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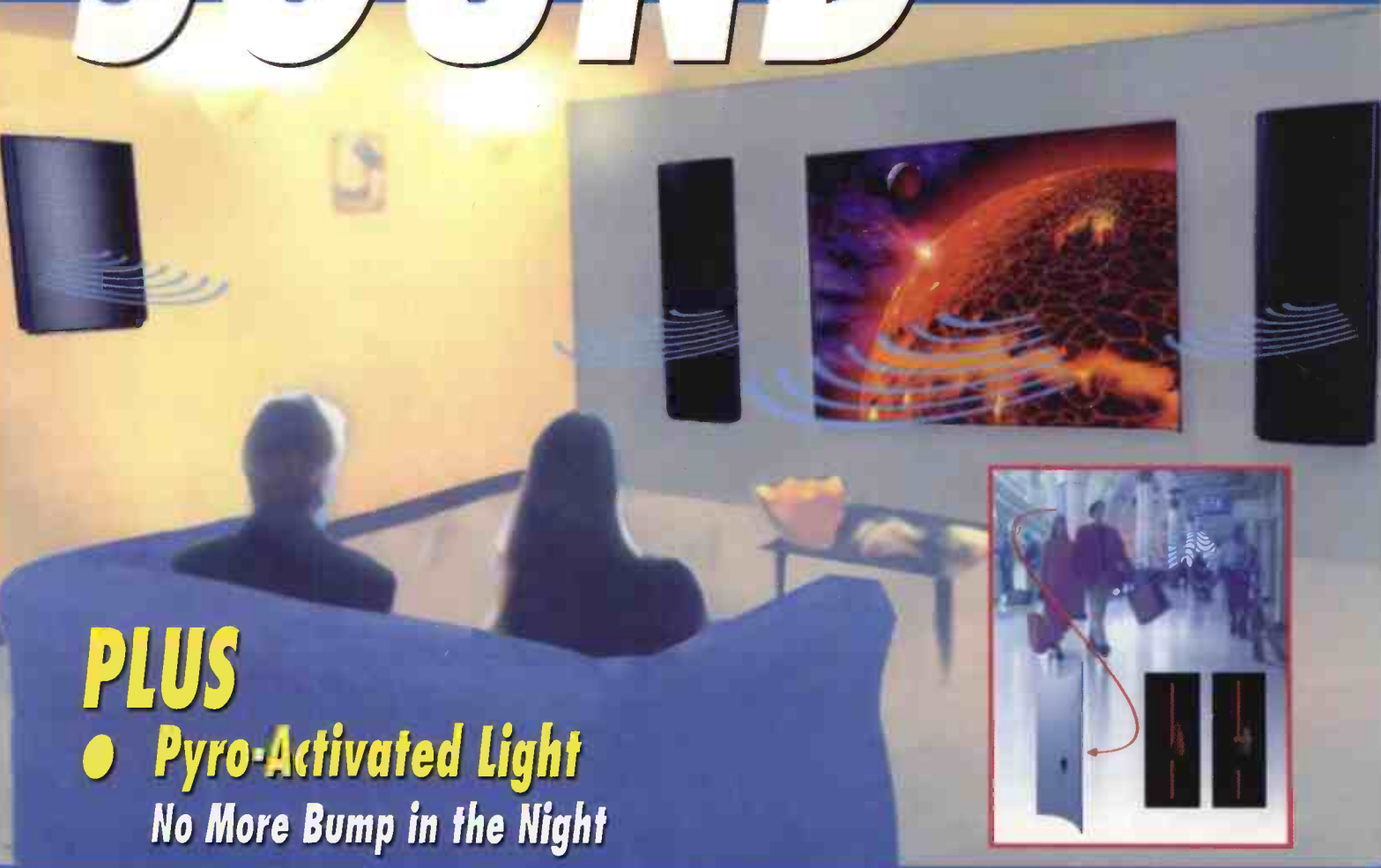
**VIRTUAL pH METER**  
For PC computers

**PIC PROGRAMMER REVISITED**  
More features, easier to operate

**WIN**  
Two Tickets  
for the Air Tattoo  
See Page 47

# WALL OF SOUND

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**AND NOT**  
**SEEN**




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- **Handy Moisture Meter**



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Electronics World Dec 96

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Educational Computing & Technology Oct/Nov 96

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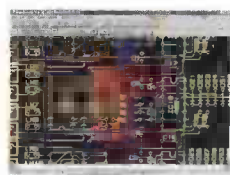
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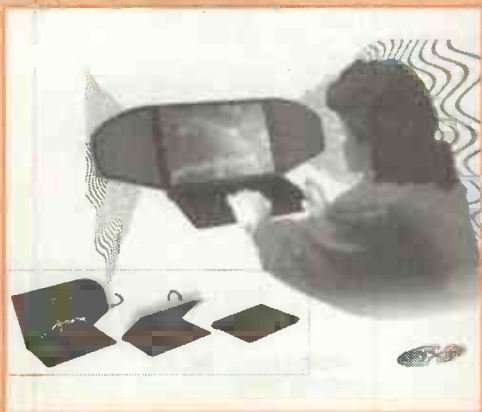


# Contents

Volume 26 No.6

## & Features Projects

Next Issue 20th June 1997



## Regulars

News

8, 9, 11

PCB foils

66, 68

Round the Corner

74

### Wall of Sound

13

In the future we will be able to hear our loudspeakers more clearly than ever before - even in difficult locations like railway stations and aircraft. But we may not be able to see them. Andrew Armstrong reports.

### Project Designers Wanted

23

ETI is looking for new projects to publish - could one of them be yours?

### Continuity Quick-Tester

25

Terry Balbirnie's continuity tester is battery-free - it works on light, even room lighting from an ordinary light bulb, and is handy for testing fuses and filament lamps, switch and relay contacts, wire or PCB continuity and faulty connections in plugs and sockets.

### IR Activated Auto-Light

29

A pyro-sensor-activated safety light for indoor use, Robert Penfold's brainchild responds to movement nearby and, once switched on, remains on for a user-defined time after the last activation.

### PIC Programmer Re-Visited

39

Robin Abbott's popular PIC Programmer has been updated - it now has a 40 pin multi-width ZIF socket which can take the 8-pin 12C50X, 18-pin 16C55X, 6x, 7x, 8X, F8X, and PIC14000 with an adaptor.

### Win Two Tickets to the Royal International Air Tattoo

47

Use your skill to spot the difference - you may win tickets to one of Britain's fastest and most fascinating days out at the Air Tattoo.

### Fast Fivers

49

The game of Put-and-Take has been popular since the Middle Ages and is still popular with modern humans of all ages. By Owen Bishop.

### Virtual pH meter for use with the PC

51

Valentin Obec Roda and Ronaldo Bruno has developed the hardware and software for this scientific instrument that is easily transportable and connects to a PC.

### Handy Moisture Meter

61

A simple device with two small prongs - no, not a pitchfork, but a pocket moisture-meter to put you on guard when hunting for a home, says Raymond Haigh.

### ETI 1995 Index

71

All the projects and main features from ETI 1995 on a single-page index



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## DIGITAL MULTIMETERS

### CM2300 DIGITAL MULTIMETER



- FEATURES:**
- 3.5 LCD DISPLAY
  - HEIGHT 12mm
  - MAX READING 1999
  - HV INDICATION FOR HIGH VOLTAGE
  - SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
  - ALL RANGES OVERLOAD PROTECTED
  - 10A DC CURRENT TEST
  - DC VOLTAGE 2V/20V/200V/500V
  - AC VOLTAGE 200/500V
  - DC CURRENT 200mA
  - RESISTANCE 2K $\Omega$  /20K $\Omega$  /200K $\Omega$  /2M $\Omega$
  - SUPPLIED WITH TEST PROBES
- ORDER CODE: CM2300**  
**PRICE: 975p**

### CM2400T DIGITAL MULTIMETER WITH TEMP MEASUREMENT



- FEATURES:**
- 3.5LCD DISPLAY
  - HEIGHT 12mm
  - MAXIMUM READING 1999
  - 10A DC CURRENT TEST
  - DC VOLTAGE 200mV/2V/20V/200V/1000V
  - AC VOLTAGE 200/750V
  - DC CURRENT 0.2mA/200mA/20mA/200mA/20A
  - RESISTANCE 200 $\Omega$  /2K $\Omega$  /20K $\Omega$  /200K $\Omega$  /2M $\Omega$
  - SUPPLIED WITH TEST PROBES
  - TEMPERATURE MEASUREMENT
  - CONTINUITY TEST
  - DIODE TEST & CONTINUITY CHECK
  - ALL RANGES OVERLOAD PROTECTED
- ORDER CODE: CM2400T**  
**PRICE: 1450p**

### CM2900 PACKET DIGITAL MULTIMETER



- FEATURES:**
- 3.5 LCD DISPLAY
  - COMPACT AND LIGHTWEIGHT POCKET SIZE
  - MAXIMUM READING 1999
  - DC CURRENT 7 RESISTANCE OVERLOAD PROTECTED
  - SLIDE SWITCHES FOR FUNCTION AND RANGE OPERATION
  - SUPPLIED IN WALLET WITH TEST PROBES
  - DC VOLTAGE 2V/20V/200V/500V
  - AC VOLTAGE 200V/500V
  - DC CURRENT 200mA
  - RESISTANCE 2K $\Omega$  /20K $\Omega$  /200K $\Omega$  /2M $\Omega$
- ORDER CODE: CM2900**  
**PRICE: 1150p**

