation of the signal must be carried out to a high standard. Otherwise, even if the rest of the system is well designed, the overall performance will be disappointing. Since the aim of this article is to cover DSP itself, I shall cover only the highlights of digitisation.

An analogue signal, which may also be called a continuous time sequence, may be converted into a digital signal or discontinuous time sequence by sampling at regular intervals and assigning a digital value corresponding to the voltage of the signal at the instant of sampling. This principle is illustrated in figure 1.

In some cases the voltage to be measured will always be positive, in which case a binary representation starting at all zeros for the lowest voltage to be represented to all ones for the highest voltage will be suitable. However, in many cases positive and negative values must be represented, as in an audio signal. There are two major methods of using binary numbers to represent such voltages, offset binary, and twos complement.

Offset binary is straightforward to understand. If 8 bits are used to represent the signal than the zero point is set to 127

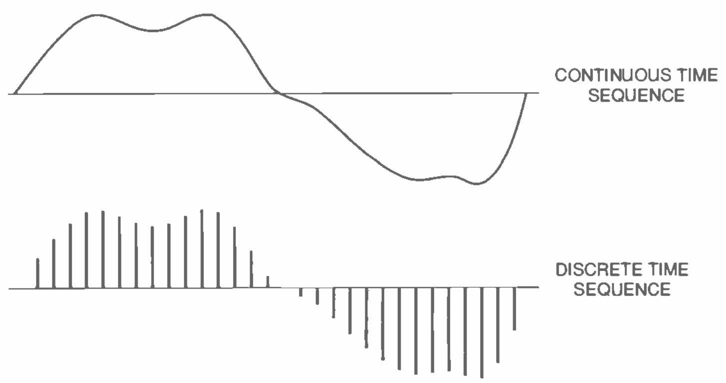


Figure 1: Sampling an analogue signal

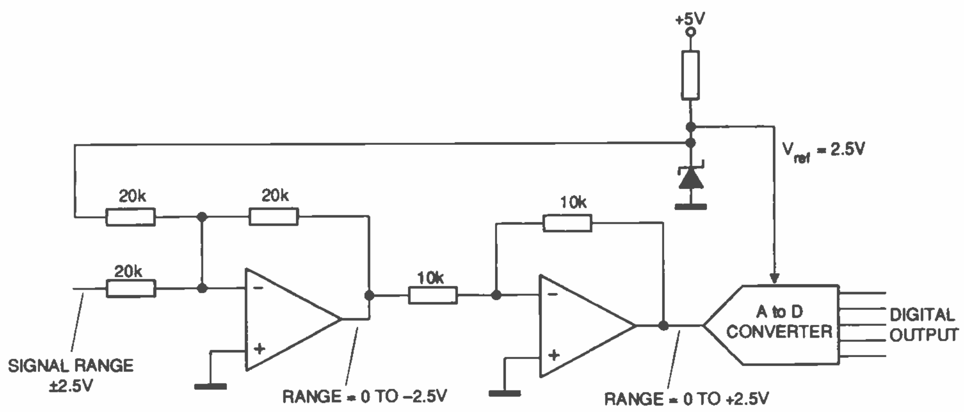


Figure 2: Converting a bipolar signal to a unipolar signal

(01111111 in binary, 7F in hexadecimal). A simple way to do this is illustrated in figure 2. Here a signal with a range of +/- 2.5V is halved and added to a halved copy of the 2.5V reference, converting it to a signal having a range from zero to -2.5V. An inverter converts this to an equivalent positive range, which matches the voltage reference of the analogue to digital converter. This provides offset binary independent of the number of bits.

This can be useful for such things as data logging on a PC, where the data logging program can do the necessary calculations for offset and scaling. It is less useful for real time digital signal processing, where calculations must be done with maximum speed. For this purpose "two's complement" is more useful. This is a means of representing positive and negative values with a single binary sequence, in a manner compatible with binary arithmetic operations, so that if a positive and a negative number are added, the resulting number is correct.

To convert a number to two's complement, invert all the bits and add 1. This is the same as saying that the most significant bit is the sign bit, with 0 representing positive numbers and 1 representing negative ones. It is also necessary to ignore the carry bit.

Here are some examples of additions:

00010110 (+0010110)
11111101 (-0000011)

100010011 (+0010100) (Disregard the carry bit, and the sign bit is 0, meaning positive)

00000011 (+0000011)
11101010 (-0010100)

11101101 (Two's complement for -0010011)

Most analogue to digital converters intended for use in DSP can output data in two's complement mode. Often the converter itself cannot accept negative input voltages, but can use an analogue ground offset of half the reference voltage. In this case a voltage of half the reference is added to the signal in a manner similar to that shown in figure 2 for the offset binary conversion.

Conversion techniques

There are a number of ways to convert a voltage to a binary number. The fastest is the flash converter, in which, for an eight-bit conversion, 255 comparators are used with a reference chain and the output is encoded into binary. This principle is illustrated in figure 3, which shows a two-bit flash converter.

Two bits of binary can have a total of four states: 00, 01, 10, 11. To split an input voltage into four states requires three comparators, with the states being: all comparators off, one on, two on, and all three on. In general, one comparator less than the number of states is needed, so 255 comparators would be needed for an eight-bit conversion. For video encoding, six bit flash converters are sometimes used, with one converter for each of the colour signals (RGB).

The advantage of a flash converter is that it is as fast as a single comparator, faster than any other technique.

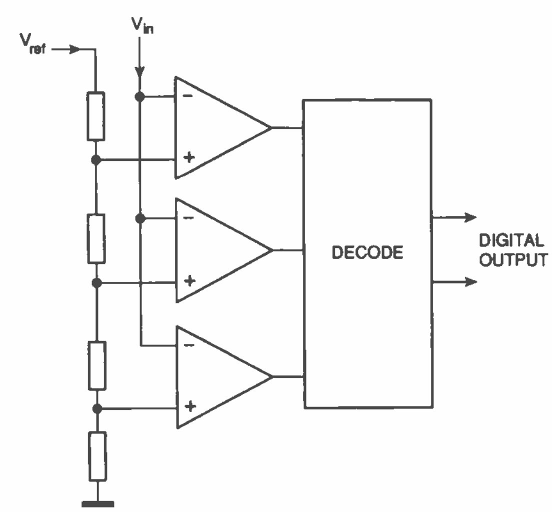


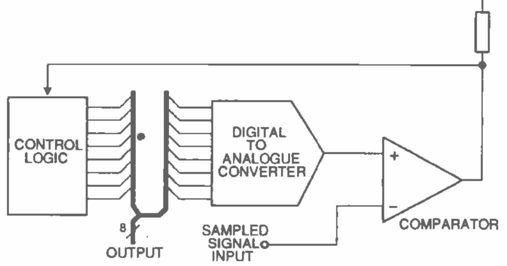
Figure 3: the operation of a flash converter

Disadvantages include the large number of comparators needed, and the power dissipation of the resistor chain. It is normally only considered practical to use integrated flash converters.

Perhaps the most accurate, and slowest, is the dual slope converter, used widely in digital multimeters. However, the majority of converters for medium frequencies (including audio) use a variety of successive approximation technique. The idea is illustrated in figure 4.

The procedure is to start with all bits set to 0, then set the most significant to 1 (that is, half scale). If the comparator switches, then the most significant bit gives too high a voltage, so it is set to 0 and the next most significant bit is set to 1. This

Figure 4: a successive approximation converter



process continues until all the bits have been tested. Thus a sixteen-bit conversion takes sixteen comparisons.

Normal digital to analogue converters use a series of resistors, either weighted in the sequence 1, 2, 4, 8 etc. or the widely used R-2R network.

It is difficult to integrate precision resistors of the quality required for accurate conversion using normal chip fabrication technology. Even for a 12-bit conversion, the most significant bit resistor must be accurate to one part in 4096. A 16-bit conversion requires an accuracy of one part in 65536.

Another interesting technique used in some A to D converters is to use capacitors instead of resistors, with analogue switches to sample and integrate the charge. Capacitor errors can be corrected by comparing larger value capacitors in the chain with all the smaller ones, and averaging the errors. Correction figures are stored in registers and used to correct the output for calibrated linearity errors. A detailed discussion of this is beyond the scope of this article, but various semiconductor manufacturers literature explains it in more detail.

It is worth noting that, in order to design a good quality DSP-based system, the analogue signal conditioning must be of an adequate standard. If the noise and offsets of the signal conditioning exceed one least significant bit, then the signal conditioning is probably degrading the overall result significantly.

Aliasing

When converting an analogue signal to a digital form, it is sampled at fixed times. It must be sampled sufficiently often that the instantaneous signal value has not changed too much since the last sample. Sampling less than once per half cycle of the maximum input frequency causes a particular problem, that of the generation of non-existent lower frequency signals as a result of a beat between the sample rate and the input frequency. This is illustrated in figure 5.

The resulting frequency in this example is in the audible range, and would definitely interfere with the sound of a CD if this effect were present on the recording. A sampling rate of exactly two samples per cycle is called the Nyquist frequency. This sample rate is the lowest possible one that avoids aliasing.

Clearly, it is better to sample at well above the Nyquist frequency if possible. There are several reasons for this. One is that, to avoid aliasing, the analogue signal must be filtered to remove all frequency components above half the sampling frequency. A higher sampling frequency permits the filter cutoff frequency to be well above the maximum frequency of interest, which improves the phase response in band. This is of interest in audio applications, where the effects of very sharp filters can be heard.

In addition, sampling generates noise power spread evenly over the spectrum. If the sampling rate is higher, the spectrum over which the noise power is spread is greater, so the proportion in the band of interest is less.

A digitisation technique particularly well suited to audio applications is called sigma-delta conversion. The sampling rate

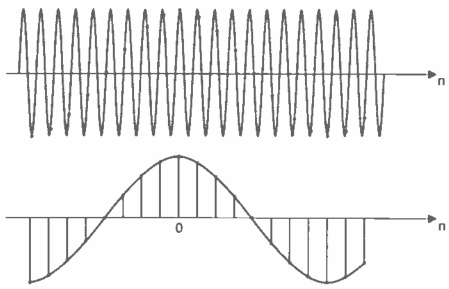


Figure 6: aliasing

is much higher than the Nyquist rate, but the conversion is only one bit. In effect, the one bit says whether the signal went up or down during the preceding sample period. Figure 6 shows the block diagram of a sigma-delta analogue to digital conversion. The loop here acts as a low pass filter for the input signal and a high pass filter for the quantisation noise. This noise shaping suits audio requirements well.

After the one-bit conversion is a decimation filter, which

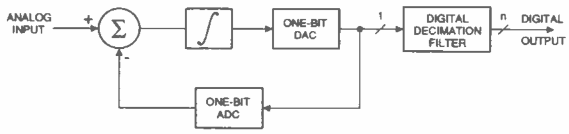


Figure 7: a sigma-delta converter

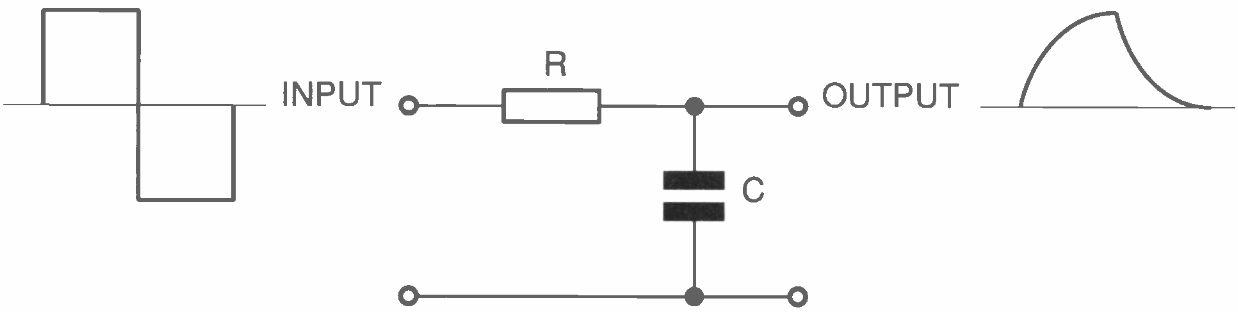


Figure 5: an RC filter

OUTPUT FROM ONE-BIT ADC:-

0 0 1 0 1 1 0 0 1 0 1 0 1 1 1 1 1 0 1 0 1 1 1 0 1 0 1 0 1 1 1 0 1

4x0 3x1 = 0 | 3x0 4x1 = 1 | 2x0 5x1 = 1 | 3x0 4x1 = 1

OUTPUT FROM DECIMATION FILTER (÷7)

0 1 1 1

Figure 8: operation of a digital decimation filter

lowers the data rate and increases the accuracy. Figure 7 shows the effect of the decimation filter.

Simple filters - FIR and IIR

The first point to note is that almost all other filter technologies give an infinite impulse response. This is easily illustrated by the simplest possible low pass filter, using one resistor and one capacitor, as shown in figure 8. The output voltage from this filter is affected by all previous inputs back to the time it was built, because the charging and discharging of the capacitor is exponential. The voltage on the capacitor approaches its aiming point more and more closely, but never actually reaches it. The exact voltage at any given point on a charge or discharge waveform is affected by the starting voltage, which is itself affected by the starting voltage of previous charge and discharge waveforms.

Equally, a tuned circuit will ring forever, with decreasing amplitude, after being excited with one impulse. So, the defining characteristic of an infinite impulse response filter is that its output is dependent on all the inputs it has ever received, and its output for a given input will persist theoretically to infinity. In real systems, the output will decline to a negligible level after a short time, but this level, though too small to measure, is not zero.

The infinite impulse response of analogue filters is not always brought out in mathematical descriptions. When Laplace transforms are used to analyse the filter response, there is normally an implicit assumption that the starting state of charge of all capacitors is zero, and that the initial inductor current is also zero. A rigorous Laplace transform would have to include the initial conditions of the system being analysed.

By contrast, a transversal filter using surface acoustic wave technology, shown in figure 9 is, apart from any imperfections, a finite impulse response filter. Different parts of the input signal are fed to the output with different amplitudes and delays, and after the input signal ceases, and has passed through the filter, its output is zero except for the effects of stray reflections from the acoustic absorbers.

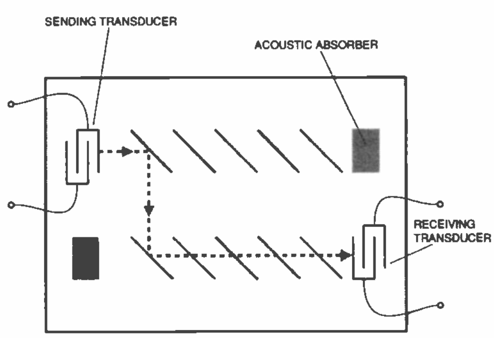


Figure 9: surface acoustic wave transversal

Figures 10 and 11 show examples of FIR and IIR filters. Note that the FIR filter has no feedback paths, and that the feedback paths are what make the filter infinite impulse response. Signals can be fed round and round the loop, being modified (probably attenuated) each time, but theoretically persisting forever. In practice, of course, the amplitude of the recirculating signal in a practical IIR filter will rapidly fall below one least significant bit.

DSP is often thought of as something only esoteric, but, although the term is not often used in this context, the averaging of a series of readings (to average out the noise) in a microprocessor based control system, is a simple form of digital signal processing.

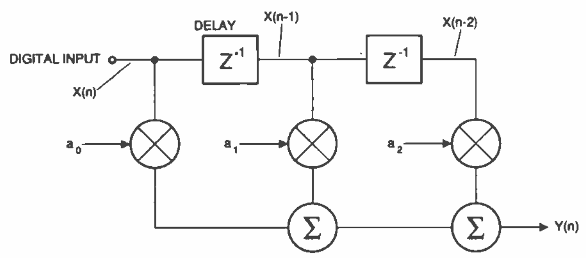


Figure 10: a simple finite impulse response filter

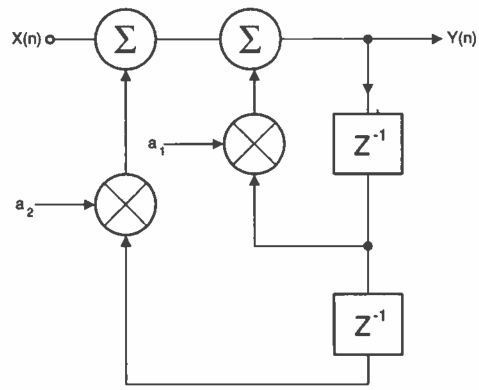


Figure 11: a simple infinite impulse response filter

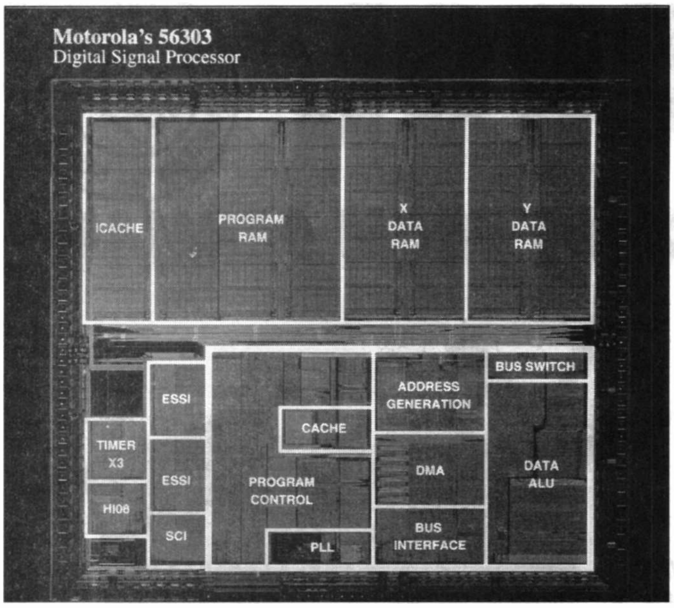
Characteristics of FIR and IIR filters

FIR filters can be linear phase and cannot oscillate. They also need a lot of stages to achieve a sharp cutoff.

IIR filters could oscillate if badly designed, and normally have a non-linear phase response, but a much sharper cut off than a similar order of FIR filter.

DSP chip major functions

As may already have become apparent, digital signal processing can be carried out on any microprocessor. The basic mathematical functions used - addition, multiplication etc. - are just the same. The reason for having specific chips or whole dedicated chip sets is because the arithmetical functions required involve a great deal of repetitive computation which is usually done in real time. A general-purpose microprocessor, while being capable of performing such 'number crunching', in practice would not be able to provide sufficient signal bandwidth to be useful. To overcome this, the chip designers have taken some of the software functions - such as



Motorola's 56303
Digital Signal Processor

multiplication - and provided a dedicated hardware multiplier that will provide the product of two digital numbers very quickly while the DSP processor is performing another task. The advantages of this are that a multiplication task is performed faster than the processor could do it, but at the expense of cost because the chip includes extra hardware.

On the other hand, it is optimised for the job, and in many cases a cheap dsp chip could perform dsp better than a Pentium.

The techniques of DSP have been around for a considerable time, but have been used much slower than real-time on previous generations of computers. For example, an audio recording could be digitally reprocessed to remove clicks and noise, and a new recording made to a quality more suitable for broadcast. Even if the process took several hours to improve a five-minute recording, the quality of the result was good enough to be worth the effort.

Nowadays, however, the term DSP is used to refer to real-time processing, often on audio or video frequency signals. Instead of the microprocessor carrying out multiplications using successive additions with shifts in between (shift and add), a hardware multiplier is used to do what is otherwise a software function. It is this approach that enables DSP chips to keep up with the real world signals that they are required to process.

Equally, time can be saved in fast Fourier transforms by incorporating a special addressing mode in the DSP chip (bit-swapped addressing). This permits samples to be stored in the order in which they occur, and be addressed in the order in which they are required, without doing any extra address calculations.

A major function of DSP chips is to carry out Fourier transforms. The reason is that the Fourier transform is a representation of a waveform in terms of frequency instead of time. In this representation, it is simple to remove a frequency component from the signal to generate a notch, or to make any other modification to the frequency response. To understand this, it is unavoidably necessary to look at the mathematics to a certain extent.

Fourier transforms

All complex (non-sinusoidal) signals are made up of various component frequencies. Viewing a square wave on an oscilloscope will show an easily recognisable trace, but feeding that same waveform into a spectrum analyser gives a very different picture indeed. The spectrum analyser, through the use of linear filters (or, if it's more modern, DSP), breaks the square wave up into its component frequencies and displays them as relative amplitudes. It is important to note that they are both giving the same information but in different domains. The oscilloscope shows the signal in the time domain with the horizontal axis representing time as defined by the timebase control. The spectrum analyser displays the signal in the frequency domain where the horizontal axis shows the frequency range over which the instrument is working. But note: the spectrum analyser does not give phase information of the displayed frequencies, which is vital to reconstituting the original signal from the displayed data.

In order to understand how a software program can calculate the frequency spectrum of a signal it is necessary to simplify for a moment by leaving out the effect of the sampling, and by using a repetitive signal such as a square wave. The Fourier transform converts between the time domain and frequency domain according to the following formula:

$$X(\omega)=1/2\pi.{}_{-\infty}\int^{+\infty} X(t).e^{-j\omega t}.dt$$

Where X(t) is the time waveform; X((ω) is all the component frequencies that go to make up the time waveform; 1 / 2πs converts between radians and hertz; e-jωt is a phasor representation of both sine and cosine terms represented as a time dependent waveform; and dt is the differentiation of the time waveform (X(t)) with respect to time (t), which extracts the rate of variation of the time waveform in time.

Examining this formula shows that it encompasses minus infinity to plus infinity, which means that it can cover random signals. The square wave, because it is repetitive does not need to solved over this range, only the period over which one complete cycle exists.

If a single frequency is represented by a sine wave and, as described above, the square wave contains many different frequencies, then the formula must describe the shape of the waveform in order to be able to extract the frequency data. Therefore to convert the square wave from a time domain waveform to a composite set of frequencies and phases, we modify the Fourier transform formula as follows:

For a square wave of amplitude (V and duration at each level T (that is, the total period 2T), the Fourier series is:

$$X(\omega)=1/2\pi.{}_{0}\int^{t}(+V).e^{-j\omega t}.\ dt + 1\ /\ 2\pi.{}_{t}\int^{2t}(-V).\ e^{-j\omega t}.\ dt$$

Where ∫ indicates integration.

This formula describes the basic shape of the waveform mathematically over the various time periods that go to make up the overall signal, a positive DC level which lasts for T seconds followed by a negative DC level which also lasts for T seconds. In fact any repetitive waveform can be described in this manner and the associated frequency spectrum derived accordingly.

When the data describing the waveform is entered into the formula it was presented in the form "over the time period 0 to X, the waveform was a DC level of +V volts", "over the time period X to Y the waveform was a DC level of -V volts". Examining the form of the data entry shows that we have described the shape of the waveform completely in a theoretical manner. In effect we have looked at the waveform outside of time and described how it varies with respect to time.

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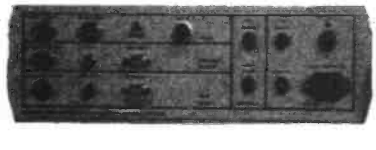

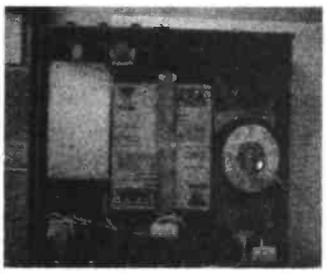

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FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

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

9-0-9V 4A TRANSFORMERS, chassis mount. £7 ref LOT19A.

FRESNEL PERSPEX SCREENS 11"x11"x316" as used in overhead projectors etc. New. £19 ref FRESN

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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Discrete transforms

If a dsp processor analyses a waveform it cannot "look ahead" to examine the whole waveform, all it can do is look at the signal level now plus a data array of historical values which describe the shape of the waveform over a specific period. To be able to analyse the signal fully, the dsp must be able to process sufficient sampling points to cover the entire square wave from its start point to the end point. Obviously the more complex a waveform is, the more sampling points are necessary and the larger the number of computations the processor has to cope with. Equally the samples must accurately describe the waveform shape without missing any fast transient edges.

All this applies to repetitive waveforms but not to the more random waves that dsp is really targeting. If a single sentence of speech is considered, there is virtually nothing within it that can obviously be described at repetitive, yet the sentence is rich with fundamental frequencies and associated harmonics, all of which can be extracted and either displayed or mathematically adapted.

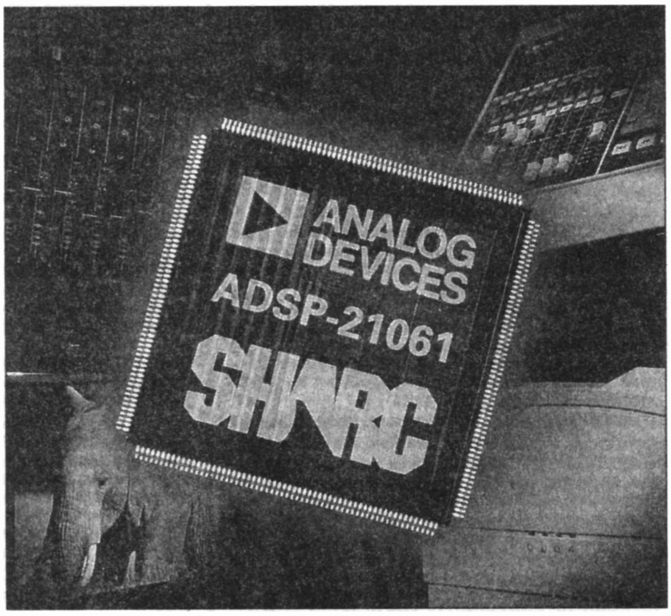
Try connecting a microphone to a spectrum analyser and looking over the range 50Hz to 20kHz. Speaking into the microphone will show a continually varying display of frequencies. This is an important aspect of the digital processing of a real time signal - the information is not constant as in the square wave analysed above. Thus a modification to the Fourier transform is needed, one that can cope with real world signals with time varying frequency components. The discrete Fourier transform is used to do this, and it works on a range of data samples during a discrete time period that can be used to interpret a portion of the incoming waveform and extract the frequency and phase information. Thus the dsp processor has to extract information from a small time window that contains a limited number of digitised samples of data. The more samples in a given window means a more accurate frequency description equally a bigger window will also increase the accuracy.

