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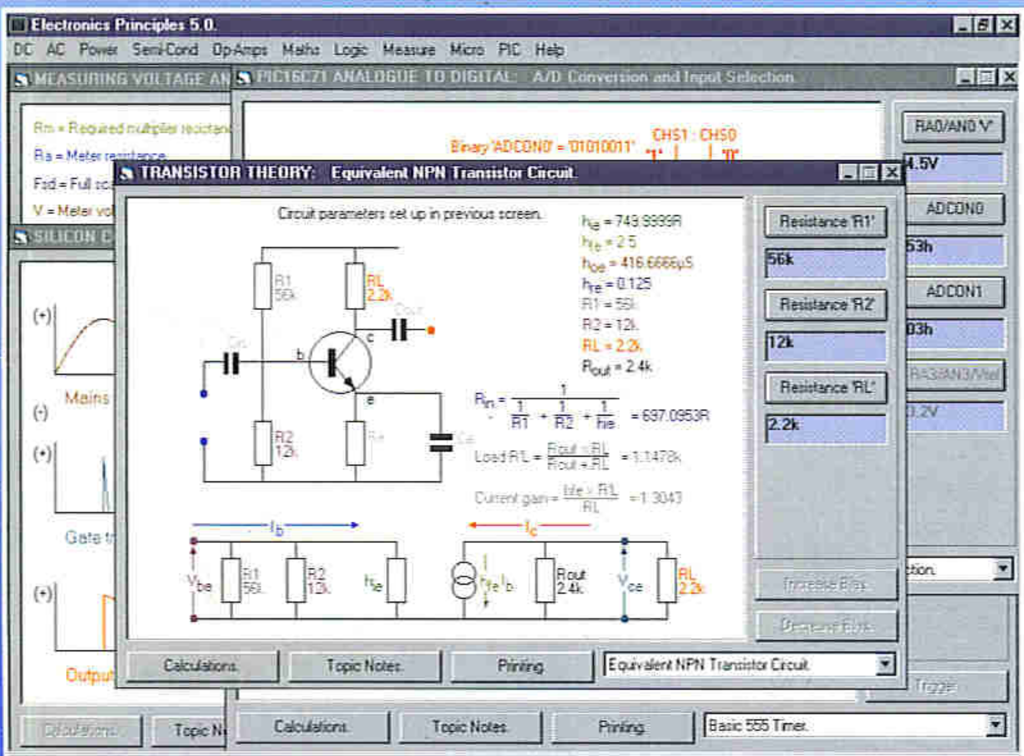
Electronics Principles 5.0

'A COMPLETE PC BASED ELECTRONICS COURSE'

If you are looking for an easy and enjoyable way of studying or improving your knowledge of electronics then this is the software for you.

Now includes the PIC16C84 & PIC16C71 hardware and instruction set.

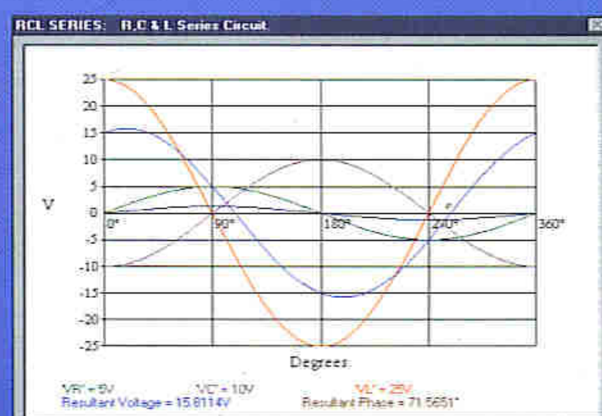


Electronics Principles 5.0 is a significant upgrade of our popular electronics educational software. Now containing even more analogue, digital and microcomputer theory, PLUS over a hundred new mathematics topics to further your understanding of formulae and calculations. Telephone for a comprehensive list or upgrade details.

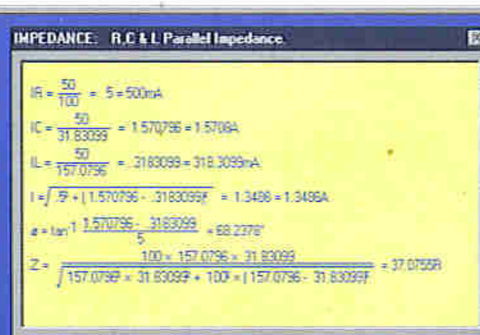
This software has been developed to teach electronics and is suited to both the complete novice and the more advanced student or hobbyist wanting a quick revision and access to hundreds of electronics formulae. It is extremely easy to use. Just select a topic, which is always presented as a default diagram (no blank screens!) and input your own values. Alternatively, use those from any standard electronics text book to see the results as frequency response curves, calculations, logic states, voltages and currents etc.

Graphics presentation has been enhanced and speeded-up with new menus and indexing which enables a quicker access and more informative description of the extended range of five hundred and sixty electronics and mathematics topics.

The PIC16C84 microcontroller hardware and instruction set has been introduced and brought to life through colourful interactive graphics where you can study the architecture of this device by changing the data values to simulate all of the registers, direct/indirect addressing, program/data memory and input/output port configuration. Along with those analogue to digital functions of the PIC16C71. If you would like to learn more about the principles of these popular microcontrollers then it could not be made easier.



Electronics Principles software is currently used in hundreds of UK and overseas schools and colleges to support City & Guilds, GCSE, A-Level, BTEC and university foundation courses. Also NVQ's and GNVQ's where students are required to have an understanding of electronics principles.



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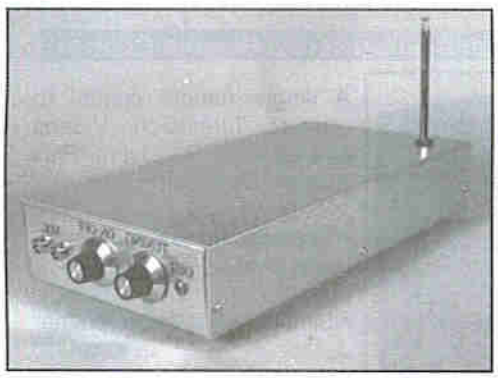

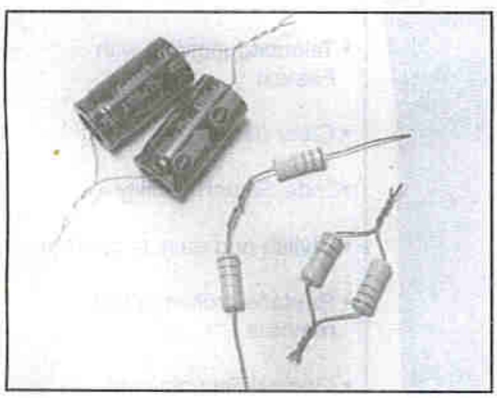

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IN4003	3P
IN4004	3P
IN4005	3P
IN4006	3P
IN4007	4P
IN4148	2P
IN5400	9P
IN5401	8P
IN5402	8P
IN5403	8P
IN5404	8P
IN5405	11P
IN5406	12P
IN5407	12P
IN5408	12P
RGP10	25P
RGP15	25P
RGP30	16P
SKE4F2/06	60P
SKE4F2/08	60P
SKE4F2/10	100P
SR2M	60P

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 10.95-11.70 GHz Gold Range	LNB1	2160p
Cambridge AE14 Universal LNB 10.7-11.7/11.7-12.75 GHz	LNB2	2500p
Cambridge AE21/AE5 Single O/P Switching LNB 1.0dB Standard	LNB3	2050p
Cambridge AE19/AE6 Single O/P Switching LNB 1.0dB Enhanced	LNB4	2050p
Cambridge AE23/AE12 0.8dB Enhanced 10.7-11.8GHz Gold Range	LNB5	2160p
Cambridge AE8 Dual O/P H-V Separate Enhanced	LNB6	4000p
Cambridge AE7 Twin O/P H+V Both Enhanced	LNB7	4000p
Cambridge AE2 Dual O/P H-V Separate Enhanced	LNB8	3550p
Grundig Super Universal 'Anis' 10.7-12.75 GHz 0.8dB	LNB9	2600p
Grundig Universal 'Anis' 10.7-12.75 GHz 1.0dB	LNB10	2250p
Cambridge AE1 Twin O/P H+V Both Standard	LNB11	4000p

FUSES

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

NB.

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

CERAMIC PLUG TOP

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

20mm CERAMIC TIME LAG

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

38mm CERAMIC TIME LAG

CURRENT RATING	ORDER CODE	PRICE
10A	FUSE48	815P

32mm CERAMIC SLOW BLOW

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

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

TRANSISTORS

PART	PRICE
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	16p
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	60p
6a/200V	
BR64	72p
6A/400V	
BR251	150p
25A/100V	
BR252	165p
24A/200V	
BR254	165p
25A/400V	
BR2156	200p
25A/600V	
BR258	240p
25A/800V	
BR351	165p
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
4095	58p
4096	60p
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	16p
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	28p
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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OVERSEAS READERS

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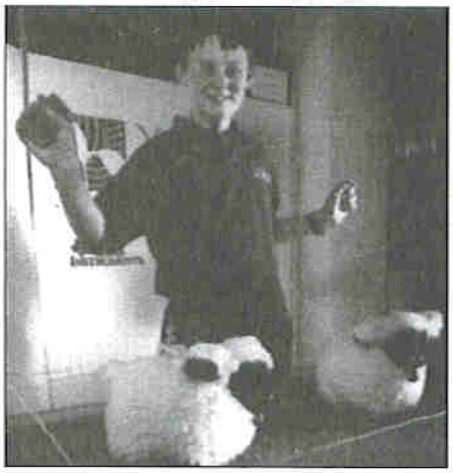
Young Electronic Designer Award 1998

Now in its thirteenth year, the Young Electronic Designer Awards of 1998 are sponsored by Cable and Wireless, and The Institution of Electrical Engineers (IEE). The Awards are presented annually to students in three age groups between 12-25 for the development of an electronics-based system or device which meets an everyday need. Students must develop their innovative talents, improve their technical know-how and develop business and marketing acumen, all essential for preparing for an engineering career. Project work can be undertaken as part of students' studies within the National Curriculum.

The deadline for the receipt of entry forms is 2 March 1998. Schools and colleges should be notified of the Awards. If your class or department has not considered preparing an entry for the awards, suggest it to them quickly. However simple your project is, preparing for the competition, whether at GCSE, A Level or University level, will be a useful learning experience, raising your awareness of the needs of practical electronic design in the real world.



The judges award marks in each of five categories within each age group: originality; technical competence and reliability; construction and presentation; everyday usefulness, and commercial feasibility. Entrants are asked to provide a brief (200-word) description of their product, explaining it to a lay person: What does the product do? Who will use it, and why? How does it work? What other products exist that could do the same job? And so on.

Prizes include awards of up to £2,500 to be shared by the students and their school or university, plus equipment, certificates and trophies. The 1998 awards ceremonies will be held at the Museum of Science and Industry in Manchester on 28 and 29 June 1998, as part of the celebrations marking the 50th Anniversary of the world's first stored-program computer, developed at the University of Manchester and unveiled in 1948.

As the picture of last year's Best Newcomer, Mark Gauld and his sheep, there's room for a certain amount of fun as well as brow-wrinkling when designing a serious project.

For information and entry forms, contact The Yeda Trust, 60 Lower St., Pulborough, W. Sussex RH20 2BW. Tel 01798 874767 Fax 01798 873550

Monitors detect extremely low frequency and microwave leakage

Concern about health risks from extremely low frequency (ELF) radiation has been added in recent years to concern about microwave leakage from domestic and commercial microwave ovens. Both are likely to occur, if they occur at all, in homes and workshops, for instance in electrical equipment where the live and neutral lines run on different paths, so that the normal mains field is not cancelled out along the wire paths. Users may wish to avoid sitting right next to equipment of this kind.

Perspective Scientific produced three new monitors to provide easy measurement of these electromagnetic fields. The ELF Electrical Field Monitor (£125 plus VAT) measures electrical fields in volts per metre from mains electricity sources, and can also be used to check faulty wiring. The company recommends the Electric Field Monitor for measuring ELF electrical fields generated by building wiring, overhead and underground power lines, and ELF fields emitted by electrical appliances like computers, television tubes, microwave ovens, bedside radios and electric blankets.

The ELF Microwave Monitor (£135 plus VAT) is a hand-held monitor weighing 100 grammes, which will measure the electromagnetic field from 30MHz to 3GHz, which includes low-level RF, microwave ovens and all cellular phone frequencies. Increasing medical research is being undertaken all over the world into the effects on health of EMR from cellular phones.

The EMFields Professional is a digital combined electric and magnetic field meter (£295 plus VAT). Magnetic fields can be measured from 0 - 19.99 microtesla, and electric fields from 0 - 1999 volts per metre.

Perspective Scientific also have on the market the hand-held ELF Magnetic Field Monitor (£110 plus VAT- to measure the magnetic fields from mains electricity sources in nanotesla. The company also makes the RadAlert Professional and RadAlert GEM for the measurement of background radiation (calibrated for gamma rays and able to detect the presence of x-rays and alpha and beta radiation contamination) and also distribute Mini Instruments and Holaday Industries monitors for ionising and non-ionising radiation.

Further information on these monitors is available from Perspective Scientific at 100 Baker St., London W1M 5LA. Tel 0171 486 6837 Fax 0171 487b 3023 Email sales@perspective.co.uk Website www.demon.co.uk/radiation-instruments/ More information on ELF research is available on www.powerwatch.org.uk

ETI News...

High resistivity materials measurement system

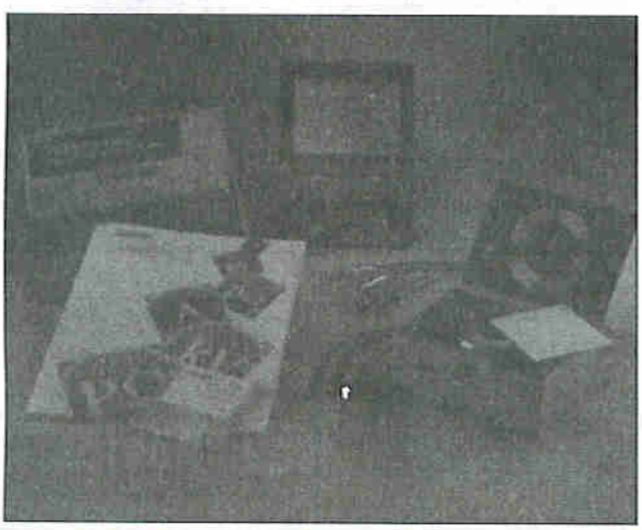
Keithley Instruments Model 62 and 65 high resistance packages provide a solution to the problem of getting accurate resistance measurements on high resistivity materials. These are the first integrated measurement system, Keithley tells us, that solves the problem of background current in insulators and other high resistivity materials such as polymers and pcbs. The packages consist of a Model 6517A electrometer, low noise test fixture and model 6524 software to allow fine tuned test sequences that eliminate background current errors.

Insulating material exhibit background current due to piezoelectric effects, polarisation effects and capacitance charged by static electricity. Measuring the resistance of resistivity of these materials is done by applying a voltage, measuring the current and applying Ohm's Law. Due to the high resistance, however, the stimulated current is often as low as the background current in the material being measured. Because the background current is similar to the stimulated currents, this frequently results in unstable and inaccurate resistance or resistivity readings, or even false negative values.

The model 6517A solves this by using an alternative polarity test sequence. Each sequence applies a positive polarity voltage, and after an appropriate delay measures the stimulated current. The voltage polarity is then reverse, and the current measured again after the same delay time. This is repeated, usually for about seven cycles, until the user observes a stable reading. The instrument than calculates the resistance based on a weighted average of the previous four readings.

When optimum test parameters are determined, up to nine sets of parameter and test sequences can be stored in the 6517's internal memory.

For more information contact Keithley Instruments Ltd., The Minster, 58 Portman Rd., Reading, Berks RG30 1EA. Tel. 0118 9575666.



Anti-stat spray package

Technotrend has revamped the popular ASP40 antistatic fluid into a 500ml pistol-grip spray container. The spray is meant primarily for spraying onto carpets or video/computer screens in static-sensitive areas.

The fluid works by reducing the natural surface resistivity of the materials treated from a typical 10 to the 11th /16th power ohms down to around ten to the 7th to 9th power ohms. For example, when sprayed onto a carpet, static disappears immediately and the carpet will remain anti-static and dust and dirt-retarding for six to eight weeks after a single spraying. One spray bottle, priced around £9.55 (plus VAT), will treat up to 25 square meters. The fluid is harmless but should not be used close to food.

Technotrend also supply a range of static electricity measuring instruments and related equipment. For further information contact Mr. D Roberts, Technotrend Ltd., Unit B5, Armstrong Mall, Southwood Summit Centre, Farnborough, Hants GU14 0NR. Tel 01252 373242 Fax 01252 373440.

Competition helps new bands

Musical equipment supplier John Hornby Skewes & Co. are the principle sponsors in 1998 for the Bright Young Things national band competition. The competition, in its 7th year, is open to all bands whose members are under 21 years of age, and is organised by Leeds Leisure Services (a division of Leeds City Council).

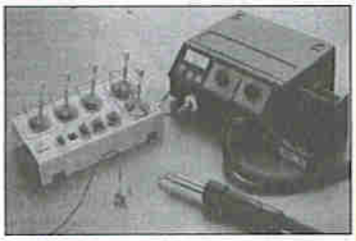
Seven finalists will be chosen from a series of national, regional and local heats to be held at notable venues throughout the country. As part of their sponsorship, JHS are donting the first prize, musical products to the value of £2,500.

The prizes of Ovation, Rhythm Tech, Kinsman, Scanner and Vintage instruments and accessories will be awarded to the band voted this year's winner by a panel of industry expert judges.

Enquiries to John Hornby Skewes Ltd., Salem House, Parkinson Approach, Garforth, LEeds LE25 2HR, UK. Tel 0113 5381 Fax 0113 286 8515.

ETI News...

Accurate hot-air desoldering for surface-mount



Desoldering, as everyone who has ever had to change an IC or repair anything more complicated than a conventional resistor will remember with trepidation, is an order of magnitude more difficult than soldering, at least when it comes to getting a component off the board without damaging either the component (could be troublesome) or the board (will be troublesome). The best advice to a newcomer asking "Can I take it out again if it's wrong?" is "Yes - but you won't enjoy it." You might think that desoldering surface-mount is easier because you do not have to work a heated component out of its pin-hole, but surface mount boards have the opposite problem: components fall off the board all too easily.

The JT6040 hot air desoldering station represents the state of the art of benchtop surface-mount desoldering. Hot air desoldering normally uses a hood or shield attached to the heat source and covering the device. The disadvantage is that heat leaks out of the four corners of the hood, and this can dislodge surrounding components, and because they are making contact with the pad, it is up to the operator to ascertain the time and temperature for safe removal of the component. If the operator gets that equation wrong - a frequent occurrence even with experienced operators - the track can be lifted off the board when the device is removed, damaging the board for commercial use.

With the JBC system, collateral damage to the board in this way is impossible, because no contact is made with the pad. The shield cup fits flush with the board, which stops air escaping through the four corners and so protects the surrounding circuitry.

The system also boasts a unique plunger in the middle of the protector, which is on a very light spring that sits on top of the device. The delicate operational capabilities this gives the operator means that devices can be used repeatedly. An integrated surface mount device (SMD) can be de-soldered in 20 seconds.

At £1065 plus VAT, the rescue solution does not come cheap, but for a prototyping or production workshop a device of this kind can save much time and trouble.

For more information contact Robin Smith at JC Soldering Solutions Ltd., Marshall House, 255 Wellington Road South, Stockport, Cheshire SK2 6NG

Palmtop ruggedised for extreme working conditions

New from Workstation Source is the Ultimax range of ruggedised palmtop computers able to withstand extreme working environments. The Ultimax 2000, shown in the photograph, is a fully functional Intel-compatible 386X DOS-based computer that weighs only 28 ounces, including batteries. It has 4 megabytes of DRAM memory, upgradeable to 16 megabytes, two built-in serial ports operating at up to 19200 baud and a CGA-compatible LCD with full 640 x 200 panning control.

The Ultimax 4000 is fully functional and Windows '95 compatible. The Intel 486DX2/66 MHz CPU will run any MS-DOS or Windows-compatible software. It supports high speed data processing, communications networks, and simultaneous interfaces. The Ultimax 4000 has two serial ports, one external configurable connector, a parallel port and an external keyboard connector. It comes as standard with 4 megabytes of DRAM, upgradeable to 32 megabytes. The full colour VGA display supports text and graphics.

Ultimax palmtop computers undergo full temperature cycling from -20 degrees to +50 degrees and are 100 percent functionally tested through all operating modes. Environmental testing includes humidity, vibration, shock and immersion tests in three feet of water for 30 minutes. Ultimax palmtop computers are fully FCC and CE compliant.

For further information, contact Mark Lipscombe, Workstation Source, Unit 1 Danehill, Cutbush Park Industrial Estate, Lower Earley, Berks RG6 4UT. Tel 0118 922 7828.

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Sescom Inc. in the USA has produced its 1997 Sescom MI-series Audio Transformers catalogue for professional users. The catalogue describes 59 different transformers for high quality audio applications, with technical, electrical and mechanical information. Tel. 0800 96 7106 or 001 702 565 3400. Fax 001 702 565 4828 (from the UK). email sescom@anv.net ...

Introducing Digital TV

Digital television holds out all kinds of promises for the future. Mike Bedford sorts out the facts from the fiction.

Thirty years is a long time in the fast-moving world of consumer electronics, but this is how long British terrestrial TV broadcasting has remained largely unchanged. While you could hardly claim that things have remained totally static during the last three decades, most of the changes we have seen have not been revolutionary. Teletext, in the form of the BBC's Ceefax, appeared in 1972. It's useful if you don't subscribe to a broadcasting guide, but otherwise the information on it is limited. NICAM stereo was introduced in 1991, but although it was appreciated by music lovers, it did not amount to a dramatic change in the way we watch television. BBC1, BBC2 and ITV were augmented by Channel 4 and much more recently Channel 5 (still to reach some areas), but everyone has pointed out that this is just more of the same. For the last really major shake-up, we have to go back to 1967, specifically to the live coverage of tennis at Wimbledon on BBC2 in July of that year. This was the first programme to be broadcast in colour in the UK, and the beginning of the long decline of all our black-and-white tellies.

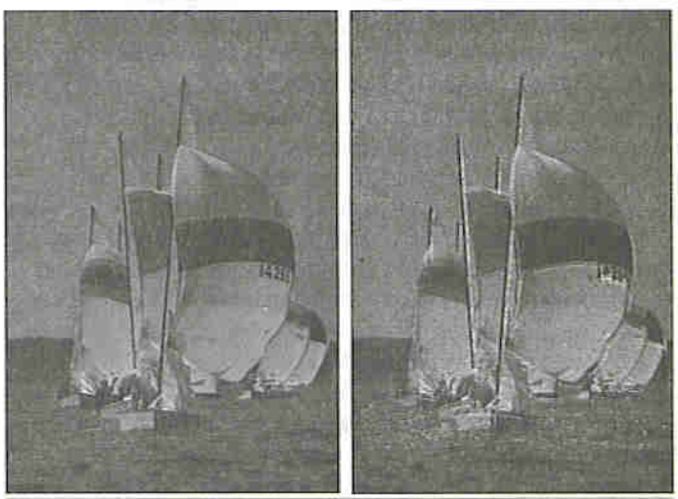
Thirty years might be a long time to wait for another major revamp, but at long last it is nearly with us. The broadcasters are keen to tell us that it will be worth the wait. You are going be hearing a lot about the introduction of digital TV to the UK during 1998.

So what will viewers gain from digital TV? And how does it work? First of all, we'll take a look at what's on offer. We'll attempt to identify the real benefits, sorting out the truth from the hype - after all, suppliers only have to mention the magic word "digital" to get consumers queuing up for their latest offerings - and we'll take a look behind the scenes, investigating how digital programs are broadcast, and decoded in our living rooms. To finish, we'll indentify the equipment you need to experience the digital revolution, and touch on what the more distant future may hold.

Why digital?

Before we start to look at the benefits of digital TV, let's recall some of the benefits of digital compared to analogue when applied to anything electronic - audio recording, radio broadcasting and video editing, for example - and not just to television.

To recap, an analogue signal is one in which the amplitude varies continuously with time. So, if you display the wave-form on an oscilloscope, it should display smoothly, with no jumps or discontinuities. This is the most obvious way to represent sounds or pictures; after all, we live in an analogue world which we perceive using our analogue ears and our analogue eyes. However, there is one very obvious drawback to recording and manipulating signals in their natural analogue form. The signals are very susceptible to noise. This is one of the major reasons people give for preferring CDs to vinyl records: problems with surface noise due to dust and other contaminants on the disk are very much reduced, because the smooth CD coating does not have hundreds of little grooves for dirt to get embedded into. But whereas this is physically-induced noise, the same principle applies to electrical noise. There's no such thing as noise-free electrical circuitry, so every time an analogue signal is copied or processed in some way, a small amount of noise ends up being added to it. Noise in small amounts may go unnoticed, except to those people with magic ears, but the effect is cumulative: it builds up so that, sooner or later, the signal will be seriously degraded. If you've ever recorded yourself and bounced down or copied your efforts to the 10th generation on a music cassette, you'll know what we're talking about. And whereas electrical noise manifests itself on an



Digital TV will eliminate ghosting and "snow" (shown in the Right hand picture here). Another "fix" for picture problems like this, however, is often just to get a better analogue aerial.

audio signal as audible noise, exactly the same principles apply to video signals in the form of visual noise, such as "snow", or just a lack of contrast or definition. Unacceptable levels of noise are not an inevitable consequence of analogue techniques, but it does mean that the uttermost care has to be taken in the design of ultra low noise circuitry, and that in turn (as any hifi enthusiast will tell you at some length) involves serious expense.

A digital signal, on the other hand, is one that has been split into just two voltage levels representing the zeros and ones of binary numbers. An analogue signal is converted to a digital equivalent by "sampling". This involves measuring the amplitude of the analogue signal (taking the "sample") and rendering the measurement into a binary representation at regular intervals. The great advantage is that the amplitude of any noise is tiny compared to the difference between the two signal levels. For example, if a digital signal operates at levels of 0V and +5V, the typical millivolt or microvolt of noise levels will have no impact: zeros will still be read as zeros and ones will be read as ones. But more importantly, there's no build-up of noise. Every time a zero or one is correctly interpreted, it is re-written as a perfect digital signal - every generation of the signal is effectively an original.

So noise control is one of the major motivations for going digital, but once you've got your signal in a digital form, there are more benefits. Digitising an analogue signal significantly increases its bandwidth. For example, audio CDs can reproduce sounds up to a maximum frequency of 20kHz, so the bandwidth of an equivalent analogue signal in stereo would be 40kHz. However, the sound on the CD is sampled at 44.1kHz (according to the Nyquist Theorem, the sampling frequency must be at least twice that of the maximum frequency to be reproduced) and each sample is represented by a 16-bit binary value. So the raw data of a stereo signal on a CD, after the various stages of encoding, occupies a bandwidth of several megahertz, many times that of the analogue original. This looks like a serious drawback - radio bands would fill up quickly, and vast amounts of storage would be required - but this does not take into account the fact that digital data can be compressed. In the realm of computer storage, we're used to being able to compress files down to half their original size. But audio and video signals contain far more redundant information, and can, therefore, be compressed to a much greater extent. Audio digitised data can be compressed down to about the same bandwidth as the original analogue signal, but video signal can be reduced significantly beyond this, and with lossless compression to boot. If you are prepared to go one further and accept a degree of loss in sound or picture quality, much greater compression ratios can be achieved.

But digital data can also be processed in much more imaginative ways. As soon as a signal is in the digital domain, computing power can be brought to bear on it. Effects that would be either prohibitively expensive or virtually impossible by analogue means become viable. Imagination, not the cost of hardware, becomes the only limiting factor. So for example, in PC sound cards, digital signal processing is used to generate a pseudo-surround sound effect from one pair of front speakers, in a product costing a few tens of pounds. Furthermore, since we're now talking about software or firmware, new products can often be brought out without a complete re-design of the circuit board, and upgrades can be made to installed equipment at the cost only of supplying new software.

What's on offer?

One of the major benefits to a company bringing out a digital product is that the magic word "digital" can be used for marketing. People have come to associate that word with innovation and quality. You'll remember, however, that improved quality was not one of the inevitable benefits of digital techniques that we listed in the previous section. Digital techniques do not necessarily yield better results than a similarly priced analogue equivalent. This is abundantly clear in the field of photography. Digital cameras with a resolution of 1024 x 768 cost in the region of £600, but offer image quality comparable to that of a £50 film camera. And even if you pay £25,000 for a digital model, you won't equal the picture quality of a conventional SLR costing a few hundred pounds. The fact is, because of the sampling process, and because of the limit of the word length, a digital signal can only be an approximation to the original analogue signal. In some cases it may be sufficiently close to fool our eyes or ears, but in other instances - low-cost digital cameras, for example - this may not be the case, and quality will be degraded.

I mention this to counter one of the most commonly quoted advantages of digital TV, which is that it gives improved picture quality. For a number of years, Japan has been broadcasting programmes in High Definition Television (HDTV). This is an analogue rather than a digital system. And the digital TV which will be launched in the UK this year will not give this level of resolution. Rather, the quality will be much closer to that of current 625-line PAL analogue TV.

So where does the "high quality" tag come from if the design aims were for the picture quality to approximate that of analogue? One of the strengths of digital is its behaviour under poor signal strength conditions. As we're all aware, with a poor signal - perhaps due to the use of a set-top antenna - ghosting and "snow" are common and, as the signal deteriorates, these get worse to the point where the picture becomes

To get the "letterbox format" 16:9 aspect ratio without black bars at the top and bottom of the picture, you will need to buy a wide-screen television. (Photo: Panasonic.)

unrecognisable. Digital signals, on the other hand, aren't affected by noise in this way, so the picture will hold up for much longer, giving you a good picture on your poor antenna. Unlike the situation with analogue, however, a point will come at which the picture is totally lost - with digital, there is no half-way house.

However, if this is the only perceived benefit of digital TV, it would be far cheaper to stick with analogue and buy a better antenna.

But if digital TV won't offer you a better quality picture, it will at least offer you one which is a different shape. It's hard to say exactly what the aspect ratio is of the human field of vision. The edges are not clearly defined, with vision becoming much less well defined towards the right and left edges rather than cutting out completely. Nevertheless, it's probably fair to say that the image we see is much wider than it is tall. By way of contrast, conventional TVs and computer monitors have a 4:3 aspect ration which means that the picture is only marginally wider than it is tall. Clearly this isn't ideal, and a more appropriate aspect ratio is one of the advantages on offer with digital TV. In particular, it will offer the possibility of producing programs in the so-called letterbox format, which has a 16:9 aspect ratio. Yes, you will get wide-screen programming (but only if you buy a wide-screen TV; if you stick with an ordinary TV and add a digital set-top box, you'll get the same wide-screen programming as we do at present, that is, with black bands at the top and bottom), but this has nothing to do with the digital signal. It would have been quite possible to design an analogue TV system with a 16:9 aspect ratio. The only reason it's tied up with the digital TV package is that broadcasters have made the decision to go wide-screen at the same time.