### CM3900A DIGITAL MULTIMETER



- FEATURES:**
- LARGE LCD DISPLAY
  - HEIGHT 18mm
  - MAXIMUM READING 1999 + UNIT
  - SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
  - AUTO POWER OFF (APPROX 15 min)
  - DIODE TEST FUNCTION
  - ALL RANGES OVERLOAD PROTECTED
  - SUPPLIED WITH TEST PROBES
  - DC VOLTAGE: 200mV/2V/20V/200V/700V ACCURACY  $\pm 0.5\%$
  - AC VOLTAGE: 200mV/2V/20V/200V/700V
  - DC CURRENT A: 200 $\mu$ A/20mA/200mA/2A/20A
  - AC CURRENT A: 200 $\mu$ A/20mA/200mA/2A/20A
  - RESISTANCE: 200 $\Omega$ /2K $\Omega$ /20K $\Omega$ /200K $\Omega$ /2M $\Omega$ /20M $\Omega$

**ORDER CODE: CM3900A**  
**PRICE: 2900p**

### CM3920 DIGITALMETER WITH TEMP MEASUREMENT



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

**ORDER CODE: CM3920**  
**PRICE: 4100p**

### CM2700 AUTORANGING DIGITAL MULTIMETER



- FEATURES:**
- 3.75 LCD DISPLAY WITH DECIMAL POINT
  - 33 SEGMENT BARGRAPH DISPLAY
  - OVERRANGE INDICATION
  - ROTARY SWITCH FOR FUNCTION SELECTION
  - AUTO POWER OFF (APPROX 15 mins)
  - AUTO POLARITY WITH INDICATION
  - DIODE TEST & CONTINUITY TEST WITH BUZZER
  - ALL RANGES OVERLOAD PROTECTED
  - LOW BATTERY INDICATION
  - SUPPLIED WITH TEST PROBES
  - DC VOLTAGE: 320mV/3.2V/32V/320V/600V
  - AC VOLTAGE: 320mV/3.2V/32V/320V/600V
  - DC CURRENT A: 320 $\mu$ A/3200 $\mu$ A/32mA/320mA/10A
  - AC CURRENT A: 320 $\mu$ A/3200 $\mu$ A/32mA/320mA/10A
  - RESISTANCE: 320 $\Omega$ /3.2K $\Omega$ /32K $\Omega$ /320K $\Omega$ /3.2M $\Omega$ /32M $\Omega$
- ORDER CODE: CM2700**  
**PRICE: 4050p**

### CM3230 DIGITAL CAPACITANCE METER



- FEATURES:**
- 3.5 LCD DISPLAY
  - HEIGHT 18mm
  - MAXIMUM READING 1999
  - CAPACITANCE 9 RANGES FROM 200pF-20000 $\mu$ F
  - MEASURING FROM 1pF - 20000 $\mu$ F
  - SINGLE MANUAL ROTARY SWITCH FOR FUNCTION AND RANGE OPERATION
  - ZERO ADJUST KNOB
- ORDER CODE: CM3230**  
**PRICE: 3950p**

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SRDR45	
SRD500	SATPSU4
SRX320, SRX340, SRX345, SRX350	SATPSU5
SRX100	SATPSU6
SRD600	SATPSU14
SAT250, SR950, SRD700, SRD950,	SATPSU16
SRX1002, SRX2001, SRX301,	
SRX501, SRX502	
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 6500, SR7700, SR8700	SATPSU12 SATPSU13

FIGSON	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
SOPRENSEN TYPE PSU ONLY	SATPSU15

NETWORK	CODE
9000, 9200	SATPSU2

NOKIA	CODE
SAT1500	SATPSU2

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

PHILIPS	CODE
STU802/05M	SATPSU1
STU801	SATPSU2

THOMSON	CODE
SRS4	SATPSU2

TOSHIBA	CODE
SAT99, TU-SDU200	SATPSU1

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

### PACE SATELLITE TUNERS

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

### PACE SWITCH MODE TRANSFORMERS

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

## SATMETER

THE SATMETER IS A PROFESSIONAL PORTABLE SATELLITE STRENGTH 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 IMPEDENCE: 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	MAKE & MODEL	ORDER CODE	PRICE
Cambridge AE22/AE5 0.8dB standard 10.95-11.70 GHz Gold Range	LNB1	2160p	Cambridge AE7 Twin O/P H+V Both Enhanced	LNB7	4000p
Cambridge AE14 Universal LNB 10.7-11.7/11.7-12.75 GHz	LNB2	2500p	Cambridge AE2 Dual O/P H+V Separate Enhanced	LNB8	3550p
Cambridge AE21/AE5 Single O/P Switching LNB 1.0dB Standard	LNB3	2050p	Grundig Super Universal 'Anis' 10.7-12.75 GHz 0.8dB	LNB9	2600p
Cambridge AE19/AE6 Single O/P Switching LNB 1.0dB Enhanced	LNB4	2050p	Grundig Universal 'Anis' 10.7-12.75 GHz 1.0dB	LNB10	2250p
Cambridge AE23/AE12 0.8dB Enhanced 10.7-11.8GHz Gold Range	LNB5	2160p	Cambridge AE1 Twin O/P H+V Both Standard	LNB11	4000p
Cambridge AE8 Dual O/P H+V Separate Enhanced	LNB6	4000p			

## FUSES

CURRENT RATING	TIME LAG (20MM)		QUICK BLOW (20MM)	
	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
1A	FUSE08	60p	FUSE24	60p
1.25A	FUSE09	60p	FUSE25	60p
1.6A	FUSE10	60p	FUSE26	60p
2A	FUSE11	50p	FUSE27	60p
2.5A	FUSE12	50p	FUSE28	60p
3.15A	FUSE13	55p	FUSE29	50p
4A	FUSE14	55p	FUSE30	50p
5A	FUSE15	60p	FUSE31	50p
6.3A	FUSE16	60p	FUSE32	50p

### CERAMIC PLUG TOP

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

### 20mm CERAMIC TIME LAG

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

### 38mm CERAMIC TIME LAG

CURRENT RATING	ORDER CODE	PRICE
10A	FUSE48	815P

### 32mm CERAMIC SLOW BLOW

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

NB.