The easily understood means to carry out a Fourier transform on a set of sampled data is to generate data points for sinewaves of different frequencies which fit exactly into the length of the sample. The lower frequency limit is where one cycle fills the available space, while the upper limit is either the highest frequency of interest, or when there are only two samples per cycle.

These sinewaves are multiplied by the data samples point by point, and the amplitude of the resulting signal is computed. The same is done with cosine waves. Then, for each frequency computed, there is a sine and a cosine amplitude. This defines the amplitude and the phase, necessary to reconstitute the signal in time from frequency information.

Of course, to be useful the process is continuous, and as soon as one set of sampled data has been computed a further set is processed, to give a time varying set of frequency and phase components, like a spectrum analyser but with the addition of phase information. Often successive sets of data will overlap, to give a better representation of the waveform being processed.

This can be useful if, for example, a very sharp cutoff filter is required. For a lowpass filter, all that is necessary is to ignore frequencies above the cutoff point, then reconstruct the time varying waveform from the sine and cosine components from below the cutoff point. This would appear to be a perfect filter, but it is not because of the finite number of samples in a given window, and because not every frequency component in the



input signal has a whole number of cycles fitting within the set of samples used.

Also, it is fundamental to the principle of a Fourier transform that it is carried out on a waveform that repeats. Clearly speech or music waveforms do not fit this criterion, so that the answer is an approximation to the truth rather than being perfect. One way to improve this situation is to use a windowing function before the Fourier transform. This is effectively a means of scaling the data samples so that the ones at the beginning and end of the sequence are reduced in amplitude relative to the ones at the centre. This artificially makes the samples seem to contain only waves with whole numbers of cycles fitting in the window. Then the data is moved along by one sample and the whole process is carried out again.

This all takes a great deal of processing, and a typical DSP chip might only be able to deal with signals up to a few tens of hertz using the straightforward approach to the Fourier transform. However, looking at the maths carefully, it is discovered that the straightforward approach involves much duplication. An improved numerical technique called the fast Fourier transform has been developed. This reduces the computation to a series of pairs of additions, for which the only difficulty is that they are not done on consecutive addresses. Therefore many DSP chips have a special addressing mode called bit swapped addressing which automatically addresses the correct data points without extra machine samples. The fast Fourier transform is then a rapid and practical means to process signals, and it is widely used.

Image processing

There are a number of ways to process images so that they can be transmitted in less bandwidth. A widely used technique, typical of the field, is the discrete cosine transform. This analyses blocks of pixels to extract their frequency components, after which the higher frequency parts can be processed to reduce the total bandwidth requirement. There are two major approaches to this: one is simply to ignore high frequency components, perhaps below a certain amplitude. The other is to make use of the fact that the high frequency components are almost always of a lower amplitude than the rest of the signal and assign reduced length bit sequences to them. This is just a sample of what dsp is and can do. As mentioned in a previous editorial, dsp chips are now available to carry out all the functions of television intermediate frequency

GAS HOBS Standard domestic units, new and boxed, 3 burner, household gas, brown. Bargain at just £12.95 ref BAR318

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

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

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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

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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.

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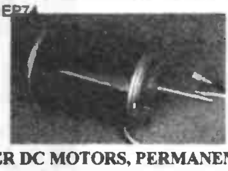

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ELECTRONIC SPEED CONTROLLER KIT For the above motor is £19 ref MAG17. Save £5 if you buy them both together, 1 motor plus speed controller rrp is £41, offer price £36 ref MOT5A

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
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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

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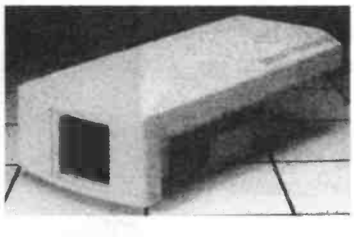

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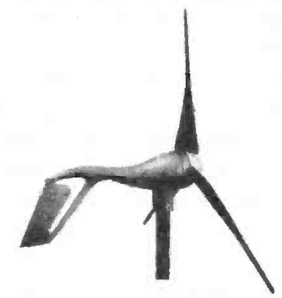

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amplifiers, with very good filter response. This has for some years been done using surface acoustic wave devices, but inevitable dsp will take over in an increasing number of television sets.

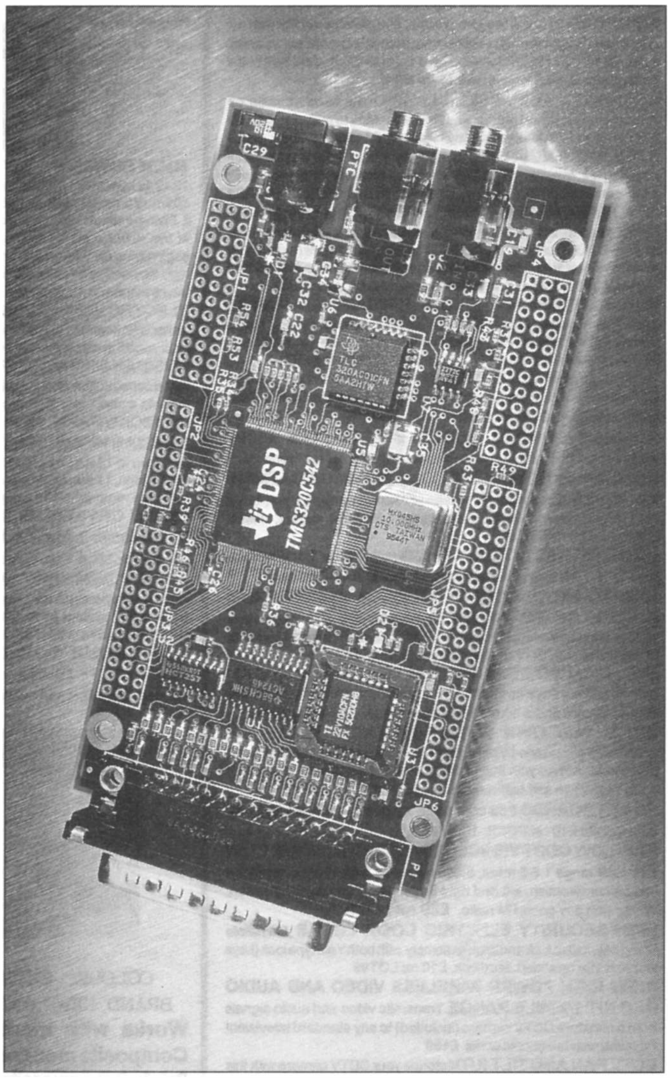
Digital television will only be practical because of the substantial bandwidth reduction possible due to dsp, thought the actual processing used will be multi-stage and more complex than just a discrete cosine transform.

Another function available from dsp is to correct for unpleasant frequency and phase responses by applying the reverse function. Thus it is possible to cancel the effects of room resonance etc much more accurately with DSP then with a graphic equaliser. It is also possible to do this automatically, so that the correction characteristics can adapt to a dance floor filling up during the evening.

Echo cancellation can be carried out conveniently using DSP. An algorithm analyses the time delay, amplitude, and frequency response of any echo on, for example, a telephone line, and subtracts a suitable signal to cancel the echo. This is important to permit modems to run at higher speeds.

As time goes on, more signal processing previously done by analogue electronics will instead be carried out using DSP. In most respects this will result in improved performance for less cost. The slight downside, which it is wise to try to avoid, is to put too trivial functions into DSP, so that a signal may be digitised, processed, and turned back into analogue, all to do what could be done just as well with one op-amp and four passive components.

DSP is not a panacea, but it is an increasingly important aspect of signal processing, enabling otherwise impossible functions to be carried out cheaply. Like the conventional microprocessor, DSP chips will soon be widely found in consumer electronics.



In the market

I have selected three examples from major semiconductor manufacturers to give an outline of what is happening in the field. The manufacture of dsp chips is now a widespread field undertaken by many semiconductor companies.

Texas Instruments have introduced a new dsp chip, the TMS320C6x, which is aimed at the digital cellular telephone market - not the handsets but base stations! The high points are the 200MHz operation, and an architecture called Very Long Instruction Word, which packs up to eight 32-bit instructions into a cycle. The performance is rated at 1600 mips, and it is able to carry out a 1024 point complex fast Fourier transform in 70ns.

The chip includes dual buffered serial ports intended to interface to standard telecommunication systems, and can implement a base station with 30 full GSM channels with a single dsp chip.

Another chip in the Texas range, the TMS320C54x, is used in a well-known range of 33.6kbps modems designed to be upgradable to 56kbps.

Analog Devices have recently added a lower cost dsp device to their high-power family, named SHARC (presumably from the Super Harvard Architecture). This is intended for applications such as home theatre, professional audio mixers, office scanners and printers among many others. Harvard architecture machines store code and data in separate memory banks with separate busses to speed access to program and data.

This is no device for the amateur, though. Costing $49 in quantity, the chip is supplied in a 240 lead quad flat pack.

The ADMC300 series is aimed at a very different function, that of motor control. By measuring various electrical parameters it is possible to determine the speed of an ac motor, how close it is to stalling, and so on, but to do this without sensors on the motor a dsp chip is needed. The ADMC incorporates five channels of 12-bit sigma-delta analogue to digital conversion for the necessary measurements, with an interface designed for position encoders for applications requiring this function.

Analog Devices even have a chip (the ADSP-2104) whose applications include use in toys. Other uses include telephone answering machines and music synthesisers. The chip provides 20 mips for $4.50 in quantity

Another semiconductor giant, Motorola, has recently released their DSP56300 family, whose features include one instruction per clock cycle, a low power consumption per MIPS, and carefully chosen instruction sets to give enhanced performance per mips. The chip is designed to carry out in one instruction what many chips must do in two.

The chip runs at 81MHz, but uses an internal phase locked loop frequency multiplier to permit the use of a lower frequency crystal. Applications at which the chip

is aimed include DVD (digital versatile disc), HDTV, and receivers incorporating Dolby AC3, for which Dolby labs have certified it.

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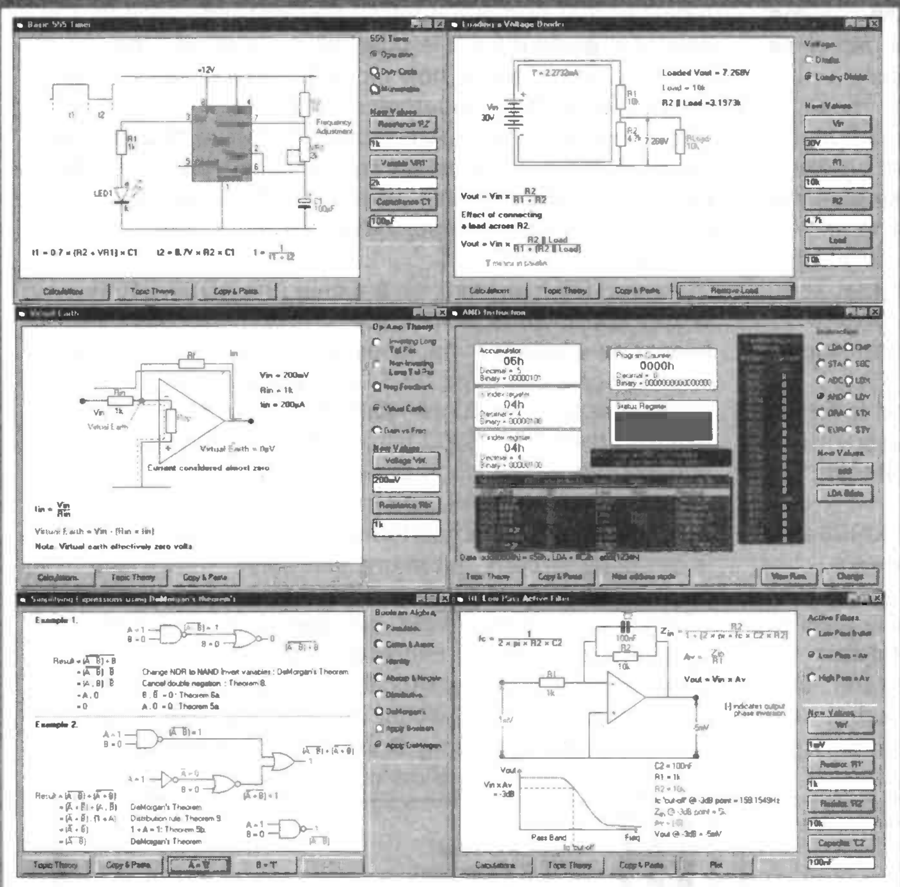

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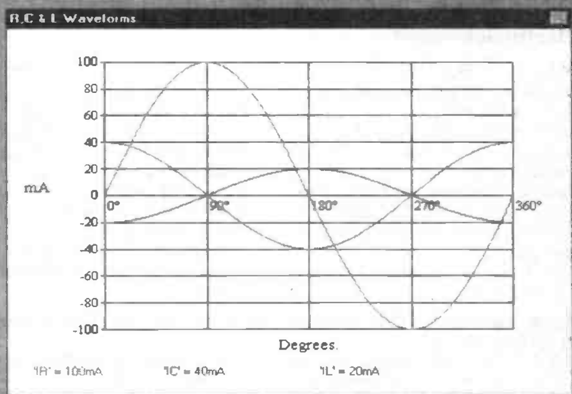

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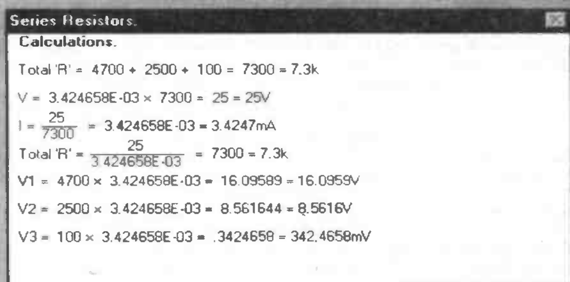

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A Total Harmonic Distortion Meter

For testing audio amplifiers, Robert Penfold's Total Harmonic Distortion (THD) meter incorporates a good quality notch filter and an audio millivoltmeter

When dealing with audio equipment there are several important parameters that often need to be measured. Most of these, such as frequency response and voltage gain, can be measured using just a sinewave generator and some form of audio millivolt meter. Total harmonic distortion (THD) is slightly more difficult to measure as it also requires a high quality audio notch filter. Furthermore, the quality of the audio signal generator is much more important for distortion measurement than it is for frequency response testing, etc. There is no point in trying to measure 0.1 percent distortion using a signal generator that itself has about 1 percent distortion on its sinewave output signal. Fortunately, most modern signal generators have very low distortion levels, and even some quite low cost units have a distortion figure of only about 0.01 percent at middle audio frequencies. This is more than adequate to measure the THD of all but the highest quality audio equipment. Note, though, that most function generators do not have low distortion output signals and are unsuitable for distortion measurements on all but the cheapest of audio equipment. Sinewave distortion figures of around 0.5 to 2 percent are quite common for this type of equipment.

The THD meter featured here consists of a high quality notch filter and an audio millivolt meter. The filter is tunable from about 100Hz to 10kHz in two ranges. The audio millivolt meter has four ranges with full scale values of 1mV, 10mV, 100mV, and 1 volt rms. These correspond to full scale distortion levels of 100 percent, 10 percent, 1 percent, and 0.1 percent. A separate signal generator is required, and any good quality Wien type audio generator should suffice.

THD basics

The two main forms of audio distortion are total harmonic and intermodulation distortion. Intermodulation distortion is where two frequencies are mixed to produce sum and difference frequencies (for example, signals at 1kHz and 3kHz would produce new signals at 2kHz and 4kHz). Total harmonic distortion is the more simple form, and it results in the generation of harmonics (multiples of the input frequency). For example, with a 1kHz test signal the harmonics will be at 2kHz, 3kHz, 4kHz, etc. This is the type of distortion normally specified in data sheets, amplifier specifications, etc. It is relatively easy to measure, and the block diagram of figure 1 shows the basic arrangement used.

The amplifier under test is fed with a high quality sinewave signal. The salient point here is that a sinewave signal consists of just the fundamental frequency, and has no harmonic content. The signal generator is set to provide the required output level from the

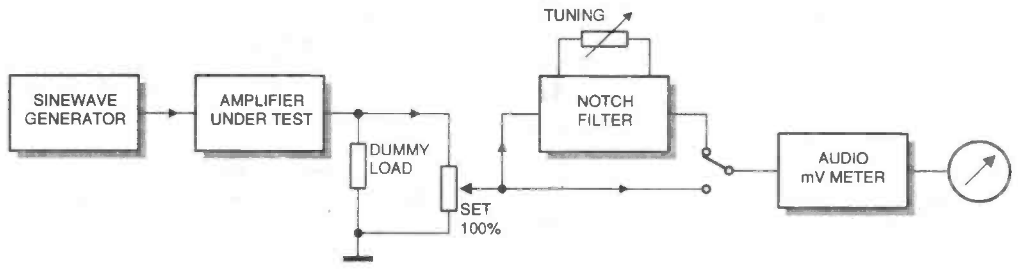
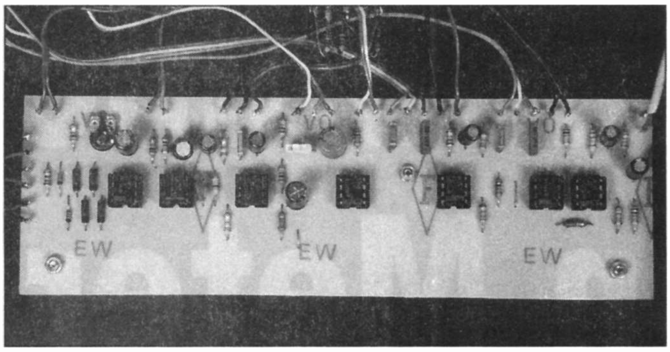


Figure 1: the basic arrangement used for measuring total harmonic distortion



amplifier, and if necessary a dummy load resistor is used at the output of the amplifier. When testing a preamplifier it may not be necessary to include this load resistor, but it will invariably be required when testing power amplifiers. This is due to the fact that power amplifiers provide greatly reduced performance when driving a low impedance load, which is of course the way that they will operate in normal use. Without the dummy load resistor the test will give a highly flattering account of the amplifier's performance.

A variable attenuator at the output of the amplifier enables the signal voltage to be reduced to a convenient reference level. This distortion meter is designed to operate at an input level of 1 volt rms, and the output of the attenuator is switched direct to the input of an audio millivolt meter so that the correct signal voltage can be set. The meter is then switched to monitor the output of the amplifier via a high quality notch filter. The tuning control of the notch filter is carefully adjusted to the test frequency so that the signai from the audio generator is removed. In practice it requires some careful adjustment of tuning and balance controls in order to obtain a really high degree of attenuation, but the fundamental signal can be reduced by about 80 dB. This application requires a very high quality filter as it must provide around 80 dB of attenuation in the notch, but it must provide no significant attenuation at twice the notch frequency or it will significantly reduce any second harmonic component in the signai.

With the fundamental signal removed, all that remains are the harmonics generated by distortion in the amplifier, plus any noise generated by the amplifier. This gives a figure for the noise and distortion of the amplifier, and this is called the distortion factor. The total harmonic distortion is equai to the distortion factor minus the noise level. The noise revel can be determined by disconnecting the signal generator from the input of the amplifier, short-circuiting the amplifier's input, and then measuring the noise using the audio millivolt meter. We are assuming here that the signal generator is perfect, and that it does not produce any noise or distortion of its own. In reality the noise and distortion from the signai generator will sometimes be a significant factor, and must be determined by initially measuring the direct output from the generator. Where necessary, the noise and distortion level of the signal generator itself can then be deducted from the figure obtained when testing an amplifier.

When you start testing modern audio equipment you soon discover that it is quite common for low cost equipment to have more mains hum on the output signal than general background noise and distortion. In fact the hum level can sometimes be many times higher than the harmonic distortion, resulting in the distortion products being swamped by the hum. In such cases it is only possible to make an accurate assessment of the distortion level if a hum filter is added ahead of the distortion meter circuit. Such a filter should be regarded as an essential item rather than as an optional extra if you intend to test a lot of "budget" audio equipment.

Circuit operation

The circuit diagram for the filter section of the unit appears in figure 2. The filter is based on a Wien network, which is the same type of network that is used as the basis of most high quality audio signal generators. In this case the two sections of the Wien network are fed with anti-phase signals, as shown in the skeleton circuit of figure 3. At a certain frequency there will be zero phase shift through both sections of the network, And precise cancelling of the two signals will result provided the signal levels are accurately balanced. This balancing is achieved by having the gain of the inverting amplifier variable, so that it can be adjusted to precisely match the amplitudes of the two signals. This produces a notch of very high attenuation at the frequency where zero phase shift occurs, but at other frequencies the amount of phase shift is unequal, and little cancelling of the signais occurs.

If we now consider the circuit of figure 2, VR1 is the variable input attenuator. From here the signal is coupled to a buffer amplifier which is based on IC1 and operates in the inverting mode. The signal is then applied to the main filter circuit which has IC2 as the non- inverting buffer stage and IC3 as the inverting mode amplifier. VR3 and VR4 enable the voltage gain of the inverting mode amplifier to the varied, and these two potentiometers respectively act as the fine and course balance controls. The restive elements in the Wien network are R5 plus VR2a, and R10 plus VR2b. VR2 is, of course, the tuning control. S1 enables either C4 and C7, or C5 and C8 to be used as the capacitors in the main network. This gives the unit its two tuning

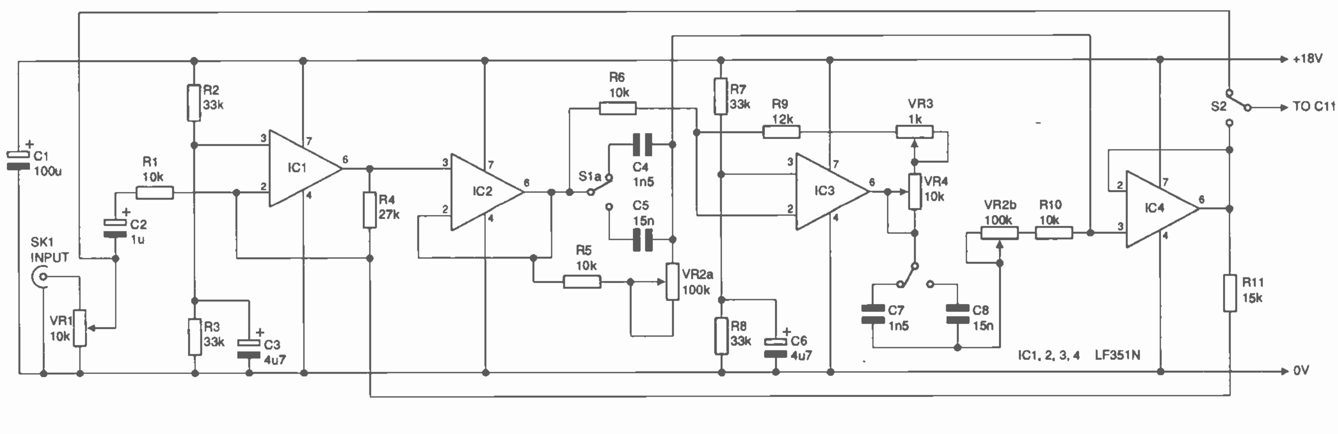


Figure 2: the circuit diagram for the filter section of the THD meter

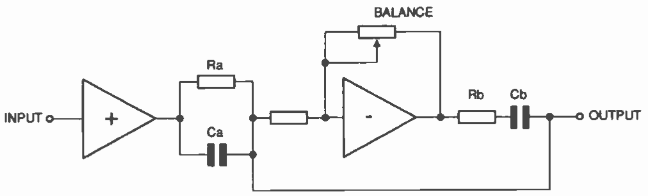


Figure 3: the basic configuration used in the notch filter. Ra, Rb, Ca and Cb are the Wien network

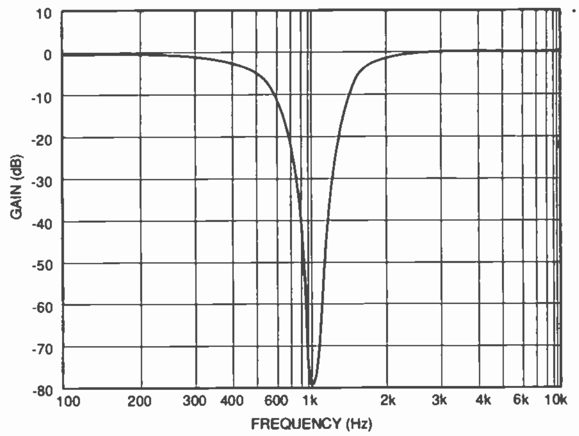


Figure 4: the frequency response of the prototype filter when turned to 1kHz

ranges of approximately 100Hz to 1kHZ (C5-C8) and 1kHz to 10kHz (C4 and C7). IC4 simply acts as a buffer stage at the output of the filter. Either the direct output of the input attenuator or the filtered signal can be selected using S2.