So far, we seem to be doing a good job of debunking the benefits of digital - one of the widely reported advantages won't be realised at all, and another could just as easily have been done with analogue. However, there will be major benefits, but we need to separate the fact from the fiction. The major advantages of digital TV all stem from the fact that data compression reduces the bandwidth by a factor of around six. That could have meant that six times as many channels were accommodated, but this is not the way the system has been implemented. Instead of allocating individual channels, as at present, each carrying a single programme, the ITC has allocated a number of so-called multiplexes, each having a

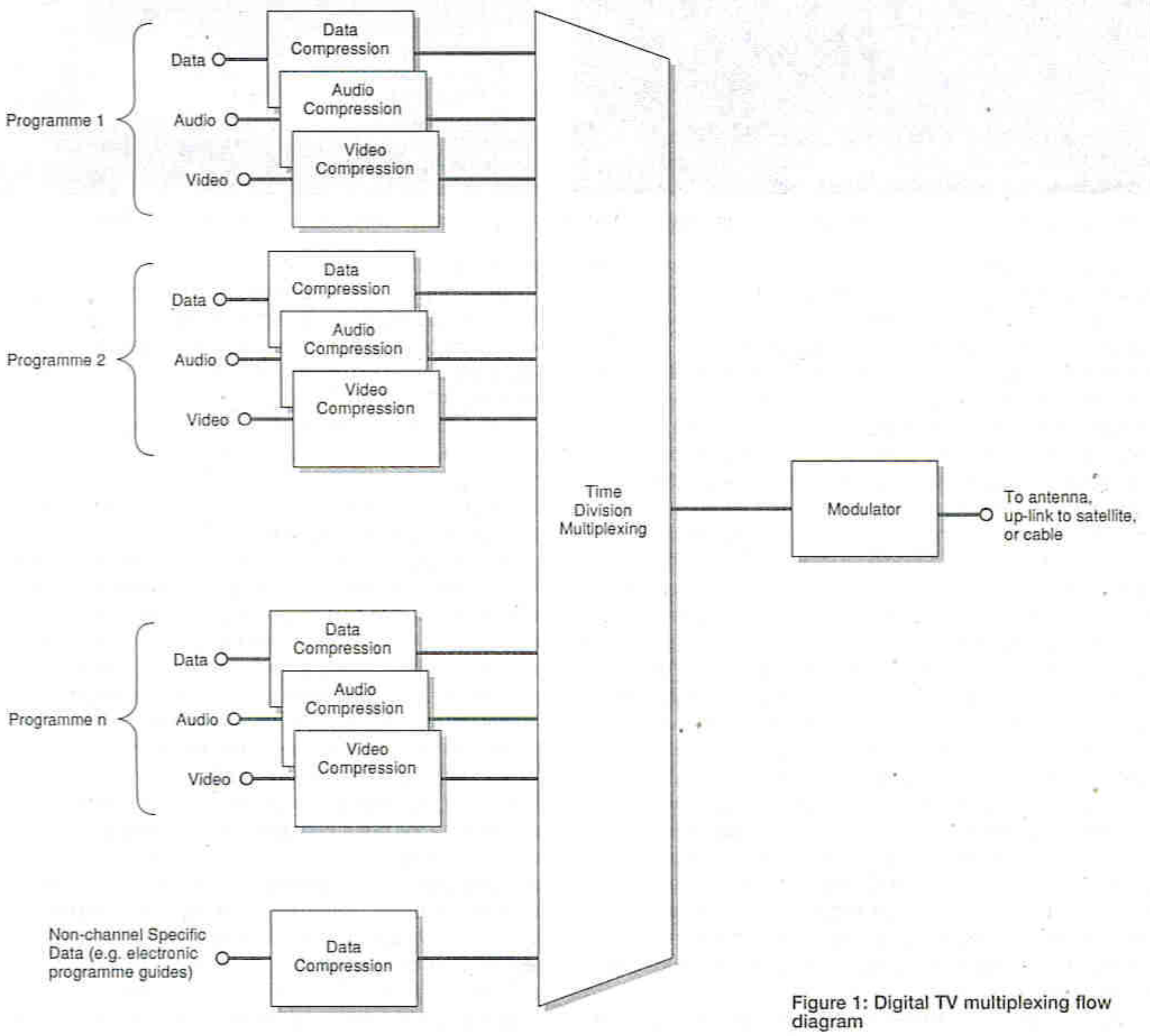
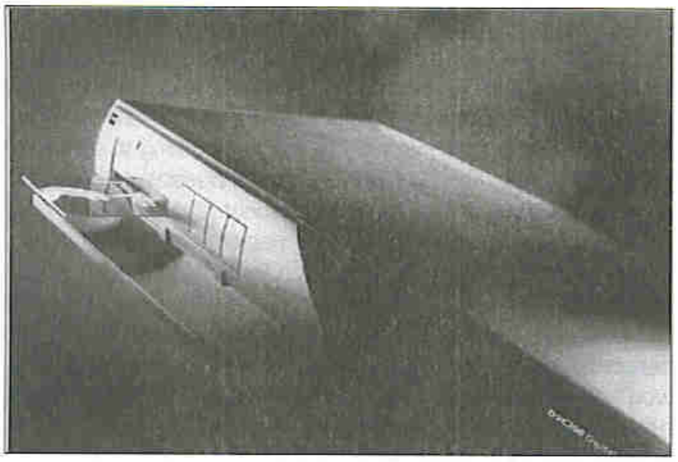
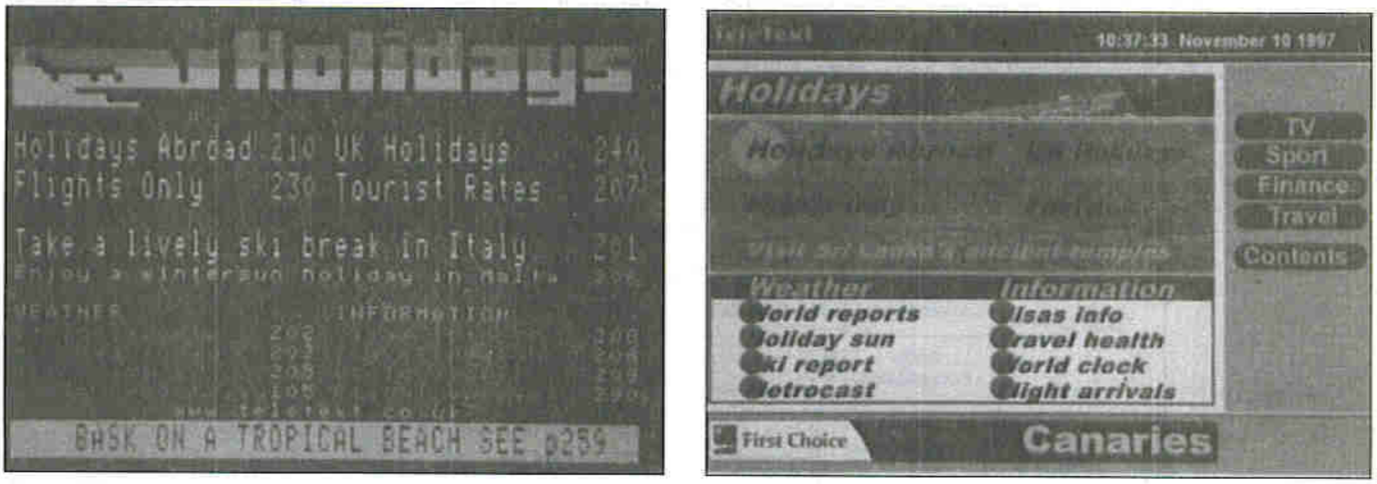


Figure 1: Digital TV multiplexing flow diagram



A digital cable set-top box - a typical slimline design



With the advent of digital TV, traditional chunky analogue teletext (left) will give way to a smoother digitally encoded style (right).

bandwidth equivalent to a current analogue TV channel. **(See figure 1.)** This gives the broadcasters far more flexibility.

The vital factor is that each multiplex has a "bandwidth budget". The broadcaster can decided just how this "budget" is spent. One obvious way is to transmit a number of separate programmes in the multiplex, and indeed, each of the companies to whom the six digital multiplexes have been licensed will offer between three and six programs. Instead of five analogue programmes, we might have as many as thirty digital programmes. And even at this level, the use of multiplexes offers advantages over narrow, independent, digital channels each carrying a single programme. The MPEG-2 compression algorithm doesn't provide a fixed compression ratio. It will be possible to compress different programs to different degrees. Anything with a lot of motion will be harder to compress than a fairly static scene, and although MPEG-2 may be able to compress TV signals to a sixth of their analogue bandwidth (on average), there's no guarantee that it will be able to do so all the time. And if it can't achieve the necessary amount of compression, frames will be lost and the picture will be jumpy - at least, this would have been the case with independent channels. If one company is operating a complete multiplex, however, and if one program requires some extra bandwidth to cope with a short burst of action, this can be borrowed from one of the other programmes which does not need so much bandwidth. Distributing the bandwidth budget in this way means that you only have to ensure that your average compression ratio is adequate.

More choice for the viewer is only one way of spending the bandwidth budget. Effectively, the definition of what a programme is will become vaguer. For example, a broadcaster may choose to dedicate four channels in a multiplex to a major sporting event. One may carry a normal edited program such as we see today, another two may carry specific camera angles or views, and one may carry continuous slow motion action replays. It's one programme - but the viewer can flip between different aspects. Another option is not to cram the maximum number of programmes into the multiplex, but to keep some of the bandwidth budget free for supplementary information. This could include small windows carrying a picture of someone signing the soundtrack of the main programmes for deaf viewers, or a large number of foreign language soundtracks for the main programmes. The improved bandwidth efficiency of digital TV will also be used to provide an improved sound track - CD-quality surround sound - and a better quality of Teletext, with no more chunky characters and block graphics.

Most of what we've seen so far refers to digital terrestrial television, but satellite and cable TV are also going digital. If the equivalent of 30 programmes sounds like a lot for terrestrial TV, digital satellite or cable TV could offer literally hundreds. How will they all be used? The good news is that we won't simply see a proliferation of channels, many full of low grade programming. With a capacity corresponding to hundreds of video signals, satellite and cable operators will make much more use of "pseudo interaction". This is the official name for the scenario we looked at earlier where the viewer can select camera angles. It isn't true interaction, of course, since the viewer isn't transmitting signals back to the broadcaster, but it feels similar. Another example of pseudo-interaction which will be popular on satellite and cable is almost video on demand. Instead of broadcasting a movie at a single time during the evening, multiple channels could be used to transmit it at, say, quarter hour intervals. Now, the viewer can pick the most convenient start time. And whereas this all involves pseudo-interaction, cable offers the possibility of true interaction. True interaction has been discussed in conjunction with terrestrial and satellite TV, but a phone line and modem would have to be used for the return path. Accordingly, some set-top box manufacturers are considering including a modem. And once we get to true interaction, the sky's the limit. For example, we could have shopping channels where you can order from your remote control hand-set without having to pick up the phone, political documentaries which take immediate viewer polls, and quiz shows with viewers taking part from their own homes.

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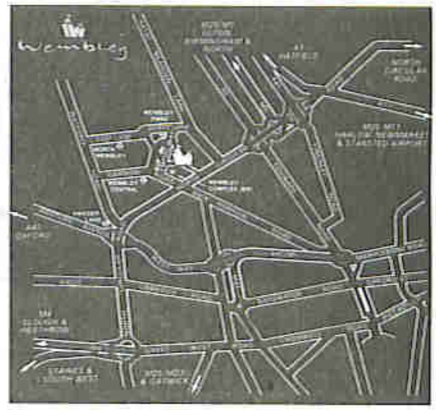

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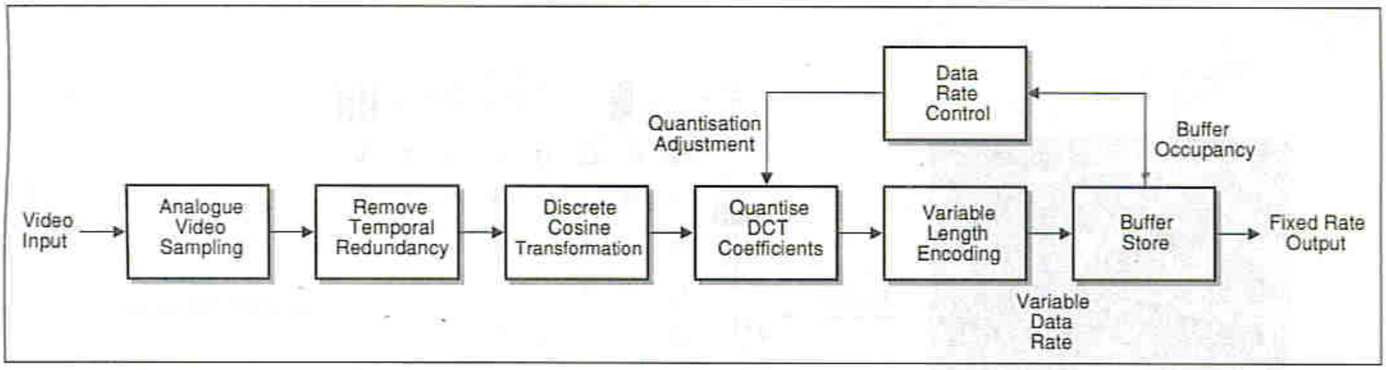

Figure 2: MPEG-2 compression flow diagram

The technology

That is about as much as we want to say about the benefits of digital. You will be hearing a lot about this from the broadcasters over the next few months. Just watch out for the hype. Let us now turn our attention to what goes on behind the scenes and start with MPEG-2 compression **(figure 2)**, as something that applies to all types of digital TV, terrestrial, satellite and cable.

MPEG-2

If a TV signal with the same resolution as that of today's PAL transmissions was to be digitised at 13.5MHz for the luminance signal and at 6.75MHz for the two colour difference signals, each using 8 bits per sample, the resultant signal would have a bandwidth of 108MHz. This compares unfavourably with existing analogue satellite transmissions, which occupy a 27MHz bandwidth, and PAL terrestrial signals which are even more frugal at 8MHz. To break even, we would need a compression ratio of 13.5:1 for terrestrial TV. However, we've already seen that digital TV claims to cram six times more information than analogue into a given bandwidth, which implies that a compression ratio of about 80:1 is required. This is achieved using the MPEG-2 compression scheme, the successor to the original MPEG (Motion Picture Expert Group) algorithm, which allowed video to be recorded on CD-roms and displayed in tiny windows on a PC screen.

Unlike many of the data compression schemes used for computer files - LPZ, for example - which employ a single compression algorithm, MPEG-2 uses a whole arsenal of techniques. MPEG-2's first form of compression takes account of the fact that a moving picture, with frames sent at 1/25-second intervals, normally has comparatively small differences between successive frames. Compression that makes use of this is called temporal compression **(see figure 3)**. In theory, it's only necessary to transmit a single full picture and, from that point onwards, transmit only the changes, achieving a significant degree of compression. This clearly is not entirely satisfactory, as any errors would be carried forward, and a TV receiver newly switched on would not be able to build up an image from the list of changes to a picture it has not received. In practice, therefore, full frames (called I frames to indicate that they only employ intra-frame compression - see below) are transmitted at regular intervals. Between the I frames, P frames (Predictive frames) are sent. P frames contain only those 8 x 8 pixel blocks which have changed since the last I frame or P frame, and typically this is only a small portion of the overall picture. However, further temporal compression can be achieved simply by not transmitting an I frame or a P frame every 1/25th second - in other words, by leaving gaps. These gaps have to be filled in by the decoder, using B frames (Bi-directional predictive frames). To do this, the decoder looks at the most recent previous reference frame (an I frame or a P frame) and the nearest future reference frame and uses motion estimation to make a guess at the missing frame. Differing amounts of compression can be selected by changing the ratio of reference frames to B frames.

That is temporal compression in brief, but this leaves quite a lot of scope for further compression. Specifically, both I frames

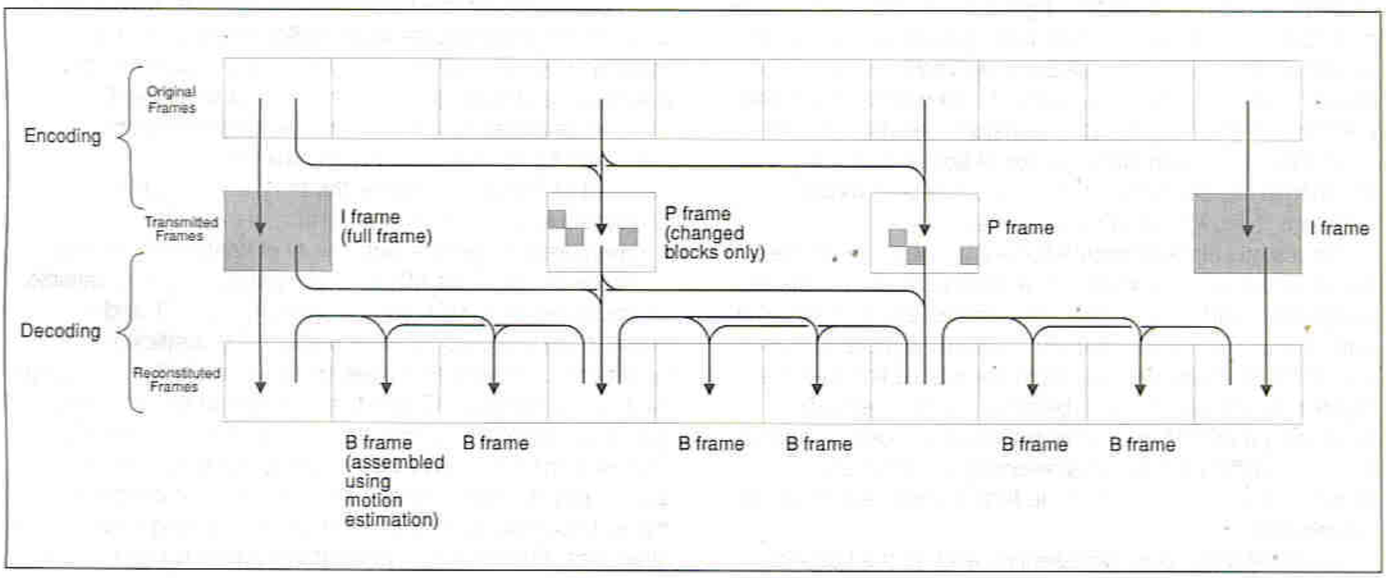

Figure 3: Temporal redundancy is removed in MPEG-s compression by sending the occasional full (I) frame, plus some (P) frames containing only change information, and leaving the decoder to assemble the remaining (B) frames using motion estimation.

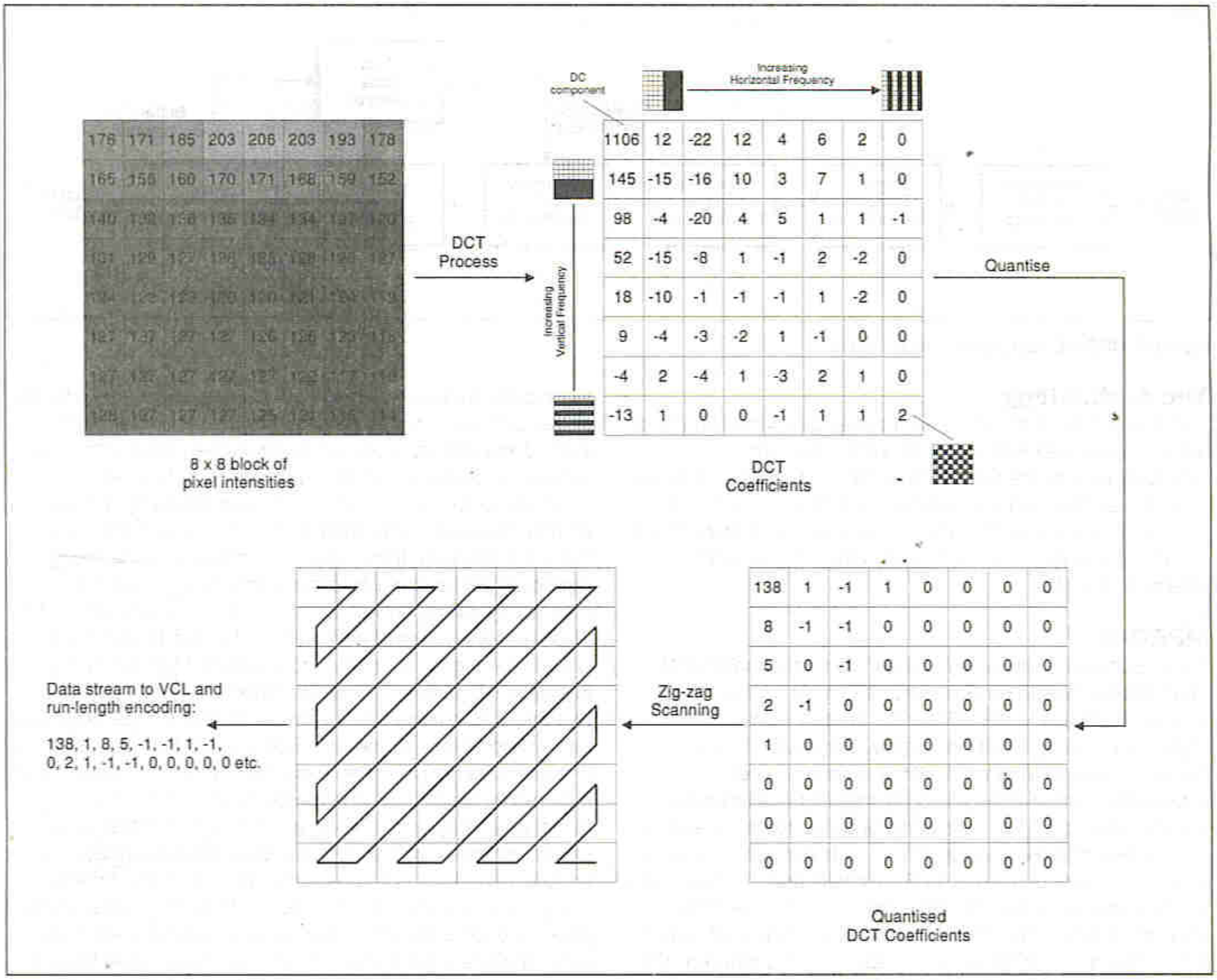

Figure 4: MPEG-2 uses the discrete cosine transformation (DCT) to achieve spatial compression

and P frames can be compressed further by looking only at intra-frame information, that is, the information within each frame. This concerns spatial compression, and the main technique relies on a mathematical function called the Discrete Cosine Transformation (DCT) - **figure 4**. The DCT is carried out on blocks of 8 x 8 pixels, the smallest picture element which can be compressed in the MPEG-2 algorithm and, as we've already seen, the smallest amount of data which can be sent in a P frame. Performing the DCT transforms the 64 bytes of luminance information into 64 bytes of spatial frequency information representing both the horizontal and vertical directions. Let's look at some examples.

For a static block of information - if all the 64 pixels were the same colour - we would find a value representing the DC component, and all the higher frequency coefficients would be zero. But as the detail in that block becomes more intricate, and as the changes become more abrupt, we find that the higher frequency coefficients become progressively larger. Performing a DCT in itself does not effect any compression; it is simply a different way of representing the information. However, it does pave the way to further compression using quantisation.

Quantisation involves representing each of the frequency components as one of a limited number of integer values. In 8-bit quantisation, 256 levels are available. At 4 bits this reduces to 16 and at 2 bits, it is down to 4, for example. The human eye notices low frequency picture information more easily than high frequency information, so the least significant high frequency components can be quantised with fewer bits than the more significant low frequency components. Initially, the quantisation process uses quantisation coefficients that will make no noticeable difference to the picture, but if the MPEG-2 encoder is struggling to keep the output to a specific bit rate, this can be altered to achieve a higher degree of compression, albeit with some loss of quality. In other words, if a sequence has a lot of motion and hence the temporal compression achieves a lower level of compression, this can be compensated by using a higher level of spatial compression.

The final part of the MPEG-2 compression applies variable character length or VCL compression. In the DCT and quantisation process, although a frequency coefficient may have been quantised as a three bit value, it is still, at this stage, held as a single byte. Clearly this cancels out any advantage gained by quantising to less than 8 bits. This is where VCL comes to the fore. Instead of allocating 8 bits to each and every value, a variable length encoding scheme assigns short codes to commonly encountered values and long codes to the rarer ones. Furthermore, run-length encoding is used so that, when a string of identical values is to be transmitted, rather than sending that value multiple times, a shorthand code is

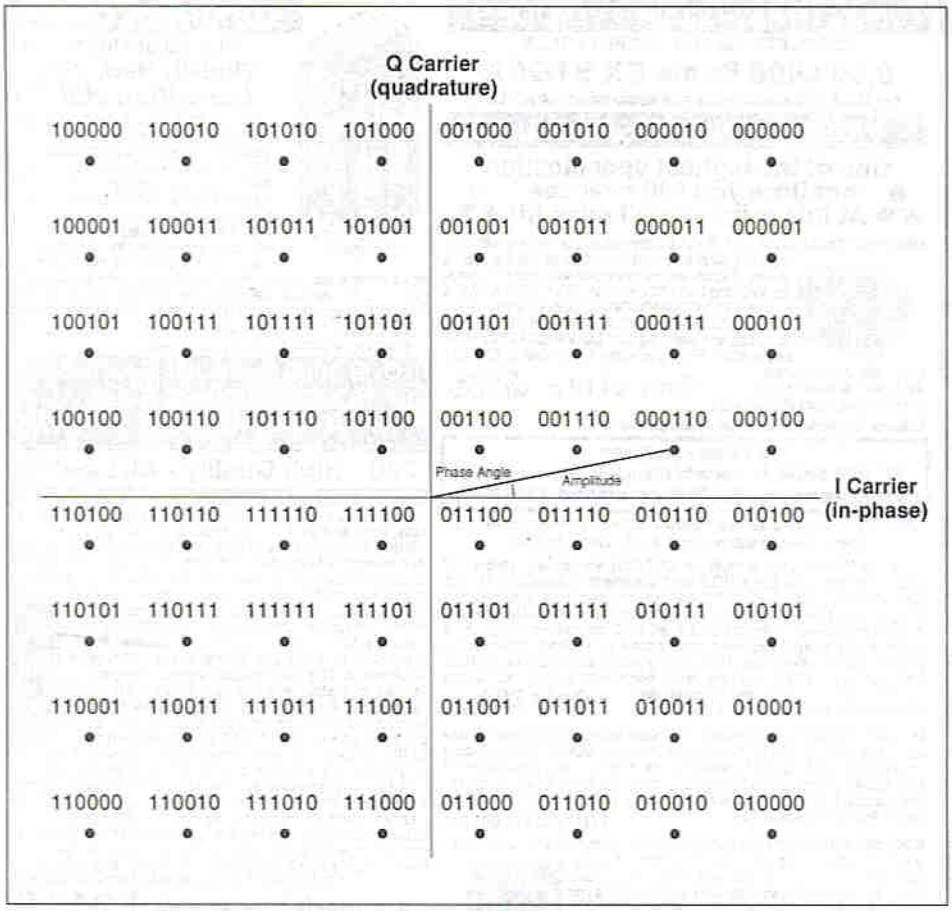

Figure 5: the constellation diagram for 64 QRAM modulation

Modulation

Everything described so far applies to digital TV of any flavour - cable, satellite or terrestrial. After this point the similarity ends, as different modulation schemes are used for each transport mechanism in order to best handle the strengths and weaknesses of the different communication channels.

Cable is the most robust communication channel and this allows the signal to be modulated in a way that utilises the bandwidth more efficiently than the other distribution methods. Specifically, the signal is modulated using QAM (quadrature amplitude modulation) which will be familiar to those who have learned about modem technology. A pair of orthogonal carriers (that is, they are separated by 90 degrees) are used, each of which can be transmitted at a variety of amplitudes and phase angles. The particular QAM that tends to be used is 256QAM, and here, the two carriers provide 256 combinations of amplitude and phase angle,

used. This shorthand code gives the value and the number of times it should be repeated.

According to the broadcast companies, the end result of all this is that a digitally encoded TV signal can be broadcast in around one-sixth of the bandwidth of an analogue one. However, this rule of thumb assumes that the picture quality is equal to that of PAL analogue. But as we've seen, the MPEG-2 compression scheme has lots of scope for controlling the degree of compression. For example, to increase the compression ratio, fewer I and P frames could be transmitted and/or the DCT coefficients could be more coarsely quantised. Instead of six PAL-quality pictures, around 30 VHS video-quality pictures could be crammed into 8MHz. And although the terrestrial broadcasters say that they do not intend to take this route, other operators could choose to use some of their bandwidth on low quality specialist or local interest programming.

Multiplexing

We've looked at how MPEG-2 compresses the video stream, and although this is far more involved, it also specifies a means of compressing the audio stream. Additionally, there will be data or text associated with each program, and this will also be compressed. So at the end of the compression stage, we have compressed video, audio and data streams for each programme. There will also be data streams concerned with the service as a whole, as opposed to any particular programme. In order to generate a single data stream for broadcasting, all these data streams must be time division multiplexed and interleaved into packets to produce the final digital signal.

HDTV and the Standards Wars

Digital TV is not the same thing as high definition TV (HDTV), since the designers of the digital TV system had to replicate the resolution achievable on existing analogue PAL TV. To be more accurate, this was the aim of the European DVB (Digital Video Broadcasting) group. In the USA, a separate standard has been drawn up by the ATSC (Advanced Television Systems Committee), and this offers HDTV with a resolution of 1,920 x 1,152, compared to the European 720 x 576 (not all of PAL's 625 lines carry picture information). So, following its ancestral history of the PAL/NTSC situation existing in the analogue field, it looks as if the TV standards wars are set to continue. Ironically, it now seems that the US will adopt the quality system, with Europe lagging behind, in marked contrast to analogue situation where America's 525-line NTSC system (known colloquially even in the USA as 'Never Twice the Same Colour') was visually inferior to PAL.

However, the needs of the rest of the world may prevent us from implementing a digital TV system that could soon be left well behind the state of the art. Although the European broadcasters have perceived no desire from their customers for improved picture quality, the same is not true of the rest of the world. Much of Asia has yet to make a decision on which digital TV system to use and could well be swayed by the availability of HDTV. So, the European DVB consortium has extended its specification to encompass HDTV in an attempt to woo this lucrative market. This means that for Europe the path to HDTV will remain open. New studio equipment would be needed and the consumer would need to buy new high resolution TVs, but the basic broadcasting infrastructure at least would be compatible.