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

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AC126	30P	BD649	50P	BU412	175P	UX55	800P	MPSA20	15P	2N3585	650P
AC127	30P	BD675	40P	BU413	175P	BUX80	180P	MPSA42	15P	2N3702	9P
AC128K	40P	BD676	40P	BU414B	250P	BUX81	160P	MPSA43	15P	2N3703	9P
AC141K	45P	BD677	38P	BU415A	170P	BUX84	50P	MPSA44	40P	2N3704	9P
AC176	22P	BD678	40P	BU426A	70P	BUX85	50P	MPSA55	12P	2N3705	9P
ACY16	48P	BD679	40P	BU433	120P	BUX86	30P	MPSA56	12P	2N3706	9P
ACY19	48P	BD680	40P	BU500	100P	BUX87	50P	MPSA70	15P	2N3707	9P
AD149	60P	BD681	45P	BU500D	225P	BUX88	350P	MPSA92	20P	2N3710	12P
AF125	50P	BD682	45P	BU505	90P	BUX98A	150P	MPSA93	20P	2N3711	12P
AF139	30P	BD705	50P	BU505D	90P	BUY47	150P	MPSU10	200P	2N3711	85P
BC107	8P	BD707	50P	BU505DF	90P	BUY57	125P	MPSU45	550P	2N3722	90P
BC108	8P	BD709	50P	BU506	100P	BUY69A	250P	MPSU56	400P	2N3773	100P
BC109	8P	BD711	50P	BU506D	70P	BUY71	250P	MPSU60	350P	2N3792	150P
BC109C	10P	BD736	50P	BU506DF	120P	BUZ10	65P	MR510	35P	2N3799	18P
BC140	20P	BD826	50P	BU508A	70P	BUZ11	200P	MR856	36P	2N3819	29P
BC142	20P	BD828	50P	BU508AF	95P	BUZ11A	175P	OC28	350P	2N3820	70P
BC143	20P	BD839	55P	BU508APH	80P	BUZ14	550P	OC29	250P	2N3823	40P
BC147	8P	BD897	50P	BU508D	90P	BUZ20	225P	OC35	350P	2N3866	110P
BC149	8P	BD899	50P	BU508DF	115P	BUZ21	250P	OC36	250P	2N3903	40P
BC159	8P	BD977	50P	BU508DR	130P	BUZ24	350P	OC45	50P	2N3916	11P
BC160	30P	BDX33	60P	BU508V	110P	BUZ25	450P	OC200	180P	2N3925	375P
BC171	10P	BDX37	100P	BU508VF	100P	BUZ32	125P	R2008B	100P	2N3958	375P
BC172	10P	BDX44	100P	BU526	75P	BUZ36	800P	R2010B	100P	2N4031	25P
BC177	14P	BDX47	75P	BU536	100P	BUZ44A	525P	S2000A3	175P	2N4033	25P
BC178	14P	BDX54C	75P	BU546	125P	BUZ45A	800P	S2000AF	175P	2N4036	29P
BC179	14P	BDX62C	150P	BU603	125P	BUZ50B	800P	S2055A	175P	2N4220	175P
BC182	7P	BDX63C	175P	BU606D	225P	BU53A	500P	S2055AF	200P	2N4347	130P
BC182L	7P	BDX64C	175P	BU608D	120P	BUZ71	75P	S2530A	100P	2N4391	60P
BC183L	7P	BDX65	175P	BU626	120P	BUZ71AF	100P	S2800M	72P	2N4392	50P
BC184	7P	BDX66C	80P	BU705	130P	BUZ72A	100P	TIP29	15P	2N4393	55P
BC184L	7P	BDX67C	275P	BU706DF	175P	BUZ72AF	100P	TIP29A	22P	2N4399	200P
BC184L	7P	BDX71	70P	BU706F	150P	BUZ73A	150P	TIP29C	25P	2N4401	12P
BC212	7P	BDX77	175P	BU724A	100P	BUZ76A	110P	TIP29E	40P	2N4403	12P
BC212L	7P	BDX87C	175P	BU801	70P	BUZ80	200P	TIP30	25P	2N4418	120P
BC213	7P	BDX88C	150P	BU806	70P	BUZ80AF	200P	TIP30C	25P	2N4420	75P
BC213L	7P	BDW24	55P	BU807	60P	BUZ83	200P	TIP31A	22P	2N4427	75P
BC214	7P	BDW83	50P	BU807F	75P	BUZ90A	180P	TIP31C	22P	2N4429	50P
BC214L	7P	BDW94	50P	BU808DF	300P	BUZ91A	400P	TIP32	24P	2N4922	30P
BC237	7P	BDY29	225P	BU810	110P	BY448	20P	TIP32A	21P	2N4923	30P
BC238	7P	BDY56	225P	BU824	450P	BYT11	25P	TIP32C	28P	2N5038	175P
BC239	7P	BDY58	500P	BU826	120P	C106D	120P	TIP33	50P	2N5061	20P
BC300	20P	BDY90	125P	BU826A	100P	COY80	40P	TIP33C	60P	2N5088	20P
BC301	20P	BDY92	100P	BU826B	110P	IRF120	225P	TIP34	65P	2N5109	100P
BC302	20P	BF137	35P	BU903	110P	IRF130	475P	TIP34C	65P	2N5116	175P
BC303	20P	BF167	30P	BU910	80P	IRF140	550P	TIP35C	65P	2N5154	150P
BC304	25P	BF181	18P	BU912	100P	IRF230	550P	TIP36C	65P	2N5160	60P
BC327	7P	BF183	20P	BU920	100P	IRF240	425P	TIP42A	20P	2N5179	40P
BC328	7P	BF195	70P	BU922	110P	IRF250	375P	TIP41C	22P	2N5241	50P
BC337	7P	BF199	80P	BU930	130P	IRF330	600P	TIP42A	20P	2N5241	500P
BC338	7P	BF200	16P	BU932	175P	IRF340	325P	TIP42C	22P	2N5245	45P
BC441	28P	BF225	30P	BU941	250P	IRF350	750P	TIP47	40P	2N5294	30P
BC446	8P	BF240	16P	BU2508A	130P	IRF450	650P	TIP48	40P	2N5296	30P
BC477	18P	BF245	25P	BU2508AF	130P	IRF10	150P	TIP50	60P	2N5320	50P
BC516	22P	BF254	15P	BU2508D	130P	IRF520	150P	TIP51	80P	2N5401	10P
BC537	25P	BF255	12P	BU2508DF	150P	IRF530	150P	TIP52	80P	2N5416	40P
BC546	8P	BF256	18P	BU2520AF	225P	IRF540	200P	TIP54	85P	2N5416	40P
BC547	8P	BF257	18P	BU2520DF	225P	IRF610	150P	TIP102	70P	2N5448	12P
BC548	8P	BF259	18P	BU2525A	325P	IRF611	150P	TIP105	65P	2N5457	45P
BC549	8P	BF262	25P	BU2525AF	325P	IRF620	160P	TIP106	65P	2N5458	55P
BC550	8P	BF270	18P	BU2527AF	400P	IRF630	150P	TIP107	65P	2N5480	55P
BC556	8P	BF273	15P	BU405A	200P	IRF640	200P	TIP110	40P	2N5461	75P
BC557	7P	BF311	21P	BUH315	200P	IRF642	200P	TIP111	40P	2N5462	45P
BC558	8P	BF336	20P	BUH336	250P	IRF650	200P	TIP112	35P	2N5484	55P
BC559	8P	BF337	20P	BUH35	200P	IRF710	150P	TIP112H	50P	2N5551	12P
BC560	8P	BF338	20P	BUH35D	250P	IRF720	150P	TIP115	30P	2N5671	350P
BC637	20P	BF362	30P	BUH517	275P	IRF730	150P	TIP116	30P	2N5672	400P
BC639	20P	BF367	13P	BUH517D	175P	IRF740	150P	TIP117	30P	2N5680	55P
BC640	20P	BF371	17P	BUH715	425P	IRF820	150P	TIP120	37P	2N5825	175P
BCY33	200P	BF421	18P	BUK431	375P	IRF830	160P	TIP121	35P	2N5886	325P
BCY34	200P	BF422	21P	BUK444/	200P	IRF840	150P	TIP122	30P	2N6031	250P
BCY70	16P	BF423	25P	BUK444/	200P	IRF9140	1000P	TIP125	30P	2N6049	55P
BCY71	16P	BF455	12P	BUK444/	200P	IRF9150	150P	TIP126	40P	2N6059	150P
BCY72	16P	BF458	19P	BUK444/	200P	IRF911	150P	TIP127	35P	2N6098	50P
BD115	30P	BF462	50P	BUK445/	200P	IRF920	150P	TIP130	30P	2N6099	45P
BD124P	50P	BF471	28P	BUK446/	400P	IRF930	400P	TIP131	30P	2N6107	40P
BD131	25P	BF472	28P	BUK446/	400P	IRF931	200P	TIP132	30P	2N6109	40P
BD132	25P	BF479	30P	BUK455/	200P	IRF940	300P	TIP136	40P	2N6211	400P
BD133	50P	BF494	16P	BUK455/	200P	IRF9541	200P	TIP137	65P	2N6248	150P
BD135	20P	BF495	16P	BUK456/	200P	IRF9610	150P	TIP162	110P	2N6284	250P
BD136	20P	BF595	16P	BUK456/	200P	IRF9620	150P	TIP141	65P	2N6287	225P
BD137	20P	BF596	16P	BUW81A	150P	IRF922	200P	TIP143	75P	2N6292	40P
BD138	20P	BF615	30P	BUW81B	190P	IRF930	325P	TIP145	50P	2N6385	120P
BD139	20P	BF617	30P	BUR52	1900P	IRF940	375P	TIP146	70P	2N6403	160P
BD140	20P	BF670	40P	BUS11A	200P	IRFD9220	100P	TIP147	80P	2N6427	25P
BD144	90P	BF763	40P	BUS12A	200P	IRFBC30	200P	TIP150	90P	2N6476	250P
BD157	38P	BF870	22P	BUS14A	500P	IRFBC40	400P	TIP151	60P	2N6488	90P
BD166	30P	BF871	22P	BUS23	225P	IRFP140	250P	TIP295S	60P	2N6491	90P
BD175	30P	BF960	38P	BUS48A	175P	IRFP150	300P	TIP305S	50P	2N6547	300P
BD177	30P	BF961	35P	BUS48B	55P	IRFP240	300P	TIP1760	100P	2N6609	375P
BD179	32P	BF964	38P	BUT11AF	55P	IRFP250	400P	TIP1762A	200P	2N6660	375P
BD181	45P	BFQ232	75P	BUT12	80P	IRFP350	325P	TIP1763A	200P	2N6675	175P
BD182	60P	BFQ252A	60P	BUT13	310P	IRFP450	400P	TIP1791A	80P	2N6678	225P
BD184	60P	BFR90	85P	BUT18	80P	IRFP460	775P	TIS61	15P	4N35	50P
BD187	30P	BFRT1	99P	BUT18A	80P	IRFP9140	1450P	TIS90	15P		
BD201	38P	BF43	30P	BUT30V	1700P	IRFP920	500P	TIS93	20P		
BD202	38P	BFX29	25P	BUT56A	100P	IRFRC50	600P	TRC107	11P	RECTIFIER	
BD203	42P	BFX84	20P	BUT76A	80P	IRFRC20	250P	ZTX108	11P	DIODES	
BD204	42P	BFX85	20P	BUT90	1300P	IRFZ20	65P	ZTX109	11P	BY127	8P
BD222	31P	BFX87	15P	BUT92	1200P	IRFZ42	275P	ZTX122	12P	BY133	8P
BD225	31P	BFX88	15P	BUV18	650P	IRFZ44	275P	ZTX130	20P	BY164	40P
BD232	31P	BFX89	60P	BUV20	650P	MJ900	200P	ZTX201	16P	BY179	35P
BD233	30P	BFY50	14P	BUV21	400P	MJ10001	200P	ZTX302	10P	BY184	32P
BD234	32P	BFY51	24P	BUV23	475P	MJ1001	200P	ZTX303	20P	BY206	11P
BD235	28P	BFY52	14P	BUV24	350P	MJ2501	100P	ZTX304	10P	BY207	20P
BD236	30P	BFY56	25P	BUV25	110P	MJ2955	55P	ZTX320	20P	BY227	19P
BD237	21P	BFY64	25P	BUV26	150P	MJ3000	100P	ZTX502	10P	BY228	28P
BD238	24P	BFY90	45P	BUV27	125P	MJ3001	100P	ZTX503	10P	BY298	15P
BD239	30P	BLY48	85P	BUV28	110P	MJ4032	175P	ZTX502	18P	BY299	18P
BD240											