There is a slight problem with the basic filter circuit in that it provides about 6dB of attenuation at twice the notch frequency, which means that it would tend to reduce any second harmonic distortion and produce an unrealistically low total harmonic distortion figure. This problem is overcome by introducing some overall negative feedback to the circuit, and this feedback is provided by R11. As one would expect, the negative feedback reduces the voltage gain of the circuit and tends to flatten the frequency response. The reduced voltage gain simply brings the gain down to the required level of unity, and the flattening of the frequency response results in losses at double the notch frequency being reduced to about 1 dB. This level of attenuation is not high enough to significantly affect results and is therefore perfectly acceptable. One slight drawback of using the negative feedback is that it also tends to reduce the amount of attenuation in the notch, but this does not prevent the circuit from achieving some 80 dB or more of attenuation if the tuning and balance controls are carefully adjusted. Anyway, it is a price that has to be paid in order to obtain low levels of attenuation at the frequencies of the harmonics. Figure 4 shows the frequency response of the prototype filter when set for a notch frequency of 1 kilohertz.

Figure 5 shows the circuit diagram for the millivolt meter section of the unit. IC5 is used as a non-inverting buffer stage that provides the circuit with a high input impedance of 500 kilohms. A high input impedance is essential as the millivolt meter circuit will otherwise significantly load the input attenuator when S2 is switched to the direct mode. This would give a jump in the input level when S2 was set back to the filter mode. An input impedance of 500 kilohms is more than adequate to ensure that there is no significant change in the signal level when S2 is operated. The output from IC5 is coupled into a conventional four step attenuator which provides attenuation levels of zero, 20, 40, and 60dB. The basic sensitivity of the circuit is 1 millivolt rms, and the attenuator therefore provides additional ranges of 10 millivolts, 100 millivolts, and 1 volt rms. These correspond to full scale distortion figures of 0.1 percent, 1 percent, 10 percent, and 100 percent. Having the attenuator in a low impedance part of the circuit enables fairly low values to be used, thus avoiding the need for any frequency compensation capacitors.

IC6 is used as a simple non-inverting amplifier which has a voltage gain of about 40dB and an input impedance of 470 kilohms. This high input impedance ensures that there is no significant loading on the attenuator and that its accuracy is not impaired. SK2 enables the filtered signal to be monitored using an oscilloscope, or the signal can be monitored via a crystal earphone (but do not connect any other type of headphones or earphone to SK2). Testing the filtered signal "by ear" or using an oscilloscope can be quite revealing as it will show the nature of the noise and distortion signal. If the signal is predominantly mains hum or "hiss" type noise, it will be immediately obvious. The meter only shows you the level of the noise and distortion, with no hint as to its exact nature. You may also find that it is easier to null the fundamental signal "by ear" rather than using the meter as a signal level indicator.

IC7 is used in a conventional full-wave precision rectifier. A passive rectifier circuit based on semiconductor diodes gives inadequate performance due to the non- linearity of the diodes. In the case of ordinary silicon diodes this non-linearity is very severe

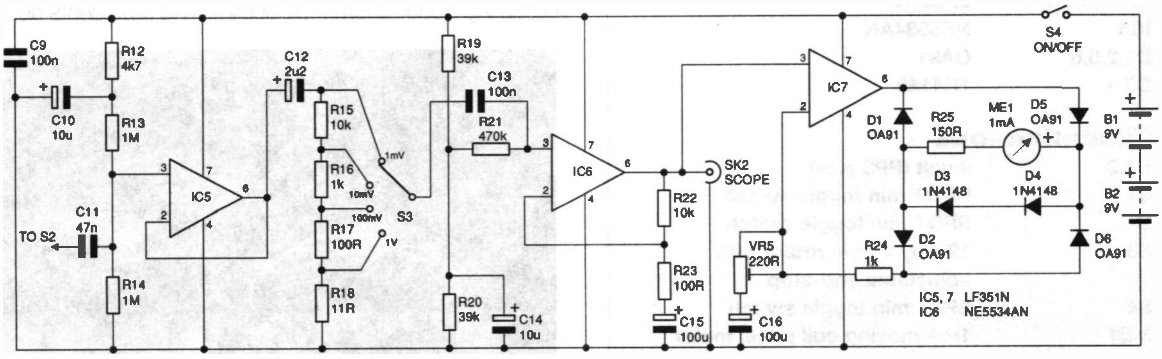


Figure 5: the circuit diagram for the audio millivolt meter section

indeed, and a forward voltage of about 0.5 volts or so is needed before any significant current starts to flow. Germanium diodes have much better performance in this respect, but they still provide something well short of good linearity. The standard approach to counteracting this non-linearity is to use the diodes in the negative feedback circuit of an amplifier. The general idea is to have non-linear feedback that counteracts the distortion through the diodes. This distorts the output signal of the amplifier in such a way that it accurately balances the non-linearity of the diodes and gives linear scaling on the meter.

In this precision rectifier circuit diodes D1, D2, D5, and D6 form a conventional bridge rectifier. Germanium diodes are used in the rectifier circuit as their better linearity places less demand on the amplifier, and provides better performance at high frequencies where the open loop gain of the amplifier is relatively low. The meter (ME1) is driven from the output of the rectifier via series resistor R25. D3 and D4 provide overload protection for ME1. IC7 is used in the non-inverting mode, and the rectifier circuit is connected in a negative feedback network which has VR5 and R24 as the other elements. The closed loop voltage gain of the rectifier circuit is controlled via VR5, and this is adjusted to give the circuit the correct sensitivity. The millivolt meter circuit has a -3dB point at about 100kHz.

The circuit requires a supply voltage of at least 18 volts, and this is provided by two nine volt batteries connected in series. On the face of it a supply potential of 9 volts would be adequate, since the circuit is handling a maximum input level of 1 volt rms (about 2.8 volts peak-to-peak). However, at some points in the filter circuit the signal level is very much higher than this, and the operational amplifiers provide better performance with a higher supply voltage anyway. The current consumption of the circuit is about 12 to 14 milliamps. Two PP3 size batteries are just about adequate to supply this, but it would probably be more economic to use higher capacity batteries if the unit is likely to receive a great deal of use.

A mains power supply unit can be used, but this should have a well smoothed output. Obtaining really good results using a mains power supply can be difficult though, with the general hum and noise level severely compromising results on the one millivolt range of the unit. In many areas the mains supply seems to be contaminated with a fair amount of noise, and it can be difficult to effectively screen sensitive audio circuits from this interference. Also, using a mains power supply unit is likely to introduce problems with hum loops unless you are very careful. Using a battery supply is an easy way of ensuring that a high level of performance is attained.

Construction

The component overlay for the printed circuit board is provided in figure 6. None of the integrated circuits are static sensitive types, but it is still advisable to fit them in DIL holders. Do not overlook the to link-wires (one just to the right of IC2, and the other above and to the right of IC4). D1, D2, D5, and D6 are all germanium diodes, and as such they are more easily damaged by overheating than silicon types. Take due care when soldering these components to the board, and try to complete each soldered joint reasonably quickly. In other respects construction of the board is perfectly straightforward.

Although the printed circuit board and batteries require only a modest amount of space, it will almost certainly be necessary to use a fairly sizeable case in order to accommodate the controls, sockets, and meter on the front panel. The prototype is housed in a metal and plastic instrument case which has a front panel measuring about 235mm by 90mm. This represents about the

PARTS LIST for the THD Meter

Resistors

(All 0.6 watt 1 percent metal film)

R1,5,6,10,15,22	10k
R2,3,7,8	33k
R4	27k
R9	12k
R11	15k
R12	4k7
R13,14	1M
R16,24	1k
R17,23	100R
R18	11R
R19,20	39k
R21	470k
R25	150R

Potentiometers

VR1	10k log rotary
VR2	100k lin dual gang rotary
VR3	1k lin rotary
VR4	10k lin rotary
VR5	220R min hor preset

Capacitors

C1	100u 25V radial elect
C2	1u 50V radial elect
C3,6	4u7 50V radial elect
C4,7	1n5 polyester
C5,8	15n polyester
C9	100n ceramic
C10,14	10u 25V radial elect
C11	47n polyester
C12	2u2 50V radial elect
C13	100n polyester
C15,16	100u 16V radial elect

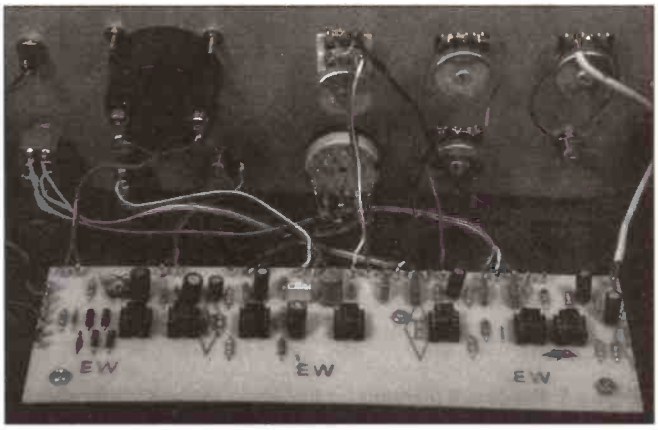
Semiconductors

IC1,2,3,4,5,7	LF351N
IC6	NE5534AN
D1,2,5,6	OA91
D3,4	1N4148

Miscellaneous

B1,2	9 volt (PP3 size)
S1	DPDT min toggle switch
S2	SPDT min toggle switch
S3	12 way 1 pole rotary with adjustable end-stop
S4	SPST min toggle switch
ME1	1mA moving coil panel meter
SK1,2	Phono socket

Instrument case about 246 x 220 x 100mm printed circuit board, 8-pin DIL holder control knob, battery connector, wire, solder, etc.



minimum size that will comfortably accommodate everything, although a slightly smaller panel will be acceptable if the two sockets are relegated to the rear panel. With sensitive test equipment such as this there is some advantage in using an all metal case which will provide screening of the components and wiring. No significant problems with stray pickup were experienced with the prototype equipment, but it is clearly not a good idea to operate the unit close to any likely sources of interference if it is housed in a non-metallic case.

Use a front panel layout that will make the unit reasonably straightforward to use, but also use one that will avoid too many long collecting wires, especially in the millivolt meter section of the unit. I used phono input and output sockets, but it is acceptable to use BNC sockets or any other type that will fit in better with your other equipment. Mounting the meter on the front panel can be slightly awkward as it requires a large circular cut-out which is 38 millimetres in diameter for a standard 60 by 45 millimetre panel meter. This can either be cut using a special hole cutting tool, or using something like a coping saw or an Abrafile. Once the large cut-out has been made the meter itself can be used as a sort of template to help locate the positions of the four small mounting holes. These are for the four threaded mounting rods that are built into the meter. These rods require three millimetre diameter mounting holes.

A substantial amount of hard wiring is required, and details of this wiring are provided in figure 7 (which should be used in conjunction with figure 6). Resistors R15 to R18 are mounted on S3, which helps to avoid problems caused by stray capacitance in the wiring. S3 is a standard 12 way 1 pole rotary switch having an adjustable and-stop, and in this case it is obviously set for four way operation. Fitting the resistors on the switch should be very easy provided the ends of the leadout wires and the tags of the switch are tinned with solder first. The rest of the wiring is perfectly straightforward, but with so much hard wiring it is obviously necessary to proceed carefully and to check everything very thoroughly once the wiring has been completed.

The 0-1 scaling of the meter is correct for the 1 percent range, and it is not difficult to convert readings into the corresponding distortion figures on the other ranges. Consequently, it is probably not worthwhile bothering with any recalibration of the meter's scale. If you should decide to do this, the front of the meter simply unclips, and removing two small screws then enables the scale plate to be slid clear of the meter movement. Rub-on transfers can then be used to add further numbers to the meter's scale, after which the meter is reassembled. Moving coil meter movements are very delicate mechanisms, and great care must be taken or the meter could be irreparably damaged.

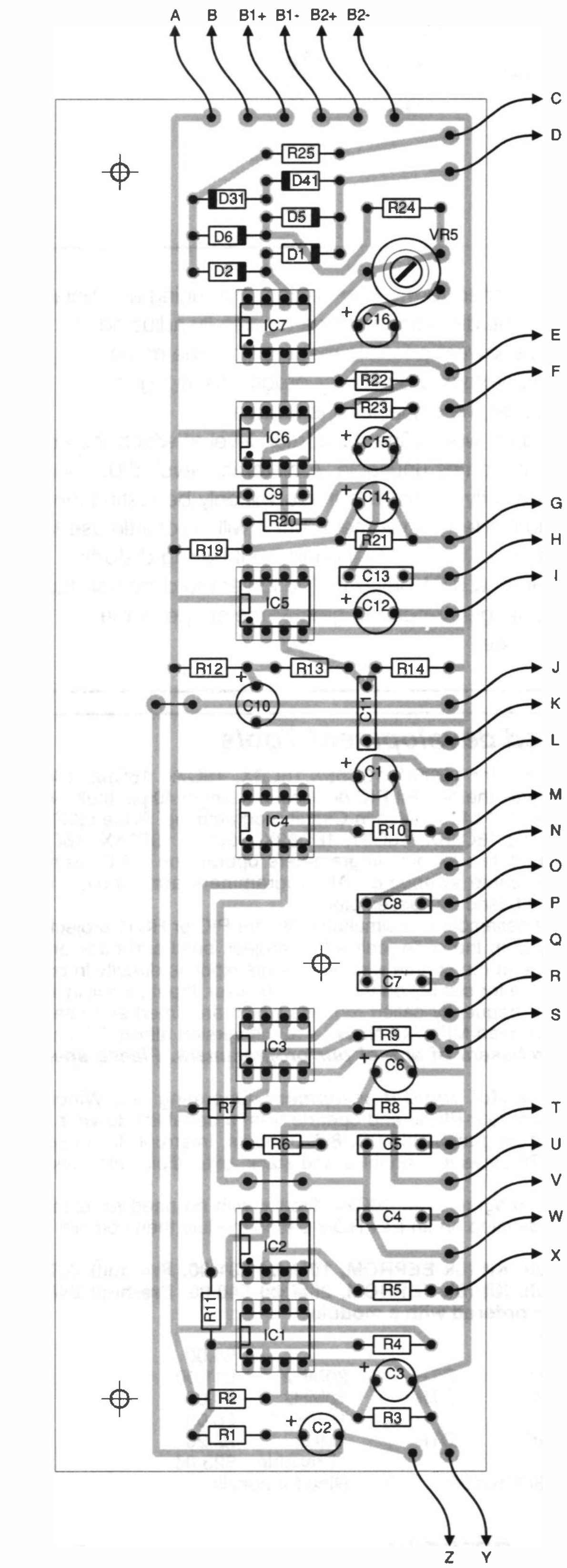


Figure 6: the component layout for the printed circuit board

Calibration and use

The millivolt meter must be calibrated before the unit can the be used in earnest. In order to do this the unit must be fed with an audio sinewave signal having an amplitude of 1 volt rms. Most ready-made audio signal generators have accurately calibrated output attenuators that make it easy to set the required output level. This feature is absent on most home constructed generators, and with these it will be necessary to measure the output level so that it can be set with a fair degree of accuracy. Most multimeters can measure a potential of 1 volt rms with moderate accuracy, but note that many multimeters (especially the digital variety) have very restricted bandwidths and will only give accurate results if the signal generator is set at a frequency of no more than a few hundred hertz. Fortunately, any error in the calibration will not impair the accuracy of results, it will simply mean that the unit is operating at a signal level which is not precisely 1 volt rms.

Start with VR5 at a roughly middle setting, and VR1 set in a fully clockwise direction. S2 should be set so that the millivolt meter is fed direct from the wiper of VR1, and S3 is set to the 1 volt position. With a suitable test signal applied to SK1,VR5 Is then adjusted to provide a full scale reading on the meter. The unit is then ready for use.

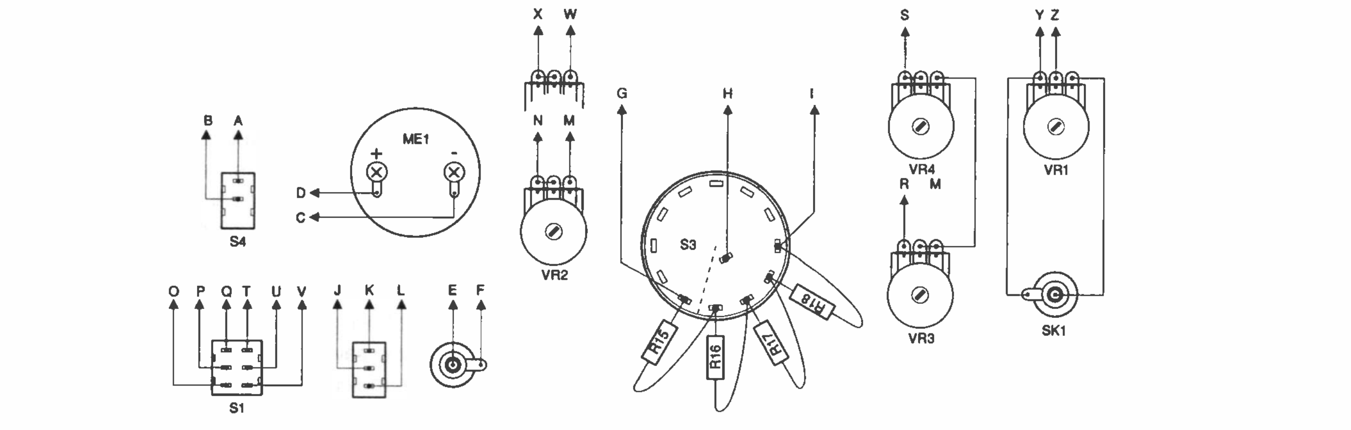


Figure 7: the hard wiring (use in conjunction with figure 6)

Before making any meaningful distortion measurements it is necessary to determine the distortion level of the signal generator you will be using. This is basically just a matter of making a normal distortion measurement, but the input of the distortion meter is fed direct from the signal generator rather than via an amplifier. The distortion performance of signal generators often varies quite significantly with changes in the output frequency, and it is therefore advisable to check the distortion figure of the generator at 100 hertz, 1 kilohertz, and 10 kilohertz. In each case it is a matter of first setting the signal generator to the correct output frequency, switching S2 to the direct mode, and setting S3 to the one volt range. VR1 and the output level controls of the generator are then adjusted to produce a full scale reading on the meter. With S2 switched to the filter setting, the tuning and balance controls of the distortion meter are carefully adjusted to produce the lowest possible reading from the meter. The millivolt meter should be set for progressively higher sensitivities as the signal level is reduced.

There is no well defined distortion level at which the audio generator becomes unusable. A distortion level of 0.1 percent may be perfectly acceptable if you will only be testing low and medium fidelity equipment, but it will be of little use for testing "state of the art" hi-fi equipment having distortion levels of around 0.01 percent. The lower the distortion factor of your audio generator, the greater the scope of the distortion meter.

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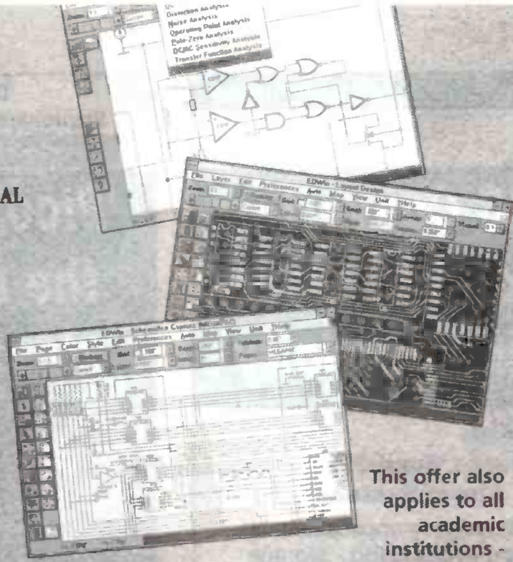

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Maximum number of multi-segment traces: 32,000, with a total of 64,000 trace segments.
ANSI/IEC libraries
Full Gerber, NCD, pic and place output

Schematic Capture

Up to 100 schematic sheets.
Up to 64" x 64" sheet size.
Industry standard sheet sizes.
Rotate, scale and mirror symbols.
Real-time dragging of components and wires.
Automatic package and pin assignment.
Orthogonal and free mode manual routing.
Automatic bus annotation.
Block save, load, move and delete.
Direct access to mixed mode simulation.
Autorouting of connections.
Merging and splitting of nets possibility.
Definable line width, also for bus-lines.
Swapping of component positions.
Automatic component renumbering by swapping.

PCB Layout

32 layers (28 route layers, 2 silk-screen layers (front and back), 2 soldermask layers (front and back)).
User definable trace sizes.
User definable pads.
Curved traces.
1 mil grid resolution - Fine grid 10 micron.
SMT, fine line, analog support.
Component repeat, rotate and mirror.
Components "Move by name".
Component, gate and pin swap.
Automatic component renaming.
Trace repeat.
On-line, multi-layer routing with automatic via insertion.
Pin-to-pin, free or 45 degree routing.
Change segment side and width, trace side and width.
Fast interactive generation of ground planes with user definable cross-hatch or solid fill.
Automatic ground plane with thermal relief insertion.
Automatic DRC with user specified parameters.
Electrical connectivity checking.
Linear rotation of symbols.
Gerber input read and use possibility.
Built-in interface for Spectra 6.0, Max route 6.0 and Arizona Autorouter.
Bitmap functions (logos, drawings, ...).
Sophisticated database viewer.

Mixed Mode Simulation

AC analysis (Frequency domain).
DC analysis (Linear/non-linear).
TD analysis (Time domain).
Diagram generator.
Dynamic parameter definition of active and passive components.
Output graphs displayed on screen, hardcopy or placed on schematic.
Oscilloscope function.
DLL based analog/digital simulation primitives, modelling language and library creation tools.
Built-in model generator for discrete devices.

Please Note: Some of the above are ONLY provided on the De Luxe 3 Version. EdSpice and Thermal Analysis are available as bolt-on extras.

MKII Electronic Auto-Checker

Tim Parker has updated the original multi-purpose Multi-checker to be a new, improved audible/visible low voltage tester, with a special relevance to cars

Regular readers will remember the Multi-checker from the August 1995 issue of ETI. Excellent piece of handy test gear though it was, it only had a visual indicator, lacking any audible feedback to the user. This made testing for voltages in awkward places a little difficult, since the user had to be able to actually see the tester in order to check the states of the two LEDs. The scenario which immediately comes to mind will be recognised by anyone who has tried to find a supply line, or install even the simplest pieces of equipment anywhere near the dashboard of a motor vehicle: lying on your back in either the driver's or the front passenger footwell, with your feet and lower leg portions either on, or up the back of the seat! As if that wasn't uncomfortable enough, if it's the drivers side, you also have the added pain in the neck - literally - from the control pedals folding up your skin like a baker kneading dough!

Once you have managed to get into this position, you then have to start the testing, prodding around with the test leads in the hopes of finding a 'live' wire, only to discover you cannot see the test equipment without inducing excruciating cramp in your neck or your stomach, or both. By this time you are in no position to manoeuvre your body to ease the pain.

To overcome this problem, and also in response to numerous requests from constructors for some form of audible indication, the original Multi-checker has now acquired a 'voice' - well, a buzzer at least. The overall operation of the original tester has also been made much simpler, converted from a (slightly tedious) three position slide switch, to a simple, one-press pushbutton operation. Given the above scenario, and because the majority of enquiries related to motor vehicle work, the new tester is known as the Auto-Checker.

As a reminder, figure 1 shows the circuit diagram of the original Multi-checker. This has two basic modes or functions: a voltage finder with polarity indicator, and a continuity/component tester. We won't ponder on the original circuit for long, because it was explained fully in the earlier issue of ETI, but a brief recap of how it works, using the new circuit in figure 2, will benefit new readers. We should point out that the Auto-Checker is not aimed solely at motor vehicles; it should satisfy the majority of basic 'good/no good' testing requirements for a range of low-volt electrical and electronic components, where just a simple indication of whether or not a device is working will do, or whether a low voltage connection has a potential on it or not.

The Auto-Checker uses two LEDs and a piezo buzzer to indicate the status of its two test points, to which a pair of test leads can be attached if required. A third LED is provided to warn you that the internal battery is being used, and serves as a reminder to switch off the tester afterwards. The test pads shown in figure 1, and which were fitted to the front of the original unit have been removed, because it was possible for either or both these to come into contact with (earthed) metal body parts during testing and, since they were connected directly to the test probe sockets, this was perhaps an undesirable situation with respect to motor vehicle testing, whereby a test pad in contact with the chassis of the vehicle might just happen to be the one corresponding to the particular test probe you have connected to the 'live' wire!

Note: This equipment is not for use on mains voltages.