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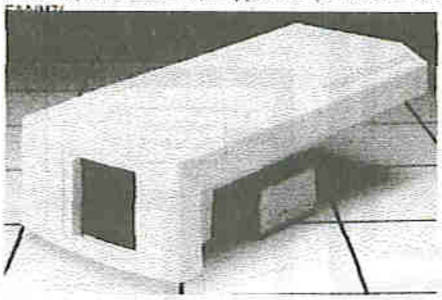

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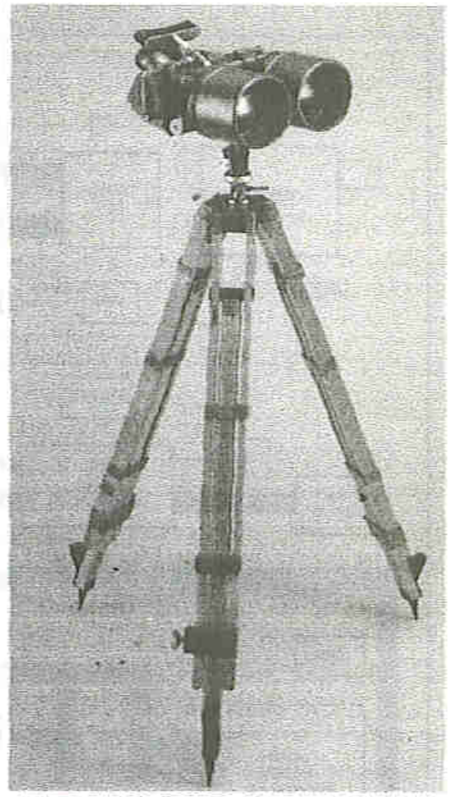

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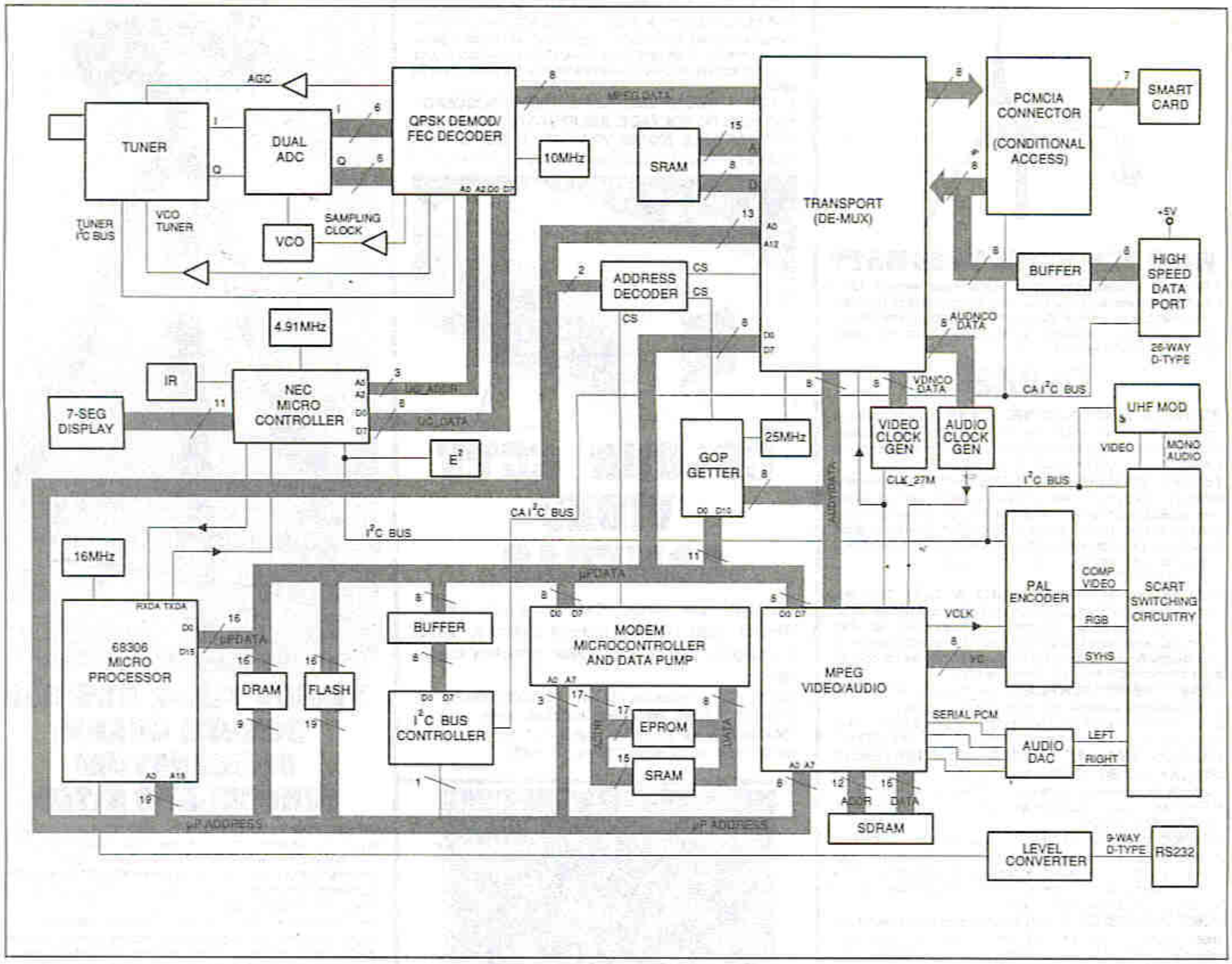
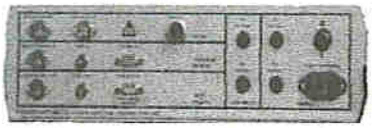


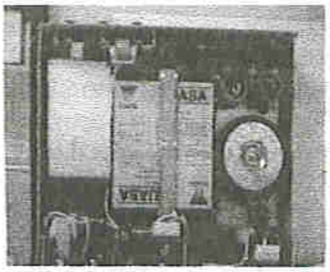
Figure 6: a block diagram of a typical satellite digital set-top box. Courtesy PACE.

permitting 8 bits to be transmitted in each time interval. Modulation schemes are often illustrated as so-called constellations, and an example constellation for 64QAM (which uses the same principles, but it easier to read) is shown in **figure 5**. On this diagram, if you draw a line from the origin to each point, the line forms a vector, the angle of which is the phase angle, and the length of which is the amplitude.

With satellite transmission, the distance between transmitter and receiver means that amplitude differences are not easily distinguishable, so modulation schemes such as QAM - which rely on being able to differentiate between amplitude levels - are not viable. Instead, QPSK (quadrature phase shift keying) is normally used, although BPSK (binary phase shift keying) is used on at least one satellite. Here, the phase of the signal is the only factor that varies and in QPSK, there are just four phases, two for each of the orthogonal carriers. This means that only one pair of bits can be transmitted per time interval and, therefore, a greater bandwidth is required. At the microwave frequency bands used for satellite broadcasting, however, this is not really a problem.

Turning our attention now to terrestrial broadcasting, the major problem to be overcome is the vagaries of the transmission path. Specifically, in the congested UHF bands, there could be interference from other services, man-made electrical noise, and unwanted multi-path propagation (that is, where the signal suffers from reflections off mountains and buildings which produce ghosting on analogue transmissions). There could also be extra man-made multi-path interference if single frequency networks are implemented. Here, all transmitters and repeaters carrying a particular multiplex operate on the same frequency. This wasn't possible with analogue TV, and it meant that in order to provide national coverage, only five channels could be allocated. With single frequency networks, however, many more multiplexes could be accommodated. The modulation method chosen to combat these effects is COFDM (Coded Orthogonal Frequency Division Multiplexing). The bandwidth of a terrestrial digital TV signal is 8MHz, the same as that of an analogue signal, and the basic premise of COFDM is that any interference or multi-path effect will not affect all of the 8MHz equally. So instead of modulating a single carrier (or a pair of orthogonal carriers) with a high data rate, which would result in a high bandwidth signal, the 8MHz is split up into 1,705 carriers (in the so-called 2K mode which will be used in the UK. The alternative 8K mode has 6,816 carriers) each of which carries a fraction of the overall data stream at a low transmission rate. The data stream is divided between the individual carriers using a pseudo-random form of multiplexing so that any adverse effects will be widely distributed and will not, therefore, have an undue effect on any one programme. The only other things to mention in our whistle-stop tour of COFDM is that data on adjacent carriers is orthoganal, which permits them to be spaced more closely





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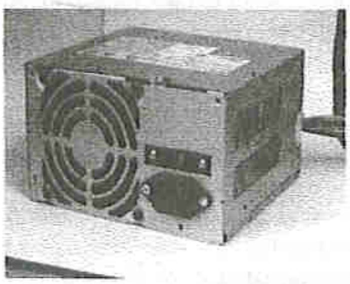

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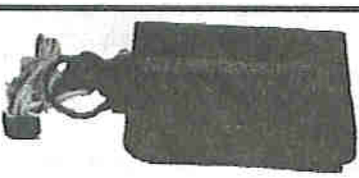

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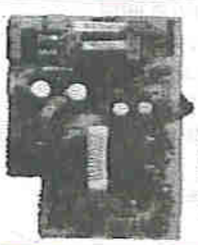

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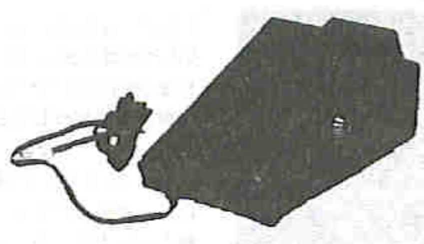

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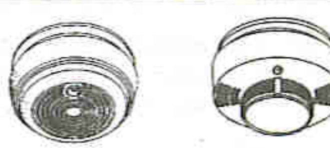

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Very complex units consisting of a smart card slot in the front plus several switches and an IR receiver. Fully cased and measuring 230 x 430 x 90mm, new and boxed.
On the back of the unit is a scart socket plus a UHF input and output. A channel tuning control numbered 28 to 40 and an IR socket.
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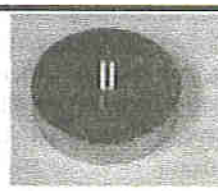
These units are sold as strippers but we imagine you could use one to convert a monitor into a TV or maybe use the videocrypt side of things for something else. Supplied complete with manual and mains lead. Clearance price just £9.95 ref BBC1X



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A digital integrated set top box carrying cable, satellite and terrestrial decoding: a serious piece of hardware

than would otherwise be possible (they can actually overlap) and the data on each carrier is modulated using BPSK (binary phase shift keying), 16QAM or 64QAM.

In practice

That is how digital TV will work, but how is this going to affect us in practice, and what equipment is needed? Throughout 1998, terrestrial, cable and satellite digital services will appear and, although the UK will not be the first country to enjoy the benefits of digital TV, we will be the first to have a digital terrestrial service.

Around the middle of the year, the BBC and the ITV will make the BBC1, BBC2, ITV, Channel 4 and Channel 5 services available via digital terrestrial, and a number of other free-to-air programmes will appear on the multiplexes that carry these familiar programmes. Another three terrestrial multiplexes carrying around 15 new channels will be launched by British Digital Broadcasting, a new company with Granada and Carlton as major shareholders. Most of these channels will be provided as a basic subscription package, although a pair of movie channels and a sport channel will be so-called premium channels for which an additional fee will be required.

In the fullness of time, manufacturers will start producing digital TVs. In the short term, however, most viewers will use their existing analogue TVs with a set-top box which will decode the digital signal and pass it to the television as an analogue signal. From our discussion of MPEG-2 encoding and the modulation methods used in digital TV, you won't be surprised to learn that a digital set-top box is a serious piece of hardware, something which will be clear from the block diagram in **figure 6**, which shows the inner workings of one of PACE's satellite set-top boxes. In passing, although this unit is intended purely for satellite use, the only difference between this and one for cable or terrestrial use is the demodulator, and many set-top boxes will be able to cope with any distribution media.

What will something like this set you back? Prices haven't been announced yet, but indications are that even with a subsidy from the broadcasters, you'll pay between £200 and £500.

The snag with sticking with your ordinary TV and buying a set-top box is that you won't enjoy all the benefits of digital. Unless you've got one of the new (and expensive) wide-screen TVs, you'll receive 16:9 format pictures with black bands at the top and bottom. And the audio amplifiers and speakers on most TV sets won't do justice to the improved sound quality of digital TV, so you would need to route the audio through your hi fi system. Plus, of course, if you want to experience surround sound, you'll need extra speakers.

The future?

Digital TV won't be cheap if you want to take full advantage of it. If you're quite satisfied with the current analogue service, you'll be relieved to hear that it will be with us for some time yet. At switch-on, digital TV will co-exist with analogue, and the change-over period will last for years. Eventually, analogue will be phased out to make way for more digital services - but not in the near future.

This changeover period raises an interesting question. The official line has always been that five television channels is the maximum that can be accommodated in the terrestrial UHF band. Channel 5 was widely dubbed the last analogue TV channel. But, as we've seen, digital TV multiplexes are 8MHz wide - the same as existing analogue channels - so where has this extra capacity suddenly come from to fit in six more digital multiplexes? The answer is that they are in the gaps between the existing analogue channels, but that still does not explain why the gaps could not be used for extra analogue channels.

Part of the answer is likely to be tied up with policy - the future is seen to be digital, so there was no incentive to put more analogue TV stations on the air, but the answer on the technical side lies in the fact that digital TV has a significant advantage in terms of signal to noise ratio over analogue transmission. The new digital multiplexes will be 20dB to 30dB down on existing analogue transmissions, so that the transmitted power could be between a hundredth and a thousandth that of an analogue signal. This means that a new digital service can be placed very close to an analogue channel without causing interference and, as we've already seen, the CODFM modulation scheme used for digital terrestrial means that the digital signals themselves are relatively immune to interference from analogue TV.

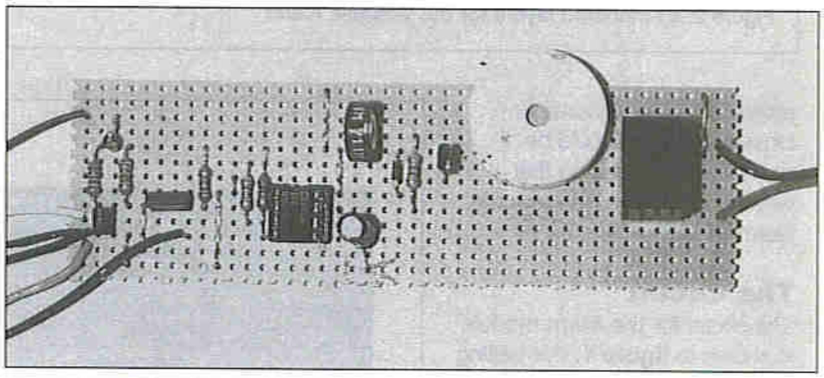
In the future, key researchers in the field of electronic entertainment believe that interactivity is the key. Until now, television has been passive, but the true interactivity that is possible with cable TV stretches far beyond shopping channels and viewer polls. There are much more innovative and futuristic possibilities which will blur the dividing line between TV and computer games. Would you like to take over the lead role in the feature film you're watching? Or make the actors respond to your actions? Or influence the plot? All these are possible, according to the Massachusetts Institute of Technology's Media Lab who are already working with digital actors and interactive story-telling agents. So if you think that digital TV is going to be a great leap forward, you ain't seen nothing yet.

Versatile Alarm Module

Terry Balbirnie

The purpose of this series is to describe some electronic modules which will be of interest to those following GCSE Technology and similar courses. The circuits will be particularly valuable as a basis for the practical projects that need to be constructed from time to time.

In common with other members of this series, the designs are given in the form of a circuit diagram and stripboard (Veroboard) layout only. Construction points such as building the unit in a box and fitting switches are left to the constructor.



Don't be alarmed

This month's module is a multi-purpose alarm. This is described as "versatile" because the sounder may be set to operate when a pair of switch contacts either open or close for an instant. The circuit panel has a small buzzer mounted on it and this will be sufficient for testing or demonstration purposes. However, there is also a relay which could operate a more powerful sounder such as a house or car alarm, using a separate power supply.

Once sounding, the unit will switch off after a preset time. This prevents it from operating continuously if the switch contacts are left in their "trigger" position. In the prototype, the timing was adjustable between two seconds and one minute approximately, but this could be easily increased if required. There is also a cancel facility which may be used to stop the alarm sounding at any time.

One possible use for the circuit is as a bicycle alarm. A simple loop of wire with an in-line plug and socket could be passed between the spokes of a wheel. Here, the plug and socket form a pair of normally closed contacts which would be opened if a thief attempted to steal the bicycle. The unit could also be used to protect windows and doors using magnetic reed switches. It could also guard a device such as a computer or video recorder using a simple switch whose contacts would "make" or "break" when the unit was disturbed.

Where a number of windows or doors need to be

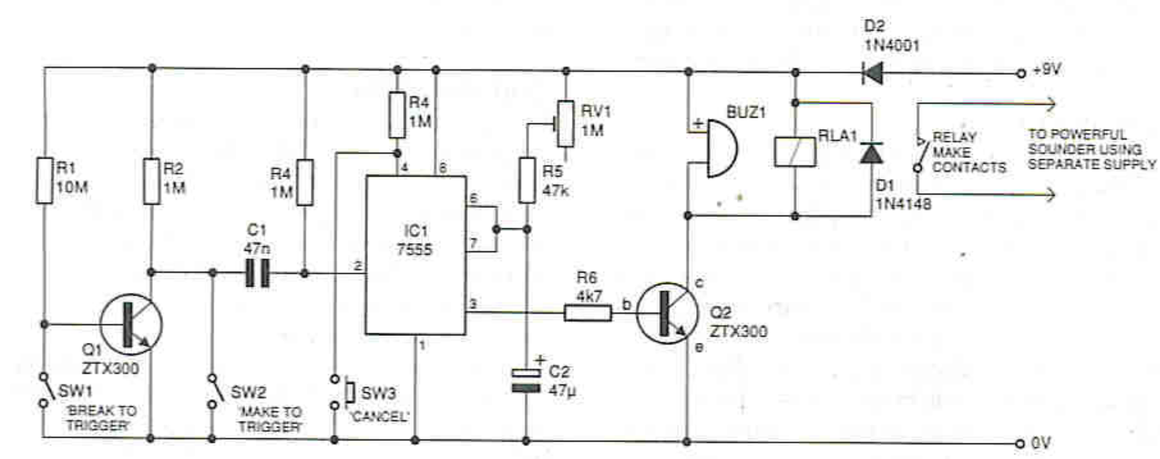


Figure 1: the circuit of the Versatile Alarm module

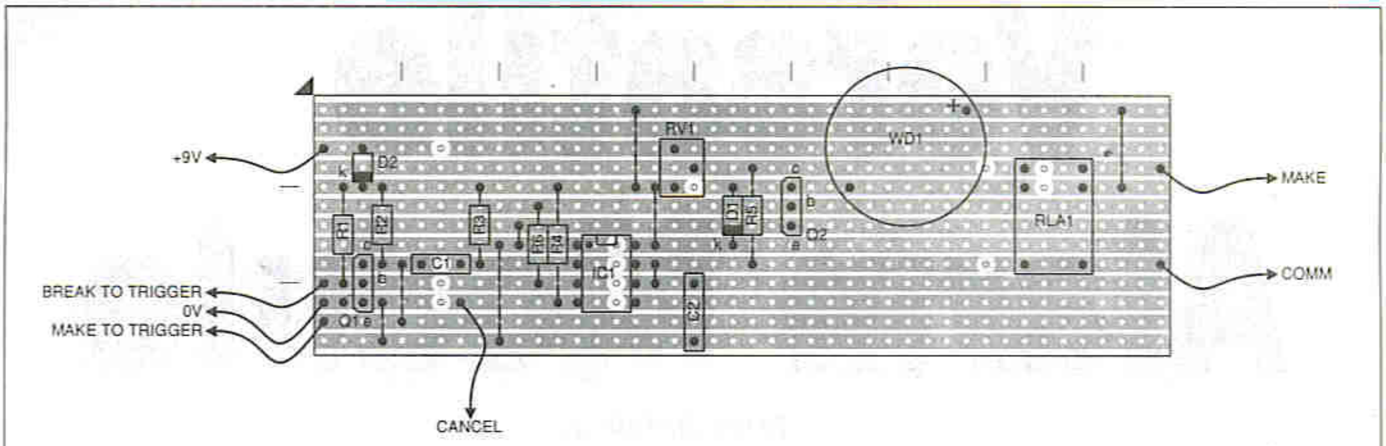


Figure 2: a stripboard layout for the Versatile Alarm

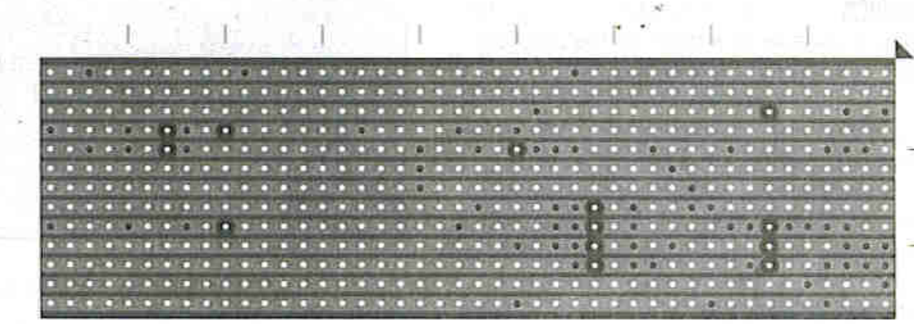


Figure 3: the back of the stripboard showing the cutaways

protected, several normally-closed switches would be connected in series so that when one of them opened, the alarm would be triggered.

The circuit

The circuit for the alarm module is shown in **figure 1**. For testing purposes or for short periods of use, power could be derived from a 9V PP9-type battery. However, for longer periods of operation or when the circuit needs to be powered continuously, it would be possible to use a commercial plug-in adaptor. More will be said about this later. Diode D2 provides protection to the circuit if the supply were to be connected the wrong way round, since it would be reverse-biased and would not conduct.

The principle component in the circuit is CMOS timer IC1 and this is configured as a monostable. Thus, once triggered by making pin 2 low or an instant, the output (pin 3) will go high for a certain time and then revert to low. Resistor R3 maintains the trigger input in a normally high condition which prevents false operation. The time during which the op-amp output remains high depends on the values of fixed resistor R5, preset RV1 and capacitor C2. RV1 provides the timing adjustment and will be set for the required effect at the end.

Making contact

Ignore transistor Q1 and the associated components for the moment - these are used for "break to trigger" operation. Concentrate on the "make to trigger" aspect which is provided by switch SW2. This has a pair of contacts which are normally open (not touching). Of course, it need not be an actual switch - any device that would provide metal-to-metal contact when operated would be sufficient. When the switch contacts close, a low pulse is given to IC1 trigger input via capacitor C1 and this will operate the monostable in the manner described earlier. If SW2 contacts were left closed, no further pulse would be given and the alarm would time out in the usual way.

While IC1 output is high, current passes through resistor R6 to the base of transistor Q2. Collector current then flows through relay, RLA1, coil and also through the low-power on-board sounder, BUZ1. The relay normally-open (n/o) or "make" contacts could be used to direct current from a separate supply to a more powerful external sounder if required. Diode D1 bypasses the reverse high-voltage pulse which appears across the relay coil when it switches off. Without this, semiconductor devices in the circuit could be damaged.

Returning to the circuit element centred on transistor Q1, the contacts of switch SW1 will be kept normally closed (touching). With Q1 base connected to the 0V line, the transistor will be off and no collector current will flow. The left-hand side of C1 is then maintained in a high state via resistor R2. This will have no effect on IC1. If SW1 contacts now open, current flows to Q1 base through resistor, R1. The collector becomes low and triggers IC1 via capacitor, C1.

Construction

The topside stripboard layout (component side view) is shown in **figure 2**. It is important to note the track breaks and inter-strip links needed. First, make the breaks using a spot face cutter then solder the link wires in place. *Most problems are caused by a strip not being broken completely, a break or link wire being omitted, an incorrect break or a blob of solder or sliver of copper bridging adjacent copper tracks. Use a magnifying glass to check!*

Solder the ic socket, the relay, and all remaining components in position. Take care to mount the transistors, diodes, capacitor C2 and buzzer the correct way round. Solder battery connectors to the "+9V" and outer "0V" points and short pieces of wire to the "break to trigger" (btt), "make to trigger" (mtt), inner 0V and cancel positions. Twist the bare ends of the "break to trigger" and 0V wire together but leave the "make to trigger" wire unconnected for the moment. Adjust

RV1 fully clockwise (as viewed from IC1 side of the PCB) to give minimum timing which is convenient for testing.

Insert the ic, taking care over its orientation. This is a CMOS device and could be damaged by static charge that might exist on the body. To make sure this does not happen, earth yourself by touching a water tap before handling the pins.

Testing

It is important to note that the circuit is triggered by a low (0V) state. On no account connect either trigger wire to the +9V rail or Q1 could be damaged. Do not connect anything to the relay contacts at this stage.

Wire up the battery - the circuit usually self-triggers when powered-up but should stop when the monostable times out after a few seconds. At the same time, the relay should operate but it may not be possible to hear the click due to the sound of the buzzer. Touch the "make to trigger" wire to the 0V one for an instant and it should sound again.

Test the "break to trigger" function. Check that the timing can be varied by adjusting RV1. If it needs to be extended, increase the value of C2 in proportion. Check that the relay is working by making a circuit through the "make" and "common" contacts using a separate battery and a small bulb to represent the auxiliary sounder. Note that if you want to use the "make to trigger" function, the "break to trigger" wire must be kept connected to the 0V line.

If you plan to use a commercial plug-in adaptor, measure its output voltage to ensure that it does not exceed 12V. If it is of the 9V or 12V stabilised type this should work well. The inexpensive non-stabilised variety may provide an excessive voltage output under the light loading of this circuit since the output voltage is usually stated for full-load conditions.

PARTS LIST for the Versatile Alarm Module

Resistors

R1	10M
R2,R3, R4	1M
R5	47k
R6	4k7
RV1	1M min vertical preset (see text)

Capacitors

C1	47n
C2	47u PCB electrolytic

Semiconductors

IC1	7555
Q1, Q2	ZTX300
D1	1N4148
D2	1N4001

Miscellaneous

RLA1 Miniature relay with 6V coil and 2A "make" contacts 0.1 in matrix stripboard. PP9 battery and connectors, 8-pin dil socket. The relay used in the prototype was order code FM91Y from Maplin.

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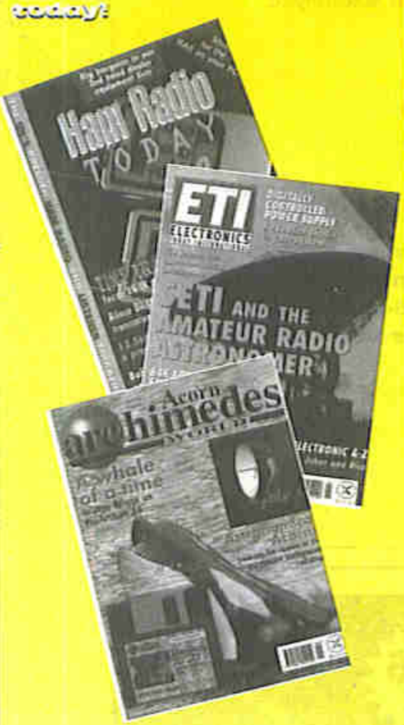

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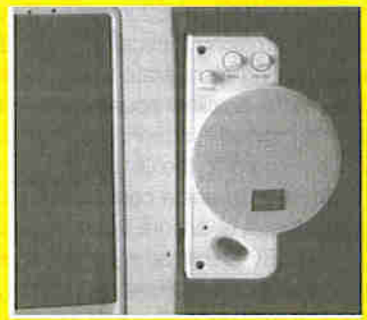

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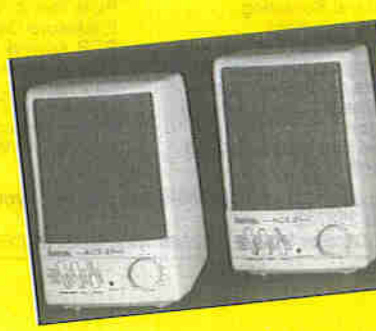

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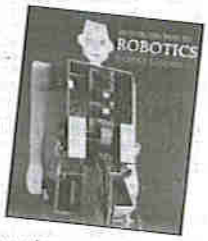

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Infra-red Theramin

A new, straightforward Theramin design by Robert Penfold uses an active infra-red system to detect the distance from the user's hand to the photocells, and eliminates drift

The Theramin is an electronic musical instrument that tends to go in and out of fashion, and at present it seems to be in the middle of a period of renaissance. Theramins are mainly associated with the weird and wonderful soundtracks of sci-fi and horror movies from the 1950s, but they actually have much earlier origins. The original instrument was designed and built in the 1930s, and was based on thermionic valves. It was designed by Leon Theramin, and manufactured by RCA.

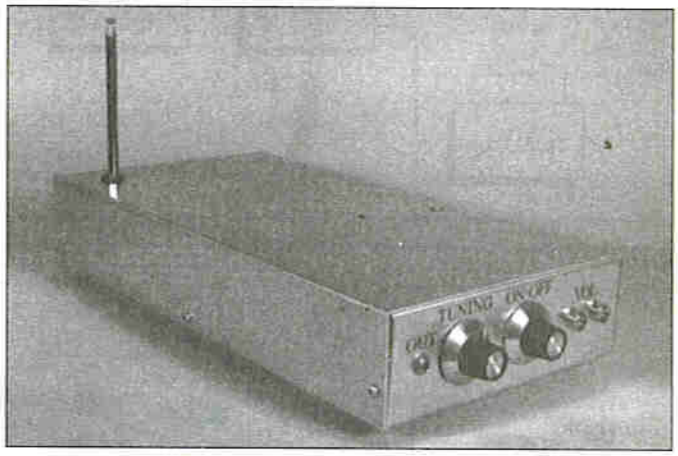
This is not the place to discuss the various legends that have sprung up around the inventor Leon Theramin, but these have certainly added to the mystique of his instrument. The Theramin has a built-in mystique anyway, due to its "look, no hands" method of playing. In fact, it is actually played with both hands, but neither of them ever need to touch the instrument while it is being played. It relies on hand capacitance effects to permit control of the pitch and volume of the sound. The Theramin is played by waving one's hands above the instrument! Perhaps the air of mystique that surrounds this instrument is felt to apply also to those who play it! A Theramin is ideal for exhibitionists who like to put on a bit of a show, but it does have real musical capabilities as well.

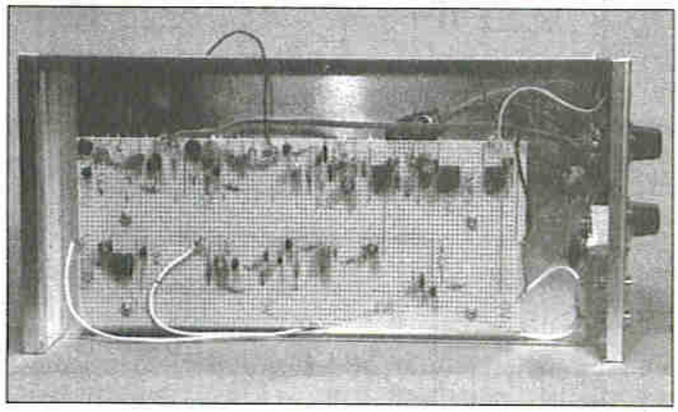
The basics

The basis of a Theramin is an L - C oscillator operating at a frequency of, typically, about 0.5 to 2MHz. In this case an operating frequency of about 0.6MHz (600kHz) is used. A short aerial is connected to the "hot" end of the tuned circuit, but this is not intended to pick up a signal. Instead, it forms one plate of a capacitor, and the user's body effectively forms other plate. The air in between provides the dielectric, and moving your hand towards the aerial reduces the gap between the "plates" and increases the capacitance. This capacitance is shunted across the tuned circuit, because the user's body effectively forms an artificial earth. The amount of capacitance produced is quite small, but it only requires a very small change in capacitance to provide a shift of a few kilohertz in the frequency of the oscillator.

Obviously, the operating frequency of the oscillator is well outside the audio frequency range, but it is quite simple to shift the output frequency down to the required range. This just requires a second high frequency oscillator and the application of the heterodyne principle. Frequency drift tends to be a problem, but it can be minimised by the use of two virtually identical oscillators, so that drift in one is balanced by almost identical drift in the other.

Several methods have been used to control the volume of the sound. It is possible to use what is essentially a second Theramin tone generator circuit, together with a frequency to voltage converter. This produces a control voltage for a voltage-controlled attenuator (VCA). While this method certainly works, it is relatively complex, suffers from drift problems, and can be awkward to set up properly.





An alternative method relies on an oscillator that is adjusted so that there is barely sufficient feedback to sustain oscillation. A metal plate, and hand-capacitance effects, are used to damp the oscillator, even causing it to cease oscillation altogether if required. Feeding the output of the oscillator to a rectifier and smoothing circuit produces the control voltage for the (VCA). Again, this method can certainly be made to work, but it can suffer from severe problems with drift, and precise control of the volume can be impossible. For example, once oscillation has ceased, it can be reluctant to restart even if the player draws his or her hand right away from the metal plate.

Several other methods have been tried, but the system finally adopted for this design is, as far as I am aware, a new one.