## TRANSISTORS

PART	PRICE	PART	PRICE	PART	PRICE	PART	PRICE	PART	PRICE	PART	PRICE	
<b>I.C. SOCKETS</b>		1A/50V		TIC116C	59p	8156	300p	4075	13p	7430	25p	
8 PIN	4P	W01	18p	8A/300V		8224	240p	4076	42p	7437	28p	
14 PIN	5P	1A/100V		TIC116D	70p	8226	240p	4077	13p	7438	30p	
16 PIN	6P	W02	19p	8A/400V		8250	750p	4078	13p	7442	38p	
18 PIN	9P	1A/200V		TIC126D	75p	8251	200p	4081	13p	7447	60p	
20 PIN	10P	W04	21p	12A/400V		8253	160p	4082	13p	7450	22p	
22 PIN	12P	LA/400V		TIC126M	90p	8257	220p	4085	36p	7451	10p	
24 PIN	13P	W06	23p	12A/600V		8271	340p	4086	30p	7454	25p	
28 PIN	13P	LA/600V		C106D	28p	8279	270p	4089	75p	7473	25p	
40 PIN	15P	W08	28p	4A/400V		8283	400p	4093	18p	7481	90p	
<b>ZENER DIODES</b>		1A/800V		BR103	37p	8284	440p	4094	44p	7482	60p	
400m	WATT	BR81D	33p	1580H	85p	8287	260p	4094	58p	7485	25p	
2V7 TO 39V	5P	2A/100V		BT106	180p	8288	650p	4098	50p	7489	75p	
1.3	WATT	BR82D	33p	BT119	100p	82C206PLCC	500p	4099	42p	7493	35p	
2V7 TO 39V	9P	2A/200V		17088	200p	8748	700p	4501	26p	7495	48p	
<b>VOLTAGE REGULATORS</b>		BR84D	37p	17089	200p	8755	800p	4502	36p	74132	42p	
7805	25P	2A/400V		17127	200p	8726	95p	4504	35p	74141	55p	
7806	25P	BR86D	43p	1580H	230p	8728	110p	4505	80p	74145	70p	
7808	25P	2A/600V		15/85R	200p	<b>CMOS IC's</b>						
7812	25P	BR88D	43p	SG 264	800p	4000	13p	4507	30p	74157	45p	
7815	25P	2A/800V		SG613	1500p	4001	13p	4508	67p	74160	50p	
7818	25P	BR32	43p	<b>COMPUTER IC's</b>					4509	30p	<b>74HC SERIES</b>	
7824	25P	2A/200V		280ACPLU	1000p	4002	13p	4510	32p	74HC03	14p	
7905	25P	BR34	43p	Z80ADMA	2000p	4006	34p	4511	30p	74HC08	18p	
7906	30P	2A/400V		Z80ACTC	140p	4007	13p	4512	38p	74HC10	20p	
7908	30P	BR36	44p	Z80ASIO-1	210p	4009	20p	4514	65p	74HC11	14p	
7912	30P	2A/600V		Z80ASIO-2	210p	4010	21p	4515	100p	74HC14	26p	
7915	30P	6a/200V		75107	65p	4011	13p	4516	36p	74HC14	26p	
7918	30P	BR64	72p	75110	75p	4012	13p	4517	36p	74HC20	19p	
7924	30P	6A/400V		75113	100p	4013	13p	4518	28p	74HC27	20p	
78L05	24P	BR251	150p	75122	110p	4014	32p	4519	36p	74HC51	20p	
78L08	24P	25A/100V		75164	100p	4016	18p	4520	36p	74HC73	24p	
78L12	24P	BR252	165p	75162	700p	4018	30p	4521	38p	74HC74	24p	
78L15	24P	24A/200V		75182	95p	4019	28p	4522	41p	74HC76	28p	
7915	30P	BR254	185p	75183	95p	4020	33p	4523	38p	74HC77	35p	
LM309K	100P	25A/400V		BR2155	185p	4021	36p	4524	65p	74HC85	33p	
LM317T	100P	BR325	200p	2114	150p	4022	34p	4525	48p	74HC86	29p	
LM323K	350P	25A/600V		2532	200p	4023	13p	4526	140p	74HC107	28p	
78H09KC	800P	BR258	240p	26LS32	75p	4024	25p	4527	29p	74HC123	35p	
79H12KC	700P	25A/800V		BR351	185p	4025	13p	4528	36p	74HC125	32p	
79HGKC	800P	BR351	185p	2732A	200p	4026	60p	4529	140p	74HC126	33p	
<b>L.E.D.'s 3mm</b>		35V/100V		2732A	220p	4027	18p	4530	60p	74HC132	33p	
RED	5p	BR352	200p	2764	150p	4028	29p	4531	30p	74HC133	33p	
YELLOW	8p	35V/200V		27C64	220p	4029	34p	4532	40p	74HC137	52p	
GREEN	8p	BR354	220p	27128	150p	4030	17p	4533	120p	74HC138	33p	
5mm	5p	35V/400V		27256-25	150p	4032	52p	4534	140p	74HC147	42p	
RED	8p	BR356	230p	27512	300p	4033	60p	4535	50p	74HC153	32p	
YELLOW	8p	35V/600V		4116	40p	4034	76p	4536	170p	74HC154	90p	
GREEN	8p	BR358	260p	4164-15	80p	4035	42p	4537	170p	74HC157	34p	
<b>RECTANGULAR LED's</b>		35V/800V		4164-12	90p	4036	46p	4538	180p	74HC158	34p	
5mm x 2.5mm	5p	BY164	40p	41256-15	80p	4040	30p	4539	55p	74HC160	44p	
RED	8p	1.5A/100V		41256-12	100p	4041	36p	4540	55p	74HC161	44p	
YELLOW	8p	BY176	40p	41256-10	110p	4042	30p	4541	48p	74HC162	44p	
GREEN	8p	1.5A/800V		41464-12	150p	4043	36p	4542	48p	74HC163	44p	
<b>BRIDGE RECTIFIER</b>		TIC206D	60p	6116	80p	4044	30p	4543	48p	74HC164	44p	
W005	16p	4A/400V		62256-12	300p	4045	42p	4544	58p	74HC165	56p	
		TIC225D	69p	6502A	360p	4046	45p	4545	120p	74HC166	60p	
		6A/400V		65C02	930p	4048	26p	4546	38p	74HC174	38p	
		TIC226D	68p	6522	280p	4049	18p	4547	28p	74HC175	38p	
		8A/400V		6800	210p	4050	20p	4548	20p	74HC190	46p	
		TIC235D	85p	6902	220p	4051	38p	4549	16p	74HC192	53p	
		12A/400V		6903	500p	4052	35p	4550	16p	74HC193	41p	
		TIC246D	105p	6908	500p	4053	35p	4551	18p	74HC194	46p	
		16A/400V		6810	150p	4054	53p	4552	20p	74HC195	46p	
		TIC253D	190p	6818	380p	4055	50p	4553	35p	74HC221	80p	
		20A/400V		6821	130p	4056	52p	4554	10p	74HC238	55p	
		TIC263D	205p	6840	290p	4057	20p	4555	30p	74HC240	48p	
		25A/400V		6845	200p	4058	40p	4556	30p	74HC241	47p	
		<b>THYRISTORS</b>		6850	90p	4059	52p	4557	25p	74HC242	55p	
		2N5061	20p	74F244	35p	4070	13p	4558	20p	74HC243	60p	
		0.8A/60V		8085A	300p	4071	13p	4559	30p	74HC245	48p	
				8086	500p	4072	13p	4560	45p	74HC251	25p	
				8088	480p	4073	13p	4561	13p	74HC257	40p	
								4562	32p	74HC259	52p	
								4563	20p	74HC273	42p	
								4564	25p	74HC280	61p	
								4565	15p	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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## Young Electronics Designers of the Year Award

His Royal Highness the Duke of York, Patron of the Young Electronic Designer Awards, presented the Young Electronic Designer Awards for 1997 to the winners in front of 200 guests at a special presentation dinner at the Science Museum, London, on 26th March. Earlier in the evening, TV Personality Sally Grey announced the winners. The Awards which are sponsored by Mercury Communications and Texas Instruments in association with the Institution of Electrical Engineers, challenge young designers to invent and produce an innovative device or system based on electronics to meet an everyday need. The competition is open to students between the ages of 12 and 25 in secondary schools, colleges and universities.

The winner of the Duke of York's Award for the most imaginative concept is 18-year-old Michael Brown of Bancroft's School, Woodford Green, Essex for his "Gremlinator" circuit testing aid. The "Gremlinator" was also highly commended in the Senior overall category. The Mercury Communications Prize for the best

communications-based project went to 14-year-old Emily Collins of Ridley High School, Blyth, Northumberland, for her SAFE (Sensory Alert For Everyday), ingeniously combining flashes and vibration to give smoke, intruder, doorbell and telephone alarm warnings for the deaf, and designed to be worn on the wrist. Her project also received a Highly Commended award in the Junior-overall category. The Texas Instruments Prize for the most commercially viable project went to 17-year-old Simon Todd of Bolton School, Bolton, Lancs, for a domestic

iron safety device. Simon's project also came first in the Intermediate (15-17 years) overall category. The winner of the IEE Award for the best new entrant to YEDA is Mark Gould, 14, of Gryphon School, Sherborne, Dorset, for a detector to indicate whether electric fences

are turned on or off, which also took the second prize in the Junior overall category. The first prizewinner in the Senior (18-25 years) category is James Smith, 22, of Brunel University for his "Manta" through-water communication device for recreational scuba divers.

Other winners are Peter Smith, 23, of the Bangor University of Wales, second in the Senior category for an integrated low-cost noise badge dosimeter for people working in noisy environments; Leighton Spicer, 21, of the Bangor University, third in the Senior category for an electronic system to reduce the incidence of pressure sores in older or disabled people; David Marson, 16, of St Joseph's College, Trentvale, Stoke on Trent, second in the Intermediate category for an electronic hand-held pedestrian crossing sign; Susannah Baker, 15, and Elizabeth Humphreys, 14, of Bishop's Castle Community College, Shropshire, for their 'Braille Rail' talking electronic map of the London Underground; Edward Brocklebank, 14, of Radley College, Abingdon, Oxon, first in the Junior category (under 15 years) for a safety device for a bicycle providing enhanced visibility at night and including left/right turn indicators; Rachel Downing, 13, Kerry-Anne Devlin, 13, Anna Burke, 12, and Anne-Marie Gaillaed, 12, of St Mary's Junior High School, Lurgan, Northern Ireland, third in the Junior category for an educational toy to enhance knowledge of the earth and solar system.