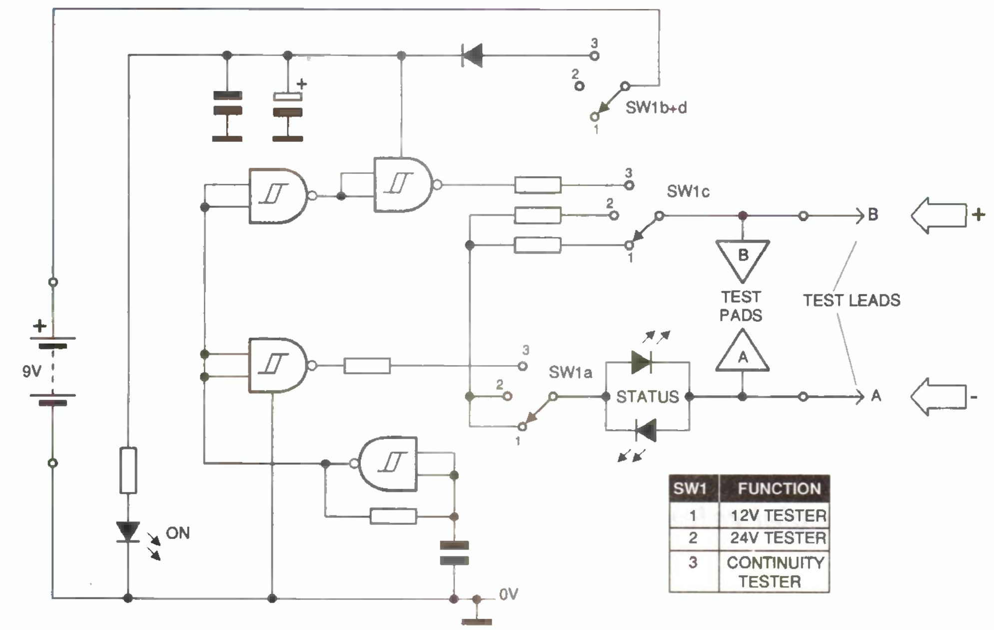


Figure 1: the original Multi-Checker circuit diagram from ETI August 1995

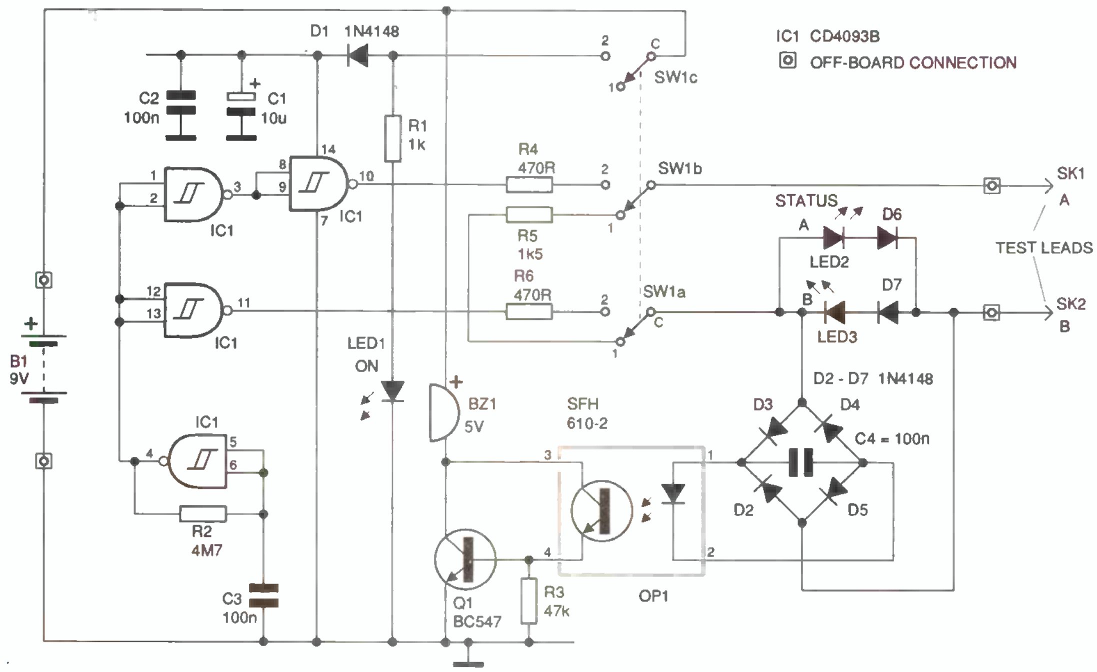


Figure 2: The Auto-checker circuit diagram

Auto-Checker Modes

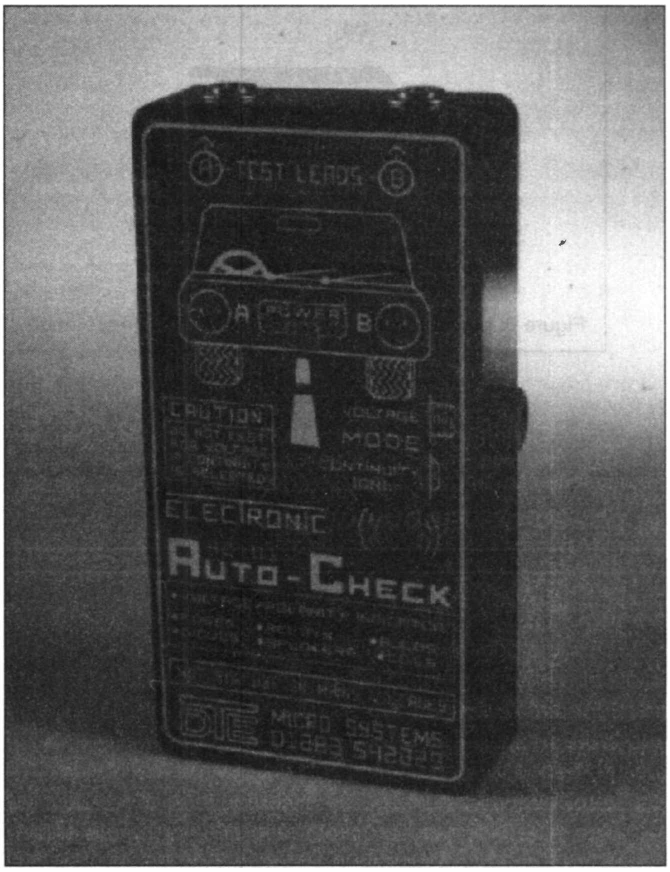
Mode 1 is a simple, low voltage indicator with an input level of up to about 25 volts. This is the default mode when the pushbutton is 'out', and the internal battery is on standby for the buzzer only. The test leads are not polarised, but are simply labelled 'A' and 'B', and you don't even have to worry about which way round to connect them to your circuit, since the Auto-Checker will light the LED(s) and sound the buzzer when a voltage is detected. The states of the LEDs and the type of sound from the buzzer indicate whether that voltage is AC, DC, or pulsing (on/off) DC up to about 20Hz. Furthermore, the Auto-Checker provides polarity indication for DC voltages, by showing which of the two test probes is connected to the positive terminal - ideal if you're looking for power when installing in-car accessories.

Mode 2 is enabled by depressing the pushbutton to the 'in' position. The Auto-Checker now becomes a simple audible/visual continuity tester, giving good or bad indication of fuses, light bulbs, switch contacts, transformer windings, speaker coils and heating elements, etc. - in fact, anything which has a relatively low resistance. This mode also provides a very useful facility for 'good/no good' testing of diodes and LEDs. By connecting them either way round across the test probes, the Auto-Checker will show which of the two probes is connected to the cathode of the device. Furthermore, if a good LED is being tested, not only will the cathode be identified, but it will also light up in a flashing manner, giving visual confirmation that it does actually work.

The circuit

With SW1 in position 1 (out), R5 is connected in series with the test points and LEDs 2 and 3. With a low voltage DC potential applied to the test points, the buzzer will sound and one of the LEDs will light, which also indicates the polarity of the voltage. If test point 'A' is connected to the positive connection then LED2 will light up. If the positive is on test point 'B' then LED3 will light up. If the voltage is pulsing at a frequency below about 20Hz, then the buzzer will pulse at the same rate, and either LED2 or LED3 will flash at this frequency, depending on which test point is connected to the pulsing line. At frequencies above 20Hz it will be difficult to detect the flashing and buzzer pulsing, which may give the (wrong) impression that the voltage is constant.

With a low voltage AC input, the buzzer sounds continuously and both LEDs light up, but each one on opposite half cycles of the input signal. Again, frequencies below about 20Hz should produce a noticeable pulsing. How apparent this is depends on the rise and fall times of the input waveform, a sinewave input will produce less flashing effect than a squarewave input, for instance.



Pressing SW1 (in) connects R4 and R6 in series with the test leads and the LEDs, and power is applied to IC1. D1 protects against reverse polarity, just in case the battery makes reverse contact with its connector clip when being replaced while SW1 is depressed. C1 and C2 provide supply rail decoupling and LED1 serves as a power on indicator, this helps to remind you to turn it off.

IC1, R2 and C3 form a low frequency squarewave oscillator with complimentary outputs on pins 10 and 11, which are connected in series with the test points, LEDs and current limiting resistors R4 and R6. With pin 10 high, and continuity or a low resistance across the test points - such as a good fuse or light bulb, current flowing through the load across the test points will light up LED3. With pin 11 high, LED2 will light up.

The buzzer circuit

Many constructors of the original Multi-checker attempted to connect a buzzer driver circuit of their own, usually by driving the base of a transistor from one of the test points via a suitable resistor (which, initially, seems the logical way to do it), only to discover it was not possible using a simple transistor switch, due to the fact that the test point terminals were bi-directional, and they also cannot have a current path to 0V. When they did manage to get it to work in a fashion, it would only respond to unipolar signals, and wouldn't work in the voltage test mode at all unless the buzzer was tied permanently to the positive supply rail. This was fine until they touched the test point terminal with just their fingers, which produced sufficient base drive to turn on the transistor and sound the buzzer, even with the Multi-checker turned off!

Bridge rectifier

In reply to all those who questioned the possibility of adding a buzzer, here's how it's done. The answer is to detect current flowing in either direction through either of the two status LEDs. This is achieved by connecting the AC input of a bridge rectifier - formed by D2 to D5 - across the LEDs themselves, and making use of the unipolar output from the bridge. Simple as this may seem in theory, it's a little more difficult to put into practice, because the voltage drop across an LED and the voltage losses through a bridge rectifier are pretty similar, the overall result being not enough usable voltage at the output of the bridge rectifier. To overcome this, D6 and D7 have been added in series with each LED to increase the amount of voltage drop across them.

On its own, the bridge rectifier hasn't overcome the problem of having a current path to 0V. For this, an opto-isolator with NPN transistor output is used - OP1. Only C4 and the internal LED of the opto-isolator are connected across the output of the bridge rectifier, which eliminates any current flow to 0V. The voltage drop across either LED can now be used to drive the LED of the opto-isolator. The transistor output from this, together with Q1 forms a darlington driver which is used to turn on the buzzer. By connecting the positive lead of the buzzer permanently to the internal battery's positive supply rail, the buzzer will sound whenever either of the test LEDs light up, which means the buzzer is functional in both voltage finder and continuity modes. To ensure negligible drain on the battery, R3 keeps Q1 turned off in the event of no input signal, and also prevents instability which is always present in open base high gain darlington driver circuits such as this.

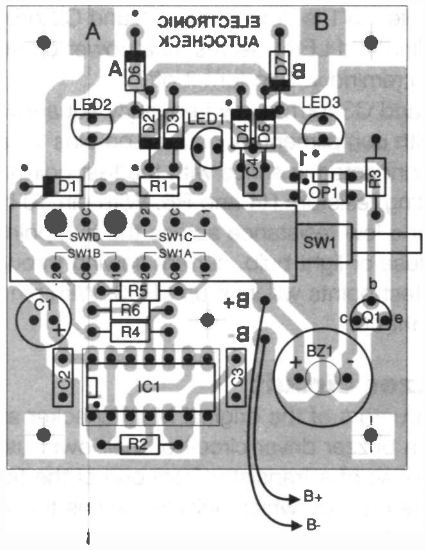


Figure 3: the component layout of the Auto-checker

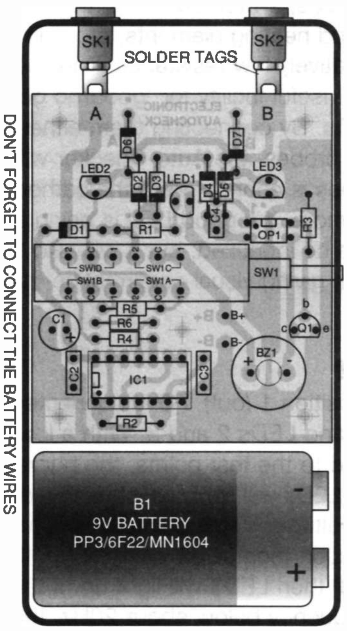
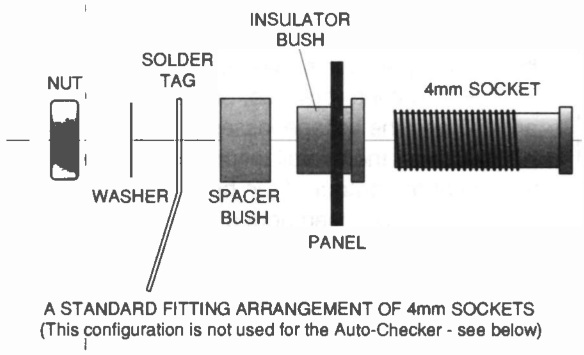


Figure 4: the layout inside the case

Construction

Compared to the original multi-checker, the overall construction of the Auto-Checker has been made much simpler. So much so, that everything is mounted on the board, which in turn is held in place by the test sockets and a double sided self adhesive foam pad. The PCB component layout is shown in figure 3. The first items to solder in place should be the solder tags supplied with the 4mm test sockets, since these are soldered to the underside of the PCB, and are used to hold the board in place. Also, they are not accessible with the board in place. Only solder about 3mm of the tag to the A and B copper pads, leaving sufficient to bend and form the remainder of the tag to facilitate the final mounting position of the board. Solder all components except the LEDs in a low-to-high profile sequence, taking care with the orientation of all the polarised ones - capacitors, diodes, ics etc. - and don't forget the leads from the battery clip.

In order to make fitting the LEDs easier, it is best to crop the leads to the correct length prior to soldering them in



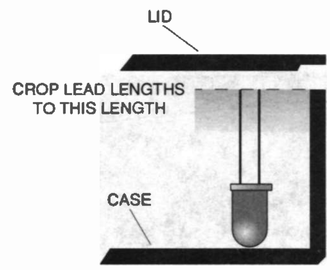


Figure 6: how to crop the LED leads to the correct length

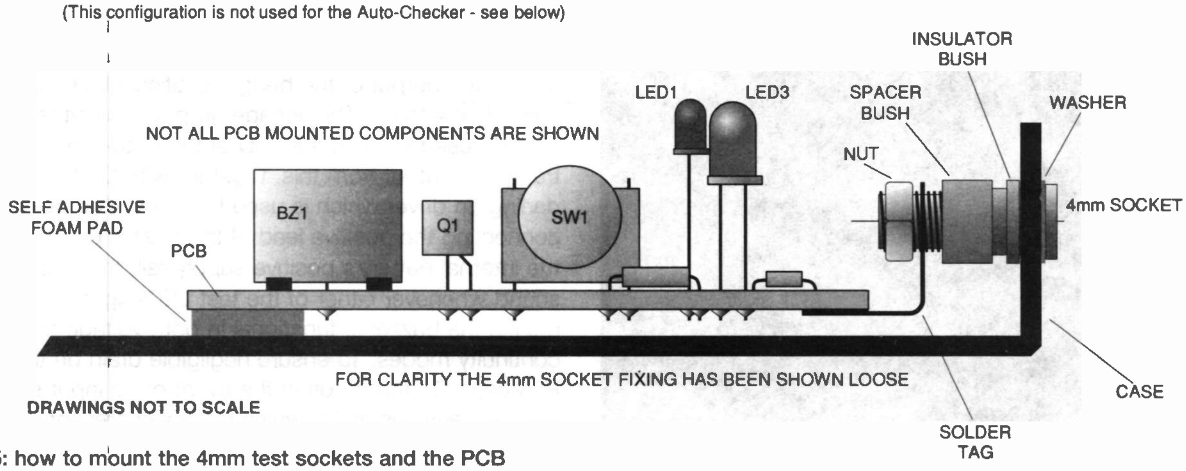


Figure 5: how to mount the 4mm test sockets and the PCB

PARTS LIST for the MkII Electronic Auto-Checker

Resistors

R1	1k
R2	4M7
R3	47K
R4, R6	470R
R5	1k5

Capacitor

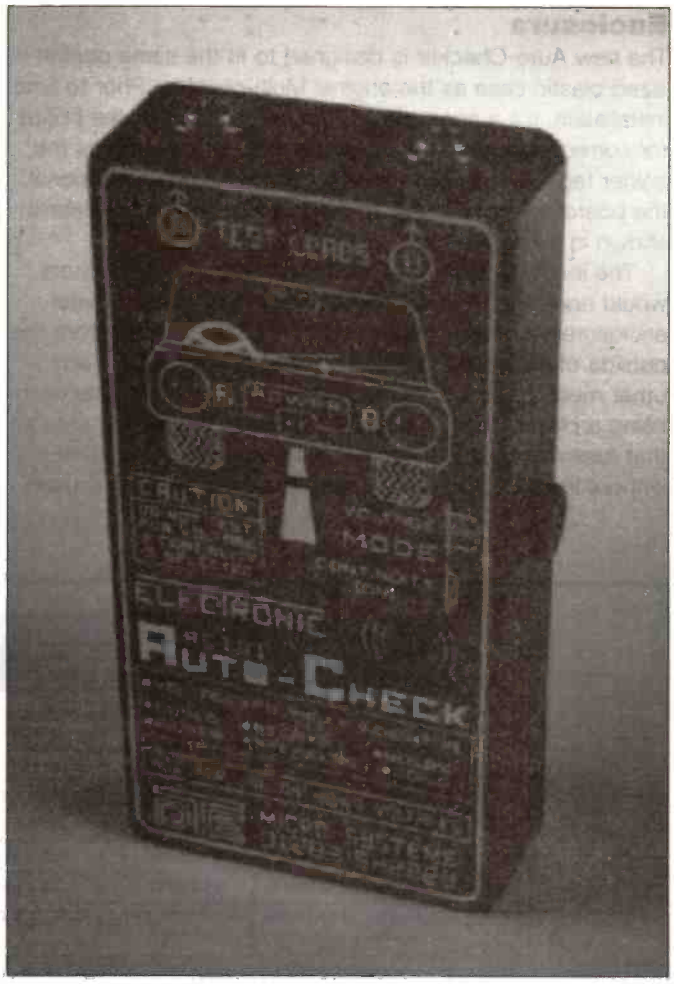
C1	10uF/35V sub-miniature radial electro
C2, C3, C4	100nF polyester or ceramic

Semiconductors

D1 - D7	1N4148 signal diode
IC1	CD4093B quad nand Schmitt trigger
LED1	3mm Green LED
LED2, 3	5mm high intensity red LED
OP1	SFH610-2 opto isolator
Q1	BC547 NPN transistor (or similar)

Miscellaneous

BZ1	5V miniature PCB mounting peizo buzzer
SK1,SK2	4mm panel mounting sockets
SW1	4 pole changeover PCB push switch
Battery clip	PP3 battery clip
Fixings	M3 nuts, bolt and washers
Case	Plastic box 56mm x 110mm x 21mm
B1	9V PP3 battery *
Probes	Pair of 4mm Test Leads & Probes
PCB	DTE "AC101 - Auto-check PCB



place, otherwise you will have to keep re-soldering them at different heights until you get them right. To do this, turn each one upside down and place the top face of the LED on the inside bottom of the case as shown in the diagram, then crop the leads level with the outer edge of the case. These can now be soldered into the PCB with about 1mm of lead protruding through to the copper side of the board, and they should be at the correct height when the PCB is finally secured in place. Note that the LEDs all face in different directions, so take care with their polarities. They won't be damaged if they are soldered the wrong way round, they just won't light up. However, if you also get one of the diodes back-to-front, then you will have the oddest results displayed when using the tester, so please pay take great care with the orientation of them all.

The front panel suggestion in figure 6 can be used as a drilling template for the three LED hole positions to ease the process of ensuring the various holes needed in the lid of the case are lined up relative to the component positions on the PCB. Only the rounded top face of the LEDs should protrude through the case, with none of the body showing, so drill undersized holes for them, and taper the insides to provide a tight fit, allowing for about 1mm of the LEDs showing externally. The shorter body length of the 3mm power on LED (LED1) means that most of it is taken up by the thickness of the case lid, so the hole diameter for this one can be full size. For a louder buzzer sound, drill a hole in the lid of the case somewhere above it. Drill two holes in the end of the case to accept 4mm test sockets, and a final hole in the side of the case for the switch button.

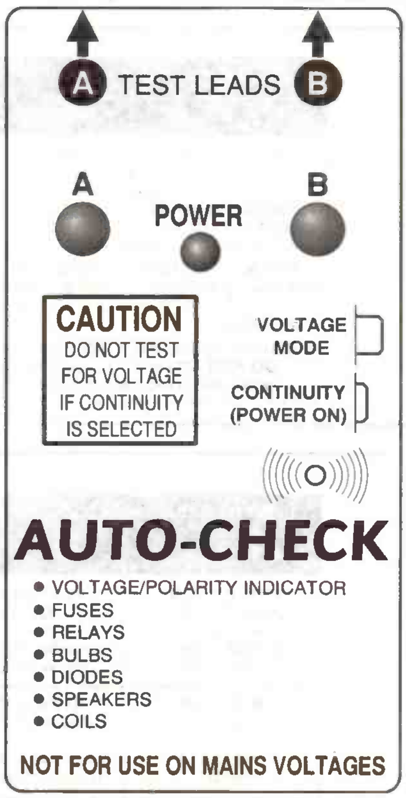


Figure 7: the pattern for the Auto-Checker front panel. Our original is white on black

Enclosure

The new Auto-Checker is designed to fit the same pocket sized plastic case as the original Multi-checker. Prior to final installation, it's a good idea to power up and test the board for correct operation by connecting test pieces across the solder tags. Once you're satisfied everything is operational, the board can be secured in place according to the details shown in figure 5.

The inset of figure 5 shows how the 4mm test sockets would normally be used, particularly in the case of metal enclosures, whereby the insulating bush is inserted from the outside of the case, so as to isolate the socket from any other metal parts. For our purposes, not only because we're using a plastic case, but also to increase the testing area so that fuses and the like can be tested directly on the unit without inserting the test probes, the metal washer is used on the outside of the case, and the two bushes are both slotted onto the shaft of the socket from the inside of the case. This forces the solder tag to be slightly further away from the edge of the case to where it would normally sit, which benefits us by preventing the PCB being too close to the test socket, where it might be more awkward to finally secure it in place, especially if the solder tags are a touch on the short side.

In use - voltage mode

This mode is used to locate or detect low voltages between about 3 and 30 volts, and is selected when the mode switch is in the out position. This mode can be used without an internal battery fitted to the Auto-Checker, and the status LEDs will function normally, but no sound will be produced

BLEEPER SOUND AND LED STATUS IN **VOLTAGE** MODE (MODE SELECT SWITCH OUT - POWER LED OFF)

A	B	BLEEPER	POSSIBLE DIAGNOSIS
OFF	OFF	NO SOUND	NO VOLTAGE POTENTIAL ACROSS A AND B. ALSO OCCURS IF BOTH LEADS CONNECTED TO THE SAME POSITIVE OR NEGATIVE VOLTAGE
ON	OFF	CONSTANT	DC VOLTAGE PRESENT. POSITIVE ON A, NEGATIVE ON B
OFF	ON	CONSTANT	DC VOLTAGE PRESENT. POSITIVE ON B, NEGATIVE ON A
ON	ON	CONSTANT	AC VOLTAGE PRESENT AT 20Hz OR GREATER FREQUENCY*
FLASHING	OFF	PULSING	PULSING DC VOLTAGE PRESENT. POSITIVE PULSES ON A*
OFF	FLASHING	PULSING	PULSING DC VOLTAGE PRESENT. POSITIVE PULSES ON B*
FLASHING	FLASHING	CONSTANT OR PULSING	AC VOLTAGE PRESENT AT 20Hz OR LOWER FREQUENCY*

*PULSES FASTER THAN ABOUT 20Hz (20 TIMES PER SECOND) MAY APPEAR ON THE STATUS LEDs AS A CONSTANT AC OR DC VOLTAGE. THIS IS NOT A FAULT, THE HUMAN EYE CANNOT EASILY DETECT LIGHT PULSES WHICH TURN ON AND OFF AT RATES MUCH FASTER THAN THIS. THE BLEEPER MAY ALSO PRODUCE EITHER A WARBLED OR CONSTANT NOTE.