It uses an active infra-red system to detect the distance from the user's hand to the photocells, and produces a proportionate control voltage for the (VCA). This method is reasonably simple, and it is also a very consistent. In fact, it is totally free from any drift problems and requires no setting up whatsoever.

System operation

The block diagram in **figure 1** shows the general arrangement used in this Theramin. The two oscillators in the tone generator

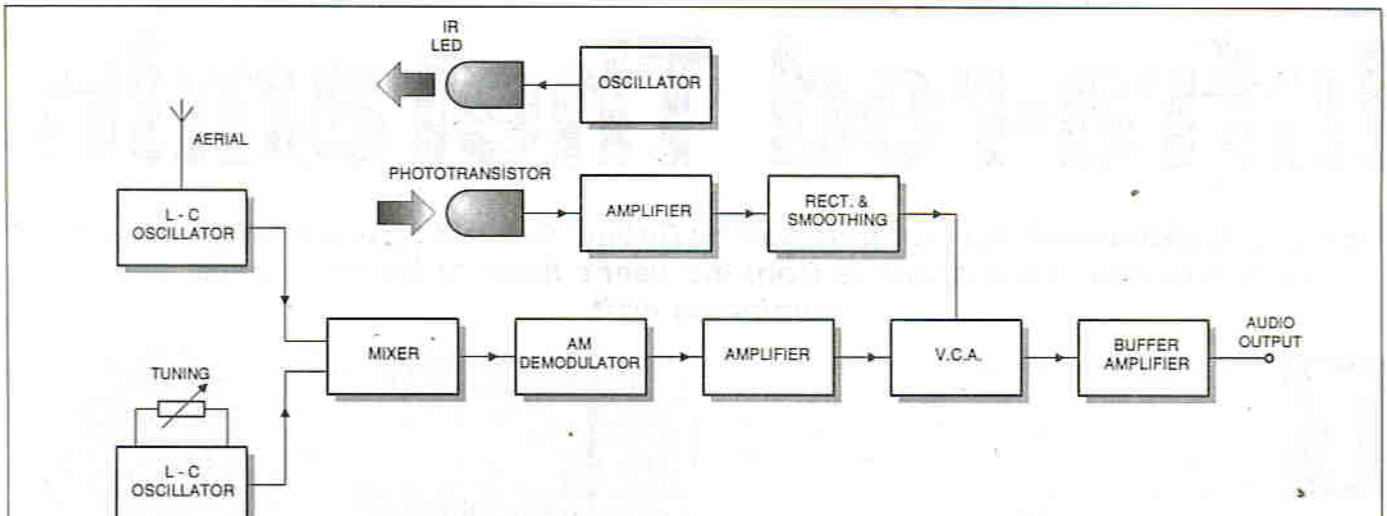


Figure 1: the block diagram of the Infra-red Theramin

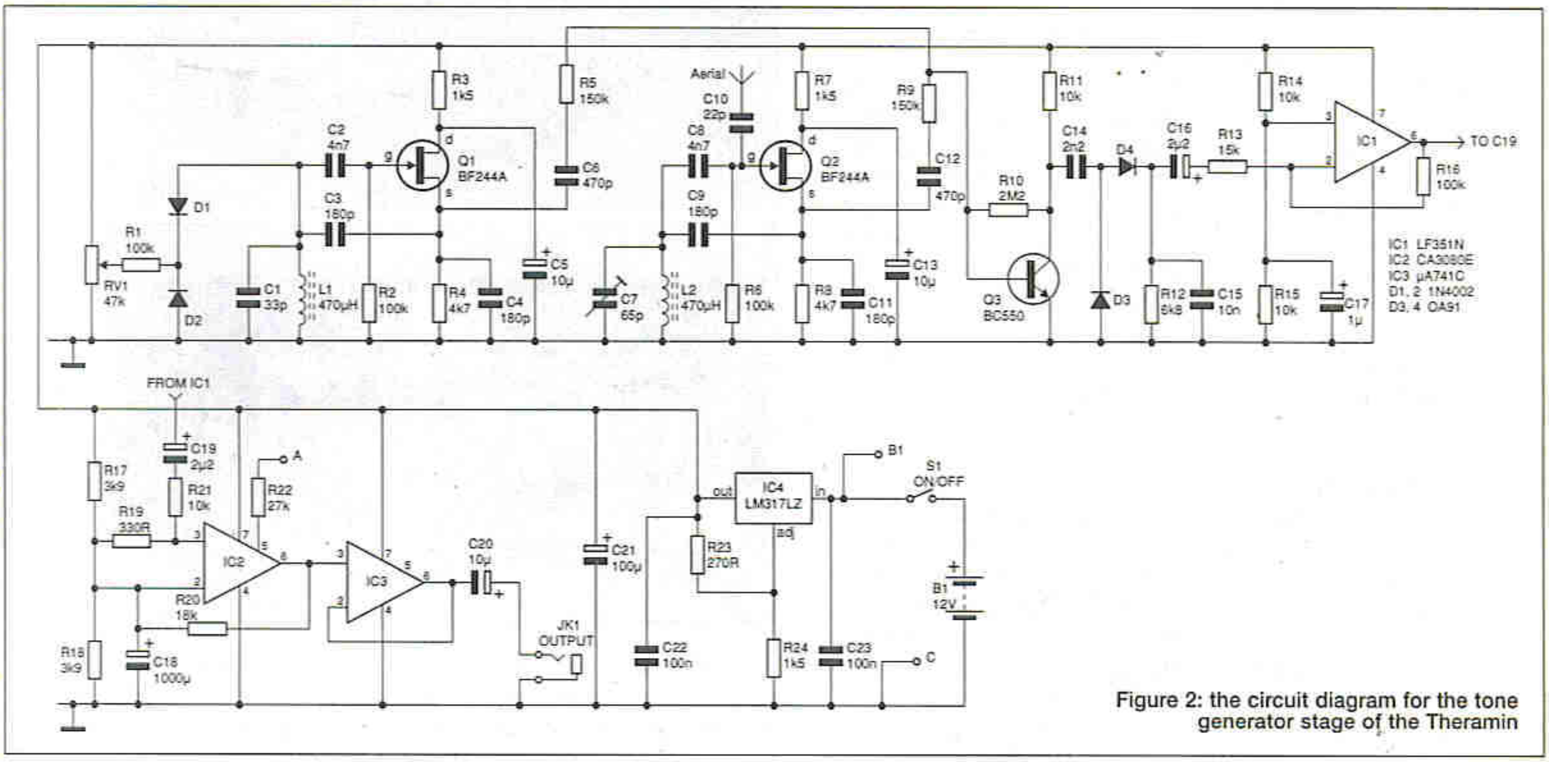


Figure 2: the circuit diagram for the tone generator stage of the Theramin

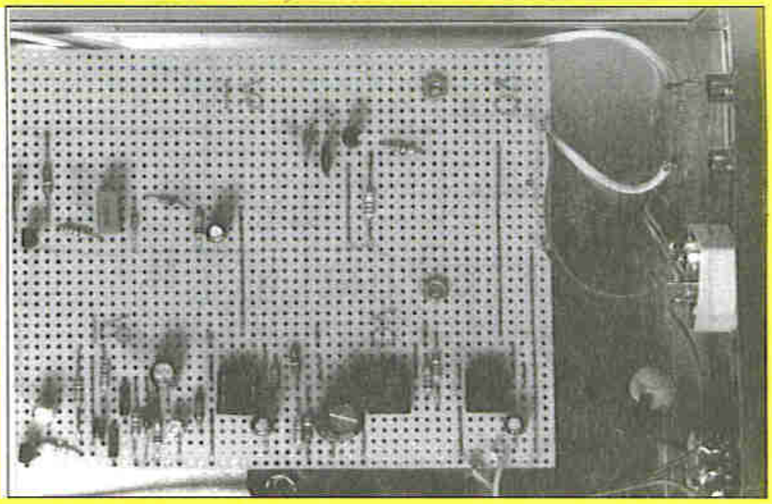
circuit are basically the same, but one has a tuning control while the other has fixed tuning but is connected to the aerial. The output signals from the oscillators are fed to a simple mixer stage and then to an amplitude modulation (am) demodulator. The demodulator produces a so-called beat note at a frequency that it is equal to a difference in the frequencies of the two oscillators. In practice, the tuning is set so that the tunable oscillator is at about the same frequency as the other oscillator, or fractionally higher in frequency. This gives either a low beat note of typically about 100 hertz, or zero output under standby conditions. Positioning one's hand close to the aerial reduces the frequency of the aerial oscillator, and increases the difference in the frequencies of the two oscillators. This increases the beat note, and in practice it is possible to generate any note from about 100 hertz to several kilohertz.

It is quite possible to do things the other way round if preferred, with the tunable oscillator at the much lower frequency and the aerial oscillator. This gives a high note under standby conditions, with the pitch of the output signal reducing as the user's hand is moved towards the aerial. However, in practice most people find it much easier to have things arranged so that moving one's hand towards the aerial produces an increase in pitch.

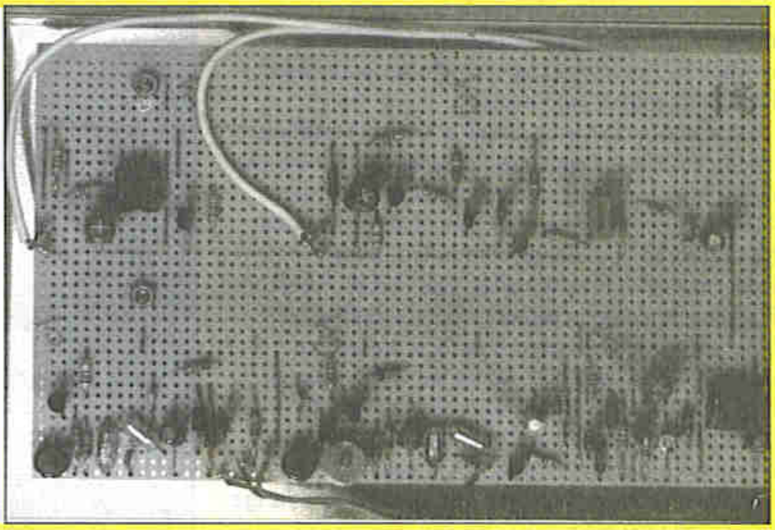
An amplifier stage boosts the demodulated audio signal slightly and it is then applied to the vca. The output of the vca feeds a buffer amplifier, and this provides sufficient output to drive a high level input of any normal power amplifier. The rest of the unit generates the control voltage for the vca, so that the amplitude of output signal can be controlled. An infra-red signal is generated by a LED, and reflected from a user's hand back to a photo-transistor. The closer one's hand is moved towards the photocells, the greater the amount of signal that is reflected back to the phototransistor. On the face it, there is no problem in using a non-modulated signal from the infra-red LED. In practice, this tends to give poor results as it is difficult to generate a strong signal using ordinary infra-red LEDs. This results in the signal from the LED being swamped by the background infra-red level.

It is therefore necessary to use a pulsed signal so that it is easily distinguished from the background infra-red signal. A frequency just above the audio range is used so that there are no problems with oscillator signal breaking through to the audio circuits. Also, using a high frequency makes it easy for the receiver circuit to distinguish between the proper signal and interference from mains powered lighting. The infra-red LED it is therefore driven by a simple oscillator. To drive current is quiet low and there is no need for a power amplifier stage to drive the LED.

The pulse signal from phototransistor will be at a very low level even when the users hand is placed close to the photocells. An amplifier stage is therefore used to boost the signal to a more useful level. It is then rectified and smoothed to produce a DC output voltage that is roughly proportional to the strength of the received pulse signal. This provides the control voltage for the vca.



Detail of the left hand end of the stripboard layout



Detail of the right hand end of the stripboard layout

Circuit operation

Figure 2 shows the circuit diagram for the tone generator and vca stages of the Theramin. Q1 is used as the basis of the tunable oscillator, and this is a junction gate field effect transistor (Jfet) used in a form of Colpitts oscillator. In order to sustain oscillation it is necessary to have positive feedback over an amplifier that has fractionally more than unity voltage gain. Q1 is used in the source follower mode, and it is easy to obtain positive feedback since the input (gate) and output (source) terminals are in-phase. The voltage gain of a source follower is slightly less than unity though, and a voltage step-up must therefore be provided by the tuned circuit. In a Colpitts oscillator the step-up is achieved by feeding the output of the amplifier into a capacitive tapping on the tuned circuit. This tapping is provided by C3 and C4, which also provide most of the tuning capacitance. The rest of this capacitance is provided by C1 and the series capacitance of D1 and D2.

The obvious way of providing the oscillator with variable tuning is to simply add a low value variable capacitor across the tuned circuit. Unfortunately, variable capacitors are relatively expensive these days, and the low cost alternative of varicap diode tuning is used instead. The 1N4002 specified for D1 and D2 is actually a small rectifier, and not a true varicap diode. Any silicon diode or rectifier will actually operate as a varicap diode, but not with capacitance values that are guaranteed to be within narrow limits for given control voltages. This is not a requirement in the present application where we simply require a cheap means of providing a variable capacitance of up to a few picofarads in value, with the exact control characteristic being unimportant.

Operation of a varicap diode relies on the fact that the depletion layer of a P-N junction becomes wider as the reverse bias voltage is increased. The pieces of P and N type semiconductor are effectively the plates of the capacitor, and the depletion layer is the dielectric. As the depletion layer widens, the capacitance of the diode decreases. Although a varicap provides a variable capacitance, it still acts as a diode, and care is needed to ensure that it does not have an adverse affect on the main circuit. The normal way of achieving this is to use two diodes in the back-to-back arrangement utilised here. RV1 provides the variable tuning voltage, and this voltage is applied to the diodes via R1. R1 ensures that RV1 does not place heavy loading on the tuned circuit, which would almost certainly prevent the circuit from oscillating.

The aerial oscillator is essentially the same as the tunable one, but it has preset tuning provided by trimmer C7. The aerial is coupled to the tuned circuit via capacitor C10. Direct connection could be used, but this tends to give problems with mains "hum" being coupled into the tuned circuit where it produces unwanted modulation effects. The low value of C10 helps to prevent problems with mains "hum", but it does not prevent the oscillator from being pulled several kilohertz from its normal operating frequency.

A simple passive mixer formed by R5 and R9 combines the output signals from the two oscillators. Q3 is used to amplify the mixed signal, and compensate for the massive losses through the mixer circuit. The amplified output signal is fed to a conventional diode demodulator circuit based on D3 and D4. The resultant audio signal is then amplified by IC1, which is a simple inverting mode amplifier that has an input impedance of 15k and a voltage gain of just under seven times.

IC2 is a CA3080E transconductance operational amplifier, and it forms the basis of the vca. A transconductance amplifier has some features in common with an ordinary operational amplifier, including differential inputs. There are some marked differences as well. Whereas an operational amplifier responds to the voltage difference across its inputs and produces an

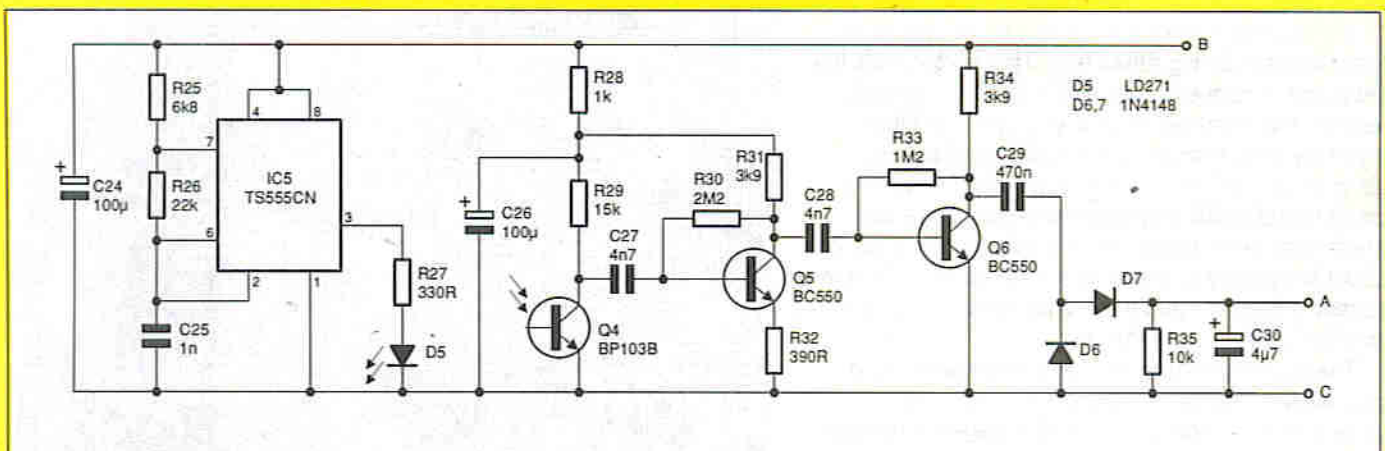


Figure 3: the circuit diagram for the control voltage generator

appropriate output voltage, a transconductance amplifier is current operated. However, in normal use resistors are used to effectively convert the device from current to voltage operation. In this case resistor R21 is used in series with the input, and R20 is the output load resistor.

A transconductance amplifier has an additional input, and the output current is a function of the bias current fed to this input and the differential input current. In other words, the gain of the device can be controlled by the bias current fed to this additional input (the "amplifier bias" input). Resistor R22 is connected in series with the amplifier bias input so that the required a voltage controlled operation is obtained. A centre tap on the supply lines for biasing purposes is produced by R17, R18, and C18. The inputs and outputs of IC2 are all referenced to this centre tap. Circuits that utilise transconductance amplifiers can look rather strange at first, as they differ from ordinary operational amplifier circuits in that they normally operate without any negative feedback. This circuit is no exception, and IC2 operates open loop. The output impedance of IC2 is relatively high, and IC3 is therefore used as a simple buffer amplifier to provide a suitably low output impedance.

For stable operation, the circuit requires a well regulated supply potential of about eight to nine volts. A suitable regulated supply is derived from the main 12 volt battery supply via a simple voltage regulator circuit based on a IC4. R23 and R24 control the output voltage of IC4, and give an output potential of about 8.5 volts.

Volume control

The circuit diagram for the control voltage generator appears in **figure 3**. The oscillator is a standard 555 astable based on IC5, and operating at a frequency of about 28kHz. This is comfortably above the 20kHz upper limit of the audio range, but is low enough to give good efficiency from the photocells. It is also low enough to avoid any problems with the signal from IC5 reacting with the two high frequency oscillators to produce unwanted heterodynes. Resistor R27 limits the LED current to about 18 milliamps, but as the LED is switched off for about 50 percent of the time, the average LED current is only about nine or 10 milliamps. This relatively modest drive current gives adequate operating range, and keeps the battery drain down to reasonable levels.

The reflected infra-red signals are picked up by phototransistor Q4. Under dark conditions, Q4 has the low leakage levels normally associated with silicon transistors, but the pulses of infra-red radiation cause an increase in the leakage current and produce small voltage changes at its collector terminal. This signal is boosted by a two-stage amplifier based on Q5 and Q6. These provide a total gain in excess of 60 decibels. The values of the coupling capacitors (C27 and C28) have purposely been made it very low so that the circuit is insensitive to 100 hertz "hum" from mains powered tungsten lighting. C29 couples the output from the amplifier to a conventional rectifier and smoothing circuit based on diodes D6 and D7.

Although germanium diodes might seem to be a better choice for the rectifier circuit, the higher voltage drop through silicon diodes is probably an advantage in this case. There is likely to be a certain amount of stray pick-up and break-through from the oscillator circuit, and this would otherwise tend to hold the vca slightly "open" without a significant voltage drop through the rectifier circuit.

With its current consumption of about 25 milliamps, this circuit requires a fairly high capacity battery. Probably the best choice is eight HP7 size cells in a plastic holder. This gives a rather bulky battery pack, and in many cases it is actually easier to accommodate the batteries in the form of two packs

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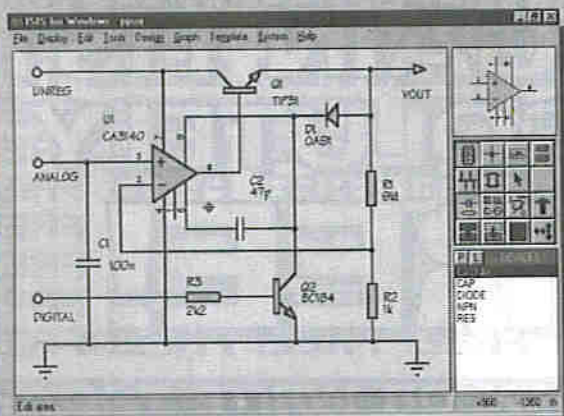

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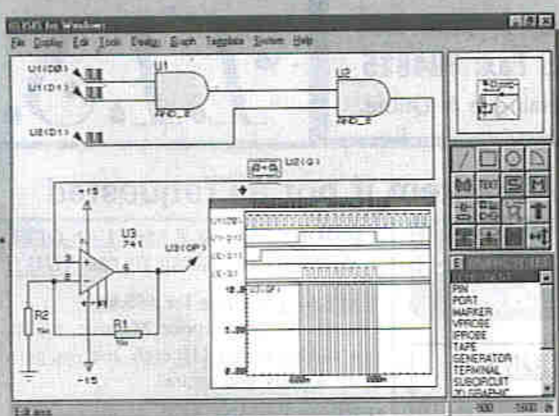

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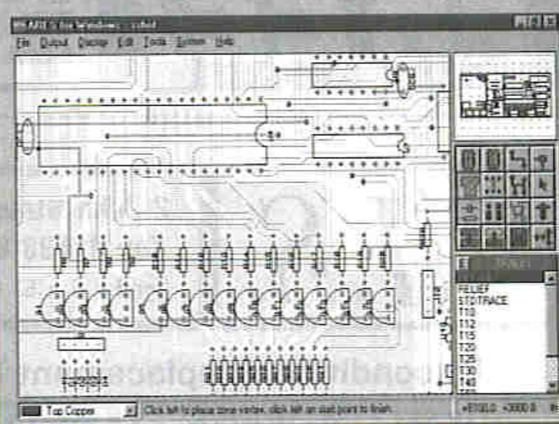

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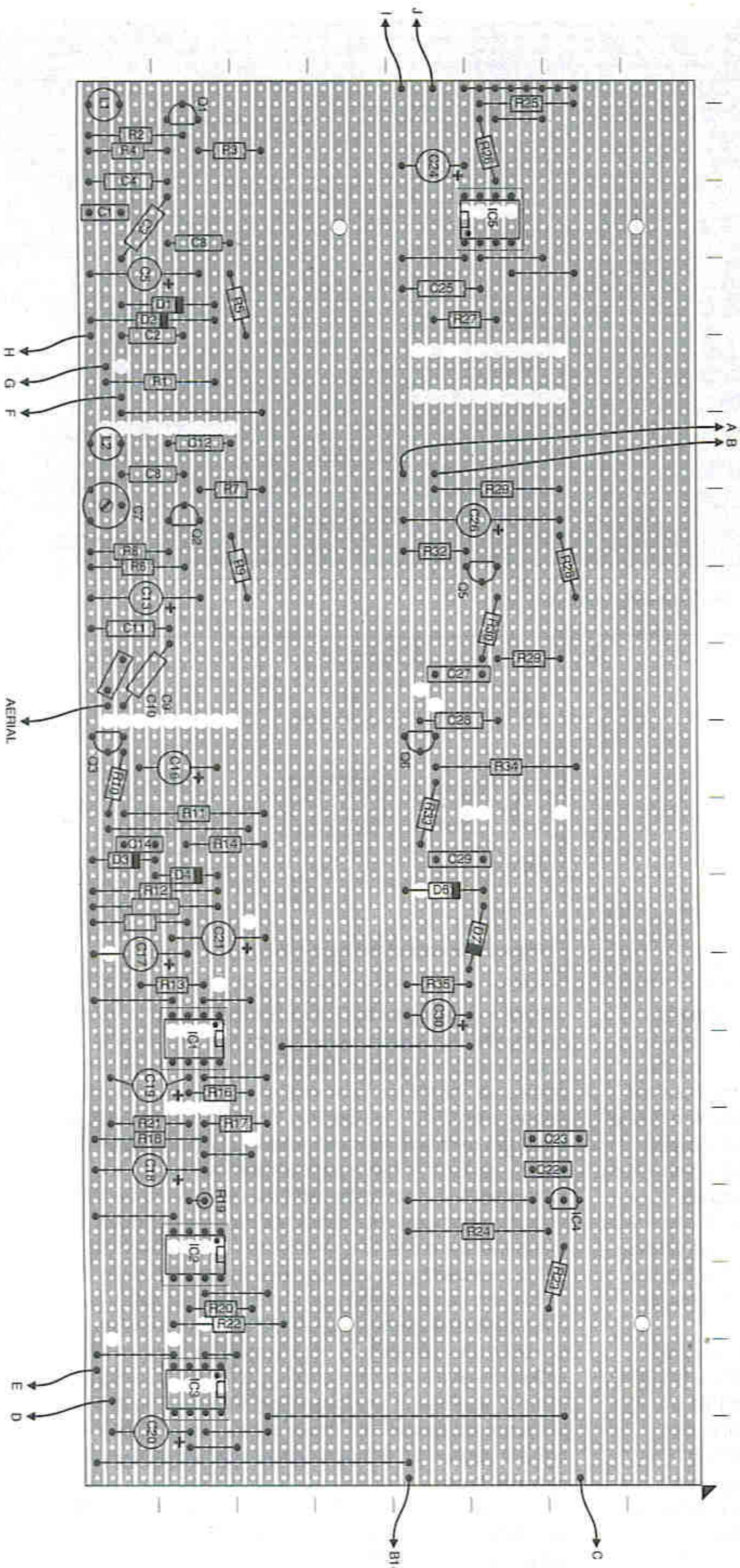

Figure 4: the component-side view of the stripboard panel

of four rather than a single pack of eight.

Construction

The unit is constructed on a 0.1 inch pitch stripboard which measures 91 holes by 39 copper strips. This can be cut down from a standard size board having 117 holes by 39 copper strips. The component and copper side views of the board are shown in **figure 4** and **figure 5** respectively. Construction of the board is not particularly difficult, but with a board of this size it is clearly necessary to take great care with the placement of all the components. Also, be careful not to miss out any of the link-wires. Some of these links are quite long and they must either be kept very taut or insulated with PVC sleeving. Radial inductors are used for L1 and L2 on the prototype, but the circuit should work just as well using simple rf chokes. Trimmer capacitor C7 might need some "friendly persuasion" but it should fit into the layout without too much difficulty.

None of the semiconductor as are static-sensitive, but it is still advisable to use DIL holders for all the 8-pin integrated circuits. Note that IC5 has the opposite orientation to the other DIL integrated circuits. It will draw a very high supply current if it is connected the wrong way round, and it would almost certainly rapidly overheat. Diodes D3 and D4 are germanium devices and they are consequently more vulnerable to heat damage than normal silicon semiconductors. It should not be necessary to use a heat-shunt when fitting these components, but each soldered joint must be completed reasonably quickly. The other diodes and rectifiers are all silicon types incidentally.

Mylar capacitors are specified for most of the non-polarised capacitors, but from the electrical point of view any form of plastic foil capacitor should suffice. However, from the physical standpoint Mylar capacitors have the advantage of the long leadout wires that can accommodate the variety of lead spacings used in this board layout. It would be very difficult indeed to fit most other types of plastic foil capacitor into this component layout.

The fairly large size of the circuit board means that it is necessary to use a large case for this project. It

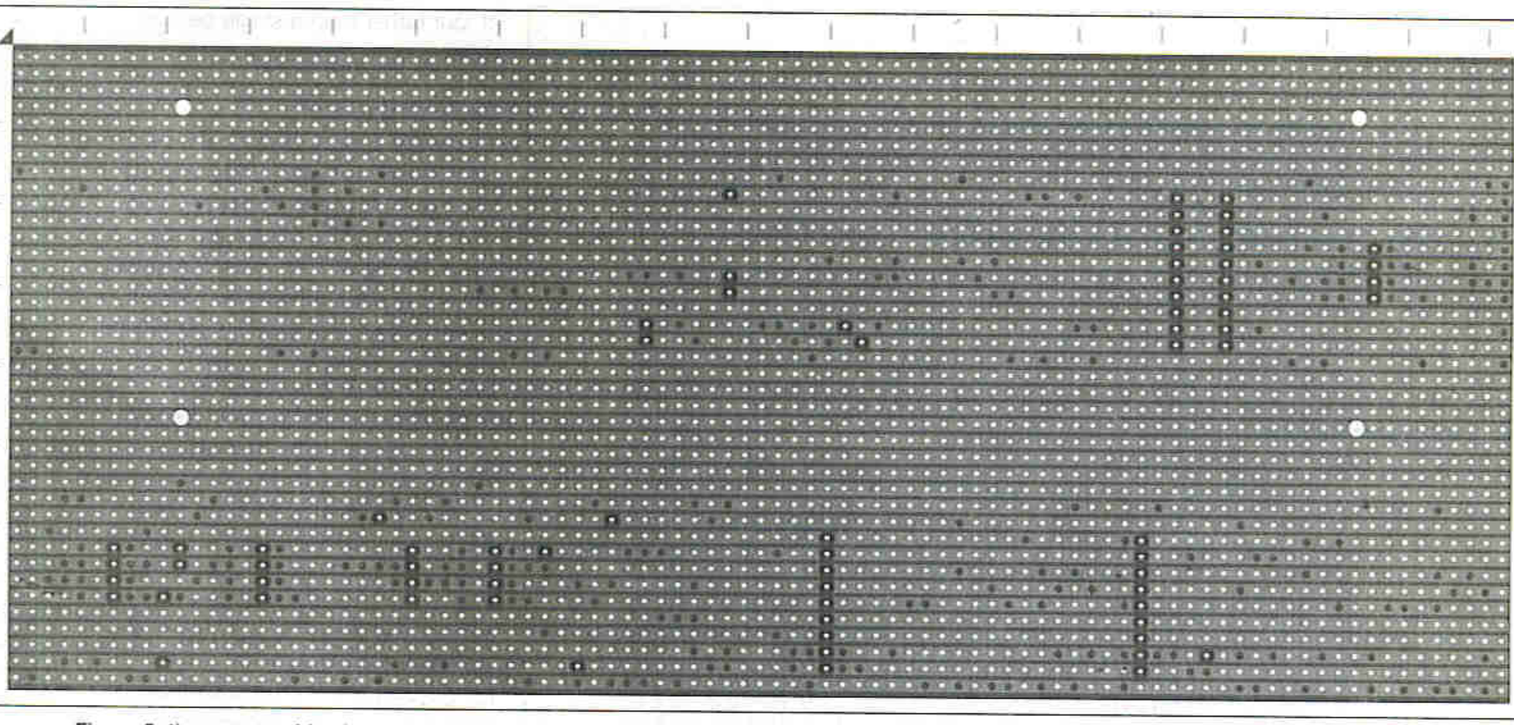

Figure 5: the copper side view of the component panel, showing cutouts

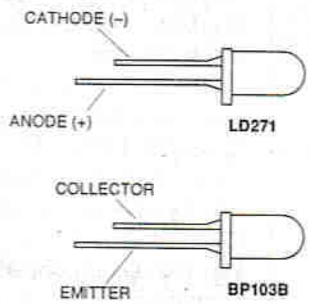

Figure 6:connection details for the two photocells

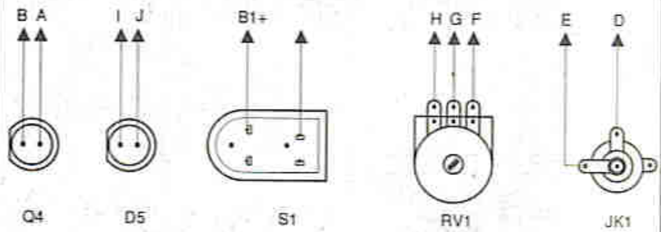

Figure 7: details of the hard-wiring

would be necessary to use a large case anyway, since it is essential to a have wide gap between the aerial and a two photocells. Otherwise there is a danger that controlling the volume will also slightly modulate the pitches of the notes as well. A case about 300 millimetres wide is the minimum that is likely to give satisfactory results. It is easier to use a plastic case as this avoids complications with insulating the aerial from a metal case. However, plastic cases having adequate dimensions seen to be difficult to obtain and the prototype was therefore housed in a case of folded aluminium construction. The exact layout use is not critical, but bear in mind that the aerial must be mounted as far away from the photocells as possible.