Also Highly Commended in the Senior category was Gwyn Jones, 22, of Bangor University for a pre-eclampsia monitoring system; in the Intermediate category Sumit Rai, 17, of Dulwich College, London, for an opto-electrical swipe entry card for a public gym; Jonathan Taylor, 15, of Bryanston School, Blandford, for the "Coxbox" device to give the rowing cox and steersmen a stroke rate readout; Andrew

Buckmaster, 16, of Radly College, Abingdon for a device for measuring and displaying the quantity of water used by showers and hose pipes (an increasingly topical subject these days); John Morton, 16, and Max Kendall, 16, for a bath temperature warning device in the form of a toy and Andrew Early, 16, of Ravens Wood School, Bromley, for a model rocket launch controller. Highly Commended in the Junior category were also Guy Kewish, 13, Philip Reid, 13, and Alasdair Lynch, 13, of Merchiston Castle School, Colinton, for BASICS (Babies and Safety in Car Seats) and Stephen Wyber, 13, of Bancroft's School, Woodford Green, for his kitchen weighing scales for the blind.

*All the competition entrants had to exhibit awareness of the ease of use, commercial applicability and production engineering of their projects, as well as the basic electronics concepts. We congratulate them and wish them good progress in their chosen careers in the future...*





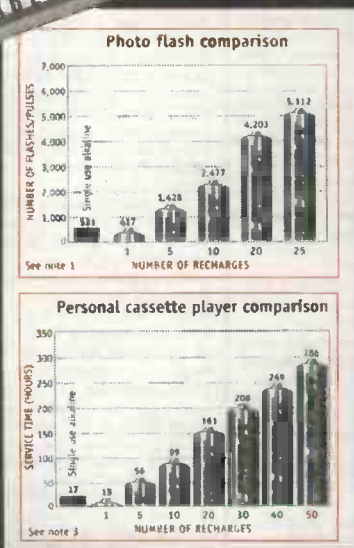
## Mercury-free batteries ready to change the market

The first mercury-free rechargeable batteries have been released in the UK. Allied Battery Technologies has announced the cells, known as RAM (tm) (Rechargeable Alkaline Manganese) cells, for use in all kinds of electronic and home equipment, including power toys, cameras, radios, audio equipment, remote controls and torches. As they are being marketed as "Pure Energy Rechargeable Alkaline", we can hope that the already thinly-stretched "RAM" acronym will not confuse buyers into thinking that these are specialist computer batteries.

The RAM cells are designed as long-life rechargeables and the company stresses that they are not to be confused with attempts to recharge conventional alkaline manganese batteries in "universal" chargers. The charge and recharge characteristics of the new batteries are such that the useful life is 10 to 50 times that of a conventional alkaline battery, or more. The simple purpose-designed RAM charger, which fits into a normal 13 amp wall socket, hold batteries ready for use. The cells can be recharged from 10 to over 50 times, and have a shelf life of five years. They come charged, and so do not have to be charged up before first use.

RAM cells have the major "green" advantage that they contain no toxic chemicals such as mercury or cadmium, used in most other types of dry cell. They have a similar application pattern to NiCads, but without the threat of pollution. The company found that the new technology captured 53% of the NiCad rechargeable market within six months.

Initially, AA cells will be available in the UK with AAA cells to follow later this year. The RAM cells are based on patented technology developed by Professor Karl Kordes, the inventor of the single-use disposable alkaline battery so well known today. They represent to performance characteristics of disposable alkaline batteries and the economic benefits of rechargeability, along with the environmental advantage of low toxicity. The Pure Energy branded RAM calls are completely interchangeable with conventional, non-rechargeable alkaline batteries, and also suitable in many cases as an alternative to rechargeable NiCads. They can also be used in equipment labelled "unsuitable for rechargeable nickel cadmium batteries", because they do not deliver "overcurrent" that is potentially damaging to some consumer electronics. There is, in addition, no "memory effect" as occurs with NiCads - RAM cells perform best when "topped up" in their charger when not in use. The Ram cell is a 1V5 cell rather than a 1V2 cell, and therefore more efficient in 3V and 6V applications.



## Chargers

Two chargers will be available for the new batteries: the MegaCharger is a table-top charger which will take up to eight AA or AAA cells for high-volume use, fully charging eight batteries in six hours. The EnviroCharger is a compact unit that will take up to four AA or AAA cells, and plugs into a 13A wall socket. It will charge four batteries overnight from a fully discharged state, and will recharge partially discharged batteries much sooner.

The Pure Energy RAM cells are described as being rechargeable from 10 times up to 25 times or more. In a high-discharge application such as a child's toy or other motor drives, the RAM cell can be recharged giving it a total life of more than 17 times a single-use alkaline battery. Tests under low-current drain conditions simulating the use of a personal cassette player in stop/start mode showed a total life more than 50 times longer than a conventional alkaline manganese battery.

The batteries will be on retail sale. Further enquires to Allied Battery Technologies, 14 Bates Industrial Estate, Wycombe Road, Stokenchurch, Bucks HP14 3RJ.

## Low-profile meter needs no soldering

First in a new family of low-profile, DIN-cased digital panel meters, Lascar Electronics' DPM 390 is housed in a snap-in DIN case and features 200 mV full scale reading, auto-polarity, auto-zero and 14.2 mm digit height. Designed to be used without the need for soldering, the DPM 390 contains internal DIP switches for selection of input mode and decimal points. Connection is made via an optional T/blk-1 screw terminal blockboard. Lascar are recommend the DPM 390 for high and low volume applications.

For more information tel. 01794 884567.





**DIFFERENTIAL THERMOSTAT KIT** Perfect for heat recovery, solar systems, boiler efficiency etc. Two sensors will operate a relay when a temperature difference (adjustable) is detected. All components and pcb. £29 ref F/L93

**MAGNETIC RUBBER TAPE** Selfadhesive 10 metre reel, 8mm wide perfect for all sorts of applications! £15 ref LOT87

**MAINS POWER SAVER** UK made plug in unit, fitted in seconds, can reduce your energy consumption by 15%. Works with fridges, soldering irons, conventional bulbs etc. Max 2A rating. £9 each ref LOT71, pack of 10 £69 ref LOT72

**YUASHA SEALED LEAD ACID** Batteries, ex equipment but ok bargain price just £5.99 each ref YA1. 100 or more £3.50 each.

**DC TO DC CONVERTERS**

DRM58 input 10-40vdc output 5v 8A £15 DRM128 input 17-40vdc output 12v 8A £18 DRM158 input 20-40vdc output 15v 8A £18 DRM248 input 29-40vdc output 24v 8A £12 DRS123 input 17-40vdc output 12v 3A £10 DRS153 input 20-40vdc output 15v 3A £20 DRS243 input 29-40vdc output 24v 3A £8

**HITACHI LM225X LCD SCREENS** 270x150mm, standard 12 way connector, 640x200 dots, tec spec sheet. £15 each ref LM2

**VARIABLE CAPACITORS** Dual gang, 60x33x45mm, reduction gearing, unknown capacity but probably good quality (military spec) general purpose radio tuner. £9 ref VC1

**ELECTRONIC FLASH PCB** Small pcb fitted with components including a flash tube, just connect 12vdc and it flashes, variable speed potentiometer. £6 ref FLS1

**THIEF PROOF PEN!** Amazing new ball point pen fitted with a combination lock on the end that only you know! £2.49 ref TP2

**JUMBO BI COLOUR LEDS** PCB with 15 fitted also 5 giant seven segment displays (55mm) £8 ref JUM1

**HOME DECK CLEARANCE** These units must be cleared leads, a n infra red remote qwerty keyboard and receiver, a standard UHF modulator, a standard 1200/75 BT approved modem and loads of chips, capacitors, diodes, resistors etc all for just £10 ref BAR33

**6.8MW HELIUM NEON LASERS** New units, £65 ref LOT33

**COIN SLOT TOKENS** You may have a use for these? mixed bag of 100 tokens £5 ref LOT20

**PORTABLE X RAY MACHINE PLANS** Easy to construct plans on a simple and cheap way to build a home X-ray machine! Effective device X-ray sealed assemblies, can be used for experimental purposes. Not a toy or for minors! £6/£5 ref F/XP1

**TELEKINETIC ENHANCER PLANS** Mystify and amaze your friends by creating motion with no known apparent means or cause. Uses no electrical or mechanical connections, no special gimmicks yet produces positive motion and effect. Excellent for science projects, magic shows, party demonstrations or serious research & development of this strange and amazing psychic phenomenon. £4/£5 ref F/TK1

**ELECTRONIC HYPNOSIS PLANS & DATA** This data shows several ways to put subjects under your control. Included is a full volume reference text and several construction plans that when assembled can produce highly effective stimuli. This material must be used cautiously. It is for use as entertainment at parties etc only, by those experienced in its use. £15/£5 ref F/EH2

**GRAVITY GENERATOR PLANS** This unique plan demonstrates a simple electrical phenomena that produces an anti-gravity effect. You can actually build a small mock spaceship out of simple materials and without any visible means- cause it to levitate. £10/£5 ref F/GRA1

**WORLDS SMALLEST TESLA COIL/LIGHTNING DISCHARGE GLOBE PLANS** Produces up to 750,000 volts of discharge, experiment with extraordinary HV effects, 'Plasma in a jar', St Elmo's fire, Corona, excellent science project or conversation piece. £5/£5 ref F/BTC1/LG5

**COPPER VAPOUR LASER PLANS** Produces 100mw of visible green light. High coherency and spectral quality similar to Argon laser but easier and less costly to build yet far more efficient. This particular design was developed at the Atomic Energy Commission of NEGEV in Israel. £10/£5 ref F/VCV1

**VOICE SCRAMBLER PLANS** Miniature solid state system turns speech sound into indecipherable noise that cannot be understood without a second matching unit. Use on telephone to prevent third party listening and bugging. £6/£5 ref F/VSS

**PULSED TV JOKER PLANS** Little hand held device utilises pulse techniques that will completely disrupt TV picture and sound works on FM too! DISCREET ADVISED. £8/£5 ref F/TJ5

**BODYHEAT TELESCOPE PLANS** Highly directional long range device uses recent technology to detect the presence of living bodies, warm and hot spots, heat leaks etc. Intended for security, law enforcement, research and development, etc. Excellent security device or very interesting science project. £8/£5 ref F/BHT1