Table 1

BLEEPER SOUND AND LED STATUS IN **CONTINUITY** MODE (MODE SELECT SWITCH IN - POWER LED ON)

A	B	BLEEPER	POSSIBLE DIAGNOSIS
OFF	OFF	NO SOUND	BAD CONNECTION - OPEN CIRCUIT, SWITCH CONTACTS OPEN, BLOWN FUSE OR LAMP, OR HIGH RESISTANCE (> 47 KILOHMS)
FLASHING BRIGHTLY	FLASHING BRIGHTLY	CONSTANT	GOOD CONNECTION - SHORT CIRCUIT, SWITCH CONTACTS CLOSED, FUSE OR LAMP OK, OR A LOW RESISTANCE (< 1 KILOHM)
FLASHING BUT DIMLY	FLASHING BUT DIMLY	CONSTANT (MAYBE POOR)	POOR CONNECTION - RESISTANCE GREATER THAN 10 KILOHMS, OR LOW INTERNAL BATTERY VOLTAGE - CHECK / REPLACE BATTERY

CAUTIONS:

1 ALWAYS DISCONNECT AND ISOLATE ANY TEST ITEM BEFORE TESTING. DO NOT CARRY OUT 'IN SITU' TESTING
2 **DO NOT** ATTEMPT TO CHECK FOR VOLTAGES WHEN THE AUTO-CHECKER IS SET TO **CONTINUITY** MODE
3 REMEMBER TO RETURN THE SWITCH TO THE OUT POSITION AFTER USE TO CONSERVE THE INTERNAL BATTERY POWER

Table 2

BLEEPER SOUND AND LED STATUS IN **CONTINUITY** MODE WHEN TESTING 'GOOD' ELECTRONIC COMPONENTS

COMPONENT	DESCRIPTION OF MULTI-CHECKER STATUS
DIODE OR >10V ZENER DIODE	FLASHING A OR B (BUT NOT BOTH). PULSED BLEEPER TONE. WHICHEVER STATUS LED IS FLASHING DENOTES THE CATHODE OF THE DIODE UNDER TEST.
SINGLE (ONE) COLOUR LED	FLASHING A OR B (BUT NOT BOTH). LED UNDER TEST FLASHING AT SAME RATE. PULSED BLEEPER TONE. WHICHEVER STATUS LED IS FLASHING DENOTES THE CATHODE OF THE LED UNDER TEST
BI AND TRI COLOUR LED	FLASHING A AND B. ALTERNATING COLOURS OF LED UNDER TEST. CONSTANT BLEEPER TONE. THE CATHODE IS IDENTIFIED BY THE STATUS LED WHICH FLASHES WHEN THE TEST LED IS RED
TRANSISTOR (NPN)	FLASHING A OR B (BUT NOT BOTH). PULSED BLEEPER TONE. THE BASE TERMINAL OF THE NPN TRANSISTOR IS IDENTIFIED BY THE STATUS LED WHICH DOES NOT FLASH
TRANSISTOR (PNP)	FLASHING A OR B (BUT NOT BOTH). PULSED BLEEPER TONE. THE BASE TERMINAL OF THE PNP TRANSISTOR IS IDENTIFIED BY THE STATUS LED WHICH DOES FLASH

REMEMBER TO RETURN THE SWITCH TO THE OUT(OFF) POSITION AFTER USE TO CONSERVE THE INTERNAL BATTERY POWER

Table 3

by the bleeper. The conditions given in both Table 1 and Table 2 assume there is a battery fitted. For testing purposes, the test leads, although red and black, can be fitted and used either way round, since the test sockets are not polarised.

In use - continuity mode

This is selected when the mode switch is in the 'in' position and the power indicator is lit. This mode can be used for testing fuses, lamps, coils, switch contacts, diodes and other electronic components.

Component testing

When testing electronic components on the Auto-Checker, in all cases they may be connected any way round across the test leads. Transistors are tested two legs at a time and may require up to three configurations before the base terminal is identified. The 'good' states of the two status LEDs are given in Table 3. Any conditions other than these states could represent a possible fault, which should be investigated further.

Finally, a word of caution. The Auto-Checker makes an ideal piece of tackle to have around the home, garage, workshop or in the tool box, and when used for its intended purposes should provide many years of trouble-free use, as long as it is not abused. When checking for voltages, make sure that you have selected mode 1 (switch in the out position) prior to starting, otherwise permanent damage to IC1 could result if the continuity mode is selected with too much voltage applied to the inputs.

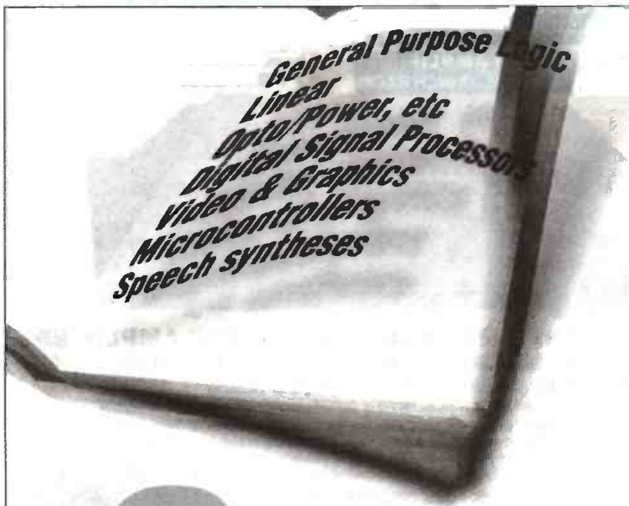
A complete kit of parts which includes the case, PCB, and a pair of test leads and probes (* battery not included) is available from the author by mail order only from:

DTE Microsystems, 112 Shobnall Road, Burton-on-Trent, Staffs DE14 2BB, UK Tel 01283 542229

The price for the complete kit of parts is £17.93
The PCB is also available separately at £ 5.30. (It is included in the kit).
Please add postage & packing (per order): £2.00 for the UK, £ 4.00 elsewhere.

Please make Cheques/postal orders payable to 'DTE Microsystems'. If ordering from overseas, payment must be in Pounds Sterling (£) and cheques must be drawn on a British bank. Goods will normally be dispatched within five working days from receipt of order (subject to availability and cheque clearance), but please allow up to 28 days for delivery.

DO NOT under any circumstances, or for any reason whatsoever, subject the Auto-Checker to mains voltage potentials. This piece of equipment is not designed for mains voltage purposes and any such misuse would be extremely dangerous and could prove fatal.



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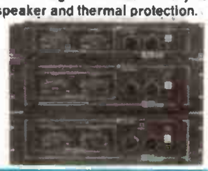

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MXF600 W19"xH5¼" (3U)xD13"
MXF900 W19"xH5¼" (3U)xD14¾"

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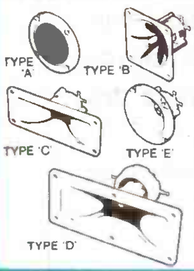

TYPE 'A' (KSN1036A) 3" round with protective wire mesh. Ideal for bookshelf and medium sized Hi-Fi speakers. Price £4.90 + 50p P&P.
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ALL POWERS INTO 4 OHMS
Features:
★ Stereo, bridgable mono ★ Choice of high & low level inputs ★ L & R level controls ★ Remote on-off ★ Speaker & thermal protection.

PRICES: 150W £49.99 250W £99.99 400W £109.95 P&P £2.00 EACH

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SUPPLIED READY BUILT AND TESTED.

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THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 123 x 60mm.
PRICE £40.85 + £3.50 P&P

OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 155 x 100mm.
PRICE £64.35 + £4.00 P&P

OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
PRICE £81.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE £132.85 + £5.00 P&P

OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
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NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

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ALL EMINENCE UNITS 8 OHMS IMPEDANCE

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RES. FREQ. 72Hz, FREQ. RESP. TO 4KHz, SENS 97dB. **PRICE £32.71 + £2.00 P&P**
10" 100 WATT R.M.S. ME10-100 GUITAR, VOCAL, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 71Hz, FREQ. RESP. TO 7KHz, SENS97dB. **PRICE £33.74 + £2.50 P&P**
10" 200 WATT R.M.S. ME10-200 GUITAR, KEYB'D, DISCO, VOCAL, EXCELLENT HIGH POWER MID.
RES. FREQ. 65Hz, FREQ. RESP. TO 3.5KHz, SENS 99dB. **PRICE £43.47 + £2.50 P&P**
12" 100 WATT R.M.S. ME12-100LE GEN. PURPOSE, LEAD GUITAR, DISCO, STAGE MONITOR.
RES.FREQ. 49Hz, FREQ. RESP. TO 6KHz, SENS 100dB. **PRICE £35.64 + £3.50 P&P**
12" 100 WATT R.M.S. ME12-100LT (TWIN CONE) WIDE RESPONSE, P.A., VOCAL, STAGE MONITOR. RES. FREQ 42Hz, FREQ. RESP. TO 10KHz, SENS 98dB. **PRICE £36.67 + £3.50 P&P**
12" 200 WATT R.M.S. ME12-200 GEN. PURPOSE, GUITAR, DISCO, VOCAL, EXCELLENT MID.
RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB. **PRICE £46.71 + £3.50 P&P**
12" 300 WATT R.M.S ME12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARD, DISCO ETC.
RES. FREQ. 47Hz, FREQ. RESP. TO 5KHz, SENS 103dB. **PRICE £70.19 + £3.50 P&P**
15" 200 WATT R.M.S. ME15-200 GEN. PURPOSE BASS, INCLUDING BASS GUITAR.
RES. FREQ. 46Hz, FREQ. RESP. TO 5KHz, SENS 99dB. **PRICE £50.72 + £4.00 P&P**
15" 300 WATT R.M.S. ME15-300 HIGH POWER BASS, INCLUDING BASS GUITAR.
RES. FREQ. 39Hz, FREQ. RESP. TO 3KHz, SENS 103dB. **PRICE £73.34 + £4.00 P&P**

EARBENDERS:- HI-FI, STUDIO, IN-CAR, ETC

ALL EARBENDER UNITS 8 OHMS (Except EB8-50 & EB10-50 which are dual impedance tapped @ 4 & 8 ohm)
BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND
8" 50watt EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 7KHz SENS 97dB. **PRICE £8.90 + £2.00 P&P**
10" 50WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS. 99dB. **PRICE £13.65 + £2.50 P&P**
10" 100WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz, FREQ. RESP. TO 3KHz, SENS 96dB. **PRICE £30.39 + £3.50 P&P**
12" 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz, SENS 93dB. **PRICE £42.12 + £3.50 P&P**
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5¼" 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB. **PRICE £9.99 + £1.50 P&P**
6½" 60WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB. **PRICE £10.99 + 1.50 P&P**
8" 60WATT EB8-60TC (TWIN CONE) HI-FI, MILTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB. **PRICE £12.99 + £1.50 P&P**
10" 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC.
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB. **PRICE £16.49 + £2.00 P&P**

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PHOTO: 3W FM TRANSMITTER

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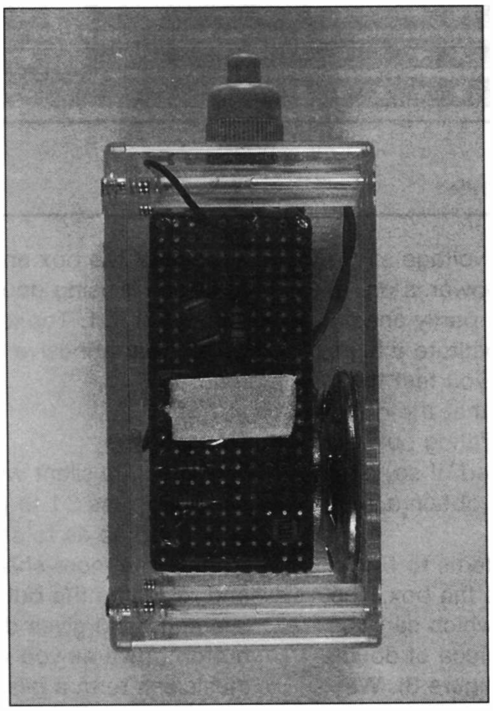
Fast Fivers

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

6. A tuneful trifle

Would you like some light music? You can produce your own with this light-controlled tone generator. This is a toy for budding young musicians in which the pitch of the note depends on the amount of light falling on the instrument. The light sensor is a light-dependent resistor (LDR) which consists of a block of semiconductor material, often cadmium sulphide. Because of this, the LDR is sometimes known as a cadmium sulphide cell (CSC). It is also known as a photoconductive cell (PCC).



The principle of the LDR/CSC/PCC is that, when the material is exposed to light, the energy of the light causes free charge carriers to be produced. The more light, the more charge carriers. And the more charge carriers, the less the electrical resistance of the material. The LDR has a pair of electrodes deposited on its exposed surface and, as the light level increases, the amount of current flowing from one electrode to the other increases roughly in proportion. In this circuit the LDR forms half of a potential divider network, with R1 as the other resistor. As light increases, the resistance of LDR1 becomes smaller in proportion to that of R1, which is fixed at 15 kilohms. As a result, the voltage across LOR1 is reduced in proportion to that across R1. Since the total voltage across the pair is fixed at 9V, the voltage at the junction of LDR1 and R1 must increase. By varying the amount of light falling on LDR1 we can vary the voltage at pin 9 of IC1.

IC1 is actually a phase-locked loop ic, but we are using only a part of it, the voltage-controlled oscillator (VCO). Now, that's enough TLAs! (Three-letter abbreviations.) The higher the voltage applied to pin 9 the higher the frequency of the tone produced. Frequency also depends on the values of C1 and R2, higher values giving lower tones. The frequency produced when the input voltage is half the supply (4.5V in this case) is f = 1/(C1 x R2). Resistor R3 also affects the frequency by producing an offset which determines the lowest and highest frequencies produced as the voltage is swept from 0V to 9V. R3 should be greater than R2, and the bigger R3 the bigger the range of tones. The capacitor and resistor values given in figure are suitable for producing a useful range of audio frequencies.

The output from IC1 appears at pin 4 and this is fed through R4 to Q1, which amplifies the signal and causes sound to be emitted from the loudspeaker, LS1.

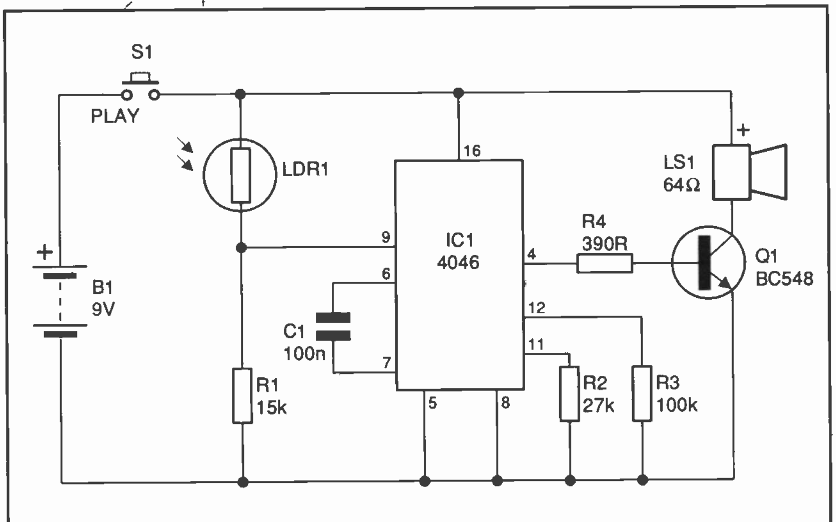


Figure 1: the circuit of the Tuneful Trifle

Construction

Although the circuit could be housed in an opaque box with a hole cut to allow light to reach LDR1, we decided to build it in a transparent box with the circuit totally enclosed. Only the push-button S1 is accessible when the lid of the box is screwed down. Drill a hole in one end of the box (figure 3) to take the push-button. Drill several small holes in the box in the region where the speaker is to be mounted.

The circuit is assembled on a piece of stripboard (figure 2). Note that the strips are cut across at D8, E5, B13 to J13 and C17. There are blobs of solder joining adjacent strips at Al5/B15 and J12/K12. There are many different types of LDR suitable for this proiect. You can use the popular ORPI2 or one of the less expensive LDRs which have a resistance of a few tens of kilohms in normal indoor

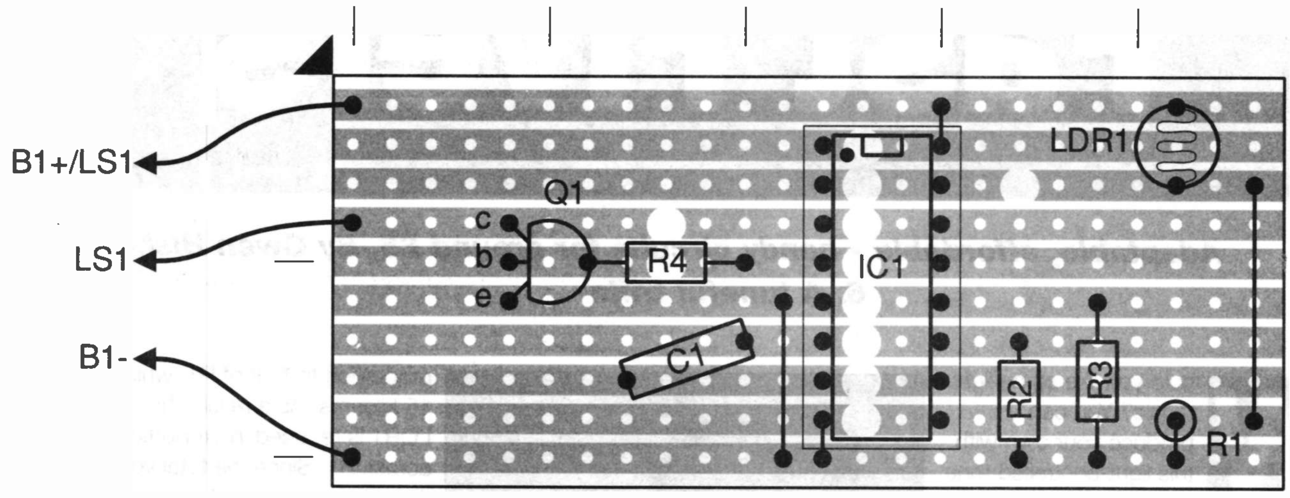


Figure 2: breadboard layout of the Tuneful Trifle

daylight levels. If in doubt, measure the voltage at pin 9 when the circuit is assembled and the power is on. It should be around 4.5V when the LDR is partly shaded. If it tends to be much lower of higher, substitute a higher or lower resistor for R1. Similarly, when you test the operation of the circuit you may decide that the notes are too low-pitched (perhaps even separating out to a rapid series of 'ticks') or too high-pitched. If so, alter the value of R2. You can increase R3 to obtain a wider range of pitch.

It is easier to connect the off-board items to the board *before* mounting everything inside the box. The circuit is powered by a 9V PP3 battery which can be fixed to the lower side of the box by a piece of double-sided adhesive tape or a 'Sticky Fixer' (figure 3). We wanted to mount the circuit board just below the upper surface of the box and found that it is sufficiently secure to attach it using double-sided tape applied to the upper surface of IC1. The loudspeaker is glued in position using clear adhesive (Uhu, for example) applied to its rim.

Playtime

The circuit is silent when S1 is not pressed, and uses no current. Press S1 to produce a note, but first position your hand so as to shade LDR1 to a greater or lesser extent. The more shading, the lower the pitch. Pressing and releasing the button for each position of your shading hand gives distinct notes. Or you can hold the button down as you vary the shading to obtain what musicians term a *glissando* effect. Waggling your fingers gives *vibrato*. Take it away, *Maesto*!

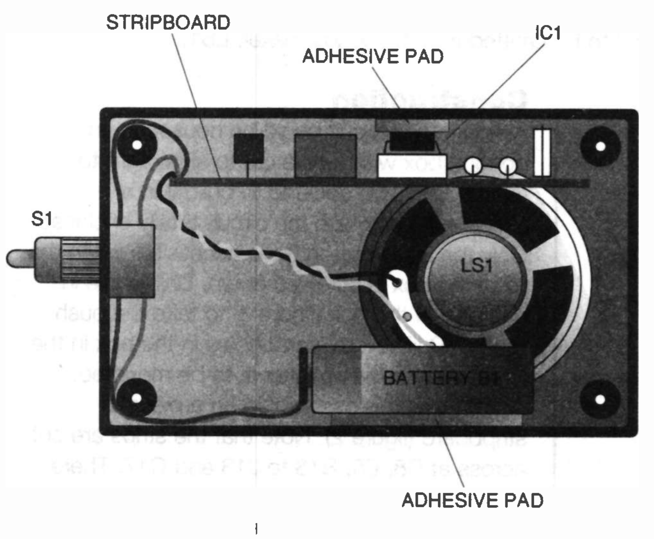


Figure 3: mounting the components in the box

PARTS LIST

Resistors

All 0.25W, 5 percent or better.

R1	15k
R2	27k
R3	100k
R4	390R

Capacitor

C1	100nF polyester layer

Semiconductors

LDR1	Light-dependent resistor (see text)
Q1	BC548 npn transistor (or similar)
IC1	CMOS 4046 phase-locked loop

Miscellaneous

S1	Push-to-make push-button
LS1	Miniature loudspeaker, 64 ohm coil

Stripboard 27mm x 60mm (10 strips x 23 holes); 1 mm terminal pins (3 off); 16-pin dil socket; PP3 battery clip; small plastic enclosure, preferably transparent.

Computer Radio Control for Home Automation Part 2

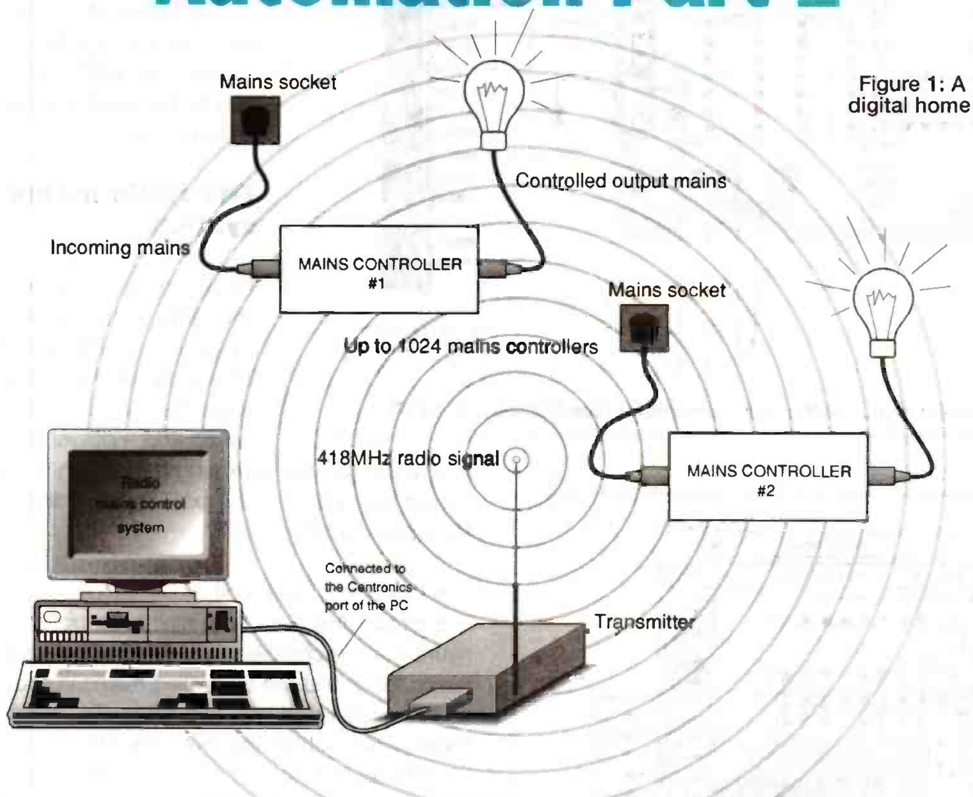


Figure 1: A PC-controlled radio digital home automation system

The Radio Mains Control System

1024 mains outlets can be computer-controlled by Dr. Pei An's home automation interfaces. Part 2 describes the mains control modules

The article describes a radio digital data control system which can be used for home automation applications. The complete system consists of one radio transmitters and 256 receivers with different addresses. The transmitter is connected to the Centronics port of a computer, and four bits of data issued by the computer can be transmitted to any one of the receivers. One of the four bits is used to control the ON/OFF of the mains of a socket. So a total of 1024 mains sockets can be controlled by one computer. The transmitting distance is about 50 meters in buildings and 200 meters in open fields. The system is illustrated in figure 1.

In the first part of this series, ETI issue 3 1997, I described how to construct radio transmitter and receiver modules and how to write a Turbo Pascal 6 software driver. In this article, I will show how to use the modules in a remote mains control application. I will also present a Windows Visual Basic software driver for the system.

A summary of the 418MHz radio transmitter and receiver

Inside the transmitter, an encoder (HT-12E) converts a 12-bit parallel data into a serial encoded data. The 12 bits are supplied to the HT-12E by a computer via the Centronics port. The first 8 bits of the data represent an address and the other 4 bits are the data to be sent. The encoded serial data modulates a 418 MHz radio frequency signal using an FM modulation scheme. The radio frequency signal is then transmitted to the surroundings. The modulation is facilitated by an FM radio transmitter, TMX-418-A. The assembly of the module is shown in figure 2.

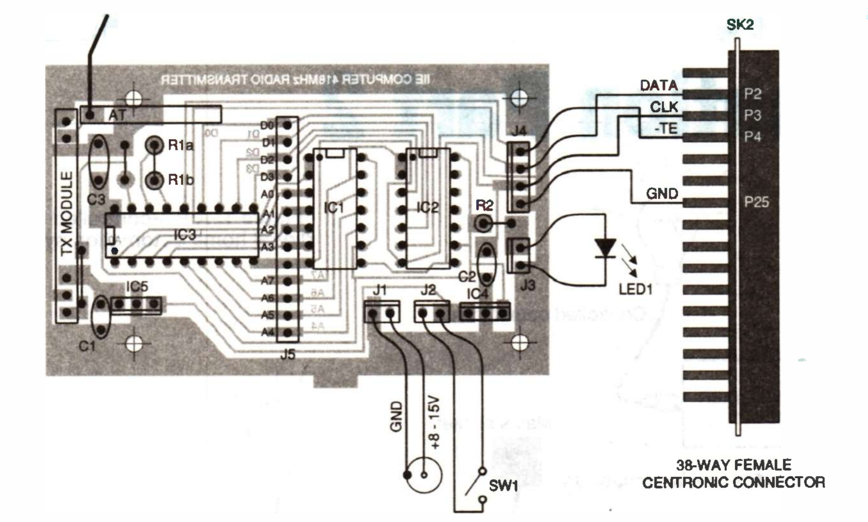


Figure 2: the component layout of the radio transmitter (see ETI issue 3, 1997)

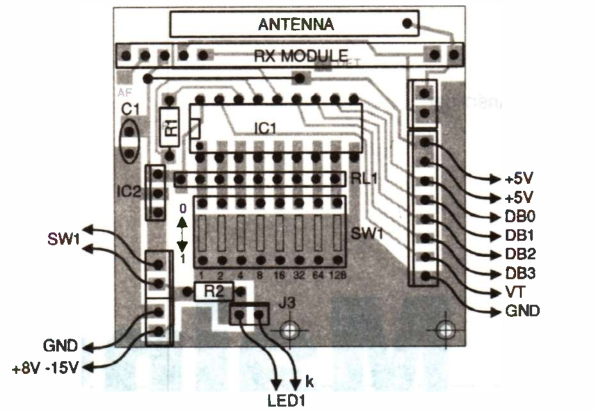


Figure 3: the component layout of the radio receiver (see ETI issue 3, 1997)

Inside a receiver, the radio signal picked up by the antenna is demodulated by an FM radio receiver module, SILRX-418-A. The demodulated serial data is fed into the serial-to-parallel decoder (HT-12D), which converts the serial data back to the parallel data. The address bits are compared with the pre-set address of the decoder. If they match, the 4-bit data is latched to the outputs. If the address does not match, the decoder ignores the data. As an 8-bit binary data has 256 possible combinations, the maximum number of receiver's address is 256. The assembly of the module is shown in figure 3.