When using a metal case it is essential to insulate the telescopic aerial from the case, and on the prototype this is achieved by fitting the aerial into a PVC grommet that is a tight fit. Apart from insulating the aerial from the case this also provides the aerial with a reasonably secure mounting. This method is unlikely to work well enough with a large aerial, but in this case size really is of no importance, and a short aerial is perfectly adequate. In fact, a large aerial will simply make the unit more vulnerable to pickup of radio frequency interference, mains "hum", etc.

The two photocells must be mounted very close together, or the desired action will not be obtained. Rather than the volume increasing as the user's hand is moved towards the photocells, the volume would at first rise and then fall away again. In order to ensure that good results are obtain the photocells should be no more than about 15 millimetres apart. Although an LD271 is specified for D5 in the parts list, any other five millimetre diameter infra-red LED should work equally well. A device that has a narrow beam will enable the instrument to be controlled with the user's hand further away from the photocells, but this is not necessarily an advantage. I found the unit easier to use with the relatively short operating range provided by an ordinary wide beam infra-red LED.

Q4 can be any silicon npn phototransistor that is housed in a five millimetre diameter LED style case (for example, a SFH200). Devices that do not incorporate a built-in lens are unlikely to give adequate sensitivity for this application. The same is also true of any form of photodiode. The base lead of Q4 is not accessible, but this is of no consequence in the present application where no connection is made to its base terminal anyway.

The leadout diagrams for both photocells are provided in **figure 6**. The cathode terminal of the LED is denoted in the usual way by having that leadout shorter than the anode lead, and also by having a "flat" on that side of the case. A similar method is used for the phototransistor, but the "flat" and short lead denote the collector terminal. It is advisable to mount both

photocells in chrome holders so that they are fully shrouded and the "light" from the LED cannot find its way direct to the phototransistor.

Testing and playing

Start with C7 at a roughly middle setting (set so that its two sets of metal vanes overlap by about 50 percent). With the output of the unit monitored using an amplifier and loudspeaker, a strong audio tone should be obtained, and it should be possible to vary the pitch of the note using RV1. Of course, something must be placed in front of the photocells to act as a reflector so that a reasonably strong audio output signal is obtained. If only weak tones can be obtained, these are caused by harmonics of the fundamental signals mixing together, and the frequencies of the oscillators are not close enough together. Try C7 at various settings until a proper tone can be obtained. By adjusting RV1, it should be possible to reduce the note to a very low pitch. In fact, the oscillators tend to lock together when they are very close in frequency, and no audio output is then obtained. The circuit has separate supply decoupling circuits for the two high frequency oscillators, and the high value resistors in the mixer circuit also help to minimise this locking effect. It is still not possible to obtain very low output frequencies, but this is not really of any practical consequence.

With the oscillators locked or producing a low beat note, the Theramin is ready to be played. By moving your hand towards the aerial and removing it again it should be possible to vary the pitch of the output signal over a wide range. In fact a compass of half a dozen or more octaves should be easily achieved. The volume should be controllable by moving your other hand towards the photocells and moving it away again. The dynamic range available is very wide, and it is likely to be some 90dB or more. I found it easier to control the pitch with my left hand and the volume with my right hand, but the instrument can be played either way round. It is advisable to leave the unit running for a few minutes before trying to play it in earnest, so that the oscillators have time to stabilise. It might still be necessary to readjust RV1 from time to time, but after an initial "warm up" period the circuit seems to be reasonably stable.

Some instruments are easier to play than are others, and a Theramin probably ranks amongst the most difficult. Although it is strictly monophonic (one note at a time), there is nothing other than the sound produced to help guide you to the correct note. Unless you have a reasonable sense of pitch and can play "by ear", you may find it difficult to play tunes. It is probably best to start by learning to play some scales and then progress to simple tunes. Since you have full control of the volume and the pitch, it should be possible to play with plenty of expression. Sound effects and "atmosphere" are easier to create, especially where you do not have to be exactly on pitch. By wiggling the fingers of the appropriate hand it is possible to obtain both vibrato and tremolo effects.

In theory the output signal is a sinewave, but in practice a certain amount of distortion occurs for one reason or another. The purity of the output signal can be improved somewhat by increasing the value of R5 and R9, but this will reduce the output level. Conversely, making these resistors lower in value will give a more distorted and "brighter" sound together with an increase in the output level. You may find this is more suitable to the kind of music you are producing. In any case, a Theramin is a colourful addition to any home studio or theatre group, or for solo performances with a difference.

PARTS LIST for the Infra-red Theramin

Resistors

(All 0.25W 5 percent carbon film)

R1,R2,R6,R16	100k
R3,R7,R24	1k5
R4,R8	4k7
R5,R9	150k
R10,R30	2M2
R11,R14,R15,R21,R35	10k
R12,R25	6k8
R13,R29	15k
R17,R18,R31,R34	3k9
R19,R27	330R
R20	18k
R22	27k
R23	270R
R26	22k
R28	1k
R32	390R
R33	1M2
RV1	47k lin rotary carbon

Capacitors

C1	33p ceramic plate or polystyrene
C2,C8,C27,C28	4n7 Mylar
C3,C4,C9,C11	180p polystyrene
C5,C13,C20	10u 25V radial elect
C6,C12	470p ceramic plate
C7	5.5/65p trimmer
C10	22p ceramic plate
C14	2n2 Mylar
C15	10n Mylar
C16,C19	2u2 50V radial elect
C17	1u 50V radial elect
C18	1000u 16V radial elect
C21,C24,C26	100u 16V radial elect
C22,C23	100n ceramic (2 off)
C25	1n Mylar
C29	470n polyester (7.5mm lead spacing)
C30	4u7 50V radial elect

Semiconductors

IC1	LF351N
IC2	CA3080E
IC3	uA741C
IC4	LM317LZ
IC5	TS555CN
Q1,Q2	BF244A
Q3,Q5,Q6	BC550
Q4	BP103B or similar
D1,D2	1N4002
D3,D4	OA91
D5	LD271 or similar
D6,D7	1N4148

Miscellaneous

S1	Rotary on/off switch
B1	12 volt (8 x HP7 size cells in holder)
JK1	3.5mm jack socket
L1,2	470uH radial inductors

Case about 300mm x 140mm x 50mm, 0.1 inch stripboard having 91 holes by 39 holes, 8-pin DIL holder, control knob, 5mm LED panel holder, battery connector (PP3 type), telescopic aerial, wire, solder, etc.

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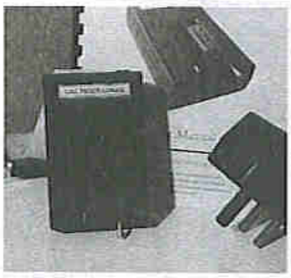

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SMARTCAM

Magnus Pihl turned a standard night security camera into an attack-resistant intelligent security camera with a fine saw, a drill, and some ingenuity...

What is "Smartcam"? It is a standard video surveillance camera adapted to make the basis of an advanced computerised surveillance component.

Most of the components that make up the Smartcam system are widely available, but you will have to exercise some care and ingenuity in putting your system together, as it is not built around one specific module or case. The case and drilling measurements given are for my prototype system - you will need to adapt it if you are using parts with different dimensions.

The elements that make up the Smartcam prototype are:

- A standard black and white video night surveillance camera
- Scotopic (night sensitive) vision when used with infra-red spotlights
- A motion detector
- Resistance to mechanical violence
- Resistance to spray paint

The night-sensitive vision is contained in the camera itself. The camera used in the prototype here is a small PCB module, with six infra-red leds. Smartcam was designed to incorporate a metal shell that is bolted to a wall with strong perpendicular bolts and is therefore more resistant to physical violence than an unprotected camera. It should be harder than usual to put it out of action by striking it, and the slanting top of the shell means that it cannot easily be covered by hanging a jacket or cap on it. Also, Smartcam has a built-in "spray-paint detector" to send an alarm output to a main alarm system or to security guards. In addition to that, Smartcam will wait a few seconds after the spray-paint detection, and then change to a new plastic lens, putting it back into full operation after a spray-paint attack.

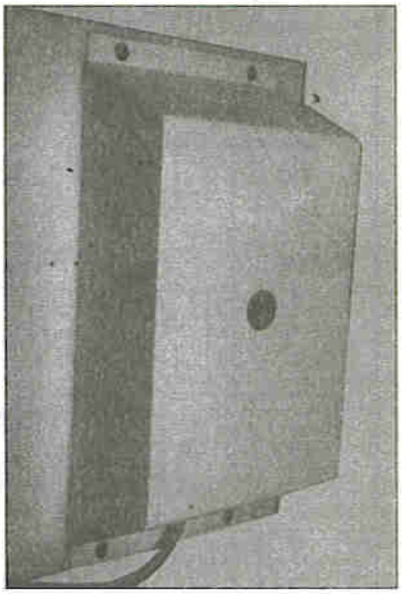
By increasing the sensitivity of the spray-paint detection it is also possible to use it as a motion detector.

If it is necessary to shut down the surveillance, or if you want to switch it off, for instance, during working hours, Smartcam can cover its aperture with a section of the lens painted the same colour as the shell, so that the camera "eye" cannot see or be seen.

The circuit

The heart of the circuit, shown in **figure 1**, is a PIC16C84. R13 and C3 form an RC network to run the clock signal for the PIC at quite a low frequency. There is no need for an exact clock speed in this application. R14 and C4 form the reset start-up delay.

I think that the most interesting part is the motion detector working with the video picture. There is no need to use an advanced processor and cut the picture into X/Y fields. There is a much easier way. This circuit converts the video signal to a DC voltage, derives it and has it under surveillance of a comparator. IC3A amplifies the video signal 1:1. This is simply an interface, so the video signal can be used again to display the picture on a monitor, as C1 will average the DC level of the video, over a time period defined by the value of C1 and the peak current drive capability of IC3A. The DC voltage will then rise and fall as the light input to the lens of the camera changes, and C2 in conjunction with R7 differentiates the signal so that the comparator only responds to fairly rapid changes.



The "transients" from C2 are therefore the motion changes in the video picture. Small transients are small alterations in the video picture, and high transients are fast alterations in the video picture (or possible spray-paint detection). If the value of R7 is too high, the camera will not notice slow movements in the picture field. IC3B is connected as a comparator, which switches if the rate of change of DC level is above a defined rate, which can be adjusted by RV1. When the comparator switches, the signal is fed to the processor through IC1F. Note here that, because the unused inputs of IC2 are unconnected, CMOS versions (HC, HCT etc.) cannot be substituted for bipolar logic.

IC4 is just a video amplifier with a 75-ohm interface to use with a monitor or VCR.

When the signal reaches the processor, there is a delay of a few seconds, so the villain won't notice the lens changing. Then, by sending RB2 or RB3 high, we can rotate the plastic disc **(see figure 2)**, which functions as the multi-lens. The network Q1 to Q6, together with a couple of diodes and resistors, is a polarity changer circuit of a type widely used to drive stepper motors. When RB2 is high, Q6 conducts, and current will flow from Q1, through the motor-servo and finally to ground by Q3. If Q5 (via RB3) conducts, current will flow though Q2, through the motor-servo (in the opposite direction) and to ground by Q4. The servo is not running when RB2 and RB3 are both inactive. If both RB2 and RB3 went high at the same time, a short circuit would occur.

The lens-disc is driven by a servo motor of the kind used in radio-controlled models. The servo cannot run through 360 degrees, so we must have full control of where the starting

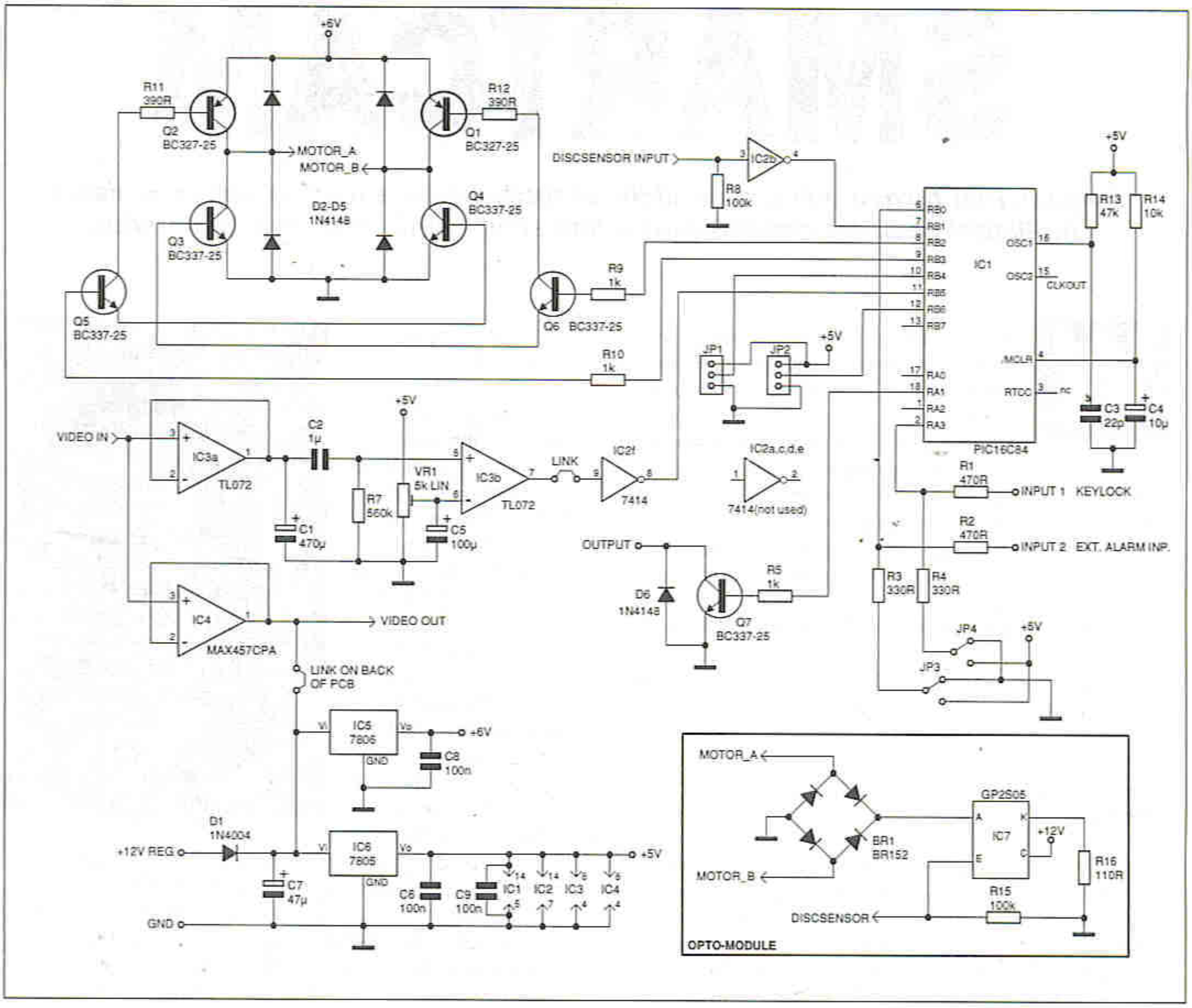


Figure 1: the circuits of the main Smartcam PCB and the Smartsensor opto module

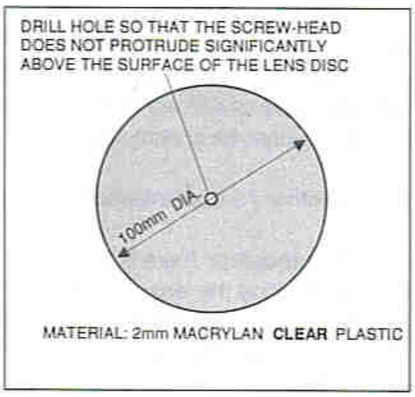


Figure 2: a dimensional diagram for the transparent plastic sheet lends disc, which must be cut carefully with a fine saw

point of the disk is. This is where the Smartsensor PCB comes in - a section of the lens disk, just enough to cover the spy-hole in the shell, is painted in the same colour as the shell. The other side of this section must be painted matt black (it is important not to use gloss black, or it might generate an unwanted reflection which would be picked up by the reflection detector). The Smartsensor PCB will detect the difference between the matt black, non-reflective section of the disc (which faces inward towards the camera eye) and the reflections from the shiny non-painted sections of the plastic disk, which act as the self-replacing lenses.

The Smartsensor PCB employs a reflection detector, IC7, which itself consists of an infra red transmitter and receiver. Almost any small reflection detector will do here. It will tell the microprocessor when the disk is in the "home" position, and that the lens is covered by the black/white sector. The infra-red transmitter must not light up during normal operation, or a bright unwanted light would appear on the surveillance monitor, as the night surveillance cameras are also sensitive to infra-red (hence the scotopic vision). The infra red led on the Smartsensor PCB should only light up when the servo motor is running. The motor terminals are driven into a rectifier and into the anode of the infra red led. R16 is the current limiter.

The collector of IC7 is tied to +12V, and the emitter is tied to ground through R15. From the emitter, the disc sensor output is fed into the processor though IC2B. R1 to R4 are used for inputs, which can be used for other parts of an alarm system as well as Smartcam, or with a codelock to control Smartcam's operation modes. Q7 is an output, which can be used to drive a small siren or alert a central alarm unit.

Finally, the power supply used in the prototype is a standard 7805 for the PIC and 7806 for the motor servo. The 7805 cannot be used to drive the servo motor as well as the PIC, as this would generate noise on the +5V and cause the circuit to malfunction. They need separate regulators.

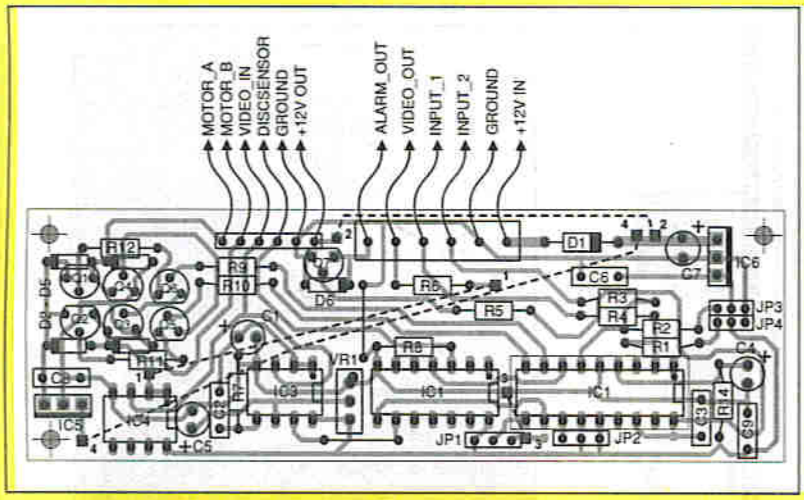


Figure 3: the component layout for the main Smartcam PCB

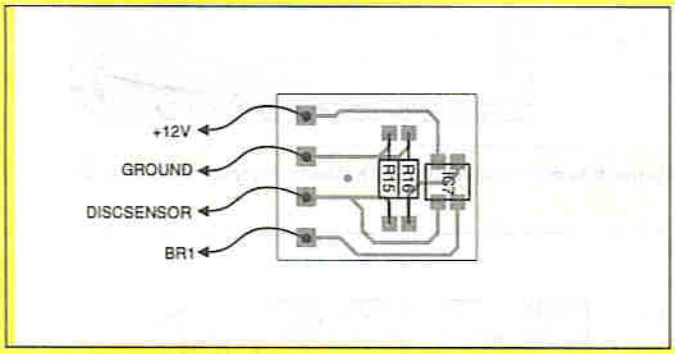


Figure 4: the component layout of the Smartsensor opto board

Construction

The Smartcam PCB

See **figure 3**. Mount the components on the PCBs. The opto-module section is mounted on the small Smartsensor PCB. JP1 and JP2 are left disconnected and can be reserved for future use. JP3 and JP4 are set to ground for normal (active high, +12V) operation. With a program change, these can be set for active low operation.

Four external wires must be placed at the back of the PCB, along with two wire links (or zero ohm resistors). Connect 1 with 1, 2 with 2 and so on. The two links are marked "Link" on the PCB. For the microcontroller (PIC) I recommended that you use an ic socket so that if you wish to modify the program you have no trouble removing the PIC.

The camera's six infrared leds must be removed or disconnected, as they will not work inside the shell. To obtain night-sensitive vision in complete darkness, you must use infra red spotlights in the area to be surveyed, or buy glass IR filters for use with any spotlight.

The Smartsensor PCB

See **figure 4**. Note that this PCB is designed for the surface mounting of conventional through-hole style components. Bend the lower part sections of the four pins of IC7 carefully out to 90 degrees from so that you can solder them flat to the PCB. Remember to support the top section of each pin (with a finger or something firm) as you bend the lower part, to stop the whole pin from bending out from the junction with the component body. Cut the leads of the resistors just short enough to bend down and turn a little bit level to the pad area on the board (with the resistor lying flat to the board) and solder the ends to the pad area. BR1 is mounted off the board.

The metalwork

An aluminium box with outside measurements of 114 (L) x 89 (W) x 55 (H) was used in the prototype, and all measurements are given for this box. The PCB, servo motor and all mechanical parts are mounted on the inside of the cover of this box. Only the lens disc appears outside the cover of the aluminium box. The whole is then covered by the security shell. Therefore, the inside measurements of the aluminium box must be at least 105mm wide, so that the PCB can be fitted across the width of the box. A dimensions diagram for the prototype is given in **figure 5**, which, when compared with **figure 6**, will indicate how I laid out the PCBs and the camera module to work together. The constructor must adapt the measurements to the actual camera/boxes used.

The camera was tightened with 35mm long M3 bolts in such a way that it could be set up the a suitable angle for the viewing position required. The long bolts will enable you to mount the corners of the camera module at an angle of your choice (if you require a very steep angle, you may need some longer bolts). It is often preferable to mount Smartcam high on a wall, and mount the camera to look down. Therefore the viewing hole in the box is rectangular, so that the line of sight can be varied. See the construction diagram in **figure 6**.

The servo motor's own PCB must be removed, so that only two wires connect the gearing to the Smartcam circuit. Smartcam itself will control the servo and lens system fully.

The lens disc is made of 2mm thick transparent plastic sheet, free of scratches and other obvious optical defects, and is cut to a diameter of 100mm. I used Macrylan, but any clear

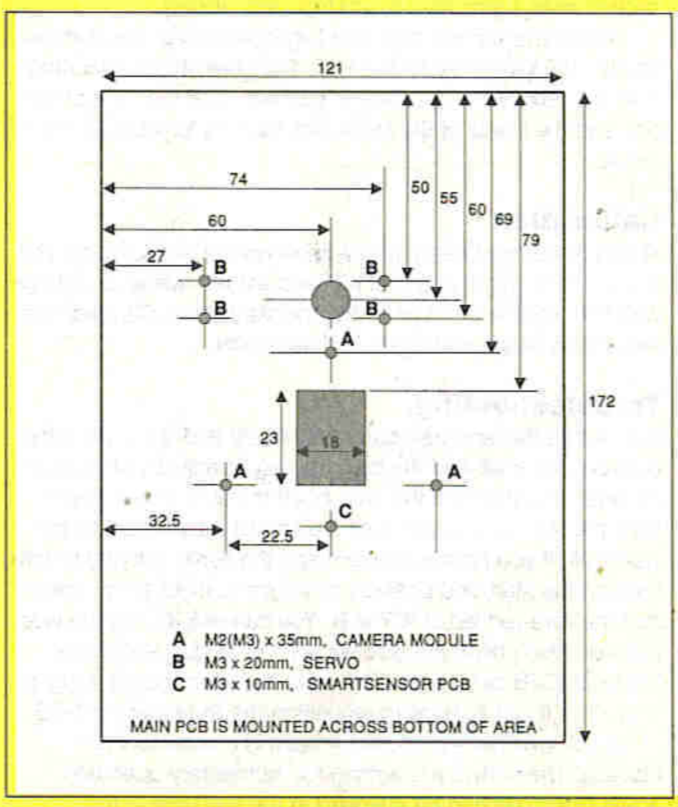


Figure 5: a dimensional diagram showing the relavitve positions of the PCBs, servo motor and camera module used in the prototype

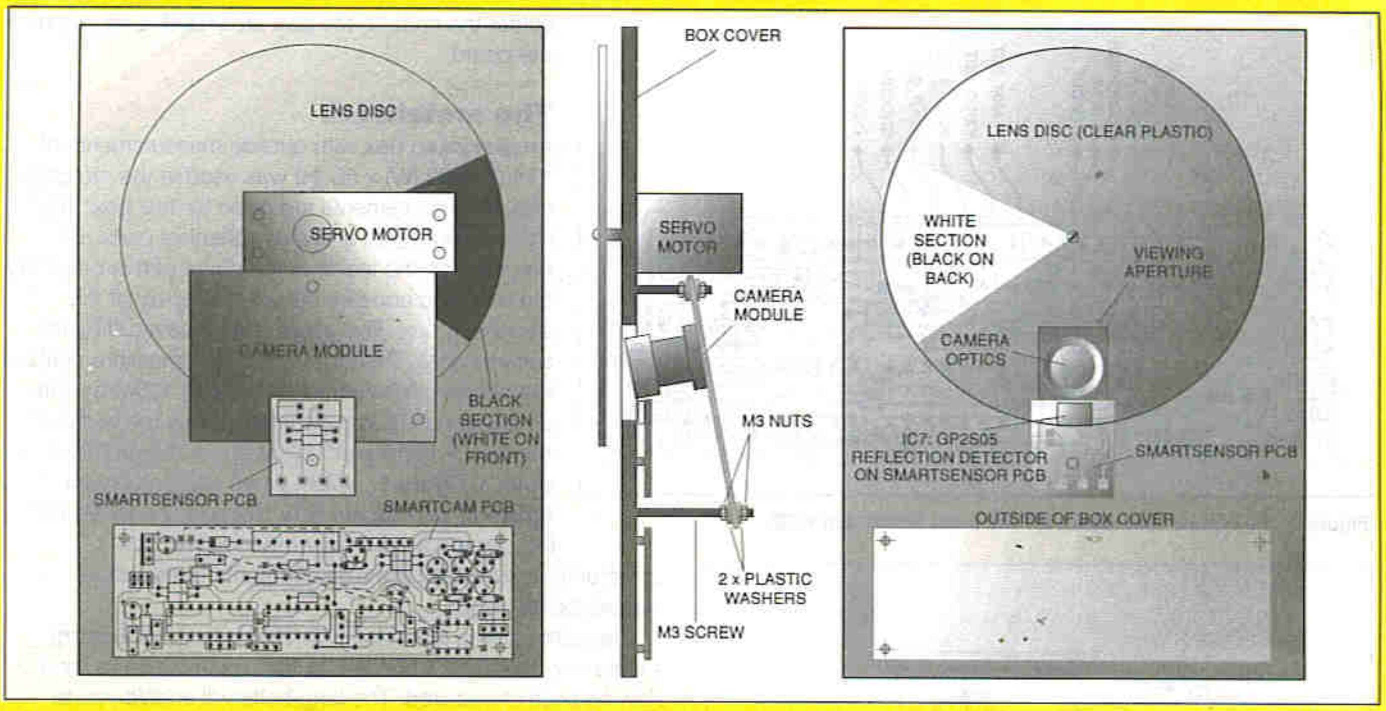


Figure 6: this diagram shows the relative positions of the PCBs, camera module and lens disc used in the prototype. Note that the reflection sensor, IC7, is positioned in the viewing aperture

plastic sheet of sufficient thickness and rigidity should be suitable. It is easy enough to make the disc with a fine-bladed saw if you clamp the plastic firmly. It is best to make a template of card, cut that out and use that to mark the plastic, as you do not want to risk compass-scratches or pencil marks accidentally getting onto a section of the disk, as this would affect the image.

When you have cut a disk to your satisfaction, paint a section of the disk just wide enough to cover the hole in the metal shell the same colour as the shell. The back of this section must be painted matt black (see above).

When Smartcam is built and fully operational, the aluminium box is mounted firmly on the wall. The steel shell is mounted over the box, allowing sufficient gap between the front of the box and the inside of the steel shell that the lens disc is free to rotate.

Calibration

This is done most easily with a two-channel oscilloscope. Put the scope on pin 5 and 6 of IC3 and set the reference voltage with RV1 so that the tops of the transients from C2 reach the reference voltage at the required sensitivity.

Troubleshooting.

Check that the lens-disc can rotate freely and is not jamming between the shell and the box. You could adjust with washers between the shell and the wall, but it is better to get it right from the start to give the shell the firmest attachment to the wall itself. If you have a problem and the servo is trying to drive through the start/end position of the servo mechanics, check that the infra-red led at IC7 is lit. You can see this on the video monitor. Also check the disc sensor's analogue and digital levels (at IC2B pin 3 and 4) to make sure that the input signal is ok. You might to have to reposition the Smartsensor PCB.

Check whether the codelock input is momentary or bistable. The software is written for momentary operation, active high. This can be changed in the software at the "on_off" labels in the program.

Check the +5V and +6V. Also check that the processor is operating, with the scope on pin 15. Are JP3 and JP4 installed correctly? Are the two links and the four external wires installed?

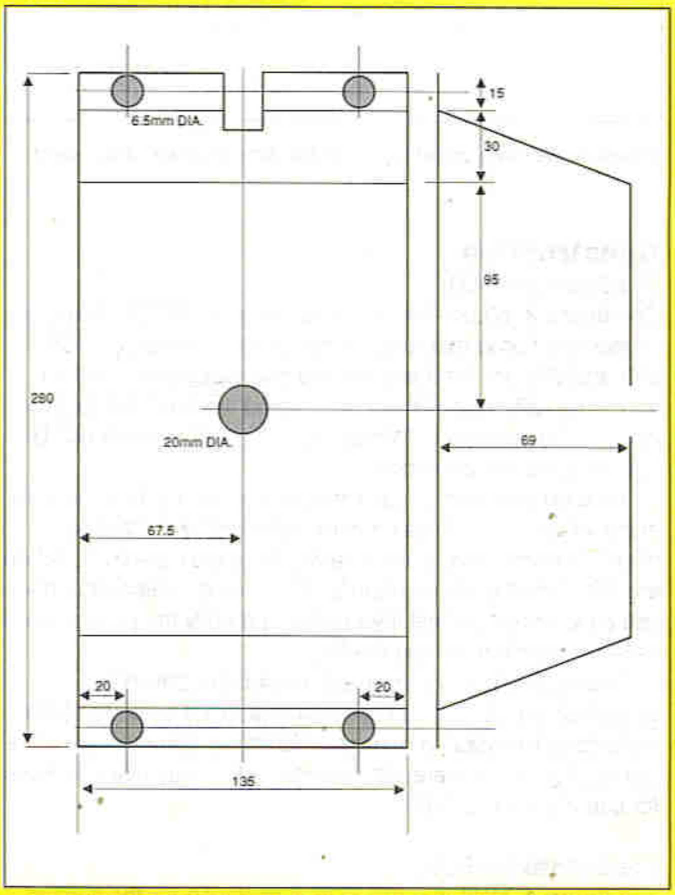


Figure 7: the dimensions of the security shell used in the prototype

Finding a suitable shell

I was lucky enough to have a 2mm steel shell left over from a production run (**see figure 7**). Suitable strong shells of this type do not seem to be that frequent in the popular catalogues, and those that are there are not quite the same as the one in the prototype. For example, the winter Farnell catalogue lists one strong polycarbonate bevelled shell with a backplate, designed mainly to house an alarm bell, and about twice the dimensions needed for the Smartcam. If a shell like this was found to be suitable, the Smartcam box would need to be mounted on spacers behind the shell, and appropriate slots cut for the lens and the cable.