**BURNING, CUTTING CO2 LASER PLANS** Projects an invisible beam of heat capable of burning and melting materials over a considerable distance. This laser is one of the most efficient, converting 10% input power into useful output. Not only is this device a workhorse in welding, cutting and heat processing materials but it is also a likely candidate as an effective directed energy beam weapon against missiles, aircraft, ground-to-ground, etc. Particle beams may very well utilize a laser of this type to blast a channel in the atmosphere for a high energy stream of neutrons or other particles. The device is easily applicable to burning and etching wood, cutting, plastics, textiles etc £12/£5 ref F/LC7

**MYSTERY ANTI GRAVITY DEVICE PLANS** Uses simple concept. Objects float in air and move to the touch. Defies gravity, amazing gift, conversation piece, magic trick or science project. £6/£5 ref F/ANT1K

**FRUIT POWERED CLOCK** Just add a fresh orange, tomato, banana or any other fruit plug in the probes and the clock works! £9.95 ref SC154

**DYNAMO FLASHLIGHT** Interesting concept, no batteries needed just squeeze the trigger for instant light apparently even works under water in an emergency although we haven't tried it yet! £6.99 ref SC152

**ULTRASONIC BLASTER PLANS** Laboratory source of sonic shock waves. Blow holes in metal, produce 'cold' steam, atomize liquids. Many cleaning uses for PC boards, jewellery, coins, small parts etc. £6/£5 ref F/ULB1

**ULTRA HIGH GAIN AMP/STETHOSCOPIC MIKE/ SOUND**

**AND VIBRATION DETECTOR PLANS** Ultrasensitive device enables one to hear a whole new world of sounds. Listen through walls, windows, floors etc. Many applications shown, from law enforcement, nature listening, medical heartbeat, to mechanical devices. £6/£5 ref F/HGA7

## WOLVERHAMPTON ELECTRONICS STORE NOW OPEN IN WORCESTER ST TEL 01902 22039

**ANTI DOG FORCE FIELD PLANS** Highly effective circuit produces time variable pulses of accoustical energy that dogs cannot tolerate £6/£5 ref F/DOG2

**LASER BOUNCE LISTENER SYSTEM PLANS** Allows you to hear sounds from a premises without gaining access. £12/£5 ref F/LUST1

**LASER LIGHT SHOW PLANS** Do it yourself plans show three methods. £6 ref F/LLS1

**PHASOR BLAST WAVE PISTOL SERIES PLANS** Handheld, has large transducer and battery capacity with external controls. £6/£5 ref F/PSP4

**INFINITY TRANSMITTER PLANS** Telephone line grabber/room monitor. The ultimate in home/office security and safety! simple to use! Call your home or office phone, push a secret tone on your telephone to access either: A) On premises sound and voices or B) Existing conversation with break-in capability for emergency messages. £7 ref F/TELEGRAB

**BUG DETECTOR PLANS** Is that someone getting the goods on you? Easy to construct device locates any hidden source of radio energy! Sniffs out and finds bugs and other sources of bothersome interference. Detects low, high and UHF frequencies. £5/£5 ref F/BD1

**ELECTROMAGNETIC GUN PLANS** Projects a metal object a considerable distance-requires adult supervision £5 ref F/EML2

**ELECTRIC MAN PLANS, SHOCK PEOPLE WITH THE TOUCH OF YOUR HAND!** £5/£5 ref F/EMA1

**PARABOLIC DISH MICROPHONE PLANS** Listen to distant sounds and voices, open windows, sound sources in 'hard to get' or hostile premises. Uses satellite technology to gather distant sounds and focus them to our ultra sensitive electronics. Plans also show an optional wireless link system. £8/£5 ref F/PM5

**2 FOR 1 MULTIFUNCTIONAL HIGH FREQUENCY AND HIGH DC VOLTAGE, SOLID STATE TESLA COIL AND VARIABLE 100,000 VDC OUTPUT GENERATOR PLANS** Operates on 9-12vdc, many possible experiments. £10 ref F/HV/M7/ TCL4

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

**MOD TRANSMITTING VALVES 6J180E £80 ref LOT112 SWITCHED MODE PSU'S** 244 watt, +5.32A, +12.6A, -5.02A, -12.02A. There is also an optional 3.3v 25A rail available. 120/240v I/P. Cased, 175x90x145mm. IEC inlet Suitable for PC use (6 drive connectors 1 m/board). £15 ref LOT135

**HYDROGEN FUEL CELL PLANS** There is a lot of interest in using Hydrogen as the fuel of the future, Hydrogen is easy to produce using chemicals and surplus solar generated electricity. It is also easy to store with little or no loss Hydrogen fuel cells are designed to store hydrogen and weight for weight will hold twice as much energy as a full petrol tank. Our plans give you loads of information on Hydrogen production, storage and practical plans to build your own Hydrogen fuel cell you will need access to a well equipped workshop for this but full construction details and drawings are included. Fuel cell plans £9 ref HY1

**VIDEO PROCESSOR UNITS? 76v 10AH BATT/24V 8A TX** Not too sure what the function of these units is but they certainly make good strippers! Measures 390x320x120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear. Inside 2 x 6V 10AH sealed lead acid batts, pcb's and a BA7 24v toroidal transformer (mains In), sold as seen, may have one or two broken knobs etc due to poor storage. £15.99 ref VP2

**RETRON NIGHT SIGHT** Recognition of a standing man at 300m in 1/4 moonlight, hermetically sealed, runs on 2 AA batteries, 80mm F1.5 lens, 20mw infrared laser included. £325 ref RETRON

**MAKE YOUR OWN CHEWING GUM KIT** Everything you need to make real chewing gum, even the bowl and treesap from the Sapodilla tree £7.99 ref SC190

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

**3-30V POWER SUPPLY KIT** Variable, stabilized power supply for lab use. Short circuit protected, suitable for professional or amateur use 24v 3A transformer is needed to complete the kit. £14 ref 1007

**1 WATT FM TRANSMITTER KIT** Supplied with piezo electric mic. 8-30vdc. At 25-30v you will get nearly 2 watts! £15 ref 1005

**FM/AM SCANNER KIT** Well not quite, you have to turn the knob your self but you will hear things on this radio that you would not hear on an ordinary radio (even TV). Covers 50-160mhz on both AM and FM. Built in 5 watt amplifier, inc speaker. £18 ref 1013

**3 CHANNEL SOUND TO LIGHT KIT** Wireless system, mains operated, separate sensitivity adjustment for each channel, 1,200 w

**power handling, microphone included. £17 Ref 1014.**

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

**STROBE LIGHT KIT** Adjustable from 1-60 Hz (a lot faster than conventional strobes). Mains operated. £17 Ref 1037

**COMBINATION LOCK KIT** 9 key, programmable, complete with keypad, will switch 2A mains. 9v dc operation. £13 ref 1114

**PHONE BUG DETECTOR KIT** This device will warn you if somebody is eavesdropping on your line. £9 ref 1130

**ROBOT VOICE KIT** Interesting circuit that distorts your voice! adjustable, answer the phone with a different voice! 12vdc £9 ref 1131

**TELEPHONE BUG KIT** Small bug powered by the phone line, starts transmitting as soon as the phone is picked up! £12 Ref 1135

**3 CHANNEL LIGHT CHASER KIT** 800 watts per channel, speed and direction control supplied with 12 LEDES (you can fit tracs instead to make kit mains, not supplied) 9-12vdc £17 ref 1026

**12V FLOURESCENT LAMP DRIVER KIT** Light up 4 foot tubes from your car battery! 9v 2a transformer also required. £8 ref 1069

**HELPING HANDS** Perfect for those fiddly jobs that need six hands. 6 ball and socket joints, magnifier. £7.99 ref YO57A

**VOX SWITCH KIT** Sound activated switch ideal for making bugging tape recorders etc, adjustable sensitivity. £10 ref 1073

**PREAMP MIXER KIT** 3 input mono mixer, sep bass and treble controls plus individual level controls, 18vdc, Input sens 100mA £15 ref 1052

**SOUND EFFECTS GENERATOR KIT** Produces sounds ranging from bird chips to sirens. Complete with speaker, add sound effects to your projects for just £9 ref 1045

**15 WATT FM TRANSMITTER (BUILT)** 4 stage high power, preamp required 12-18vdc, can use ground plane, yagi or open dipole. £69 ref 1021

**HUMIDITY METER KIT** Builds into a precision LCD humidity meter, 9v dc design, pcb, led display and all components included. £29

**PC TIMER KIT** Four channel output controlled by your PC, will switch high current mains with relays (supplied). Software supplied so you can program the channels to do what you want whenever you want. Minimum system configuration is 286, VGA, 4.1, 640k, serial port, hard drive with min 100k free. £24.99

**MAGNETIC MARBLES** They have been around for a number of years but still give rise to curiosity and amazement. A pack of 12 is just £3.99 ref G/R20

**NICKEL PLATING KIT** Professional electroplating kit that will transform rusting parts into showpieces in 3 hours! Will plate onto steel, iron, bronze, gun metal, copper, welded, silver soldered or brazed joints. Kit includes enough to plate 1,000 sq inches. You will also need a 12v supply, a container and 2 12v light bulbs. £45 ref NIK39

**Miniature adjustable timers, 4 pole c/o output 3A 240V, HY1230S, 12Vdc adjustable from 0-30 secs. £4.99**

**HY1260M, 12Vdc adjustable from 0-60 mins. £4.99**

**HY2405S, 240v adjustable from 0-5 secs. £4.99**

**HY24060m, 240v adjustable from 0-60 mins. £6.99**

**BUGGING TAPE RECORDER** Small voice activated recorder, uses micro cassette complete with headphones. £28.99 ref MAR29P1

**POWER SUPPLY** fully cased with mains and o/p leads 17V DC 900mA output. Bargain price £5.99 ref MAG6P9

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

**FUTURE PC POWER SUPPLIES** These are 295x135x80mm, 4 drive connectors 1 mother board connector. 150watt. 12v fan, iec inlet and on/off switch. £12 Ref EF6