The transmitter is type-approved to the Radiocommunications Authority specification MPT 1340 in the UK. This avoids the need to submit the final project for approval.

The radio mains control system

The radio transmitter unit

The radio transmitter module is housed in a plastic box. The assembled unit has a 36-way female Centronics-type connector, an LED indicator, a power switch and a power socket. The antenna is a whip type, the total length of which is 160 mm. Figure 4 shows the cutting of the box. Figure 5 shows the assembly of the radio transmitter unit.

The mains controller unit

The circuit diagram of the mains controller unit is given in figure 6. Euro chassis plugs and sockets are used for the mains input and the controlled mains output. The incoming 240V is converted into 12V AC by T1, which is a mains transformer with an internal fuse. The AC voltage is rectified by BR1 and smoothed by C1. It is then fed into the 7812 voltage regulator where a +12V DC is produced. This is the supply voltage for other circuits. The radio receiver module is mounted on the controller PCB board. One of the outputs of the module is connected to J6. This signal is amplified by Q1 and it controls the on/off of the relay. SW1 is used to select the automatic mode and override mode. In the automatic mode, the mains controller is controlled remotely by the computer. In the override mode, the relay is permanently energised. Two LEDs indicate the power on and off.

Important note: This project involves mains voltage. Constructors should be very careful in constructing it, in testing it and in using it in practice. Seek assistance if you are not experienced in constructing with mains voltages.

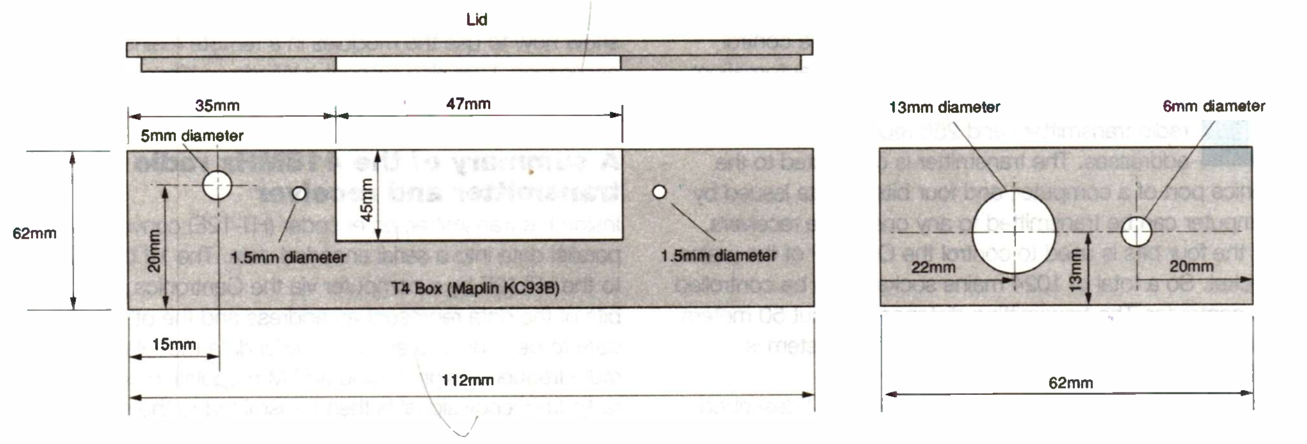


Figure 4: cutting details of the box for the transmitter

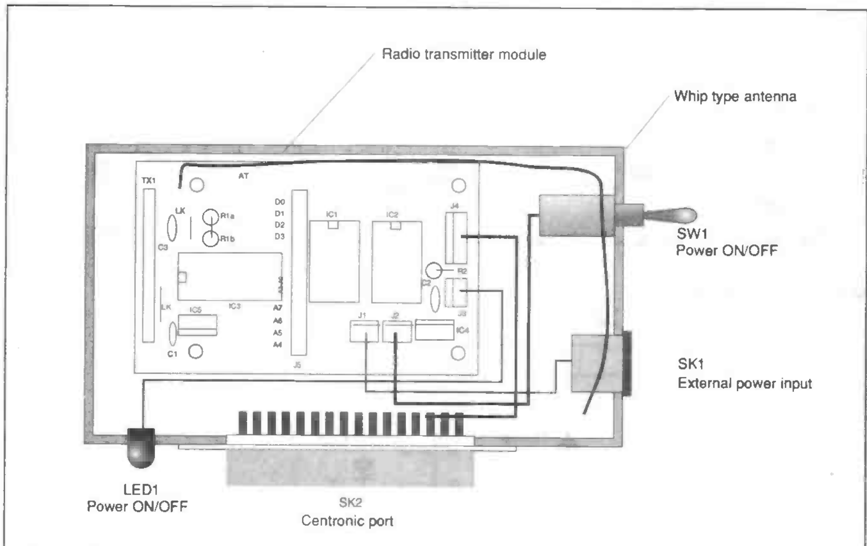


Figure 5: assembly of the radio transmitter unit in a box

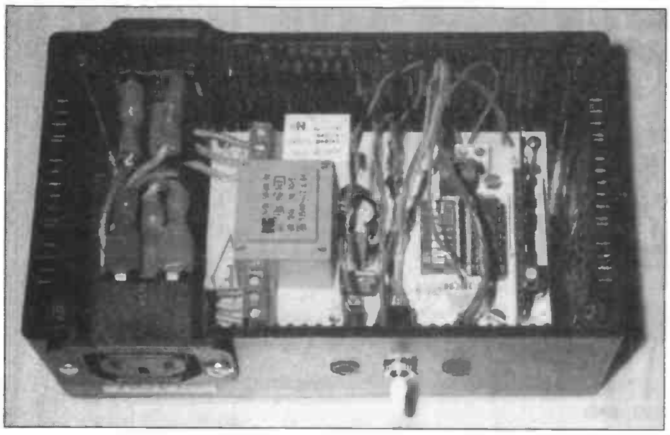
Figure 7 shows the assembly of the PCB board of the unit. The PCB board is fixed inside a plastic box. The cutting of the box is shown in figure 8 and the assembly of the unit is shown in figure 9.

The software driver

The Turbo Pascal 6 program which was listed in the previous article can be used to control the main switches.

In this article, a Windows Visual Basic software driver is described. Visual Basic allows users to develop user friendly graphic interfaces in Windows environment with ease. Although it offers a wide range of program supports for user interfaces, Visual Basic does not provide functions for direct I/O access and memory access. Dynamic link libraries (DLLs) are used to supply Visual Basic programs with functions. DLLs can be easily written using other Windows programming languages such as Turbo Pascal for Windows, Windows C, etc..

The first program list is the DLLs for the radio mains control system written in Turbo Pascal for Windows. It contains several functions. Three of them which are related to the hardware control are explained below: Centronic(x:integer):integer is a function. Centronic(0) returns the number of number of Centronics ports installed on your PC. Centronic(1) returns the port address of LPT1 and Centronic(2) returns the address of LPT2, etc. send_data (P_address, address, data :integer) :integer sends the address and data to the 74LS164 shift register. The Centronics address should be supplied. When sending the address and data, the Transmit Enable (-TE) must be high to stop transmission. Transmit (P_address,flag:integer):integer starts (flag=1) or stops (flag=0) the transmission of the encoded data. DLLs are generated by MAKE or BUILD functions in the COMPILE pull-down manual in the editor. They are executable files, but they cannot be run on their own.



The assembly of the radio control mains unit in its box

```
Listing one. WHDLL.PAS

library radio_mains_controller;
{Window DLL for the Smart Radio Mains
Control System designed by Dr. Pei
An, 4/5/97}
{74LS164 latches the data sent
serially by the computer's Printer
port.
 DB0, DB1, DB2 and DB3 are loaded
with address A0, A1, A2 and A3
 DB4, DB5, DB6 and DB7 are loaded
with data D0, D1, D2 and D3}

uses
   wincrt, windos;

var
 address,i,j,swaddress,sdata:integer;
 delaytime,lighttime:real;
 dummy,P_address:integer;
 input_char:char;

Function Centronic(x:integer):integer; export;
(* $000:$0408 holds the printer base address for
LPT1
   $000:$040A holds the printer base address for
LPT2
   $000:$040C holds the printer base address for
LPT3
   $000:$040e holds the printer base address for
LPT4
   $000:$0411 number of parallel interfaces in
binary format *)
var
     number_of_LPT, LPT1, LPT2, LPT3, LPT4 :integer;
begin
  number_of_LPT:=mem[$40:$11]; (* read number of
parallel ports *)
  number_of_LPT:=(number_of_lpt and (128+64)) shr
6;
  lpt1:=0; lpt2:=0; lpt3:=0; lpt4:=0;
  LPT1:=memw[$40:$08];(* Memory read procedure *)
  LPT2:=memw[$40:$0A];
  LPT3:=memw[$40:$0C];
  LPT4:=memw[$40:$0E];
  case x of
   0: centronic:=number_of_LPT;
   1: centronic:=lpt1;
   2: centronic:=lpt2;
   3: centronic:=lpt3;
   4: centronic:=lpt4
  end;
end;

procedure delay;
var
  ij:integer;
begin
  for ij:=1 to 10000 do ij:=ij;
end;

Function bit_weight(bit:integer):integer; export;
var
  i,dummy:integer;
begin
  if bit=1 then bit_weight:=1
  else begin
    dummy:=1;
    for i:=1 to bit-1 do dummy:=2*dummy;
```

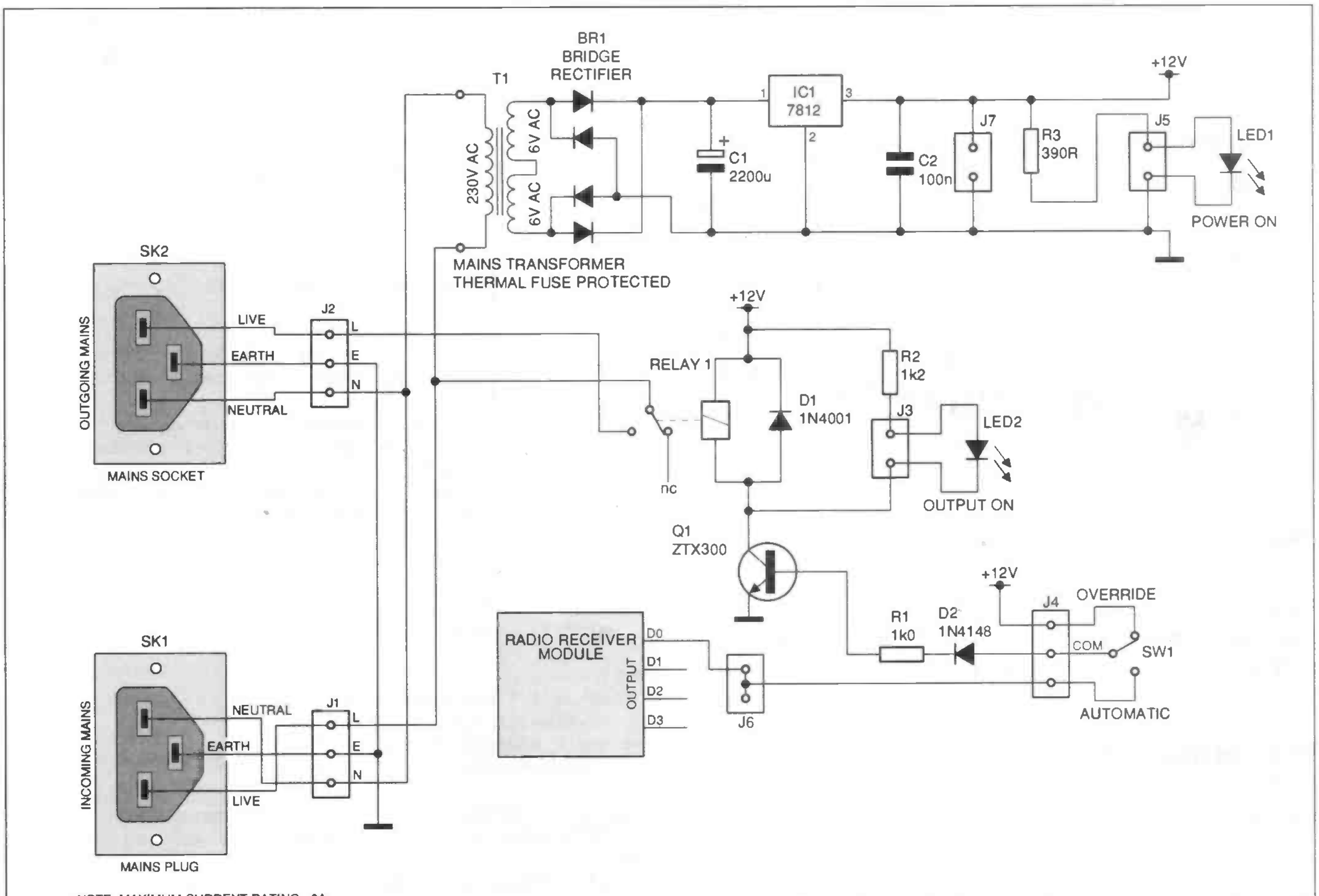
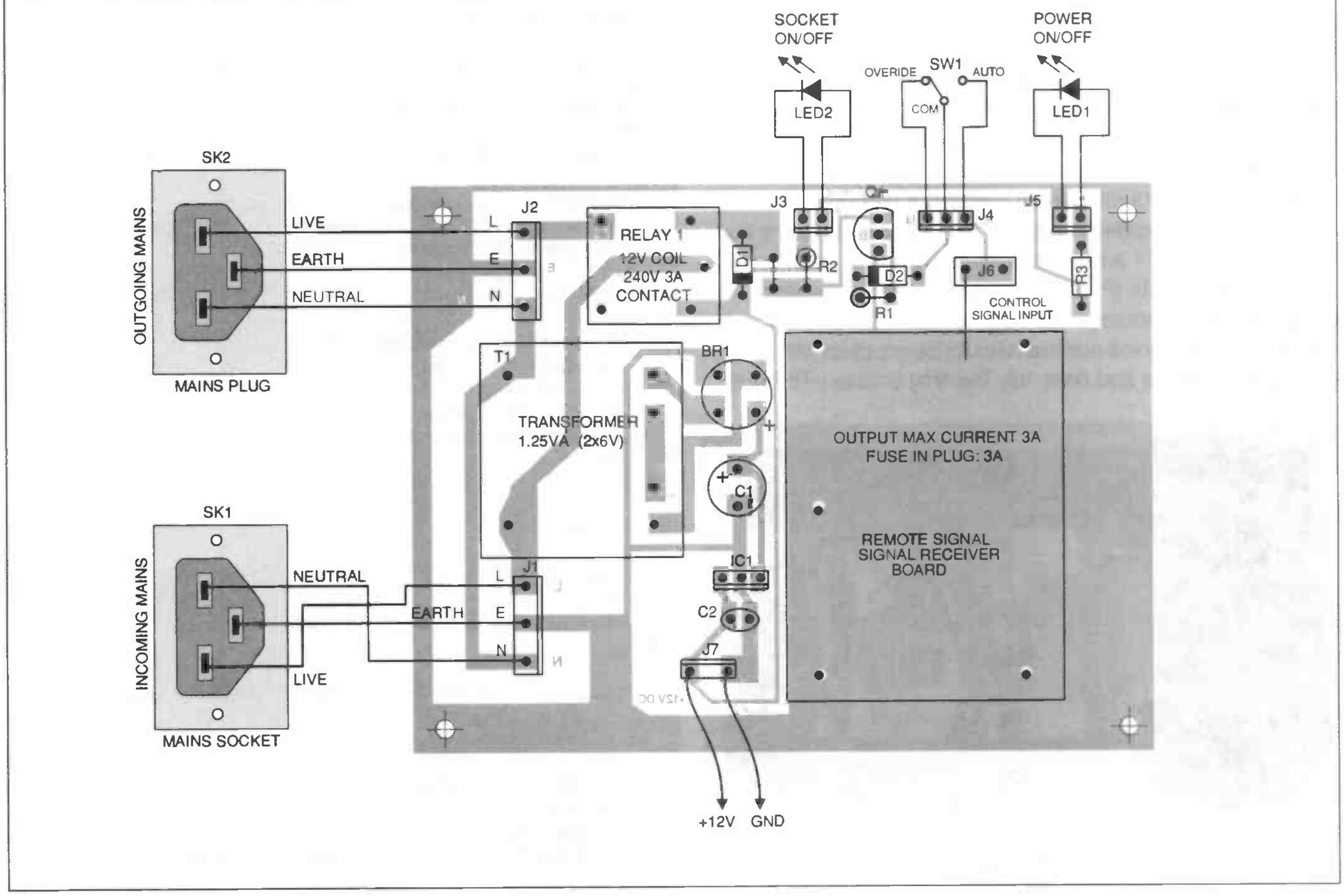


Figure 6: circuit diagram of the a mains controller unit

Figure 7: the component layout of the mains controller



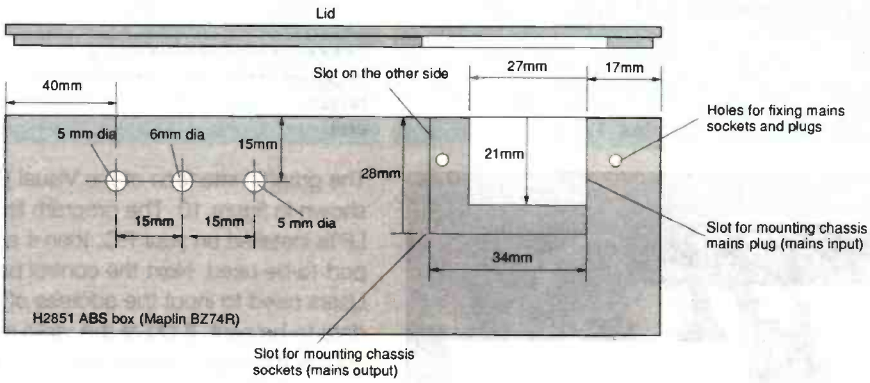


Figure 8: cutting details of the box for a mains controller

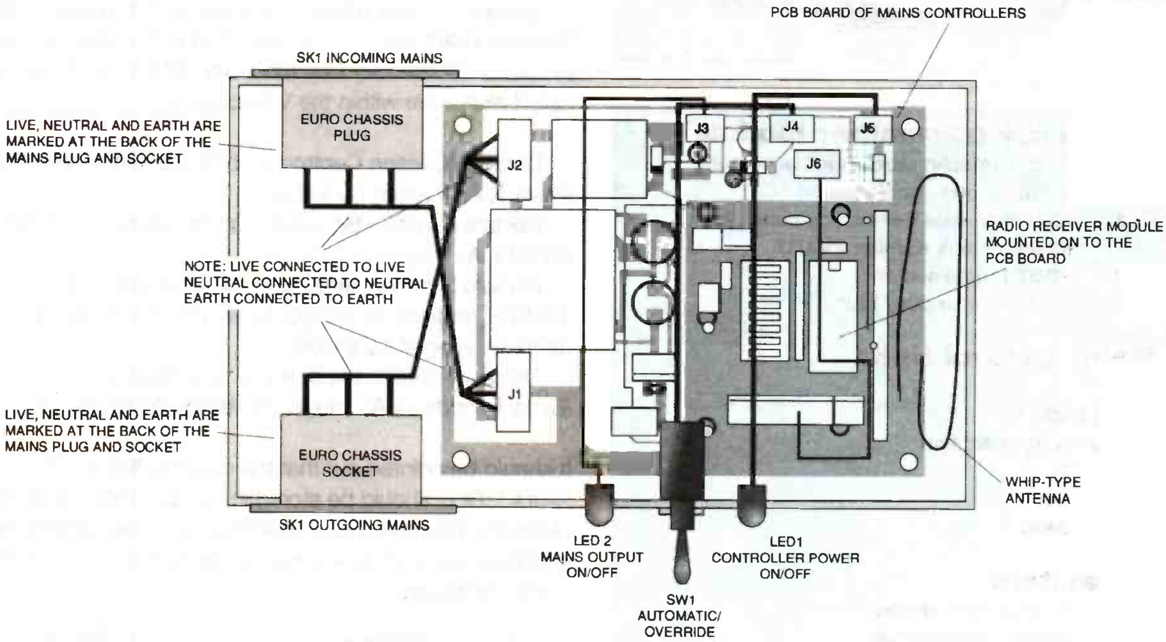
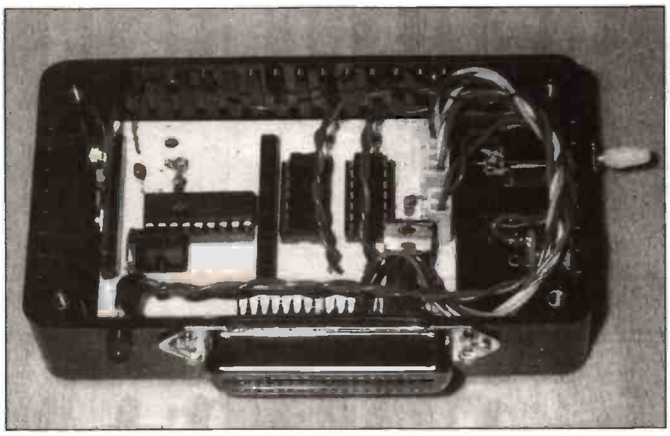


Figure 9: assembly of the mains control unit, showing a radio receiver board (ETI issue 3 1997) mounted on the PCB

```
    bit_weight:=dummy;
    end;

end;

Function
send_data(P_address,address,data:integer):integer;
export;{Send the address to the 74LS164 shift
register}
{When sending the address, the Transmit Enable (-TE)
must be high to stop transmit}
{During loading, (1) DB0 is loaded with the data
sw[i],
                  (2) DB1 (CLOCK) is made from low-
to-high-then-low
                  (3) DB2 (-transmit enable) is kept
high all the time}
var
  sw:array[1..12] of byte;
begin
  for i:=8 downto 1 do
   begin
    sw[i]:=0;
    if address>=Bit_weight(i) then begin
      address:=address-bit_weight(i);
      sw[i]:=1;
        end;
        end;

  for i:=4 downto 1 do begin
    sw[8+i]:=0;
    if data>=bit_weight(i) then begin
      data:=data-bit_weight(i);
      sw[8+i]:=1;
      end;
    end;
{loading address and data into the 74LS164
registers}
for i:=12 downto 1 do
  begin
    port[P_address]:=sw[i]+4; {DB0=sw[i], DB1=0,
DB2=-TE=1}
      delay;  {a delay}
      port[P_address]:=sw[i]+2+4; {DB0=sw[i],
DB1=1(loading into register), DB2=-TE=1}
      delay;  {a delay for loading the bit}
      port[P_address]:=sw[i]+4; {DB0=sw[i], DB1=0,
DB2=-TE=1}
    end;
end;

Function
transmit(P_address,flag:integer):integer;export;
{Start or quit the encoded data transmitting
```

```
depending on FLAG}
begin
  if flag=1 then port[P_address]:=0 else
port[P_address]:=4;
end;

Exports
 Centronic                          index 1,
```



The radio transmitter unit in the box

PARTS LIST for the Radio Control System

To box the transmitter module

Box	T4 box (Maplin stock number KC93B)
SK1	2.5 mm power socket
SK2	36-way female Centronics connector (Maplin stock number FV87U)
SW1	SPDT toggle switch
LED	5mm red standard LED

Mains Control Units

Resistors

All 1 percent metal film

R1	1k
R2	1k2
R3	390R

Capacitors

C1	2200 uF/25V electro
C2	100nF ceramic disk

Semiconductors

IC1	7812 1A +5V voltage regulator
Q1	ZTX300
D1	1N4001
D2	1N4148
LED1	5mm red LED
LED2	5mm green LED
BR1	1A rectifier
Relay	12V coil, 240V and 3A contact (Maplin stock number JM18U)
T1	240V primary, two 6VA transformer with internal fuse. (Available from author - see above.)

Connectors

J1, J2	3-way terminal blocks
J3,J5	2-way PCB connectors
J6,J7	2-way terminal blocks
J4	3-way PCB connectors
SK1	Male mains socket (Euro chassis plug, Maplin stock number MK19V)
SK2	Female mains socket (Euro chassis socket, Maplin stock number MK17T)
SW1	toggle switch
Box	H2851 box (Maplin BZ74R)

```
 Bit_weight                  index 2,
 send_data                           index 3,
 transmit                            index 4;

{*****************Main
Program*******************}
begin
end.
```

The graphic interface of the Visual Basic software driver is shown in figure 10. The program first reports the number of LPTs installed on your PC, then it asks users to select an LPT port to be used. Next the control panel appears on the screen. Users need to input the address of the mains switch and the data to be sent. If D0 of the radio receiver module is used to control the mains switch, input 1. Then users need to input the period of ON and the period of OFF of the mains switch. Clicking the Start button using the mouse starts the remote control. Clicking the Stop button any time will terminate the remote control.