The shape of the shell is simple enough to make, but to make it in steel would require metal workshop tools, so is not within the reach of everyone. Aluminium is not really tough enough for the job.

The software

The software is programmed with the power-up timer and the RC-network oscillation.

```
            list c=136
            list n=60
            list r=HEX
            list x=ON
            list t=ON
            list e=0
            list p=16c84

port_a      equ     005h
port_b      equ     006h
time_a      equ     00ch
time_b      equ     00dh

alarm_out   equ     001h    ;RAx=1000 = 008h
on_off      equ     003h    ;  bit# 3210

alarm_in    equ     000h    ;RBx=00010011 = 013h
sensor      equ     001h    ;  bit# 76543210
motor_cw    equ     002h
motor_ccw   equ     003h
cam_alarm   equ     005h

            org     0005h

;******** MAIN ROUTINE ********
main        call    power_on    ;Reset outputs
            call    close       ;Return lensdisc

day         btfss   port_a,on_off ;Request from codelock
                                  -begin?
            goto    day
            call    wait    ;Short timedelay
            call    open    ;Load first lens

night       btfsc   port_b,alarm_in  ;External alarm
                                      activated?
            goto    alarm
            btfss   port_b,cam_alarm ;Alarm from
                                      videocircuit?
            goto    lens
            btfss   port_a,on_off    ;Request - close
                                      surveillance mode?
            goto    night

            goto    main  ;Surveillance mode cancelled.
                                  Restart smartcam.

;*************** SUBROUTINES***************

power_on    movlw   008h    ;Set I/O directions to port A
            tris    port_a
            movlw   013h    ;Set I/O directions to port B.
            tris    port_b
            bcf     port_a,alarm_out  ;Reset outputs.
            bcf     port_b,motor_cw
            bcf     port_b,motor_ccw
            call    wait
                                      ;Power on timer for
                    stabilisation
            return

close       bsf     port_b,motor_ccw  ;Start lensdisc
                                       return travel
movlw       01fh    ;Give IC7 time to stabilise
movwf       time_a
call        wait1

movlw       07fh
movwf       time_a
halt1       movlw   0ffh
            movwf   time_b
halt2       btfsc   port_b,sensor      ;Lens covered?
                                       (Start of lensdisc)
            goto    halt3
            decfsz  time_b,f
            goto    halt2
            decfsz  time_a,f
            goto    halt1
            goto    error ;Timeout! Lensdisc or
                           Smartsensor PCB error
halt3       bcf     port_b,motor_ccw  ;Cut power to
                                       servomotor
            call    wait
            return

open        bsf     port_b,motor_cw ;Start servomotor
            call    time               ;Give IC7 time to
                                        stabilise
            movlw   05fh
            movwf   time_a
stop1       movlw   0ffh
            movwf   time_b
stop2       btfss   port_b,sensor ;Is lens uncovered now?
            goto    stop3
            decfsz  time_b,f
            goto    stop2
            decfsz  time_a,f
            goto    stop1
            goto    error              ;Timeout! Lensdisc
                                        or Smartsensor PCB
                                        error
stop3       bcf     port_b,motor_cw    ;Cut power to
                                        servomotor
            call    wait               ;Let it stabilise
            call    wait
            return
lens        bsf     port_a,alarm_out  ;Motion/Attack were
                                        detected
            call    wait               ;Time delay before
```

```
                                ;first lens change
        call    wait
        call    open
        goto    key
alarm   bsf     port_a,alarm_out    ;External alarm
                                    signal detected
        goto    key

key     btfss   port_b,cam_alarm;   ;Look for more
                                    attacks/restart
                                    request
        call    attack
        btfss   port_a,on_off
        goto    key
        goto    main

attack  call    wait    ;More attacks coming in
        call    wait
        call    wait
        call    wait
        call    wait    ;Time delay before change
                        to new lens
        bsf     port_b,motor_cw
        call    time    ;Time for servo to move in
                        another clean lens
        bcf     port_b,motor_cw
        call    wait
        return

wait    movlw   04fh    ;General delay routine
        movwf   time_a
wait1   movlw   0ffh
        movwf   time_b
wait2   nop
        decfsz  time_b,f
        goto    wait2
        decfsz  time_a,f
        goto    wait1
        return

time    movlw   01fh
        movwf   time_a
        goto    wait1

error   bcf     port_b,motor_cw
        bcf     port_b,motor_ccw
        btfsc   port_a,on_off
        goto    main
        goto    error
        end
```

PARTS LIST for Smartcam

Resistors

R1,R2	470R	All 1/2W carbon
R3, R4	330R	
R5, R9, R10	1k	
R6	75R	
R7	560k	
R8, R15	100kohm	
R11, R12	390R	
R13	47k	
R14	10k	
R16	110R	
VR1	5k linear	

Capacitors

C1	470u 16V
C2	1u electrolytic
C3	22p ceramic
C4	10u 16V
C5	100u 16V
C6,C8,C9	0.1u ceramic
C7	47u 16V

Semiconductors

IC1	PIC16C84-04
IC2	7414*,
IC3	TL072/CP
IC4	MAX457CPA video amplifier
IC5	7806
IC6	7805 TO220
IC7	GP2S05 reflection detector
Q1,Q2	BC327-25 or any PNP
Q3-Q7	BC337-25 or any NPN
D1	1N4004
D2-D6	1N4148
BR1	BR152 in Swedish prototype.

Use any small rectifier capable of being mounted offboard.

*Other versions must not be substituted.

Miscellaneous

6-pin connector 2.54mm spacing for PCB
6-pin connector 2.54mm spacing for crimp
6-pole screw terminal block 3.8mm spacing
18-pin IC socket for PIC16C84
Aluminium box approx 172x121x55mm
Lens disc - see text and diagrams
Camera module - see text
Motor servo - see text
PCBs
Security shell box - left to constructor. The one mentioned in the text is on page 1211 of the winter Farnell catalogue. This is only given as an example of a bevelled security box, and may not be suitable for your application.

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13A SOCKET, virtually unbreakable, ideal for trailing lead. Ref: D95.
PIEZO BUZZER with electronic sounder circuit, 3V to 9V D.C. operated, Ref D76.
DITTO but without internal electronics, pack of two, Ref:D75.
LUMINOUS ROCKER SWITCH approximately 30mm sq, pack of two, Ref D64.
ROTARY SWITCH, 9-pole, 5-way, small size ?? spindle, pack of two, Ref: D54.
FERRITE RODS, 7" with coils for Long and Medium waves, pack of two, Ref: D52.
DITTO but without coils, pack of three, Ref: D52.
MAINS DP ROTARY SWITCH with 1/4" control spindle, pack of five, Ref: D49.
ELECTROLYTIC CAP, 800µF at 6.4V, pack of 20, Ref:D48.
ELECTROLYTIC CAP, 1000µF + 100µF 12V, pack of10, Ref: D47.
MINI RELAY with 5V coil, size only 26mm x 19mm x 1mm, has two sets of changeover contacts, Ref: D42.
MAINS SUPPRESSOR CAPS).1µF 250V A.C., pack of 10. Ref: 1050
TELESCOPIC AERIAL, chrome plated, extendable and folds over for improved F. M. reception. Ref: 1051.
MES LAMP HOLDERS, slide on to 1/4" tag, pack of 10, Ref: 1054
PAXOLIN TUBING 3/16" internal diameter, pack of two, 12" lengths, Ref 1056.
ULTRA THIN DRILLS, 0.4mm, pack of 10, Ref: 1042.
20A TOGGLE SWITCHES, centre off, part spring controlled, will stay on when pushed up but will spring back when pushed down, pack of two, Ref: 1043.
HALL EFFECT DEVICES, mounted on small heatsink, pack of two, Ref: 1022.
12V POLARISED RELAY, two changeover contacts, Ref: 1032.
PAXOLIN PANEL, 12" x 12" 1/16" thick, Ref: 1033.
MINI POTTED TRANSFORMER, only 1.5VA 15V-0V-15V or 30V, Ref: 964.
ELECTROLYTIC CAP, 32µF at 350V and 50µF section at 25V, in aluminium can for upright mounting, pack of two, Ref: 995.
PRE-SET POTS, one megohm, pack of five, Ref: 998.
WHITE PROJECT BOX with rocker switch in top left-hand side, size 78mm x 115mm x 35mm, unprinted, Ref: 1006.
5V SOLENOID, good strong pull but quite small, pack of two, Ref: 1012.
FIGURE-8 MAINS FLEX, also makes good speaker lead, 15m, Ref: 1014.
HIGH CURRENT RELAY, 24V A.C. or 12V D.C., three changeover contacts, Ref: 1016
LOUDSPEAKER, 8 Ohm 5W, 3.7" round, Ref: 962.
NEON PILOT LIGHTS, oblong for front panel mounting, with internal resistor for normal mains operation, pack of four, Ref: 970.
3.5MM JACK PLUGS, pack of 10, Ref: 975.
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LOUDSPEAKER, 7" x 5" 4 Ohm 5W, Ref: 949
LOUDSPEAKER, 4" circular 6 Ohm 3W, pack of 2, Ref: 951
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PAXOLIN PANEL, 81/2" x 31/2 width electrolytics 250µF and 100µF, Ref: 905.
CAR SOCKET PLUG with P.C.B. compartment, Ref: 917.
FOUR-CORE FLEX suitable for telephone extensions, 10m, Ref: 918.
PROJECT CASE, 95mm x 66mm x 23mm with removable lid, held by four screws, pack of two, Ref: 876.
SOLENOIDS, 12V to 24V, will push or pull, pack of two, Ref: 877.
2M MAINS LEAD, 3-core with instrument plug moulded on, Ref: 879
TELESCOPIC AERIAL, Chrome plated, extendable, pack of two, Ref: 884.
MICROPHONE, dynamic with normal body for hand holding, Ref: 885
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18V-0V-12V 10W MAINS TRANSFORMER, Ref: 813.
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2 CIRCUIT MICROSWITCHES, licon, pack of 4, Ref: 825.
LARGE SIZE MICROSWITCHES changeover contacts, pack of two. Ref: 825.
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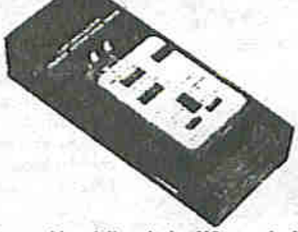

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1127	Microphone tone control	4.60
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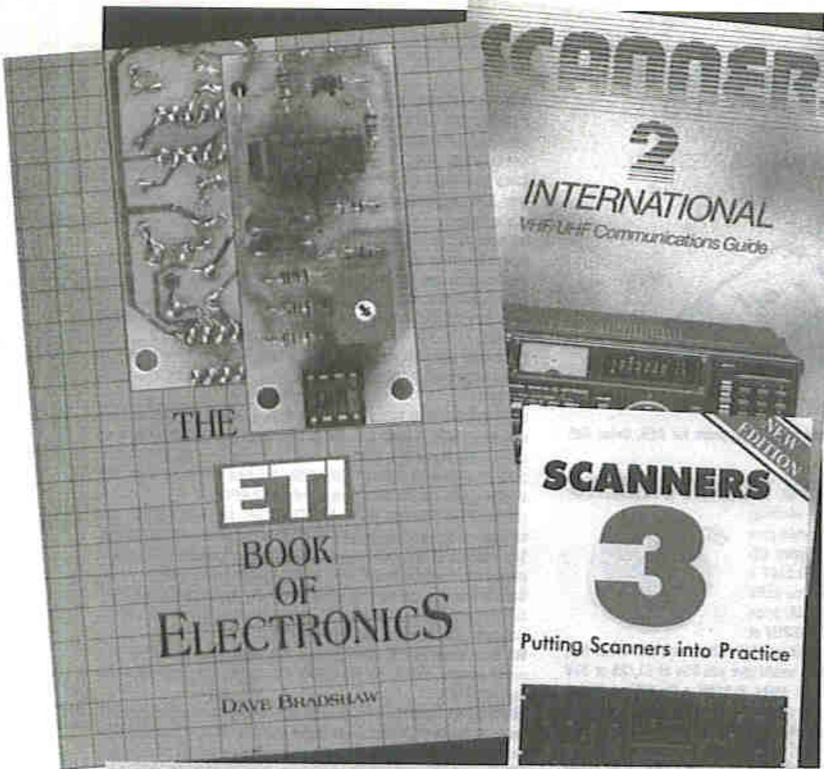
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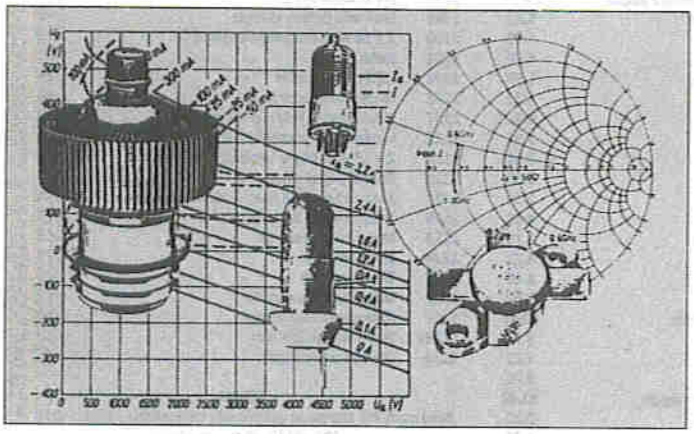
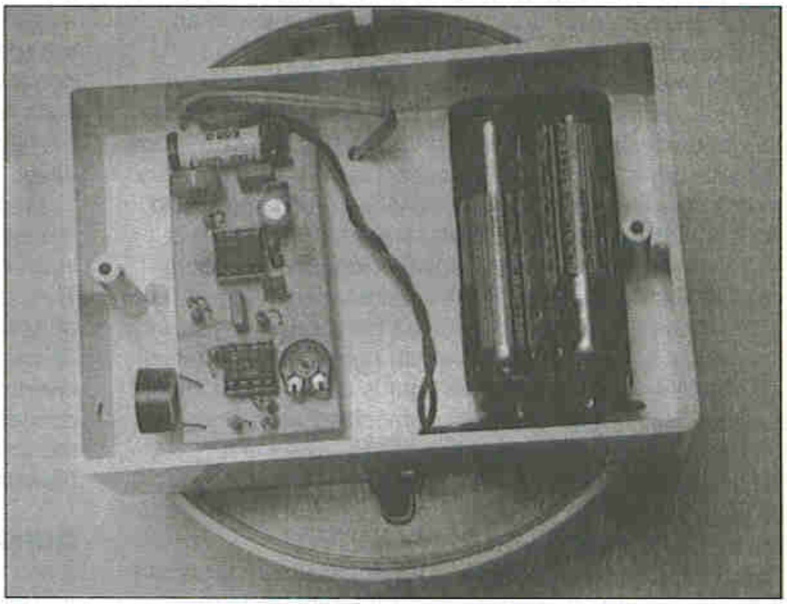


Auto Cupboard Light

A multi-purpose light-operated light! By Terry Balbirnie

Have you ever wished for a cupboard light that would come on when you opened the door and go off when you closed it? Suppose you forgot to close the door. Wouldn't it be useful if the light went off automatically after a certain time? This self-contained battery-operated unit will do all this without the need for a conventional switch. It may therefore be moved from one place to another without having to replace any wiring.



Safe and sound

Since the circuit is battery-operated, it is entirely safe for use in a child's bedroom. Parents will find the device particularly useful because of the auto-off facility - children rarely bother to close doors after removing the items they want. This feature will also benefit forgetful adults and the elderly who sometimes forget to switch items off after use.

The lamp works by detecting the small amount of light which falls on a sensor when the cupboard door is opened. Although it sounds ridiculous, the device could be described as a light-operated light! No one opens a cupboard in complete darkness. There will always be some daylight or artificial light in the room and this will be sufficient to operate the circuit if it has been properly adjusted.

Before starting work, check that the cupboard, attic, etc. in which the unit is to be used is almost dark when the door is closed. As long as the light level rises significantly when the door is opened, the circuit should be suitable.

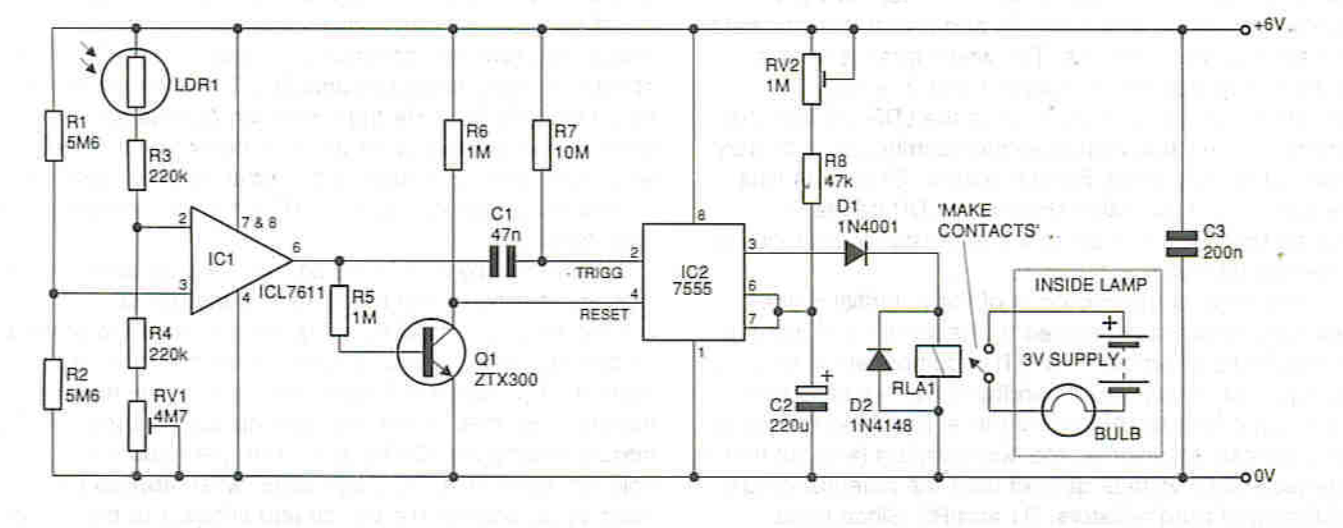


Figure 1: the circuit of the Auto Cupboard Light

Details for finding the best position for the unit and how it should be adjusted to best effect are given at the end.

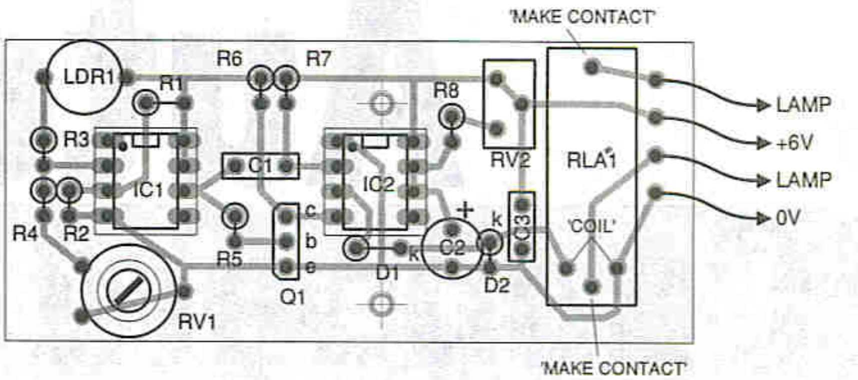


Figure 2: the component layout of the Auto Cupboard Light

Commercial lamp

The lamp itself is a commercial battery-operated "cupboard light" of the kind which can be bought very cheaply by mail order and from DIY stores. It is not really worthwhile constructing this part. These lamps usually use two "D" size alkaline cells connected in series to provide a 3V supply. There is also a large plastic translucent cover which protects the bulb and diffuses the light. The switch, which is often of the cord-operated type, will need to be removed to make the lamp suitable for use with this circuit but this is an easy operation.

The new circuit panel, complete with light sensor, will be housed in a separate plastic box and mounted on the rear of the lamp. A small hole drilled in the side of the box will allow light to reach the sensor. There is also a battery pack in the new unit because the one in the lamp would not be satisfactory. The standby current requirement is less than 100 microamps and, while actually operating, rises to a few milliamps. The 6V battery consisting of four "AA" cells may be expected to last for about one year in occasional service. The cells which operate the light itself are not drained at all while the light is off. They will almost certainly last longer than in an unmodified lamp since wastage is reduced and it is impossible to leave it switched on.

How it works

The circuit diagram for the Auto Cupboard Light is shown in figure 1. Current flows whenever the batteries are connected but all components have been chosen to minimise the continuous current drain. The light detector is light-dependent resistor LDR1. The resistance of this component rises as the light reaching its sensitive surface falls. Under near-dark conditions, it may be expected to be 1 megohm or more. When a little light reaches it, the resistance is likely to fall to a few hundred kilohms. The LDR and fixed resistor R3 comprise the top arm of a potential divider, with resistor R4 and preset potentiometer RV1 forming the lower one. The whole arrangement is connected across the 6V supply. While in a dark environment, the high resistance of the LDR will limit the current to a few microamps so the contribution to battery drain will be very small. Fixed resistors, R3 and R4 limit the current to a low value should the LDR be placed in brighter light with RV1 set to a low resistance (say, during experimental trials).

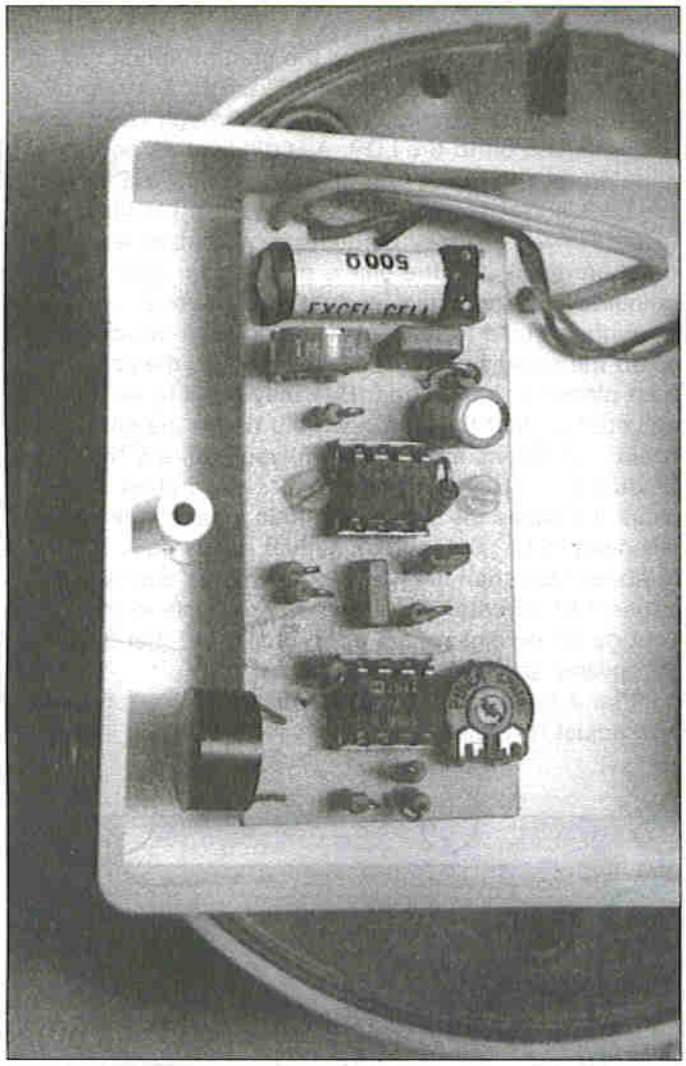
The voltage at the mid-point of the potential divider described above is connected to the inverting (-) input (pin 2) of operational amplifier IC1. This component is of a type having an extremely small standby current requirement - 10uA approximately. As the light level rises, the voltage at pin 2 will rise. Meanwhile, the non-inverting (+) input (pin 3) receives a fixed voltage derived from the potential divider consisting of fixed resistors, R1 and R2. Since these resistors have equal values, this will be about one-half supply voltage - that is, about 3V. Again, their low resistance will limit the standing current to a very low value - less that 1u. With suitable adjustment to RV1, the voltage at the inverting input will be less than that at the non-inverting one when the LDR is under dim conditions such as inside a cupboard. The op-amp will therefore be on, with its output, pin 6, high. It will then have no further effect.

When the light reaching the LDR rises slightly (as when the cupboard door opens), the voltage at the inverting input will rise and exceed that at the non-inverting one. The op-amp output will then go low. Note that the operating light level will be unchanged as the battery ages. This is because the voltages at both inverting and non-inverting inputs are derived from potential dividers connected across the supply. As the battery voltage falls, the voltages at the op-amp inputs will fall in sympathy so the relative conditions will be the same.

Quick pulse

When the op-amp output goes low, a momentary low pulse is transferred via capacitor C1 to the trigger input (pin 2) of timer integrated circuit, IC2. This device is configured as a monostable and when activated in this way, its output (pin 3), will go high for a certain time then revert to low. The time period depends on the values of fixed resistor R8, preset potentiometer RV2 and capacitor C2. With those specified, the timing may be adjusted between 11 seconds (with RV2 set to minimum resistance) and 4 minutes approximately (at maximum). These timings could be easily increased by raising the value of C2 in proportion. Any light continuing to reach the LDR will not affect the timing because capacitor, C1 will only allow a single pulse to flow. Re-triggering can only be achieved by closing the door to reduce the light below the threshold level then opening it again. IC2 trigger input is maintained in a normally-high condition by R7 which prevents possible false operation.

Under standby conditions and with the op-amp output high, current flows into the base of transistor Q1, via current-limiting resistor R5. This will provide a low state at its collector (that is, the transistor is behaving as an inverter). This keeps IC2 reset input, pin 4, low and therefore disabled. When the op-amp output goes low, the current flowing into Q1 base is interrupted and the collector goes high. This high state, when applied to IC2 reset input, enables the device and allows it to behave in the manner described earlier. If the amount of light



reaching the LDR decreases again (that is, the door is closed) before the natural end of the timing cycle, the op-amp output will revert to high and the resulting low state at Q1 collector will reset IC2 and cancel the timing. For this part to work, it will be necessary to prevent too much light from the lamp itself reaching the LDR. If this happens, possibly by reflection from nearby objects, the device will "think" that the door is still open when, in fact, it has been closed. The timing will then continue to the end before the light goes out. Ideas for reducing the amount of light reaching the LDR from the lamp are given towards the end.

Relay coil

When IC2 output, pin 3, goes high in the course of timing, current flows through the coil of relay RLA1, via D1. The "make" contacts of this component then allow current to pass through the bulb from the separate 3V supply in the lamp itself. Diode D2, connected in parallel with the relay coil, prevents the potentially harmful effect of the high-voltage pulse which occurs when the magnetic field in the relay core collapses on switching off. Further protection is given by diode D1.

Construction

Figure 2 shows the PCB topside component layout. Drill the two mounting holes as indicated, then solder the ic sockets in position. Follow with the relay and the presets noting that RV1 is of the horizontal type while RV2 is mounted vertically. Add all fixed resistors and the capacitors. Note that C2 is of the electrolytic variety and must be connected with the correct polarity - this is clearly marked on the body. Cut the LDR end leads to a length of about 12mm and solder it in position. Bend the leads so that the body projects horizontally (this can be seen in one of the photographs). Solder the diodes and transistor in place taking care over their orientation. Adjust RV2 fully clockwise (as viewed from the IC2 position). This provides minimum timing which will be most convenient for testing purposes. Adjust RV1 by approximately one-third of its total clockwise rotation. This will give a good starting point.

Solder the red wire of the PP3-type snap connector to the "+6V" pad on the PCB and the black wire to the "0V" one. Solder 15cm pieces of light-duty stranded connecting wire to those labelled "lamp".

Lamp modifications

The switch in the lamp must now be removed. Take off the plastic cover and examine the arrangement. The exact details will depend on the lamp being used. However, most types have a cord-operated switch and the parts are easily removed. The wires from the PCB will bridge the switch position so that when the relay contacts "make" the light will operate. However, do not solder the wires in position or replace the plastic cover yet. It may be necessary to substitute the bulb with one of lower current rating but more will be said about this later.

Select a box of sufficient size for the PCB and battery pack. Hold the circuit panel on the base temporarily so that the LDR window is about 10mm from the side of the box. Mark the position of the two holes already drilled in the PCB. Drill these through and attach the PCB temporarily on 12mm long plastic stand-off insulators. Mark the side of the box directly in front of the LDR window. Remove the PCB again and drill this hole with a diameter of 5mm. Now, hold the box on the rear of the lamp housing and think about suitable positions for the two holes which will be used to secure the two sections together. Consider also, the holes already drilled in the base of the box for PCB fixing and which will need to be drilled through into the lamp. When satisfied that these holes will not interfere with anything inside, drill them and attach the box using small nuts and bolts. At the same time, secure the PCB. Drill a further hole in a clear area for the wires leading from the PCB, pass them through into the lamp section and solder them to the original switch position.

Returning to the new section, insert the "AA" cells in their holder and secure it to the base of the box using a small bracket or adhesive pads. Drill a hole of minimum size in the lid directly above RV1 position so that it can be adjusted using a trimming tool or thin screwdriver when the box is assembled. Cover it over with opaque PVC insulating tape.

Insert the ics into their sockets with the correct orientation. Note that they are both CMOS components and, as such, could be damaged by static charge which might exist on the body. It would be wise to remove any such charge by touching an earthed object (such as a water tap) before handling the pins. Finally, insert the batteries in the lamp and replace the top cover.

Testing

Connect the battery snap and attach the lid of the box. Usually, the monostable will begin timing and the lamp will operate for about 11 seconds. Leave the timing as it is for a few days until it has been established that the lamp operates correctly in its chosen position.

Working in normal room lighting, cover the hole with the hand (to represent the door being closed) and wait for about ten seconds (it takes some time for the LDR to rise to its final "dark" resistance, so be patient). Note that the hole must be properly covered - a finger may be unsatisfactory because it could allow sufficient light to pass through it to prevent the LDR reaching its maximum resistance. Uncover the hole (to represent the door opening) and check that the light comes on for a time. Repeat this a few times. Try covering the hole again before the end of the timing cycle - the light should go off. Remember, it may take a second or two to do so. If this test does not work, adjust RV1 and re-try.

If the lamp is fitted with a 0.5A (500mA) bulb of, say, 2.4V rating, as was the case in the prototype unit, it may be found necessary to replace it with one of lower rating especially if the batteries are new. This is because the resistance of a cold filament is much less than a hot one so a much larger current than expected will flow at the instant of switching on. Typically such a bulb will have a cold resistance of some 1 ohm. Taking into account the internal resistance of the cells, the current is likely to reach 1.5A or more for an instant. Since the relay contacts are rated at only 1A, it may be found that they tend to stick together. If this happens (the light remaining on after it should have gone off) then tapping the case will probably part them. It will then be necessary to use a bulb having a lower current rating. A suitable one would be 2.4V or 2.5V at 300mA. The light will be dimmer but the batteries should have a much longer life. In tests on the prototype unit, there was never any tendency for the contacts to stick using such a bulb.