**VENUS FLY TRAP KIT** Grow your own carnivorous plant with this simple kit £3 ref EF34

**6"x12" AMORPHOUS SOLAR PANEL** 12v 155x310mm 130mA Bargain price just £5.99 ea REF MAG6P12

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

**ROCK LIGHTS** Unusual things these, two pieces of rock that glow when rubbed together! belived to cause rain! £3 a pair REF EF29

**3' by 1' AMORPHOUS SOLAR PANELS** 14.5v, 700mA 10 watts, aluminium frame, screw terminals, £55 ref MAG45

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

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

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

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

**BALLON MANUFACTURING KIT** British made, small blob blows into a large, longlasting balloon, hours of fun! £3.99 ref G/E99R

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

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

**SOLID STATE RELAYS**  
CMP-DC-200P 3-32vdc operation, 0-200vdc 1A £2.50  
SMT20000/3 3-24vdc operation, 28-280vac 3A £4.50

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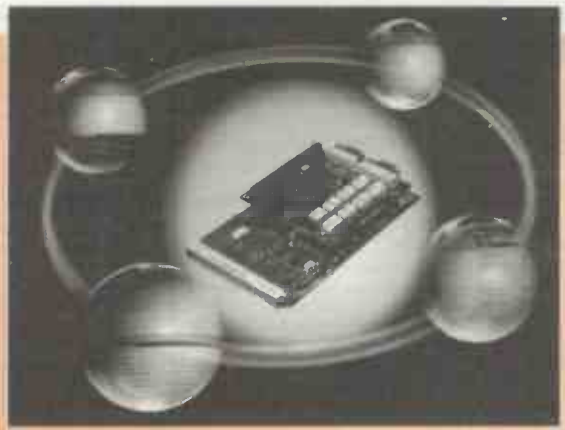


# Multi-tasking kernel assists embedded systems

Arcom Control Systems has ported an efficient multi-tasking kernel from US Software onto its new range of low-cost 16- and 32-bit embedded controllers. The software will assist in upgrading embedded control systems to much higher levels of computing performance to meet the need for greater control flexibility, connectivity and user ergonomics, while keeping down costs, timescales and the difficulties of migration.

In conjunction with Arcom's PC-based development tool, the software provides the same kind of simplicity and speed as developing a PC-based target, but without the overheads needed by a PC running Windows. This can save significant costs in hardware and software licensing for each control system installed. The Arcom controller range is based on the latest 25 MHz 188EB and 33MHz 386EX embedded processors from Intel, giving high computing performance and large memory-addressing ranges at price levels designed to attract designers currently using microcontroller chips.

For example, compared with popular 8-bit devices like the 8051, these new processors offer very considerably higher performance. The CPUs are packaged on single Eurocards with a range of real-time-oriented hardware, as well as PC/104 and (optionally) STEbus expansion interfaces.



The multi-tasking kernel, SuperTask!, allows designers to divide application programs into structured tasks which interface with a real-time database, such as control algorithms, communications, and human interface routines. The kernel ensures that each routine is serviced regularly according to user-defined priority criteria. The use of the kernel can greatly reduce the complexity of programming for advanced control systems. Benchmarks for the 396EX board show that task switching occurs in 20 microseconds, for example, with interrupt latency of less than 80 us, giving designers true determinism for critical segments of code - apparently debugged code segments can occasionally give unpredictable results due to interrupt timing; the low latency in this system addresses this problem.

Run time licenses are just £16 for medium-volume applications.

For further details contact Arcom Control Systems Ltd., Clifton Road, Cambridge CB1 4WH, UK. Tel 01223 411200 email sales@arcom.co.uk Web www.ussw.com

## Government plugs new information programmes

The UK Government (as we write) is promoting a potentially wide-ranging package of programmes under the aegis of the ISI (Information Society Initiative) "to help the UK take its place as a leading nation in the development of the Information Society ... it is an initiative which will continue until the end of the decade".

Among other things, the Government will "a new Information and Communications Technology fund which will enrich our lives ... but no money from the new fund will be available until 2001 at the earliest," reported Minister Ian Taylor.

The main ISI activities include: Programme for Business: a partnership with business to encourage development of new technologies and applications; IT for All: access opportunities for citizens to help overcome technology barriers; Education Department Superhighways Initiative: raising awareness of computer networks in education (computer networks in schools); and government.direct (electronic delivery of government services to homes and businesses). (Information from the Cabinet Office).

The Government is supporting the IT Industry Training Organisation in developing "rigorous standards" of competence at all levels of IT skill. According to the Government, this has already been done with regard to the National Curriculum. The UK is one of the few countries in the world in which IT must be used in all curriculum subjects. UK Education Departments will be publishing purchasing and good practice guidance later this year. A working knowledge of IT "to at least Level 8 in the National Curriculum for Pupils" will be integrated into teacher training qualifications. Industrial sponsors are sought for the DTI's Schools OnLine project.

Other areas to be addressed are the extension of the UK's telecommunications capabilities through investment by cable and telecomms companies. BT is investing around £2M a year to upgrade its network to fibre-optic cable to street-cabinet level. Fixed price ISDN packages are in the meantime available from telephone providers. Much of a record amount of direct foreign investment in the UK has been in information and communications technology (such as Siemens, Fujitsu, Morotola, Nortel, Samsung and LG).

A forum is to be established for industry, academia and other bodies to work together to maximise the UK's research, development and learning capabilities, "with a goal of creating a positive balance of trade in IT-related intellectual property rights by 2005. The DTI has made efforts to improve the protection of intellectual property rights (although participants still find that the situation is far from clear in many cases, the last major redraft being the Copyright, Designs and Patents Act of 1988, before many Internet services went on-line).

The ISI Programme for Business Publicity Centre Tel 0171 828 1593

### OVERSEAS READERS

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

### MODSMODSMODSMODSMODSMODS

In the **Freezer Alarm** (Vol 26 issue 4), a wire link is missing in figure 3 (the component layout). This runs from pin 8 of IC3 to the power rail on track 12 and is clearly shown on the far right of the photograph on page 26 of the article. The link can be inserted to the right of R9 without moving the resistor.

In **The Little Mule** (Vol 26 issue 3). The "missing" IC1 is a 4093 nand Schmitt trigger, available from Maplin and other suppliers.



**THERE IS ONE DANGER YOU CAN'T SEE, HEAR, SMELL OR FEEL- ITS RADIATION. THERE ARE OVER 10,000 SHIPMENTS OF RADIOACTIVE MATERIAL IN THE UK EVERY YEAR BY ROAD AND RAIL! WOULD ANYBODY TELL YOU OF A RADIATION LEAK?**

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

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

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

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

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

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

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

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

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

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

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

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

**GPS SATELLITE NAVIGATION SYSTEM** Made by Garmin, the GPS38 is hand held, pocket sized, 255g, position, altitude, graphic compass, map builder, nitro filled. Bargain price just £179 ref GPS1.

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

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

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

**SUPER WIDEBAND RADAR DETECTOR** Detects both radar and laser, X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front & rear waveguides, 1.1"x2.7"x4.6" fits on sun visor or dash £149 ref

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# Wall of Sound



**The loudspeakers of the future are thin, flat and could be built into your wall. The first ones are more likely to be built into your laptop.**

**They disobey the wave equation. They are the first serious competition for traditional loudspeaker design. Andrew Armstrong reports.**

**I**t appears that the days of the conventional loudspeaker may be numbered, and that for the most part flat panel loudspeakers will be used in the future. If you remember our editorial challenge to make a real improvement in loudspeaker performance - well, the NXT design looks like the most serious contender to provide the answer. This is an account of a visit to the labs where the loudspeakers were developed.

I went to see and hear the new loudspeakers as a sceptic, open minded enough to ask for a demonstration of this new type of technology, but not suspecting the far reaching consequences of the new developments.

V Labs at Huntingdon is a shared R&D facility for several well respected hi-fi brands including Mission, Quad, and Roksan. This in itself inspires some confidence in the quality of the work to be expected.

The working conditions are ones which would delight most designers: the computer equipment is upgraded regularly, and the "old" equipment is passed on to less critical areas of the company. I was particularly taken with the mechanical design section, in which the casework is designed with CAD software able to display any stage of the assembly and which can also show the finished equipment displayed with other hi-fi items to see if the styling is compatible with other respected models on the market, as hi-fi products are frequently "mixed and matched" by discerning users. The CAD can also provide an animated display of the casework being assembled.

This is not simply about style and marketing, however. When sample mechanical parts are needed, laser stereo lithography is used. The process uses numerical data to control laser beams directed into a tank of a plastic material which is polymerises at the crossing point of the laser beams. Thus, the lasers can draw a mechanical shape required in 3D, and this shape forms in the tank. The data

to control the laser beams is generated straight from the design in the computer, and a physical drawing is not needed. Assuming that the part produced by stereo lithography is correct, data from the same CAD file is used to control the CNC machines which manufacture the final parts (or which manufacture the moulds for plastic parts). This level of simulation cuts down the stages of development.

Many people will be relieved to hear, however, that the actual electronics prototyping is carried out in traditional manner with prototype assemblies.

## The start of the project

Before the project first began in 1994, a scientist from the Defence Research Agency (DRA) noticed that panels intended for sound deadening in airframes were acting as loudspeakers. He developed this effect into a working loudspeaker which functioned by principles not properly understood, and which were not good enough for serious use. It was only able to work over a limited frequency range, and then not very smoothly. He asked Mission if they could develop it far enough to become useful. The engineers examined it and concluded that it was too far from being useful to be worth pursuing. However, Henry Azima, the Chairman of V-labs, was not satisfied with this answer. Clearly, something worked in a way which could not be explained and he wanted to know more about it before rejecting it.