The complete VB3 program listing is shown in listing 2. The VB program is very simple, but it shows the basics in Visual Basic programming. At the beginning of the program, declare functions declare four DLL functions. All the functions can be called elsewhere within the VB3 program.

Declare Function Centronic Lib "c:\project\home\whdll.dll" (ByVal X As Integer) As Integer
Declare Function Bit_weight Lib "c:\project\home\whdll.dll" (ByVal X As Integer) As Integer
Declare Function send_data Lib "c:\project\home\whdll.dll" (ByVal P_address As Integer, ByVal address As Integer, ByVal datax As Integer) As Integer
Declare Function transmit Lib "c:\project\home\whdll.dll" (ByVal P_address As Integer, ByVal flag As Integer) As Integer

It should be pointed out that the dynamic link library, WHDLL.DLL, should be stored in the directory c:\project\home. Using the Windows DLLs provided, uses can write more sophisticated and more adventurous software for controlling the mains controllers.

```
Listing two WINHOME
Declare Function Centronic Lib
"c:\project\home\whdll.dll" (ByVal X As Integer) As
Integer
Declare Function Bit_weight Lib
"c:\project\home\whdll.dll" (ByVal X As Integer) As
Integer
Declare Function send_data Lib
"c:\project\home\whdll.dll" (ByVal P_address As
Integer, ByVal address As Integer, ByVal datax As
Integer) As Integer
Declare Function transmit Lib
"c:\project\home\whdll.dll" (ByVal P_address As
Integer, ByVal flag As Integer) As Integer

Dim address, datax, Onstatus, centronic_address As
Integer
Dim ontime, offtime As Integer

Sub Command1_Click ()
 'assign variables
 address = Val(text1.Text) 'address of the mains
controller
 datax = Val(text2.Text) 'data sent to the mains
controller
 ontime = Val(text3.Text) * 1000'period of ON
 offtime = Val(text4.Text) * 1000'period of OFF
 timer1.Interval = ontime
 timer1.Enabled = True
 Onstatus = 1
```

```
End Sub

Sub Command1_MouseMove (Button As Integer, Shift As
Integer, X As Single, Y As Single)
  label9.Caption = "Start the automatic control"
End Sub

Sub Command2_Click ()
  timer1.Enabled = flase
End Sub

Sub Command2_MouseMove (Button As Integer, Shift As
Integer, X As Single, Y As Single)
 label9.Caption = "Stop the automatic control"
End Sub

Sub Command3_Click ()
 End
End Sub

Sub Command3_MouseMove (Button As Integer, Shift As
Integer, X As Single, Y As Single)
  label9.Caption = "Quit the program"
End Sub

Sub Form_Load ()
 dummy = MsgBox(Str(Centronic(0) - 1) & " Centronic
ports are installed on your PC. Their base
addresses are: " & Format$(Centronic(1), "###") & "
" & Format$(Centronic(2), "###") & " " &
Format$(Centronic(3), "###") & " " &
Format$(Centronic(4), "###") & "Decimal", 48,
"Centronic ports on your PC")
 Centroic_number = Val(InputBox$("Input 1, 2, 3 or
4 to select a Centroic port (Centroic) for the
Mini-Lab Data Logger/ Controller", "Select Centroic
ports"))
 centronic_address = Centronic(Centroic_number)
 centronic_address = 632
 timer1.Enabled = False
End Sub

Sub Label9_MouseMove (Button As Integer, Shift As
Integer, X As Single, Y As Single)
 label9.Caption = "On-line help window"
End Sub

Sub Text1_MouseMove (Button As Integer, Shift As
Integer, X As Single, Y As Single)
 label9.Caption = "Input address of controller, 0
to 255"
End Sub

Sub Text2_MouseMove (Button As Integer, Shift As
Integer, X As Single, Y As Single)
  label9.Caption = "Input the 4-bit data 1,2,4 or
8"
End Sub

Sub Text3_MouseMove (Button As Integer, Shift As
Integer, X As Single, Y As Single)
  label9.Caption = "Input the ON period in second"
End Sub

Sub Text4_MouseMove (Button As Integer, Shift As
Integer, X As Single, Y As Single)
 label9.Caption = "Input the OFF period in second"
End Sub

Sub Timer1_Timer ()

 If Onstatus = 1 Then
  timer1.Enabled = flase
  dummy = transmit(centronic_address, 0)
  dummy = send_data(centronic_address, address,
datax)
  dummy = transmit(centronic_address, 1)
  For i = 1 To 100000
   i = i
  Next i
  Onstatus = 0
  timer1.Interval = offtime
  timer1.Enabled = True
 Else
  timer1.Enabled = flase
  dummy = transmit(centronic_address, 0)
  dummy = send_data(centronic_address, address, 0)
  dummy = transmit(centronic_address, 1)
  For i = 1 To 100000
   i = i
  Next i
  Onstatus = 1
  timer1.Interval = ontime
  timer1.Enabled = True
 End If
End Sub
```

Final words

A number of mains switches can form a mains control network which is fully controlled by one computer. To make a good control of mains, you need a good software driver. As the radio transmitter is connected to the printer port, any type of computer can be used. Have you ever thought about using your Mac, your Amiga or your Psion organiser to control such a radio mains control system? Here imagination is unlimited.

Components

The parts lists for the radio transmitter and receiver modules were given in Part 1 of this series (ETI Volume 26 Issue 3).

Part 1

For anyone who missed Issue 3 this year, Back issues of ETI are available for £3.05 each from Nexus Subscription Services, ETI, Tower House, Sovereign Park, Lathkill Street, Market Harborough, Leicestershire LE16 9EF. Backissue enquiries 01858 435322. Please make cheques payable to Nexus Special Interest.

Technical support

Constructors should be able to obtain most of the components from Maplin or Electromail. The VB3 software driver (source code and EXE files) and DLLs are available at a price of £15.00 UK from me. The PCB boards for a pair of radio transmitter and receiver module is £12.00. The PCB board for the mains switch is £8.00. The mains transformer is avialable for £3.90. I also have a limited number of kits which put everything together in a package. Please direct your enquiry to Dr. Pei An, 11 Sandpiper Driver, Stockport, SK3 8UL UK. My telephone and answer phone number is 0161 477 9583 and my e-mail is PAN@FS1.ENG.MAN.AC.UK

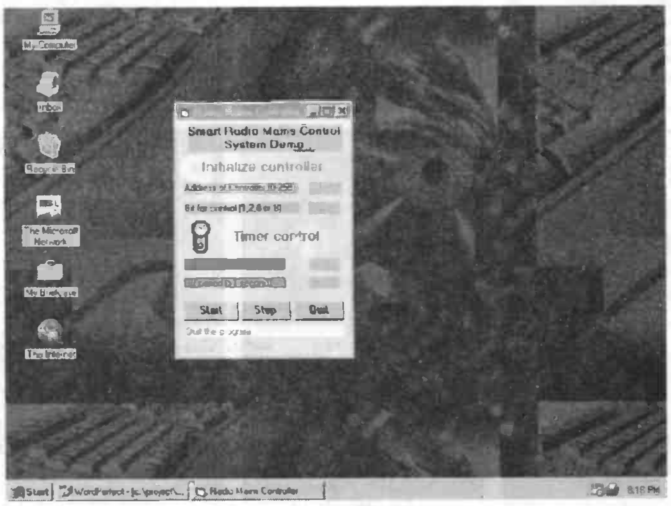


Figure 10: a Visual Basic control panel for testing the radio mains control system

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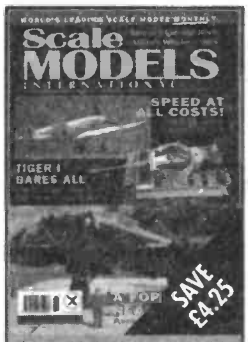

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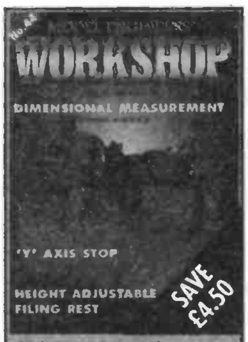

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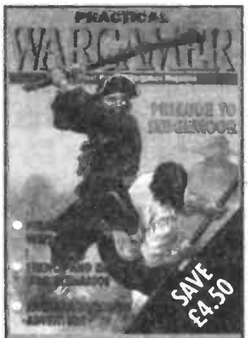

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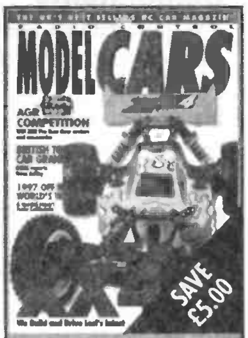

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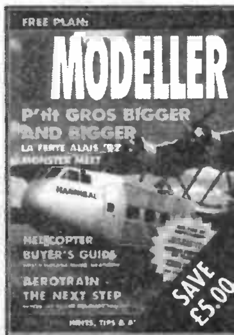

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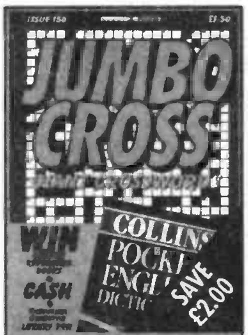

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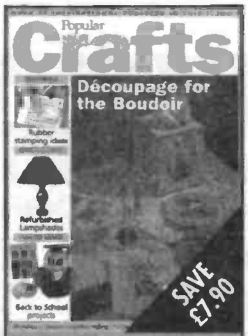

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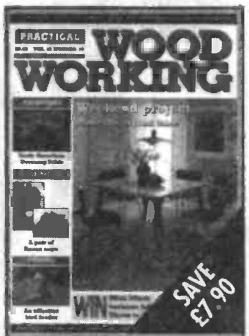

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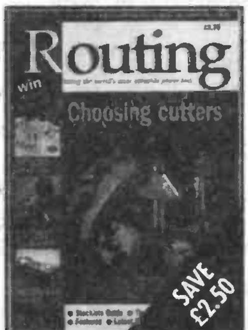

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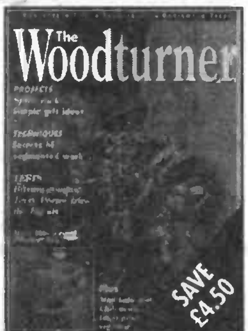

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GCSE

Sound Switcher Circuit

Terry Balbirnie starts a series of adaptable circuits for GCSE- and similar-level projects with a module to trigger a reaction when a sound it made.

Every so often during your school or college course in Electronics or Technology, you will be asked to undertake a project. Some teachers and lecturers give a fairly specific idea of what the finished device should do and what components it should contain. Some examinations boards require you to make a project with a specification set by them. However, for mid-course assessments and for many other examinations you will have to work on a project of your own choice.

Making a start

So, where do you begin? It is always best if the project reflects some specific interest which you have, such an another hobby or voluntary activity. It may be related to some other person such as an aid for the disabled, a child's toy and so on. This type of personal interest will show through when you come to write up your report. Also, since the finished device will probably be given back to you at the end of the course or module, you will have something else useful for your hard work!

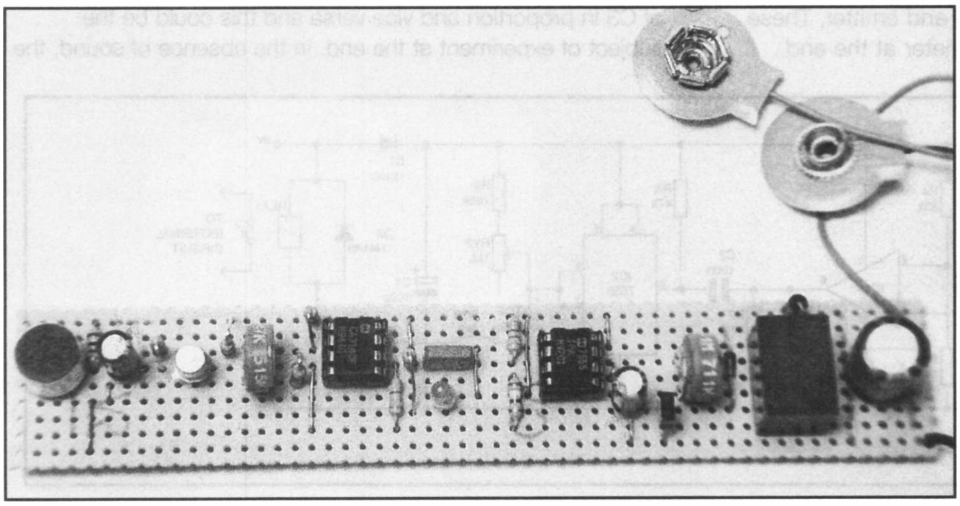
Over the coming months (although not every month), we shall provide some basic projects which cater for a variety of interests. You will be able to use a circuit as it stands or modify it for the purpose you have in mind. All the designs will be fairly basic so no one should have too much trouble understanding how their chosen circuit works or how to construct it. Any modifications and experimental work is left up to you. The designs are open-ended, so that there will be plenty to make the more able student think - in fact, there are one or two slightly off-beat features built into each one for this very purpose. The end product in each case will be a circuit panel which "does something".

All the devices are given in the form of a circuit diagram and a stripboard (Veroboard) layout. This will be useful for anyone who does not have the facility for making actual PCBs. Also, the "in-line" stripboard arrangement more resembles the circuit diagram than a true PCB and is more easily followed by some people. Of course, some students will wish to translate the circuit diagram into true PCB form.

Down, Rover

This month we shall look at a sound-operated switch which may be used to operate a toy - such as a cardboard dog which jumps out of a kennel when you whistle. It could also be used for environmental studies work where a light is meant to come on when the sound reaches a certain level. Another idea would be to use it to trigger a photographic flash gun. By setting up the camera in darkness with the shutter open, a photograph would be taken of anything that made a sound. Anyone want to try Ghost Busting?

The circuit terminates in a relay output so that it may be used to operate a wide variety of devices, including other electronic circuits, by means of a separate battery. For high-powered lamps, motors and solenoids it will be necessary to upgrade the relay to an appropriate heavy-duty type. Another idea would be to use the relay on the PCB to operate the coil of the up-rated one "piggy back' fashion.



Sound circuit

The circuit for the sound switch is shown in figure 1. Power is obtained from a 9V PP9 battery or six "M" size cells in a suitable holder. A PP3 battery is not really up to the job. Diode DI allows current to pass and charge up capacitor C4 which then gives a supply for most of the circuit. The capacitor provides a reserve of charge and helps to promote stable operation. The relay coil is powered direct - that is, before DI and C4. Its power supply needs no special treatment.

Microphone MIC1, picks up the

PARTS LIST for the Sound Switcher

Resistors

Rl	1k
R2	2M2
R3	4k7
R4	33k
R5	10k
R6	470k
R7	560R
R8	47k
R9	100k
R10	3k9
RV1	47k mm vertical preset
RV2	1M mm vertical preset

Capacitors

C1, C3	10p 16V electrolytic
C2	100n mm metallised polyester
C4	1000u 16V electrolytic

Semiconductors

IC1	CA3140E
IC2	7555
Q1	BC108C
Q2	ZTX300
D1	1N4001
D2	1N4148
LED1	3mm red LED

Miscellaneous

RLA1	Mm relay with 6V coil and 2A "make" contacts
MIC1	Mm electret microphone insert (2-pin type)

1 in matrix stripboard; PP9 battery and connectors; 8-pin dil sockets. The relay used in the prototype was type FM9IY from Maplin.

sound and converts it into electrical signals. These take the form of very weak ac which changes in frequency and amplitude to represent the sound being received. The type of microphone specified contains a FET (field effect transistor) pre-amplifier which boosts the signal given at the output. Resistor R1 provides the supply to the pre-amplifier from the positive line. Note that the pre-amplifier supply input and the signal output are the same pin.

The signals, which are still very weak, are passed from the output via capacitor, C1, to the base of transistor, Q1. This amplifies them further. Resistors R2 and R3 provide bias with some negative feedback so that the transistor is partially turned on. It is then found that about one half of battery voltage appears across the collector resistor R3. The other half exists between Q1 collector and emitter. These points could be checked using a voltmeter at the end.

Capacitor C1 allows the ac signal to flow from the microphone output to Q1 base while blocking the standing dc voltage which exists there. This would otherwise upset the bias of Q1 because the two voltages would be different.

When sound is received by the microphone, the steady voltage existing between Ql collector and emitter will rise and fall in sympathy. Whistling at a distance of 1m from the microphone in the prototype unit provided a 1V change approximately. At the end of construction and particularly if the unit fails to work, this could be checked using an oscilloscope. Preset potentiometer RV1 behaves as a potential divider and scales down the voltage between Q1 collector and emitter. This will be used as a sensitivity control and the way in which it works will be explained presently.

Voltage comparator

The next section of the circuit is a voltage comparator and is based on operational amplifier (op-amp), IC1. The rule is this: if the voltage applied to the non-inverting input (pin 3) exceeds that at the inverting one (pin 2) then the output, pin 6, will be high otherwise it will be low. Pin 2 receives a fixed voltage equal to about one-quarter that of the supply due to the potential divider action of resistors R4 and R5. RV1 will be adjusted so that the voltage applied to pin 3 is slightly less than that at pin 2. Since there is about one-half of supply voltage existing across the outer terminals of RV1, the balance point will be found at about the mid-point of the track. With the voltage at pin 3 being less than that at pin 2, the op-amp output, pin 6, will be low and LED1 *off*. The LED will be used as an aid to setting-up RV1 correctly at the end. Resistor R7 limits its operating current to l2mA approximately. When sound is detected, the rising parts of the waveform appearing at Q1 collector will be reflected in a rising voltage at IC1 pin 3 and, if is loud enough, will rise above the voltage at pin 2 on the peaks. Pin 6 will therefore go high and low as the wave rises and falls. This is passed on to the next section of the circuit which is a monostable based on the 7555 timer, IC2. Resistor R6 applies a little positive feedback to the system and this sharpens the switching action.

Good timing

When the first low pulse is received at IC2 trigger input, pin 2, the output (pin 3) will go high for a certain time then revert to low. The time during which it does this depends on the values of capacitor C3, fixed resistor, R9 and preset variable, RV2. With the specified components, the timing will lie between 1 second and 10 seconds approximately with RV2 providing the adjustment. The timing could be increased by raising the value of C3 in proportion and vice versa and this could be the subject of experiment at the end. In the absence of sound, the

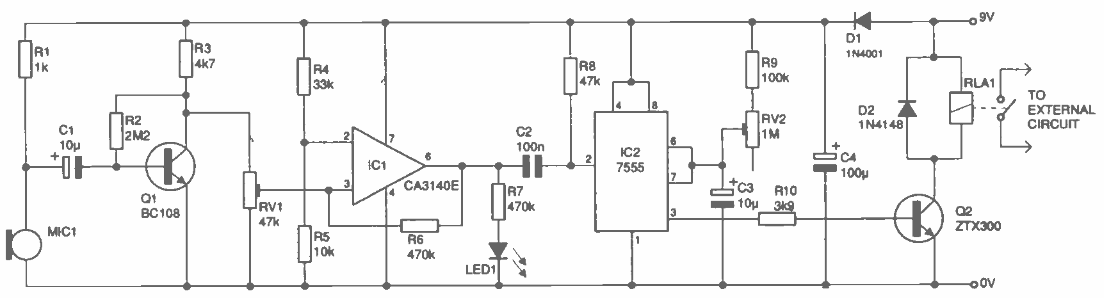


Figure 1: the circuit of the Sound Switch

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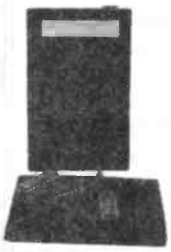

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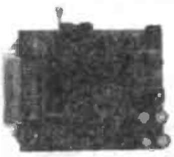

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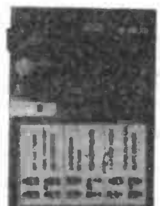

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trigger input, pin 2, is kept high through resistor R8 and this prevents possible false operation. Note that if sound continues to be picked up, IC2 will receive repeated triggering pulses and the output will remain high.

If the unit needs to be more sensitive, you will need to adjust RVl so that the standing voltage at ICl pin 3 is only slightly less than that at pin 2. The monostable will then be triggered with only a very small sound.

With the monostable output high, current flows through resistor R10 to the base of transistor Q2. This turns it on and collector current flows through the coil of relay, RLA1. The "make" contacts of this component then act as a switch for any device requiring less than 2A which is the maximum current rating of the contacts. Diode D2 allows the high-voltage reverse pulse which appears across the coil when it switches off to be bypassed. This prevents possible damage to other semiconductor components in the circuit. The external device must be powered using a separate battery - do not try to use the battery which is used to operate the circuit. If you did, the sudden increase in current would cause a dip in the supply voltage. This would probably interfere with correct operation of the main section.

Construction

Note that an electret microphone insert is used for this project. This is the working part of the microphone without the case, lead, etc. This is much cheaper than a complete microphone. Some microphone inserts have pads on the base and other have short end wires. On the whole, wires are more convenient. If the microphone used is of the "pad" type, small bare wire "stalks" will need to be soldered to them before proceeding. Some microphones are of the three-wire type but the two-wire variety is used here.

The topside stripboard layout (component side view) for the Sound Switch is shown in figure 2. Note that there are a large number of track breaks and several inter-strip links needed. Make the track breaks first using a proper spot face cutter. *Most causes of malfunction are due to strips not being broken completely, a break or "bridge" being left out, a break in the wrong place or a small blob of solder or sliver of copper bridging adjacent tracks.* Some of these are invisible to the naked eye. You have been warned! Make the inter-strip links and follow by soldering the ic sockets in position, and then all the remaining components. Take care to mount the transistors, microphone insert and capacitors C1, C3 and C4 the correct way round. Look at the underside of the microphone - the pad which connects to the case is soldered to the 0V line. Solder PP9-type battery connectors or as required to the "+9V" and "0V" tracks as indicated. Solder wires to the relay contact tracks. Adjust RV1 to about mid-track position and RV2 fully clockwise (as viewed from 1C2 position) which will give minimum timing. Insert the ic taking care over the orientation. Both of them are CMOS components and could be damaged by static charge which might exist on the body. Earth yourself by touching the bare metal of a water tap first.

Testing

It is necessary to test the circuit in a quiet room! Connect up the battery. The circuit generally self-triggers on powering-up and the relay will probably be heard to operate. It will then click off again after about one second. Adjust RV1 until the LED is off. Clap your hands near the microphone. The LED should come on momentarily and the relay should click on and off again. If this does not work, adjust RV1 a little and try again. Try increasing the sensitivity noting that if RV1 is set too finely, the circuit will go unstable and the LED will flash on and off repeatedly. The circuit will work if the LED is normally just on instead of just off. However, this tends to be a less stable arrangement.

Ideas for experiments

This circuit must not be used to operate mains appliances. It is not designed to control mains and would be extremely dangerous. The relay "break" (normally closed) contacts could be used to switch an item off during the monostable timing period although this is probably less useful than switching it on. For more sensitive operation, the supply voltage might need to be stabilised. Set the monostable time period as required. If necessary use an alternative value for C3.

A small motor at the output could be used to make something turn or move, possibly for a toy. A solenoid could give a pushing or pulling effect to make "Rover" jump out of his kennel. Motors require a much higher current than their running value while they speed up. Also, other components such as solenoids and filament lamps require more current at the instant of switching on. All this must be taken into account when choosing a suitable relay.

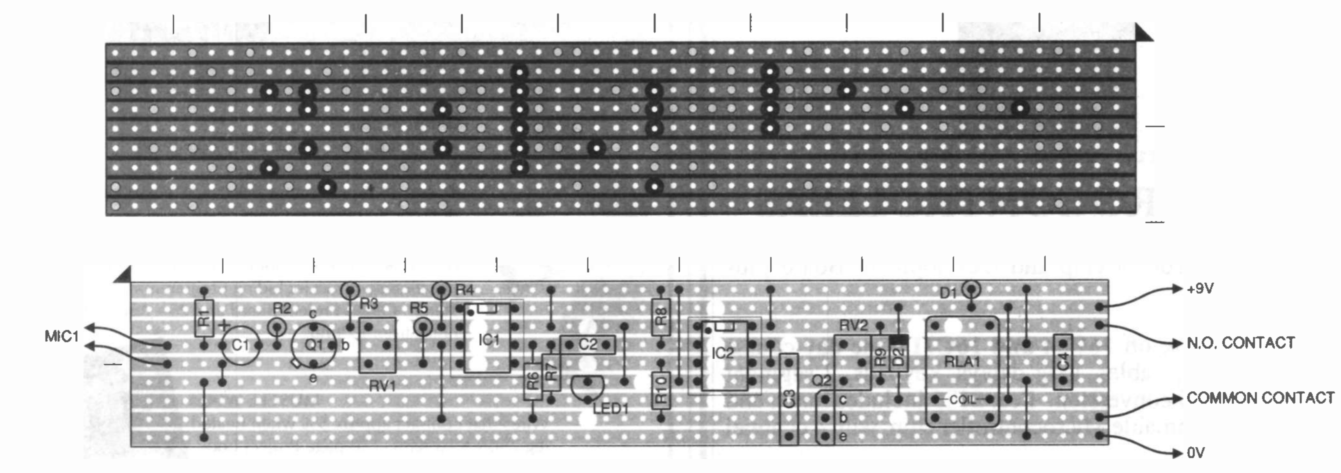

Figure 2: the stripboard layout for the Sound Switch module

Alphanumeric Morse Touchkey

Roy Bebbington's dot-dash tone touchpad can be used for Morse or for music.