Correct position

When choosing a position for the unit, attention should be given to the following points. The light entering by the opened door should fall directly through the hole in the case and on to the LDR. As little light as possible should reach the LDR from the lamp itself. The fact that the LDR is located some distance behind the hole helps. However, it may be necessary to make a cardboard shield. If the unit is placed near light-coloured objects, sufficient light may be reflected through the hole to prevent the lamp from switching off when the door is closed. For this reason, the unit is best placed in a free area. RV1 may need to be adjusted so that the light goes out under the given "dark" conditions and comes on when there a "normal" amount of light in the room. Clockwise rotation of the wiper increases the sensitivity - this means that the unit will need to be placed in an almost totally dark cupboard but then only a small amount of light will cause it to operate. If it is found impossible to make the light go off on closing the door, remember that it goes off anyway after the preset time.

After a period of use, decide on a suitable "on" time and adjust RV2 accordingly.

PARTS LIST for the Auto Cupboard Light

Resistors

All 0.6W 1 percent metal film.

R1, R2	5M6
R3, R4	220k
R5, R6	1M
R7	10M
R8	47k
LDR1	ORP12 or similar light-dependent resistor

Potentiometers

RV1	4M7 min horizontal preset
RV2	1M min vert. preset

Capacitors

C1	47n min. metallised polyester 5 mm pin spacing
C2	220u 10V radial electrolytic
C3	220n min. metallised polyester 5 mm pin spacing

Semiconductors

IC1	ICL7611 low-power op-amp
IC2	ICM7555 CMOS timer
D1, D2	1N4001 rectifier diode 1A 50V
Q1	ZTX300

Miscellaneous

RLA1 Reed relay with 1A "make" contacts and 500 ohm coil for 6V operation.
Cell holder for 4 AA size cells and alkaline cells to fit.

PCB; 8-pin dil socket (2 off); plastic stand-off insulators; small nuts and bolts; plastic case to fit; suitable cupboard light (see text).

Switched Mode Internal Power Supply

Bob Noyes designed his pet switched mode internal power supply module using the soft start and cool running of the L4960, an alternative to linear power supplies, which can dissipate a lot of heat.

For many years, low power positive regulated internal DC power supplies have been very easy to design and build. The mainstay of the fixed voltage supply has been the 78XX series, which originally had a maximum output of only 1 amp. Several superior versions have since increased this limit several superior versions.

Variable regulated supplies have normally been built around the LM317 or L200 and have dominated the market for years. These linear regulators have many advantages as well as being very reasonably priced and requiring only a few external components. The L200 is more popular than the LM317 because its heatsink is at 0V, so no insulating sets are required.

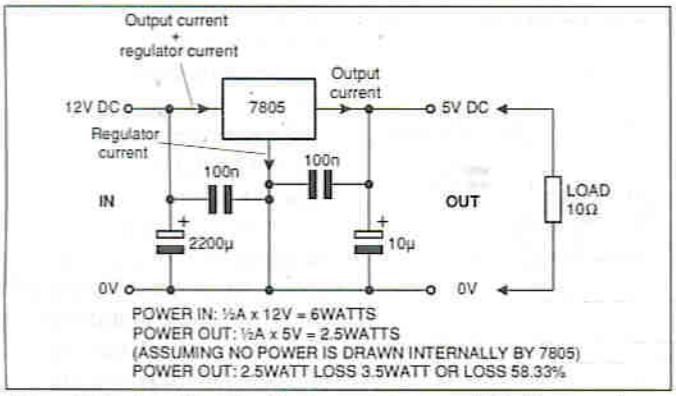


Figure 1: the function of a fixed regulated supply built around a 7805

But as in life in general, there are some disadvantages, mainly the potential losses (pun intended). Under certain conditions, the lower voltage versions, typically the 7805 and 7806, can dissipate more power in the form of heat than they deliver to the load. This is because the input current is always above that of the output, as the regulator requires power to work **(see figure 1)**. The regulator works as a series circuit, that is, all the output current flows through the regulator from the reservoir capacitor. Although this power-loss could be reduced by lowering the input voltage, that could increase the possibility of loss of regulation at higher currents. To overcome this, a much larger reservoir capacitor can be used, but this can drastically increase the cost.

The other problem with such losses is how to get rid of the heat generated as the power loss is turned directly into heat by the regulator. The two main ways of preventing an increase in temperature that may lead to thermal shut down are:

a) To increase the surface area of the heatsink, that is, by using a larger heatsink, or
b) By using a cooling fan.

In some cases the regulator's heatsink can be bolted to the chassis, if it is metal. All this leads to the problem that the power supply is not completely self-contained, and requires either extra heatsinks or a cooling air supply. This can be a problem when testing or setting up the piece of equipment that the supply is installed in.

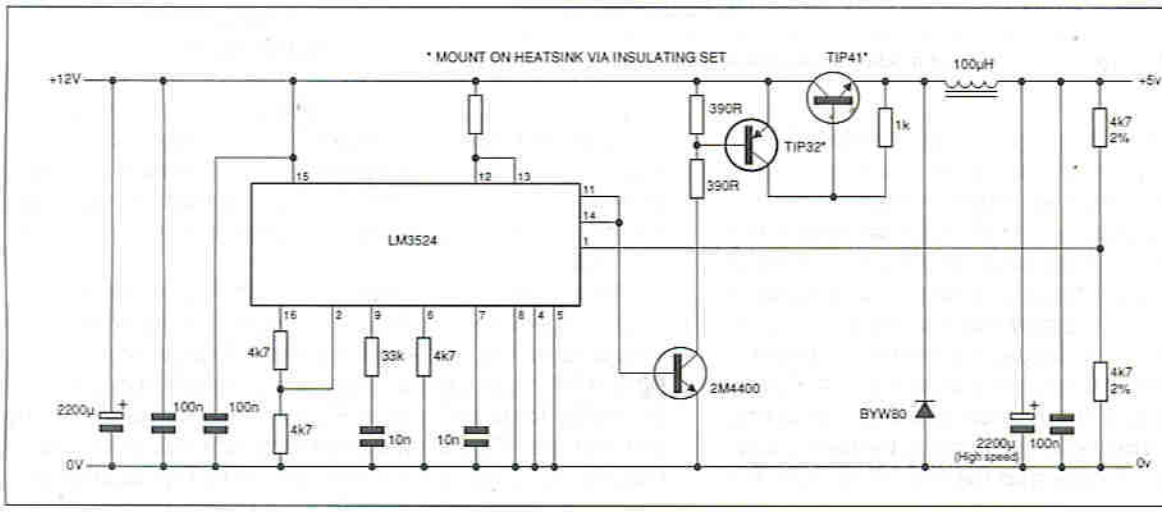


Figure 2: an early switched mode power supply design using an LM3524

Several years ago, another approach to internal power supplies was heralded as the answer to all problems: switched mode regulators. This was a radical change: current was only drawn when required to top up the output voltage. This was achieved by switching the input on and off at very high speeds, 20kHz or so, and by using pulse width modulation (or, to you and me, modifying the size of the pulses). These pulses delivered only the required power for the load; the main losses were in the switching transistor or darlington, and this was only in the switching, as they were either hard on or off and never used in an analogue mode. Although this was outwardly an advantage over the linear supplies, this advantage had a cost penalty.

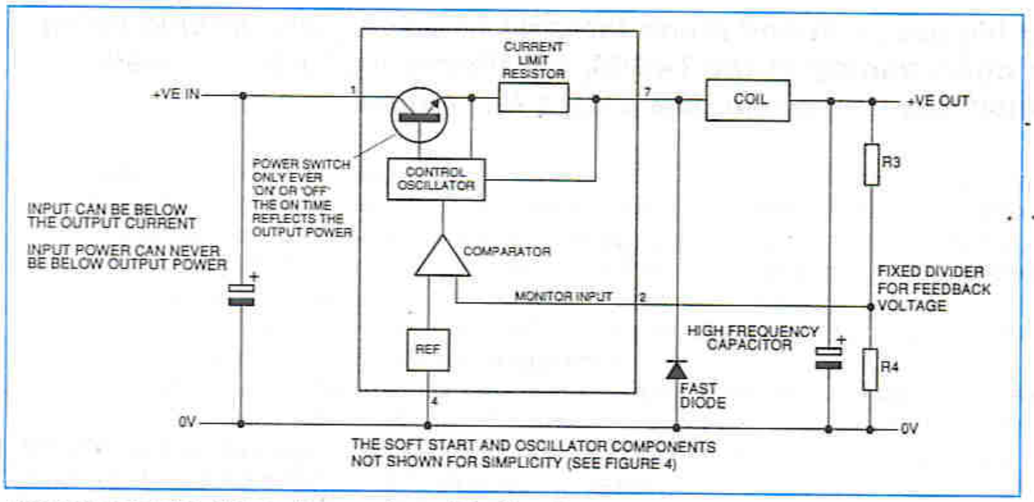


Figure 3: a simplified block diagram of a switched mode regulator

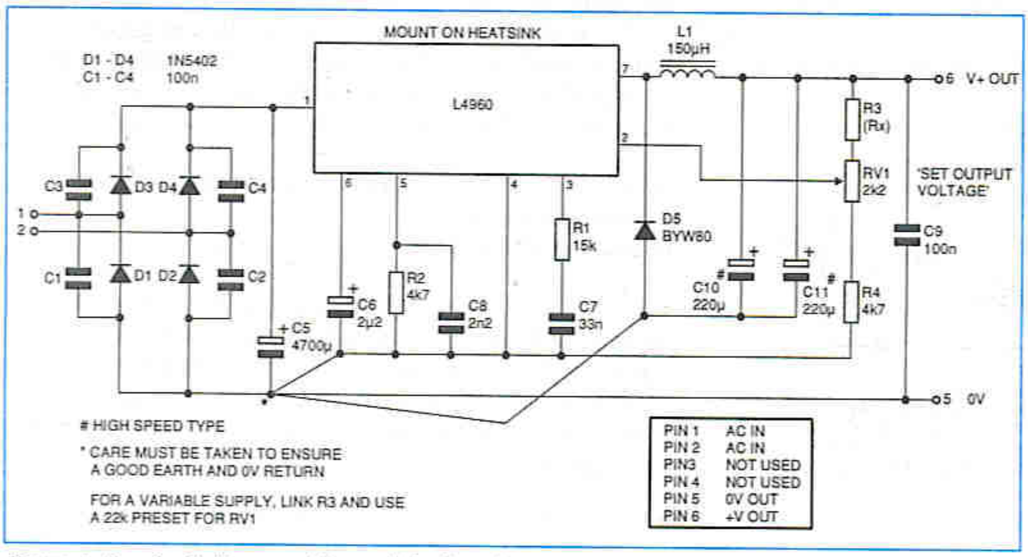


Figure 4: the circuit diagram of the switched mode power module described in this project

Figure 2 shows an early design of switched mode DC supply. The circuit is quite complicated, as well as being far more expensive than its linear equivalent. Another practical disadvantage is that the output transistors or darlingtons, being discrete components, are at rail potential and therefore require an insulating set for mounting. Later switched mode regulators have overcome both of these early disadvantages. A simplified diagram of a switched mode regulator is shown in **figure 3**.

The regulator used in the project module is the L4960 **(see figure 4)**, which is only a little more complicated than its linear equivalent, but can deliver around 2 amps at between 5 and 30 volts with no heatsink other than the one on the PCB. The transformer should be chosen to provide the required output power, plus some extra to account for the losses in the rectifier, the switched mode regulator, etc., and to account for the reduced efficiency of the transformer when driving a rectifier and capacitor load instead of a resistor. It must also supply several volts more than the maximum required output voltage under maximum load.

For most applications, transformer voltages between 12V and 24V will be suitable. If the maximum voltage of which the unit is capable is required, a 30V transformer may be used, but with caution. The dc voltage off load on the smoothing capacitor will be up to 40V (the maximum voltage rating of the regulator ic) with a nominal 30V rms from the transformer. If the 30V rating is an on-load rating, and the regulation is 10 percent, then the off load voltage could be 44V. If the mains voltage is higher than nominal, the dc output voltage can be still higher. Only if the minimum load is guaranteed to drag the dc voltage on the smoothing capacitor down below 40V is it wise to use a 30V transformer.

The heatsink is at 0V, so it can be shared with other power devices if required.

As well as the fairly simple circuit, the cost of the components has been further reduced by increasing the switching speed up at around 100kHz, which reduces the size of the filtering components, saving both space and money.

Several features are built into the L4960. As well as internal current limit at around 2.5 amps, it also has over-temperature shut down at above 100 degrees C, and soft start, that is, the output voltage rises slowly rather than just appearing at full power. All in all the L4960 is a cost-effective switched mode regulator ic that overcomes many of the old disadvantages.

The PCB **(see figure 5)** also contains a diode bridge, D1 to D4, and filtering capacitors Cl to C4. It also allows a wide range of reservoir capacitors, as these come in all sizes from tall and thin to short and dumpy. The short, dumpy ones are the most practical, as they reduce the overall height of the built PCB.

Although the power supply was originally designed as a fixed-voltage unit with a fine adjustment to set the exact voltage rather than use expensive high tolerance resistors for R3 and R4, it can easily be made into a variable supply from 5V to 28V. To do this, replace R3 (Rx) with a link, and removing VR1 from the PCB, replace it with wires attached to a panel-mounted 22k linear pot (the wires should be kept as short as

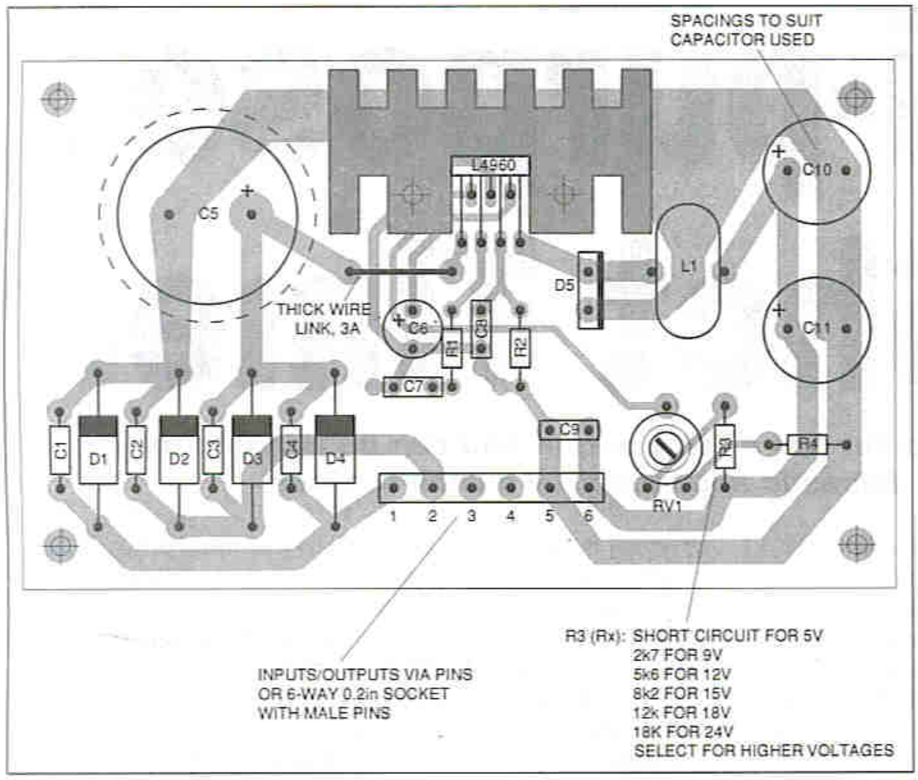


Figure 5: the component layout of the switched mode power module

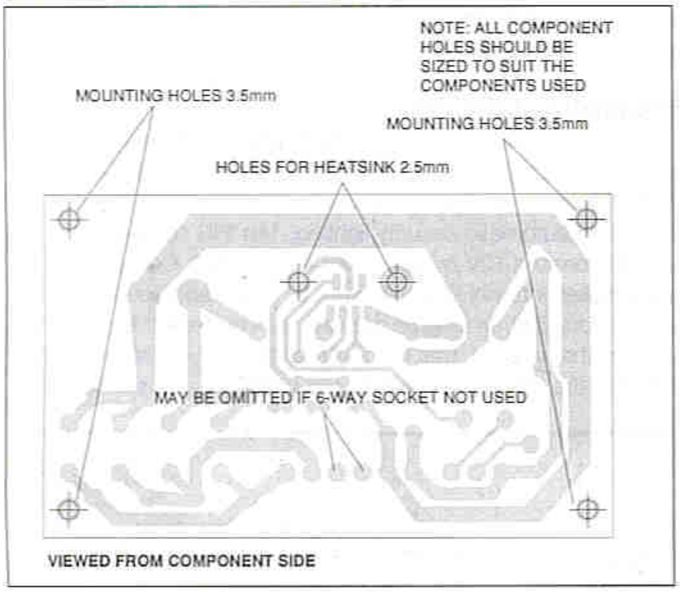


Figure 6: a drilling guide to the PCB supplied for this project

possible). Although many power supplies can give an output down to 1.5 volts or so, it is not often that a supply is required below 5 volts so this limitation should not be a problem.

A drilling guide is given in **figure 6**. Three constructional points are important, especially to those of you unfamiliar with switched mode:

1.D5 is a special fast-recovery diode and must not be substituted by anything other than a direct equivalent. The Maplin part number is given in the parts list.

2.The output filter capacitors are 220uF, 50 volt. At first glance C10 and C11 are across each other, indicating that one 470uF would do. Although the circuit would still operate, the filtering would not be as good as with two 220uF capacitors. These should be high frequency types rather than general purpose; these are a little more expensive, but they do perform better. Again, the Maplin part number is given in the parts list.

3. The output inductor L1 is a l50uH coil wound on a circle of iron dust. It should be capable of at least 3A, and normally comes as a loose-wound component, that is, the output leads are not fixed but just hang from the base of the inductor. The connections should be cut to length to go through the PCB and the enamel removed from the portion of the wire so that it can soldered. A good mechanical as well as a good electrical joint is required. A blob of glue-gun glue under the inductor will help hold it in position. Otherwise, being a heavy component, strain can be placed on the leads if care is not taken. Again the Maplin part number is given in the parts list.

Several of these power supplies have been built and are performing well in all sorts of equipment.

This is a mains project. Mains can be lethal. Seek assistance somebody with mains construction experience if you do not have that experience yourself.

PARTS LIST for the Switched Mode Power Supply Module

Resistors

R1	15k
R2, R4	4k7
R3 (Rx)	See text
VR1	2k2 horizonal

Capacitors

C1 to C4, C9	100n 50V disc
*C5	4700u 63V radial
C6	2u2 6V radial
C7	33n 100V radial
C8	2n2 100V mylar
C10, C11 (Maplin JLSIF)	220u 50V radial switched mode

Semiconductors

IC1	L4960 (Maplin UK64U)
L1	150uH 3 amp (Maplin JL72P)
D5	DYW80 (UK63T)
Heatsink	Electromail 263251

Variable supply

External pot	22k linear (see text)

Maplin: PO Box 3, Rayleigh, Essex SS6 8L. Tel 01702 554161.

Electromail: PO Box 33, Corby, Northants NN17 9EL. Tel 01536 405555.

Multi-purpose One-Shot Timer

This timed switch by Tim Parker has a relay output and can be adapted for use with a variety of domestic and industrial switch sources.

If you have a floodlight fitted outside your house, how many times have you turned it on in the dark just to nip down the garden and back, only to realise hours later that you forgot to switch it off when you returned? Or, the kids (or yourself) have fallen asleep, leaving on the light, TV, video, hi-fi or computer (in fact, probably all of them). On a short term basis, this might not be much of a problem with individual pieces of equipment, but when you add up the power consumption of these, together with the non-essential use of other electrical items, you could quite easily reach 1kW of power. Multiply this over a period of days, weeks, months, even years in some cases, and this represents quite a substantial waste of energy, not to mention an unnecessary, yet avoidable, increase in the electricity bill.

The timer described here could be used not only to overcome these domestic situations, but also to provide energy saving lighting in public and private access areas, where the lighting does not need to be left on at all times. Common areas within a block of flats, for example, where all the residents need lighting in order to find their way around the various corridors and stairways, but only for as long as it takes to reach their own private residence and turn on their own lighting. Yet, invariably these common areas remain illuminated during all the hours of darkness. In fact, when you look around these and similar premises, you might notice many have electric lights switched on 24 hours a day, 365 days a year. On a national scale, this represents a colossal waste of energy.

What is needed is a timer that you can switch on and forget about, safe in the knowledge that it will turn itself off after a predetermined period, which can be set by the user to suit different applications. This is the intention of this project, with the added advantage that it will trigger from rocker switches, standard domestic light switches, pushbuttons, burglar alarm accessories, and external signals from remote equipment.

Automatic lighting

Apart from the obvious timing function, this project represents the only interface you need between a standard passive infra red (PIR) detector and your existing floodlight, in order to convert it to automatic security lighting. The PIR can be powered from the 12V output of the timer board. Contrary to popular belief, internal PIRs will work at close range perfectly well outdoors, just so long as they are well protected from the elements (the weather, that is). The real benefit here is that you can locate the detector remote to the floodlight, you are no

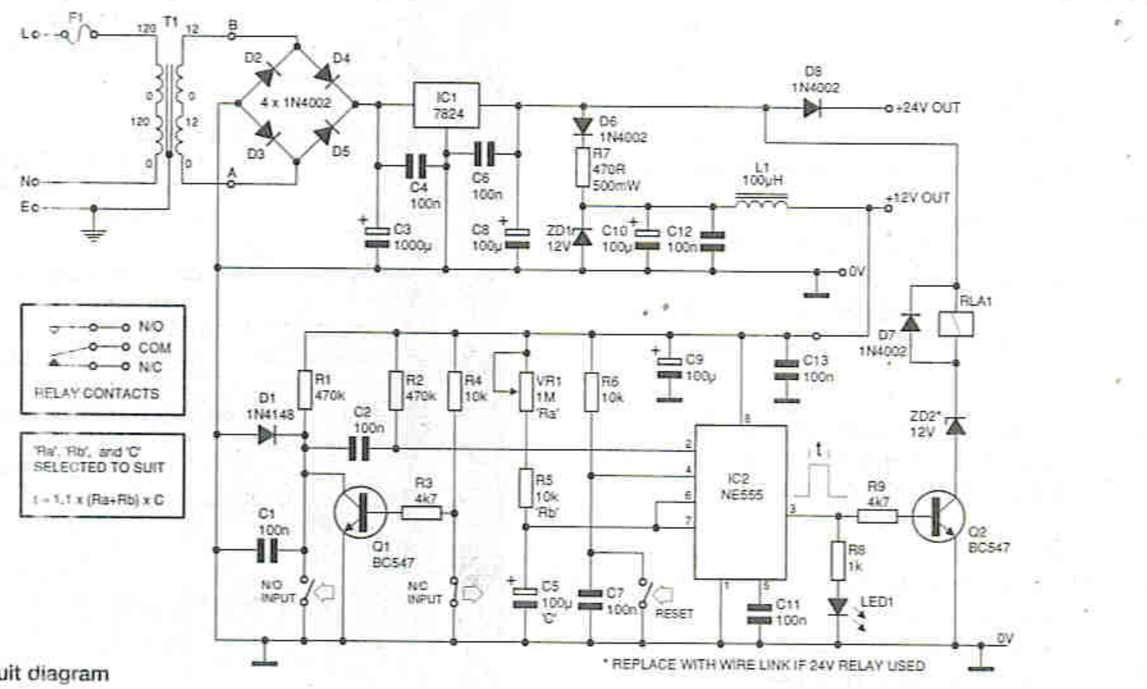


Figure 1: the circuit diagram

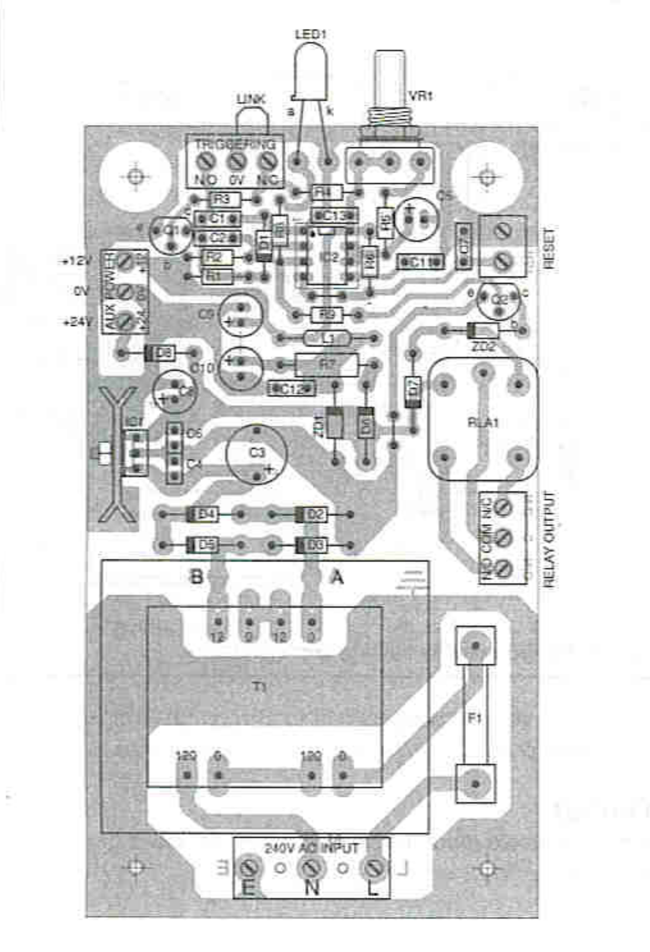


Figure 2: the component layout

longer restricted to lighting only the area of detection, as you are with commercial units, which have the detector head mounted directly underneath the floodlight. This is most useful when you need to detect a person or vehicle approaching the front of the house, but need to illuminate (say) the side of the house, where the entrance door might be, for instance.

The circuit

Figure 1 shows the complete circuit diagram for the one-shot timer. Although the initial concept was designed for domestic purposes, and can therefore be powered from the 240V AC (UK) mains supply, it was thought beneficial to expand on the design, by making it suitable for industrial applications too. Because of this, the low voltage side of the circuit as shown is intended to operate from 24 volts AC or DC, since the majority of industrial control gear is run at this level. However, the design has been made as flexible as possible, by allowing component changes for operation from 12 volts too. This will be of interest to those who want to site the timer externally, but will then need to power it from safe low voltages. This makes it suitable for automotive applications. Details on modifications for various operating voltages are given later.

The circuit is based around our 'old faithful' 555 timer ic - IC2, operating in monostable mode. The general operation of IC2 is such that if pin 4 (reset) is high, a low going pulse on pin 2 (trigger) will initialise the timer and set pin 3 (output) high. Pin 7 (discharge), which is normally held low, goes to a high impedance state, releasing the 0V clamp on C5, which in turn begins to charge up at a rate set by VR1 and R5. When the rising voltage across C5 reaches two thirds of the supply voltage, this is detected on pin 6 (threshold) of IC2 and the 555 resets, taking pin 3 low again. At the same time, pin 7 also goes low to discharge the voltage on C5 and holds it at 0V once more, ready for the next trigger pulse on pin 2.

Once triggered, IC2 will complete one full timing period, irrespective of any further low going pulses applied to pin 2. However, the timing period can be aborted at any time by applying a low going pulse to pin 4 (reset), which is normally held high by R6.

Triggering inputs

The circuit is designed to be triggered from a wide range of input signals, including normally open switches, normally closed switches, open collector transistors, negative hold-off circuits and so on. The latter of these signals are found on such equipment as burglar alarms, and usually take the form of either a normally closed relay contact which is held at 0V until the alarm is activated, or an open collector transistor which is kept turned on until the alarm is activated. In either case, the result is a normally low signal, which goes high or 'floats' once the burglar alarm has been triggered.

All input signals to IC2 are AC coupled via C2, which allows

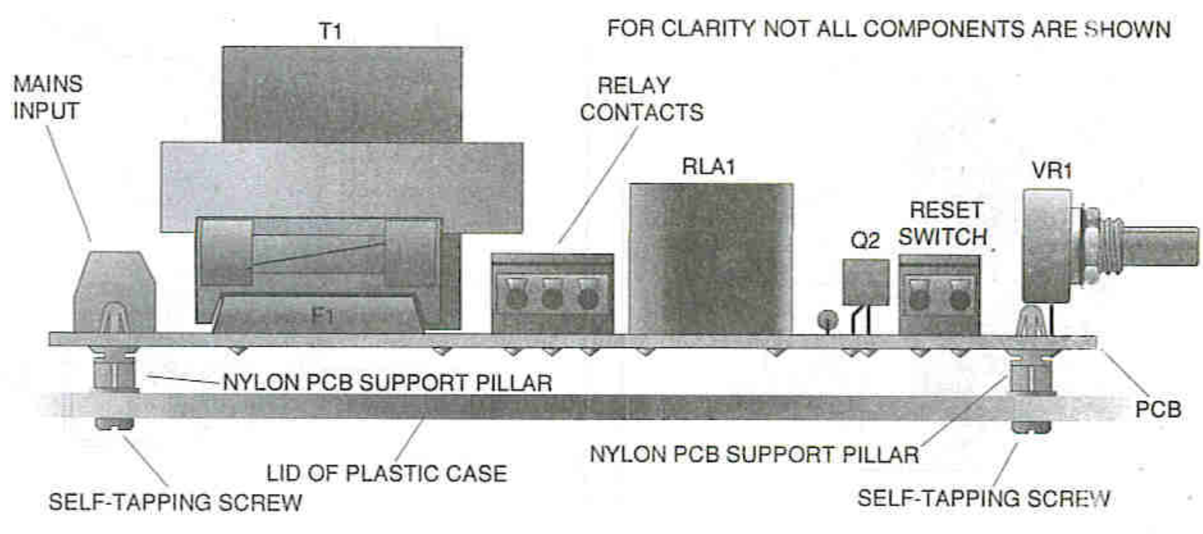


Figure 3: how to secure the PCB to the lid of the plastic enclosure

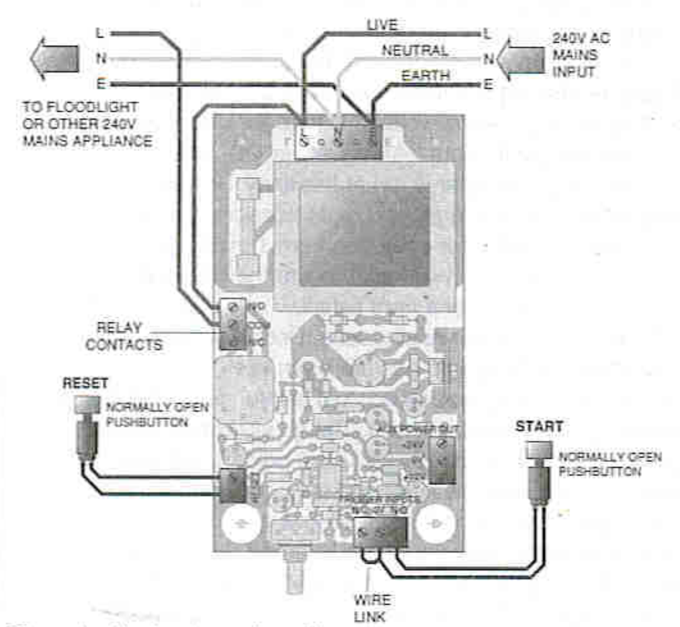


Figure 4a: the basic configuration

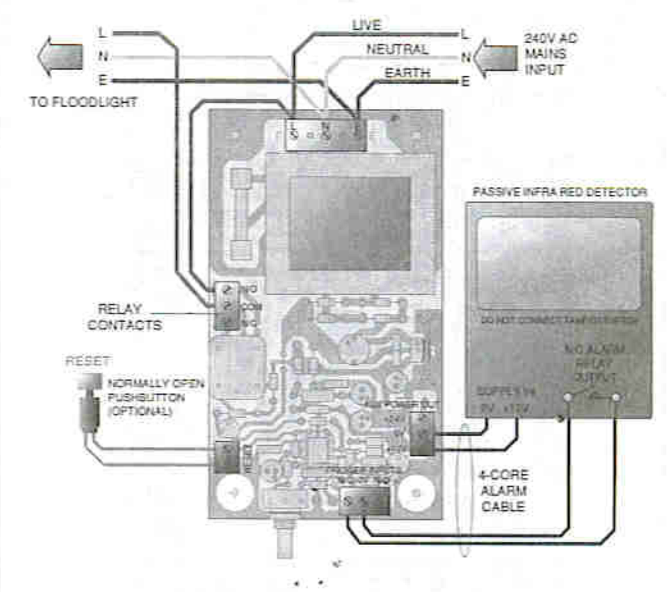


Figure 4b: PIR security lighting configuration

only brief low going pulses to reach the trigger pin (2) of IC2, no matter how long the duration of the signal on the actual PCB input terminals. This ensures that if the triggering signal is still active at the end of the timing period, the timer will always reset, and cannot be re-triggered until the input changes state, which means that rocker switches and domestic light switches can be used for triggering. In this case, the switch can be turned on as normal, then left in that position indefinitely, the timer will still shut off at the end of the timing period, and can only be started again by turning the switch off, and then back on again.

To prevent erratic triggering, C1 is used to filter out excess input noise and de-bounce the input signals when switch contacts are used, and D1 protects against negative pulses getting to IC2, which also cause erratic operation. When a normally open switch is used, this connects directly to C2 and pulls the left hand side of this capacitor to 0V when the contacts close. If a normally closed switch is used, this shorts out the base drive current for Q1 (obtained via R4) to 0V, thereby keeping the transistor turned off. When the switch opens, R4 provides base current to turn on Q1, the collector of which then pulls C2 low, and so triggering the timer.

Timing

The monostable mode timing period for the 555 is given from the formula;

$t = 1.1\ RC$

where 't' is the resulting time period gained from the formula, 'R' is the value of the timing resistor - in our case this is the value of R5 plus the setting of VR1, and 'C' is the value of the timing capacitor, here C5. The values of all three of these components can be modified to achieve timing periods best suited to your own application.

The 555 timer IC boasts accurate time periods from microseconds to hours, but not without changing the component values, mind you. On a personal note, I have, over the years, experienced strange phenomena with 555 timers; there are so many types available, from so many different manufacturers, that I have yet to find two devices which

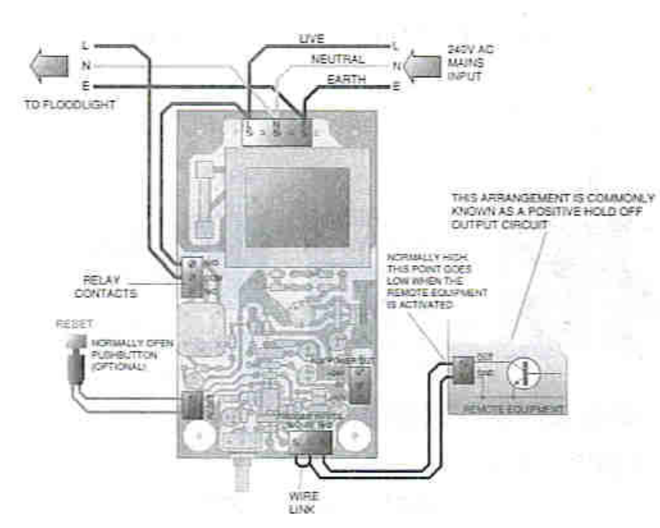


Figure 4c: remote negative triggering

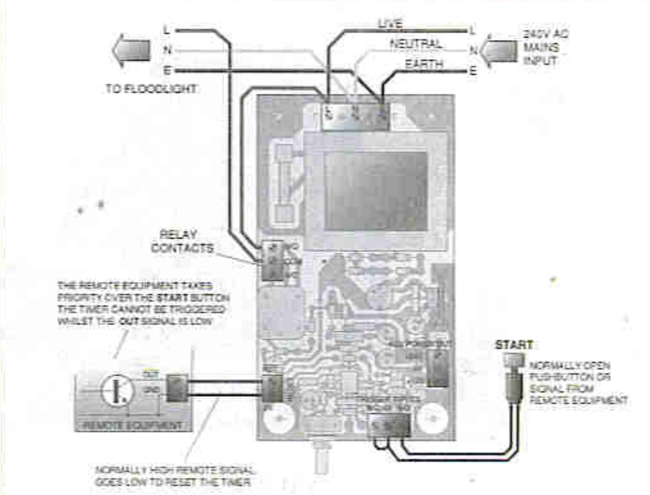


Figure 4e: resetting from remote equipment

actually produce the same timing periods using the same component values, which has left me with little faith in the above formula, so don't be surprised if the timing period you end up with is nothing like, or anywhere near the value gained from the formula!

Relay driver

When timing is initiated, pin 3 of IC2 goes high, this lights LED1 via R8 to provide a 'live output' indicator when the relay is energised, and Q2 is turned on via R9. Q2 is a standard open collector transistor switch, used to energise the relay - RLA1. Because the circuit is operating at 24 volts, zener diode ZD2 is connected in series with the relay to drop the voltage across the relay to around 12 volts. This enables constructors to use the more readily available 12V DC relays, which they are more likely to have at hand. Industrial workshops are more likely to carry stocks of 24V relays. If one of these is used instead, then ZD2 should be replaced on the PCB with a wire link to allow the full 24 volts across RLA1. Diode D7 protects against back emf produced by the relay coil when it de-energises.

Power supply

The 24V AC from the transformer - T1 is fed to a bridge rectifier made up of D2 to D5, and the rough DC is smoothed by C3. IC1 regulates the overall supply to 24V DC, and this is made available via screw terminals mounted on the PCB. Actually, there is about 23.4V DC available once it's passed through D8. This diode has been included to prevent external devices feeding voltage back onto the supply line of the timer board. The regulated 24V from IC1 is also passed, via D6 and R7, to ZD1, which drops the voltage to 12V DC, and is used to power the timer circuit. This supply is also passed to a PCB terminal for powering low current external devices, such as a couple of passive infra red detectors, for instance. But don't draw much more than about 100mA from this line, otherwise things will start getting a bit too hot!
The 555 timer is notoriously poor at rejecting noise on its supply rails, which can, and has been known to cause it to trigger for no apparent reason. To minimize this happening, L1 is incorporated into the 12V supply rail, with plenty of supply decoupling via C9, C10, C12 and C13. Indeed, the prototype timer has been tested under regular triggering conditions in an industrial environment, with quite satisfactory results.

Construction

When building up the PCB, always keep in mind the fact that this is a mains powered project, with virtually everything mounted on one PCB. Therefore, the mains voltage will appear at various points, and the utmost care and attention must be taken during the construction process to ensure all the components are firmly in place, and that all solder joints are clean and solid. If you have any doubts about building mains powered projects then ask a competent person to assist you.
Follow the PCB layout of figure 2, soldering components in a low-to-high profile order. Take care with polarised components - diodes, transistors, electrolytic capacitors etc. Don't overlook the two wire links, one above IC1, the other close to D7. Mount R7, ZD1 and L1 proud of the board by 5mm, this will allow a better air flow around them, since these are the most likely components to get warm under load. To fit IC1 correctly, first bolt it loosely to the heatsink, then insert all five pins into the board at the same time (two on the heatsink, three on IC1). Solder the heatsink first, ensuring it is level and flush to the board, then solder IC1. Finally, tighten the nut and bolt to secure them together.
You must ensure the relay, transformer, fuseholder and mains input terminals are completely flush to the PCB. Once the fuse is installed, a protective cover MUST be fitted to prevent access to the live parts. When mounting the transformer, solder two diagonal pins first, applying firm pressure to keep the whole body evenly in contact with the PCB, the remaining pins can then be soldered.
The potentiometer - VR1 - and warning indicator - LED1 - are shown soldered to the edge of the board. If you prefer, either or both of these can be mounted off-board and connected via twisted pairs of 7/0.2 wires. If only a fixed time period will ever be used, then VR1 can be removed from the PCB and a fixed value resistor soldered in it's place across the two outer PCB holes where VR1 once was.

This is a mains project. If you do not have suitable mains construction experience, seek the assistance of a constructor who has that experience.

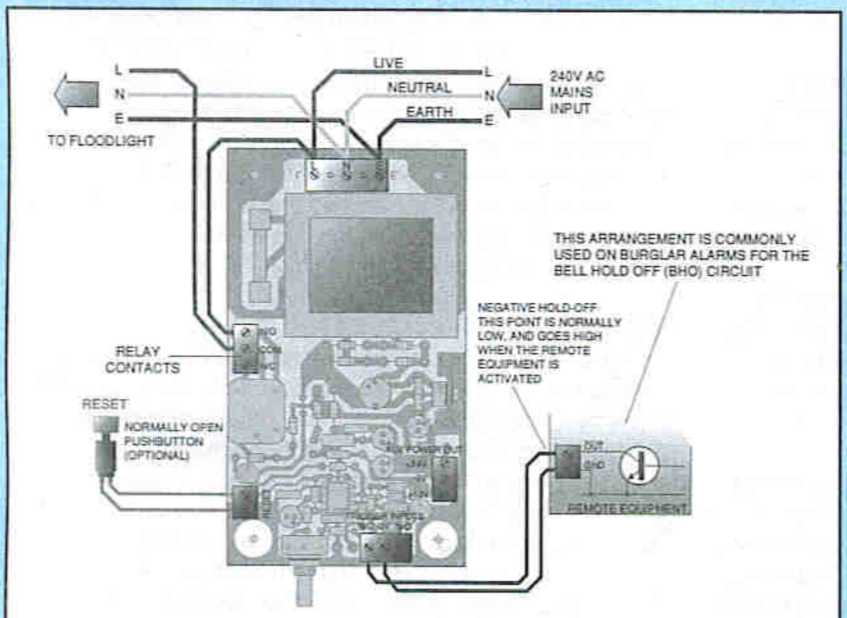


Figure 4d: remote positive triggering

Insulated enclosure

For safety reasons the finished PCB MUST be housed securely inside a suitable, insulated enclosure. The prototype was housed in a plastic case measuring approximately 160 x 100mm, with a depth of around 55mm. To make fixing the PCB easier, it can be mounted on the inside of the case lid, as shown in figure 3, rather than having to struggle with it at the bottom of the case. This method enables you to hold the nylon pillars with pliers, preventing them spinning while tightening up the self-tapping screws. This would be almost impossible if the PCB were to be mounted inside the case, since you wouldn't have access to the body of the pillars to hold them still, so nuts, bolts and clearance pillars would have to be used. The method shown in figure 3 is by far the easiest. Also, if the case is to be mounted on a wall, this allows full access to the whole back of the case, without being hindered by the PCB.

Testing

Once the PCB is fitted to the lid of the enclosure it can be tested. DO NOT carry out any testing until the PCB is fitted as mentioned, and when you are testing it, keep your hands well clear of all the mains wiring and the live parts of the board. Even though it should be difficult to touch any live parts, this doesn't mean you can't. Be warned!

Insert a short wire link across the N/C and 0V trigger input terminals (near the LED). If you are not intending to use normally closed or negative hold-off triggering, this link should remain in place after testing is complete, otherwise it will disable the N/O input too. For the time being don't connect anything to the relay contact terminals. Set VR1 fully anti-clockwise (minimum delay) and apply 240V AC to the mains input terminals. When first powered, the board may initiate the timing period - the relay clicks in and the LED lights up. If so, wait a short while and it should reset. If it doesn't reset within 5 seconds, short together the two reset terminals, the relay should drop out and the LED go off. But, if they come back on again when you remove the reset signal, then you've got something wrong, so switch off immediately and check the board for faults.

With the timer in its reset state, briefly short together the N/O and 0V trigger inputs. The timer should run for about 1 second or so, and then reset. Adjust VR1 and repeat the above step to check that different time periods are obtained. With the values shown, the maximum delay should be around 2 minutes (according to the formula).

Connections

You will notice that all terminations that could potentially have mains voltages connected to them - including the relay contact terminals - are kept well away from the low voltage and input terminals. When you attach your input devices make sure you follow this convention, by not allowing the low voltage wiring anywhere near, or to even cross over the mains wiring. Figure 4a shows the basic configuration for connecting the timer to a floodlight or other mains appliance, using pushbuttons for triggering. When the START button is pressed the relay energises and the timing begins. Pressing the RESET button during the timing period overrides and resets the timer.

Security lighting

By the addition of a standard, low voltage passive infra red (PIR) detector, the type used on domestic burglar alarms, the one-shot timer can be used to convert your existing floodlight into security lighting, whereby the light is triggered by the detection of a moving heat source - people, animals, vehicles etc. Figure 4b shows how this can be achieved. The PIR detector can be wired with standard four-core 7/0.2 alarm cable. Although four connections are shown, only three of them are actually required, as the 0V could be taken from either the AUX power output or the triggering input connector.

For lighting purposes the tamper switch wouldn't normally be used, and can be ignored, but if you want to make use of it, then connect it in series with the alarm relay output. In this way (for what it's worth!), if any attempt is made to remove the cover of the PIR detector, this would trigger the one-shot timer in the same way as normal detection.

When using standard PIRs outdoors, ensure they are protected against direct sunlight, excess frost, driving rain etc. It's also a good idea to drill a small hole in both the top and bottom of the detector to allow any water to flow out. A hole is required in the top to let air in, otherwise you might as well not bother with either. Take my word for it.

VOLTAGE	MODIFICATIONS REQUIRED AND FURTHER NOTES
12V AC TO 15V AC	1 REMOVE T1 2 REMOVE ZD1 3 REPLACE R7 WITH WIRE LINK 4 REPLACE ZD2 WITH A WIRELINK (NOT ZD1) 5 REPLACE IC1 WITH 7812 - 12V REGULATOR 6 ENSURE RLA1 IS 12V (NOT 24V) 7 CONNECT THE SUPPLY EITHER WAY ROUND TO 'A' AND 'B' *NOTES: BOTH THE 12V AND 24V AUX POWER OUT TERMINALS WILL NOW HAVE ABOUT 11.4V AVAILABLE*
9V DC TO 15V DC	1 REMOVE T1 2 REMOVE ZD1 3 REPLACE R7 WITH WIRE LINK 4 REPLACE ZD2 WITH A WIRELINK (NOT ZD1) 5 REPLACE IC1 WITH WIRE LINK ACROS THE TWO OUTER PCB HOLES 6 ENSURE RLA1 IS 12V (NOT 24V) 7 CONNECT THE SUPPLY EITHER WAY ROUND TO 'A' AND 'B' *NOTES: BOTH THE 12V AND 24V AUX POWER OUT TERMINALS WILL NOW HAVE ABOUT 10.8V AVAILABLE*
24V AC	1 REMOVE T1 2 CONNECT THE SUPPLY EITHER WAY ROUND TO 'A' AND 'B' *NOTES: ALL CONDITIONS REMAIN THE SAME AS PRESENTED IN THE ARTICLE. SEE TEXT ABOUT ZD2*

Table 1: modifications required to operate the timer from different supply voltages

Positive and negative hold-off

The one-shot timer can be triggered from other pieces of remote equipment, so long as there is a suitable signal available from that equipment, either in the form of a set of relay contacts or the collector of a transistor. A common requirement of the timer might be to incorporate it with an existing burglar alarm. Figures 4c and 4d illustrate how to connect two of the most common forms of outputs from these. Positive hold-off is perhaps less common than negative hold-off. Nevertheless, figure 4c shows how to make use of a signal which is normally high, but goes low when the alarm is activated. Figure 4d, on the other hand, shows how to make use of negative hold-off outputs. On burglar alarm panels, this will probably be marked as 'BHO', which is an abbreviation of 'Bell Hold Off'. In either case, this signal could be active high (negative hold-off) or active low (positive hold-off), and it's usually a case of trial and error to find which connection works the best.

Remote resetting

As with the triggering signals, the one-shot timer can also be reset by an active low signal from remote equipment, and figure 4e demonstrates how to achieve this. In all cases, the reset input to the timer board takes priority over the trigger inputs. If the reset input is held low, the timer cannot be triggered by any number of pulses to the trigger terminals. This provides an override or lockout facility, allowing the timer to be disabled by the user. A word of warning; no matter what purpose the one-shot timer is used for, DO NOT rely on the reset input to disable the switched mains output. ALWAYS turn off the mains supply completely when working on the live or switched live components of the timer.

Modifications

As mentioned earlier, the one-shot timer can be modified to operate from various voltages other than the standard 240V presented. Close to the transformer output terminals are two points marked 'A' and 'B', which are also marked next to a couple of pads on the underside of the PCB. These two points are actually the input connections to the bridge rectifier from the low voltage side of the transformer, where other low voltages can be applied after first removing the transformer. Table 1 gives details of the modification required for these options.

PARTS LIST for the One-Shot Timer

Resistors
(All 0.25W unless otherwise stated)

R1, 2	470k
R3, 9	4k7
R4, 5, 6	10k
R7	470R/0.5W or 1.0W
R8	1k
VR1	1M0 PCB mounting potentiometer

Capacitors

C1, 2, 4, 6, 7, 11, 12, 13	100nF/50V ceramic or polyester
C3	1000uF/35V radial electro
C5, 8, 9, 10	100uF/35V radial electro

Semiconductors

D1	1N4148
D2 - D8	1N4002
IC1	7824 +24V regulator
IC2	NE555 timer
LED1	5mm red LED
Q1, 2	BC547B NPN transistor
ZD1, 2	BZX85C12 12V/1.3W Zener diode

Miscellaneous

L1	100uH axial inductor
RLA1	12V/400R SPST relay with 240V/5A contacts
T1	0-12-0-12/6VA PCB mounting transformer
F1	20mm/500mA fuse
Fuseholder	20mm PCB mounting fuseholder
Cover	Plastic cover to suit above
Heatsink	PCB mounting TO220 heatsink for IC1
Terminal	2-way 5mm PCB terminal
Terminals	3-way 5mm PCB terminals
Terminal	3-way 10mm PCB terminal
Switches	Single pole normally open momentary switches
Wire	7/0.2 connecting wire for switches
Case	160 x 100 x 55mm plastic enclosure
Pillars	Locking nylon PCB support pillars
Screws	Self tapping screws for above
PCB	"DTE One Shot" PCB (see below)

A complete kit of parts which includes the case, PCB, switches and everything else listed above 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 £24.50
The PCB is also available separately at £8.50. (It is included in the kit).
Please add postage & packing to the total order value (per order): £2.00 for the UK, £ 5.50 elsewhere.

Please make Cheques/Postal Orders payable to 'DTE Micorsystems'. 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.

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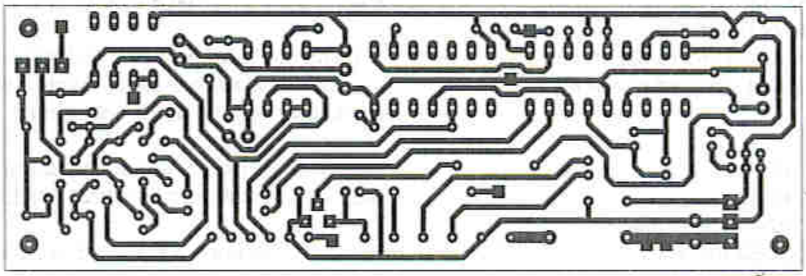

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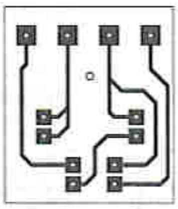

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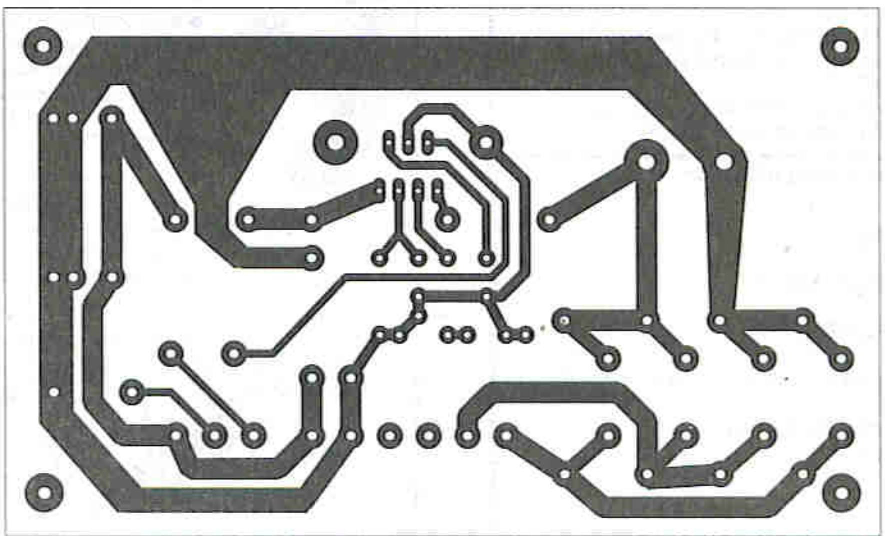

Swithed Mode Internal Power Supply

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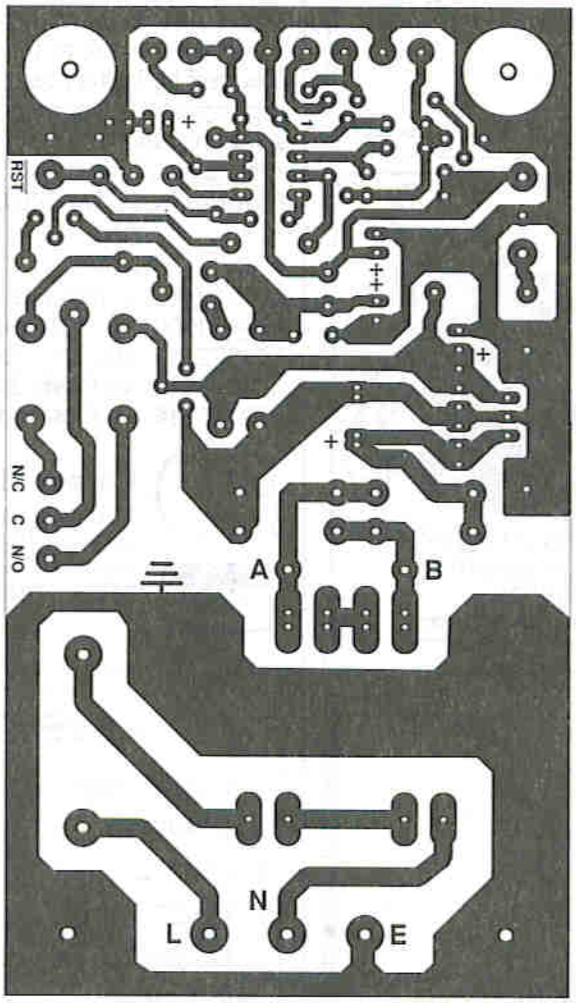
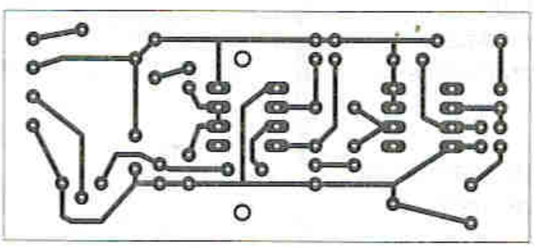


One Shot Timer



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Practically Speaking

BY TERRY BALBIRNIE

In this issue we shall look at how a number of resistors or capacitors can be combined to give the value you need

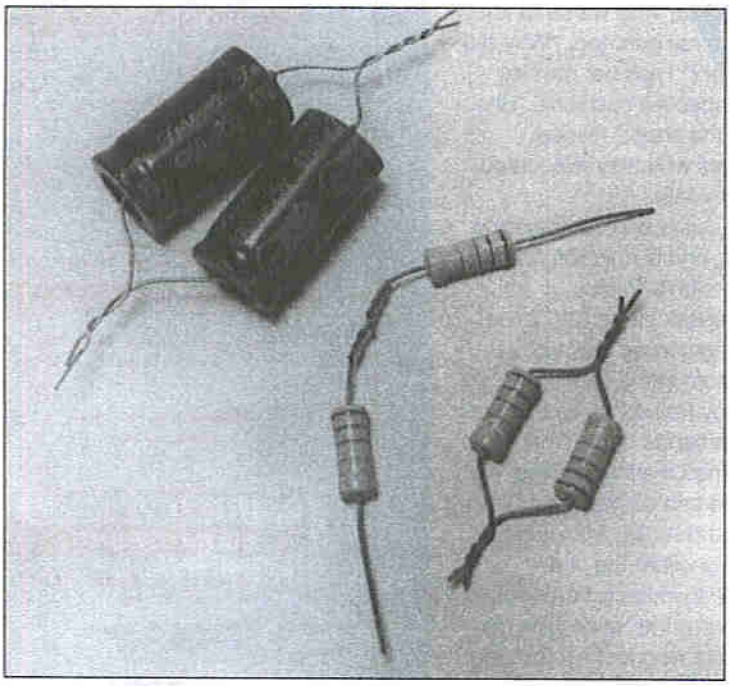

Figure 1: from left to right: capacitors in parallel; resistors in series; resistors in parallel

It is easy to connect two or more resistors in series to obtain a value you can't buy "off the shelf". The individual values are simply added together. This technique is also handy for making up a near-correct value using odd resistors that happen to be lying around, possibly for an experimental design. Whatever the tolerance of the individual resistors, the combined result will be the same. For example, if you needed a resistor having a value of 650 ohms with a tolerance of 1 percent, you could make it up by connecting a 620 ohm 1 percent unit in series with a 30 ohm 1 percent one.

Capacitors in parallel

To obtain a similar result for capacitors, you would connect them in parallel rather than in series. Imagine two capacitors connected in parallel, one having a value of 220nF and the other 330nF. The result is one of a single capacitor having a value of 550nF. As with resistors, the tolerance of the combination will be the same as that of the individual capacitors.

Capacitors have a certain voltage rating. This may be marked on the body or obtained from the supplier's data. In amateur circuits, it is usually the electrolytic capacitors and tantalum bead types that need special care to make sure this rating is not exceeded. Most other types of capacitor have a voltage rating higher than the output voltage of the power supply that is likely to be used. Suppose a 220?F capacitor is found in the junk box but it has a rating of only 6V. If this is used in a circuit where 10V will exist across it, the result could be an explosion of the case either now or sometime in the future. Where capacitors are combined in parallel, it is important to remember that the voltage rating of the pair will only be that of the lower one.

Example

Capacitor A has a value of 1000uF and a voltage rating of 10V. Capacitor B has a value of 470uF and a voltage rating of 16V. If these capacitors were connected in parallel, the combined result would be one of a single capacitor having a value of 1470uF. The voltage rating would be that of the lower one - that is, 10V.

Resistors in parallel

If resistors are connected in parallel, the result will be that of a single resistor having a value less than either one. This is worked out as follows: if R is the combined result and R1 and R2 are the individual values, then:

$1/R = 1/R1 + 1/R2$

Suppose R1 = 220 ohms and R2 = 330 ohms

Calculate 1 divided by R1:	0.0045
Calculate 1 divided by R2:	0.0030
Add the results together:	0.0075
Calculate 1 divided by this:	133 ohms

This method may be extended to any number of resistors.

Those who are used to the "1/x" and memory keys on their calculator will be able to do this very quickly.

Quick method

There is another way which may be easier to remember. Although it is applicable to two resistors only, for most purposes this will be sufficient. To find the combined result of two resistors connected in parallel, divide their product by their sum. The sum means adding them together, the product means multiplying them. The sum is then 550 and the product 72600. The result is 72600 divided by 550 giving 132 ohms. Due to slight approximations in working out the decimals in the first method, the result is not precisely the same. However, for all practical purposes, it is near enough.

There is a particular case which is very useful. If two resistors of equal value are connected parallel, the effect is that of a single resistor having half the resistance. For example, two 500 ohm resistors connected parallel, give the effect of a single 250 unit.

Capacitors connected in series follow the same formula as that for resistors in parallel. However, this is very rarely used outside industry.

Around the Corner

Via the inverse magical process by which magazines get made, "time of writing" is a few hours after Christmas. Remember Christmas? Chap in a bright red overcoat with fluffy edges? That Christmas. The great thing about the few hours after Christmas is that they are terribly quiet.

For instance, no cyberpets. Not a single cyberpet in sight - or earshot. Those of you who have examined the little varmints in a spirit of detached scientific interest may be wondering: noise? What noise? Those who have studied the things in their natural habitat, however, will know what I mean.

"Letme!Letme!Letme!LemmelemmeLEMME!" "NO! You'll kill him." "Iwannnngo!" "Go and play with your ray gun!" "WANNCYBERPET!" "MUMMYstop her! She's eating him!" The cyberpet belongs to the eldest, who shows no signs of traumatic bereavement when it "dies", but just holds it above her head (out of reach of 3rd and 4th) and re-starts it with another cyber-biscuit. Three of her mother's friends look after cyberpets for their offspring while the little dears are at school. Someone should stock up with 20-kilo sacks of batteries ("Chummie batteries for happy gadgets"), start a cyber-kennel and rake in the cash from grateful parents.

If only the dear little girls would play with their dollies, you must be thinking. Think again. The chap in the red overcoat has brought the 3rd and 4th two lovely, golden-haired, identical dollies. Under-fives reckon that whatever is nearest to them is theirs, which means that bed-time for dolly resembles the Little-Sinking-in-the-Marsh Blacksmiths' Guild Annual Resentment Tug o'War Match (best of three). But once again, technology has the answer - out comes the ray gun. Its rightlful owner, 3rd, with a manic gleam in her eye, points it at 4th and pulls the trigger.

BLAMBLAMBLAM!! WOWOWOWOWOWWW! AWOOGAH! AWOOGAH! BEEPBEEPBEEPBEEEEP!!! Yes, it has four separate sound effects. Adults dive for cover under anything with a heavy cushion on it. The only parties unscathed are 4th, who bellows happily "Iwannnngo!" and 2nd, who wants to know why he didn't get a ray gun, too. "Why did you buy that for her?" I ask her mother, from under our respective cushions. "She was enjoying it in the shop," mimes Mother. So that was why they evacuated the city centre last week.

2nd, of course, has been campaigning for an Action Man, and is now the proud possessor of Man with a Radio Microphone: you speak into a little voice recorder, pull the right lever, and Action Man in the next room starts barking orders at your betters. Boy Power! At least, it was until eldest got her hands on it. Think about it: a fully armed marine, chiding like an elder sister. She can cackle like a kookaburra-bird, and Action Man is small enough to follow us under the sofa.

We can't blame the kids for everything. It was Father who put the Spice Girls on the CD player, Uncle who lost his mobile phone in the wrapping paper (uproar!), Mum-in-law trying out her new programmable alarm clock with extra-loud alarm, Mother who put Gladiators on the telly (family favourite) and the turkey who set off the smoke alarm.

"Who buys all this noisy stuff for children?" asked Aunty. It's a mystery of nature that the chief culprits are the parents. Mother seems to be having a go on the cyberpet, and father is in a vigorous debate with a colleague about batteries.

"Did your mum ever give you anything noisy?" I asked Mr. Armstrong. "We didn't even have a telly", he said, not looking up from 2nd's computer game. Perhaps that's why he built a crystal set when he was eight, and these cyber-kids will probably grow up to be Woodworker subscribers.

Next Month...

Volume 27 no. 3 of Electronics Today International will be in your newsagents on 27th February 1998 ... Kevin Kirk describes the recently arrived Atmel AVR microcontroller family ... We have an unusual UHF model radio controller by Geoff Pike GI0GDP in preparation ... Robert Penfold presents an inductance meter as part of an inductance-capacitance pair ... Dr. Pei An has added more analogue input channels to his Centronics mini-lab data logger ... plus all the regulars, and more.

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