The Alphanumeric Morse Touchkey is designed to enable beginners learning Morse to become familiar with the dot-dash codes and their rhythmic patterns without the aid of an instructor. The touchpad consists of a metallic baseplate covered by a plastic overlay template with hole patterns representing the alphanumeric Morse characters. These characters can be sounded and visually displayed by drawing a finger across them at an even speed. As experience grows, students can graduate to a finger-tapping proficiency pad, to emulate the movement of a Morse key.

Merely looking at a list of dots and dashes and learning it off by heart, or by head as the Dutch say, is not the way to learn Morse. While it is comparatively easy to make a mental translation from the code to alphanumeric characters at slow speeds, in a 12 wpm test there simply isn't the time for this! With characters arriving in quick succession, each must be identified by its unique sound pattern. The touchpad method ensures that even beginners can immediately send and hear characters that are formed correctly. This would appear to have wide appeal for radio amateurs, sea cadets, scouts and sailing clubs where a knowledge of Morse code is required. With two of these pads linked to a common circuit, students would be able to send and receive rhythmically correct messages at a very early learning stage. And talking of 'rhythmical', music students could also benefit from a suitable plastic overlay to bone up on a few basic rhythms or to sort out a few awkward syncopated bars - always a problem for beginners.

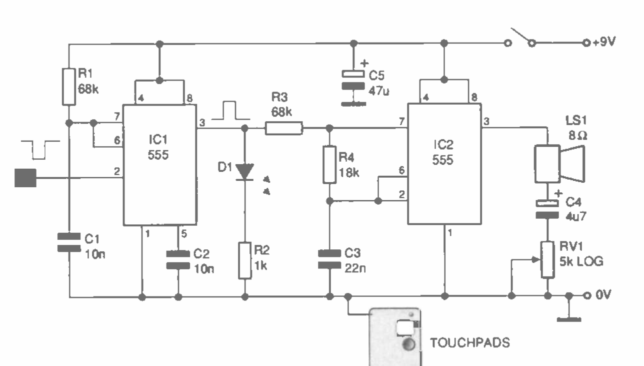

Figure 1: the Morse Code Touchpad circuit

For compactness, characters that are mirror images (for example, N is the same as A in reverse) have been combined. For instance, B is sounded by a left to right movement, and the same hole pattern sounds a V by a right to left movement.

The circuit and PBD uses two 555 timer ICs. Alternatively, these could be replaced by one 556. (This would require a different PCB or stripboard layout, which we leave to the reader's ingenuity.) There are two simple stages:

-A finger touch switch operating the first 555 in monostable mode, which triggers a tone generator formed by the second 555 in astable mode.

-A LED indicator and a loudspeaker provide visual and audible output.

The circuit

In the circuit (figure 1), IC 1 acts in the monostable mode as a touch switch. It is preferable to mount IC1 in an ic socket. When pin 2 and the 0V rail are bridged by a resistance; the body resistance in this application, a negative-going trigger pulse is applied to IC1 that turns off an internal transistor that is normally short-circuiting pin 7 to the 0V rail. This allows capacitor C1 to charge via R1, consequently, a positive-going output pulse is produced on pin 3. Light-emitting diode DI with its current-limiting resistor R2 provides a visual indication of the applied input signal. R3 feeds these long and short positive-going pulses that represent the alphanumeric characters to pin 7 of 1C2. C3 repeatedly charges via R3 and R4, and discharges via R4, oscillating at a frequency dependent on the RC values.

Frequency = 1.44/(R3 + 2R4)C3

Rectangular pulses on pin 3 practice an audible output at a frequency of approximately 1kHz in LS1. Variable resistor RVI

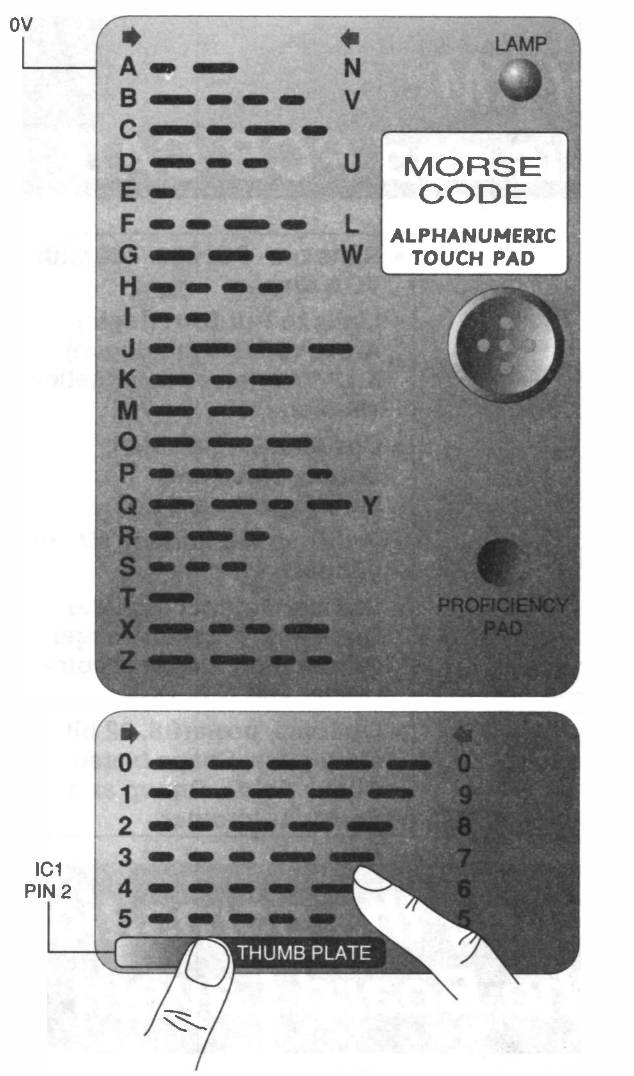

Figure 2: the baseplate and touchpad overlay

provides a series volume control to mute the loudspeaker if only visual signalling is required. A potentiometer with a switch could replace the separate on/off switch.

Construction

The prototype was built on a small piece of 0.1 in stripboard, but a suitable layout for a printed circuit board using two 555s is given in figure 5. Alternatively, a composite PCB could be made to include both the layout of the characters and the circuit.

A generous A4-sized baseplate is preferable to prevent fingers bridging the small spaces between the dots, and in the overlay, which would result in continuous sounds. Alternatively, a metal paper-clip held between the fingers can serve as a useful stylus.

The baseplate can be a sheet of polished aluminium or baking foil glued to thick card or plastic. Cut the holes in the plastic overlay with a sharp knife and tape or glue it to the metallic base. Use rub-down lettering for the alphanumeric characters or print them on the plastic overlay. A suggested layout for the plastic overlay is shown in figure 3.

The baseplate can either be free-standing or form the upper-side of the case that houses the circuit. Otherwise, you can house the loudspeaker and battery in a small case wired up to the baseplate, or even leave the loudspeaker "adrift" and the battery tacked to the baseplate with a battery holder or some double-sided tape. The left thumb touchpad can be an isolated part of the baseplate or a separate contact somewhere convenient on the case.

Musical coda

A suitable plastic overlay for sounding basic music rhythms is given in figure 4. Any other problematic rhythmic figures could also be stencilled on to a plastic overlay. However, a better solution for a teaching aid could be made up by mounting pieces of copper clad board into a multiway

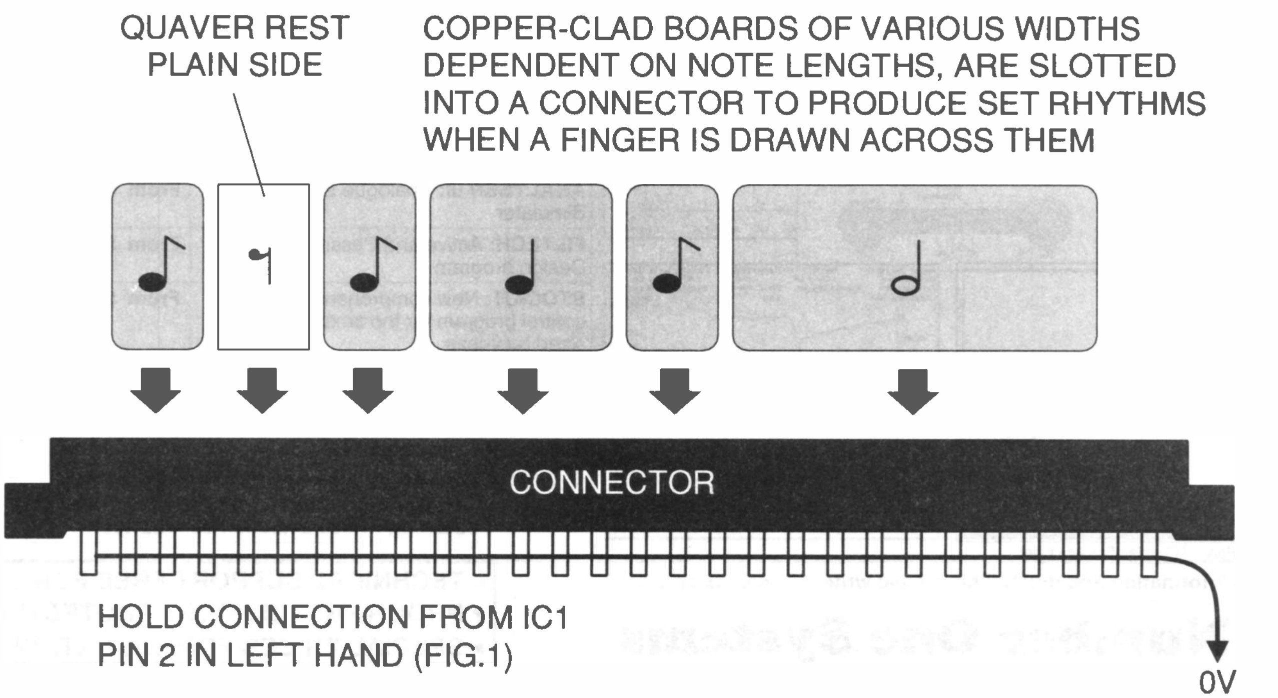

Figure 4: a musical rhythm simulator

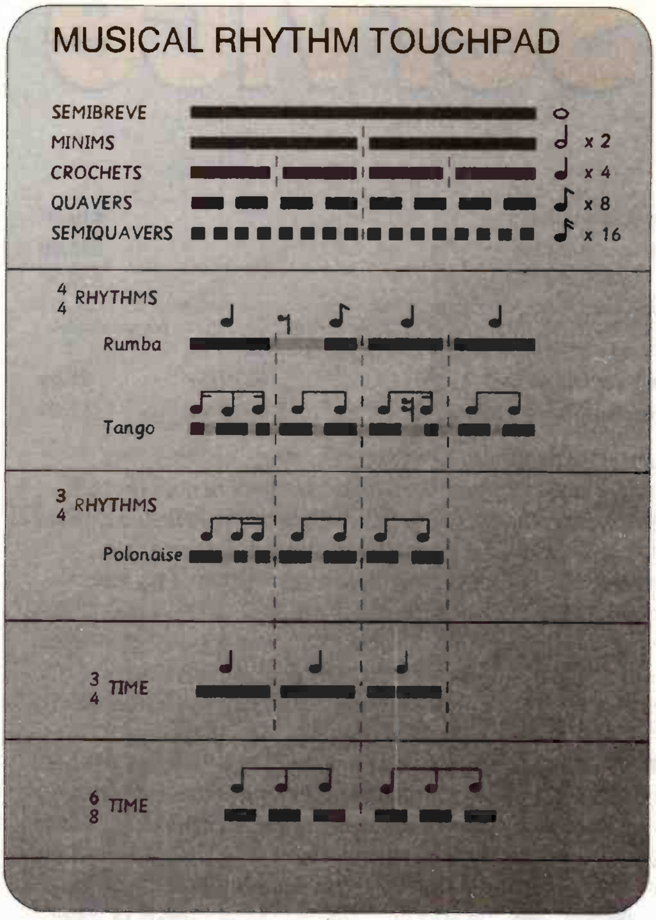

Figure 3: musical rhythm overlay

PARTS LIST for the Morse Touchkey

Resistors

R1	68k
R2	1k
R3	68k
R4	18k

Potentiometers

RVI	5k log (see text)

Capacitors

C1,C2	10nF
C3	20nF
C4	4.7u 10V elect
C5	47u 10V elect

Semiconductors

IC1	555 timer
IC2	555 timer
DI	LED

Miscellaneous

LSI	8R miniature
Switch	spst (on/off)

9V battery with clip, touchpad base and overlay, connecting wire, solder, etc.

socket as shown in the musical rhythm simulator of figure 5, using it to activate the touch circuit of figure 1. All pins of the socket must be soldered together and taken to the 0V rail. Several pieces of copper board board are needed for each type of note; quaver, crochet, etc., the widths of these depending upon the particular note values. As indicated in the diagrams, the physical widths of the notes correspond with their relative time duration; ie a crochet has a duration of two quavers, so is twice as wide as a quaver. A minim is equal to two crochets, so is twice as wide, and similarly, a semibreve is twice as wide as at minim.

The copper clad side is deleted for the notes; the reverse side (or a piece of plain board) could be selected for an equivalent rest. Slightly space the notes in the socket to allow them to sound separately ; butt any pieces together that need to sound continuously (ie as tied notes).

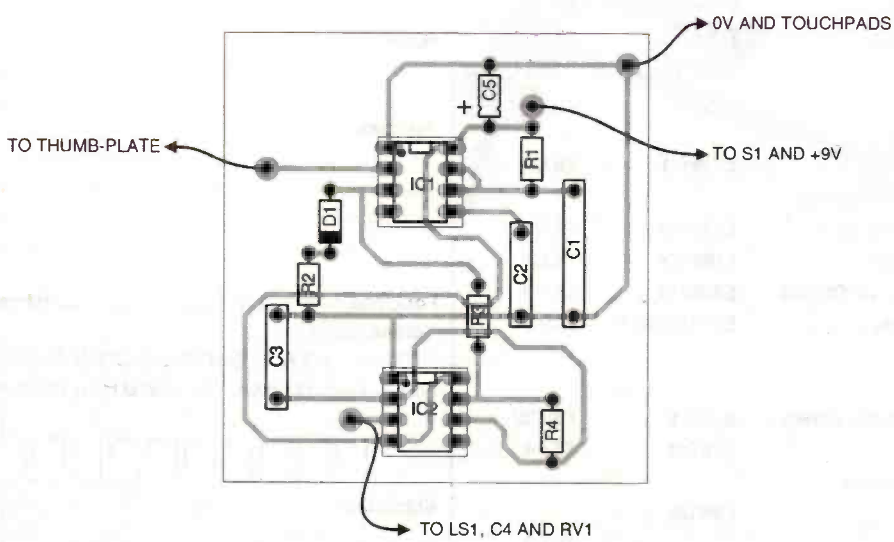

Figure 5: the component layout

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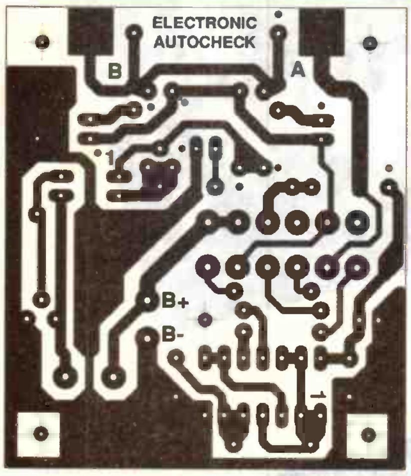

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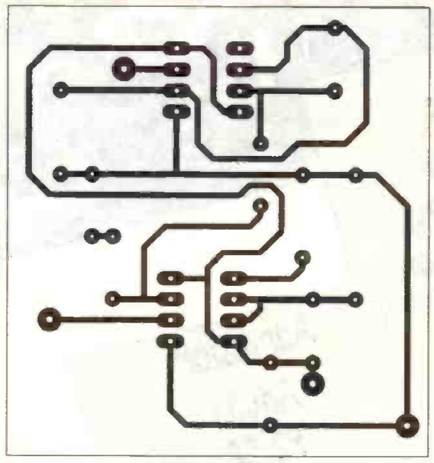
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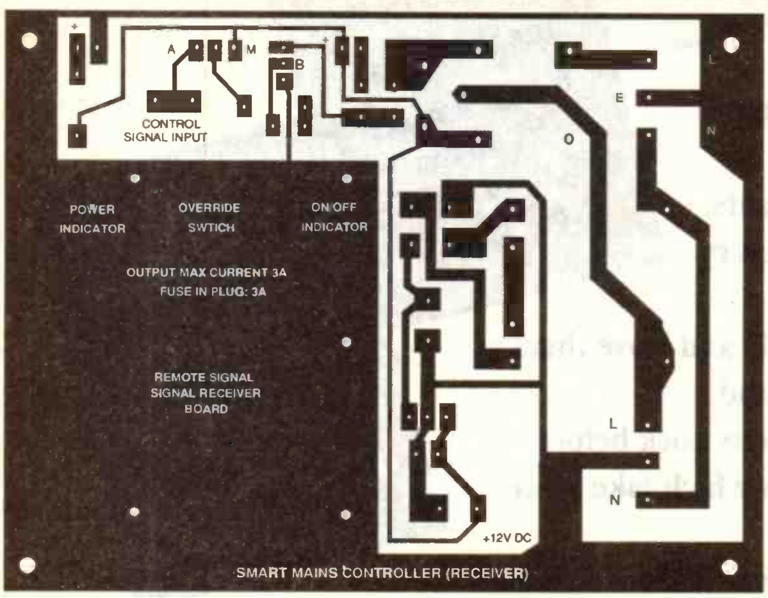

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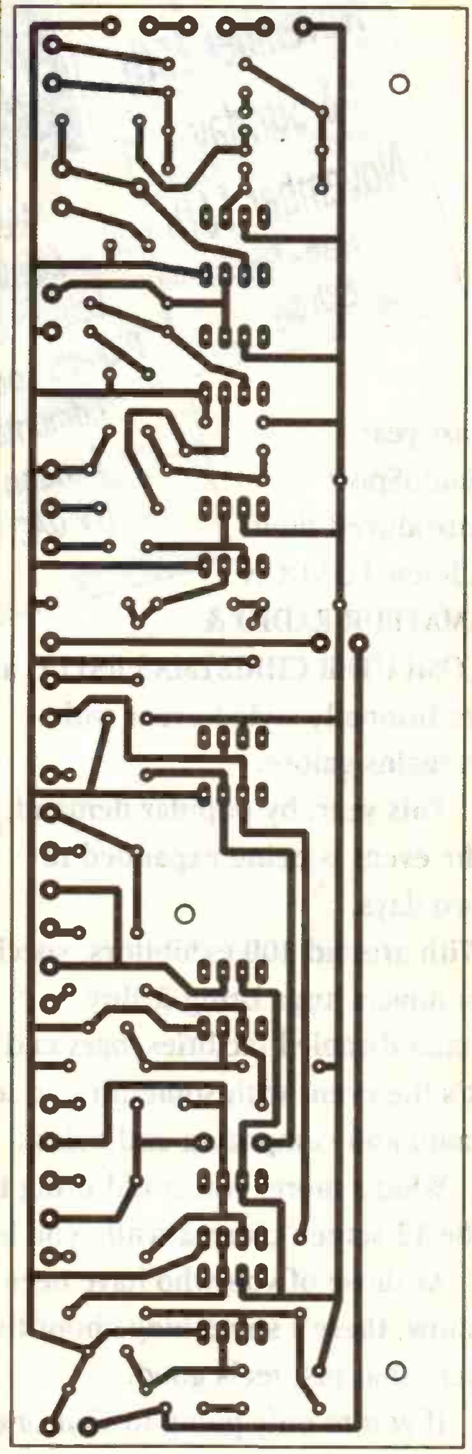
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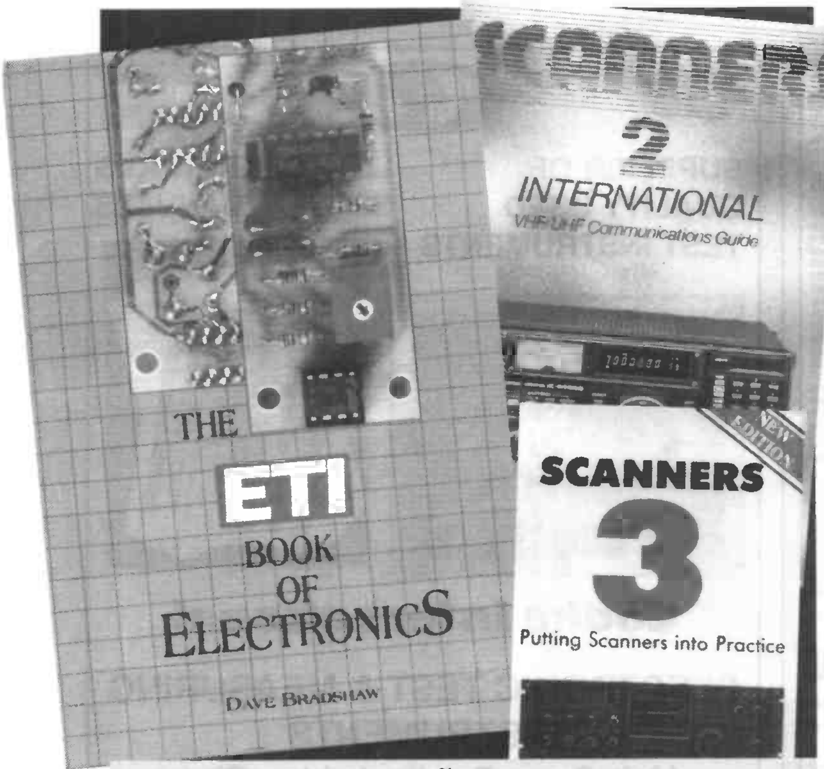

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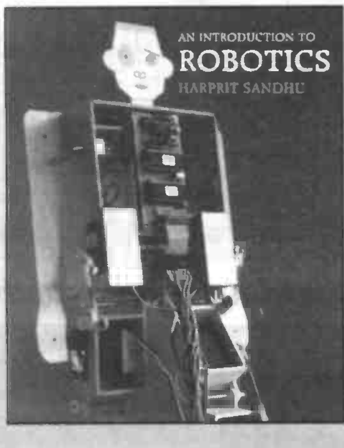

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Around the Corner

Talking of chucking old computers in skips - this is no longer the politically correct thing to do, now that the European Commission is close to publishing a draft directive on ways to recycle Europe's rocketing quantities of waste electrical and electronic equipment (WEEE for short).

You may profoundly wish to hear that your younger brother/sister/offspring's double-audio-power-blast CD-rom multimedia games PC is on its way to a landfill somewhere, but this won't be on the cards for much longer. It's more likely that the new waste directive will eat it up and spit it out as a refurbished, recycled, lower-cost, not-so-neat but just-as-loud games PC - two for the price of one! Whoopeee!

More seriously, there has been concern for some time about the future pollution potential of the increasingly large quantities of plastics, batteries, electronic components and solder and other heavy metal products being discarded as they fall out of use. Behind this concern is the wider one of waste disposal as a whole. Currently only a few materials (such as aluminium, a genuinely valuable recycling product) can be recycled with real cost-effectiveness, but landfills and other waste sites are filling up ever-faster, and local waste collection services in the UK are more and more strained. (Some people blame it on Wheelie bins tempting us to throw more in them, and others on Government spending cuts tendering out refuse collection to the lowest bidder.) And looking at the longer term, recycling is a habit that it would be good for all of us to get into, even though common materials like glass and paper are borderline in cost terms at the moment.

Once retrieval and recycling of used-up electronics becomes general, someone will have to pay for it, and it is expected that various parts of the electronics industry will pay a levy towards recycling, or arrange recycling themselves.

Already as we saw in the news pages of this issue of ETI, and the previous one, organisations with a track record in recycling electronics, or running pilot schemes, are on the move all over the UK. This will no doubt be a growth area for a while.

Some waste managers are inclined towards dismantling, separating materials and recycling as salvage, and some towards refurbishing and moving equipment (especially computers) into the second-user market, depending how viable they are. Properly organised, businesses updating quantities of equipment should be able to get a reasonable price for their old machines, while others will have to pay to get their junk removed.

Already businesses with rechargeable batteries to discard are expected to pay for removal, usually without even the option of delivering the waste themselves to collection points. It is high time the controlled collection of used batteries containing cadmium or lead was made easy, and mandatory, for everyone, including households.

As far as genuine "recycling" goes, talking to electronics constructors is preaching to the converted. Computer out of date? Cannibalise some parts, swap something with something else, add a couple of cards (wrestling with the compatibility problems - but so do people buying all-new systems) and an upgraded hard disk, and you have a new computer, with not a lot left over but a handful of screws and tags and a superannuated disk module which a mate somewhere could probably use. Dead mobile phone? There should be a card for it ... Walkman? Fit a new motor and give it to the kids. Radio? No-one ever gives up on a radio. TV? Fred's experimenting with one of those whole-wall display drivers in his garage ... and then there's the spare parts box.

It look as though industry will soon be doing all this on a Europe-wide scale.

Next Month...

Volume 26 no. 12 of Electronics Today International will be in your newsagent on 7thth November 1997 ... Mike Bedford will be looking at new electronic products that can stand tough treatment .... Ray Haigh has designed a dedicated classic medium wave receiver with high-sensitivity and reception to please the discerning ear ... Robert Penfold has been working on an Infra-red remote controller ... all the regulars, and more.
Contents are in preparation but are subject to space and availability.

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