He set two mathematicians who were experts in the field of finite element analysis to see what they could find out. After two months of work, they developed a finite

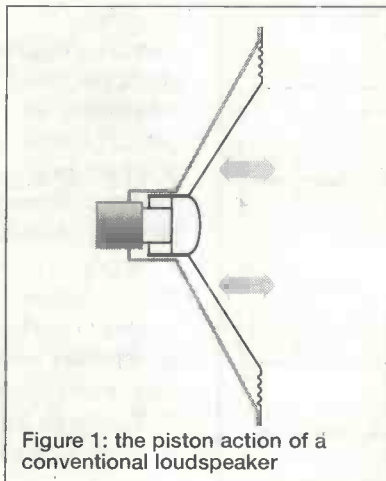


Figure 1: the piston action of a conventional loudspeaker

element analysis program which analysed the vibrational modes of the panel. It was then seen to be possible to use a different but related vibrational principle to make a loudspeaker good enough to be of use.

V-labs still licenses the original patent from DRA, and has a total of 22 patents and 450 claims on their own new technology going forward to date.

### Pistons and other vibrations

An ordinary loudspeaker works as a piston, pushing backwards and forwards a volume of air. This principle is illustrated in figure 1. Virtually all loudspeakers have worked on this principle, and a modern loudspeakers of this type would be largely familiar to a sound engineer as far back as 70 years ago. Refinements such as new cone materials, more compliant suspension, and ferro-fluid, are incremental advances which would seem very logical to the sound engineer of the past.

The NXT flat panel loudspeakers do not work anything like this. Instead of the whole panel acting like a piston and moving a mass of air, it vibrates in an apparently incoherent fashion. The analysis of this is very complicated and can probably only be understood by a few mathematicians. The computer program which is used to help design loudspeakers to this principle is said to take many hours to run even on the fastest currently available Pentium.

Figure 2 illustrates the vibration pattern of a conventional stretched panel, and figure 3 shows that of an NXT flat panel

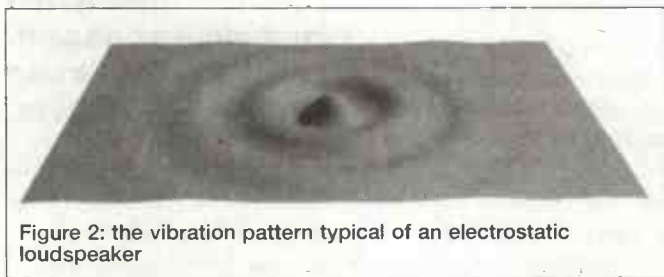


Figure 2: the vibration pattern typical of an electrostatic loudspeaker

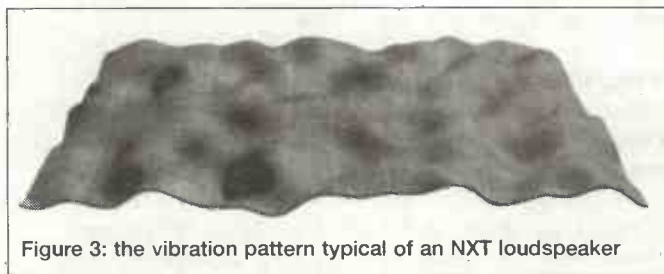


Figure 3: the vibration pattern typical of an NXT loudspeaker

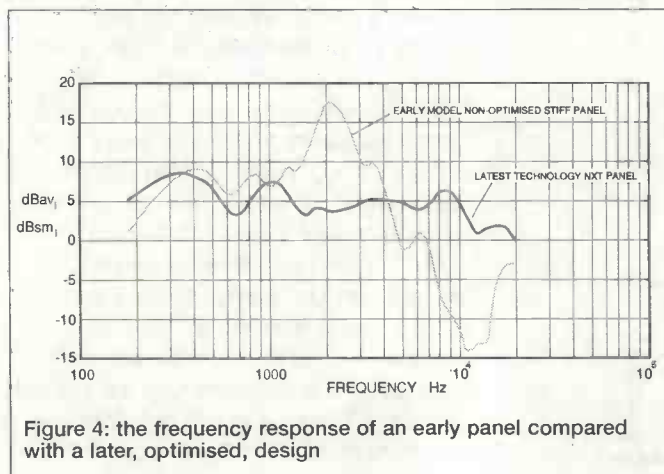


Figure 4: the frequency response of an early panel compared with a later, optimised, design

loudspeaker. The conventional stretched panel has an easily comprehensible pattern, very much like the pattern of ripples caused when a stone is dropped in a pond. Radiation from the back face is out of phase with that from the front, and therefore tends to cancel.

The NXT loudspeaker, on the other hand, has an apparently incoherent vibrational pattern, which is not the same front and back. This apparently chaotic pattern adds at a distance rather in the way that white lights add, while the addition of conventional loudspeakers is more like that of phase coherent laser beams.

### Acoustic characteristics

The acoustic characteristics of an NXT flat panel loudspeaker depend very much upon how well it is designed and built. As far as NXT are prepared to tell us how the technology works, the design is done so that the vibrational modes at different frequencies, though they may appear very different when shown as a vibrational pattern, transfer power to the air with similar efficiency.

Factors which have to be correct in order to make the transducer work efficiently and with an even frequency response include:

- the shape of the panel
- the position of the driver
- the bending stiffness
- the surface density
- the shear modulus of the core
- the damping factor
- the method by which the panel is suspended

Inevitably, the discontinuity represented by the edge of the panel gives rise to the possibility of resonance, and so adds to the complexity of the equations that must be solved to design the panel. Equally, some parts of the panel vibrate at a higher amplitude, and any damping at these points would impair the performance. It is vital that suspension points are chosen so that they affect the vibrational pattern of the panel as little as possible or in a predictable fashion which is taken account of at the initial design stage.

If the design parameters are slightly wrong, the performance is considerably reduced. Figure 4 compares the performance of an earlier design in which some of the parameters were not optimum, with a later design which is much nearer to optimum. The earlier design has a very uneven frequency response, for instance, a resonance in the middle region and a steep falling off of response at the treble end - around 15dB at 10kHz (triangles and cymbals lose sharpness). The subsequent design has a much more even frequency response. Although DSP frequency response correction could have made the earlier design sound reasonable, as a general rule using frequency correction to get rid of large peaks and troughs in the frequency response of a loudspeaker results in poorer performance than if the loudspeaker response is nearer to flat in the first place, because an unsuitably configured transducer is being forced to respond in a way that is unnatural to it and will add distortion of its own in the process.

One of the valuable characteristics of the flat panel loudspeaker is that it is not highly directional even at high frequencies. Figure 5 shows the radiation pattern from an NXT panel at a range of frequencies from 250 Hz to 16kHz showing a reasonably even pattern at all these frequencies.



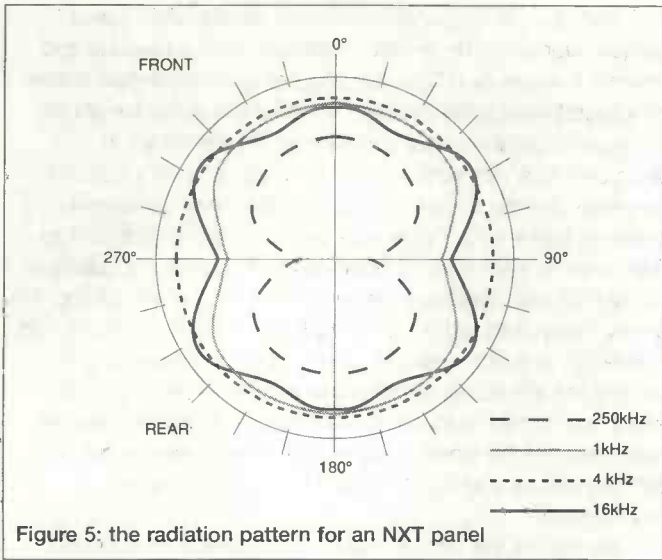


Figure 5: the radiation pattern for an NXT panel

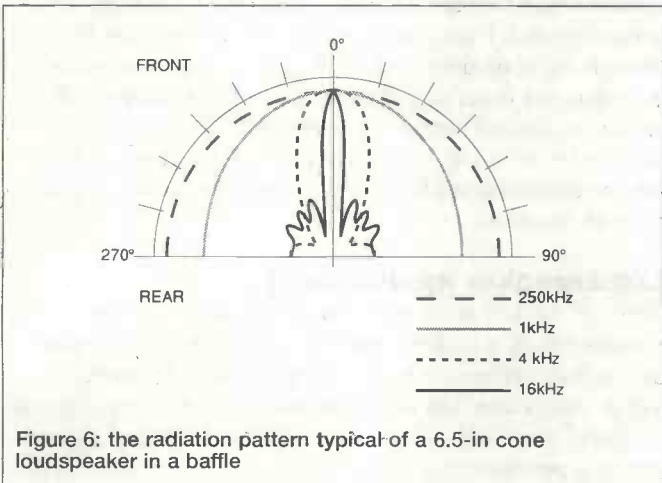


Figure 6: the radiation pattern typical of a 6.5-in cone loudspeaker in a baffle

In contrast, figure 6 shows the radiation pattern typical of a 6.5in diameter cone loudspeaker in a baffle. Even at 4 kHz, this shows a very directional pattern while at 16kHz you would be very lucky to be able to locate the optimum position to hear that frequency.

What is also noticeable from these diagrams as well as from the frequency response in figure 4 is that the one drawback the NXT panel displays is a limited low-frequency response. A very big panel can provide a tolerable low frequency response, but the people at verity labs say that at around 80 to 100 Hz the panel is working more as a piston rather than using the complex vibrational 'distributed mode' characteristic of NXT. On this evidence it is likely that conventional cone loudspeakers will retain their popularity at sub-woofers.

### Power drop with distance

With conventional loudspeakers the aim has been to approximate the effect of a point source transducer. A point source would suffer from a halving of sound level with each doubling of distance, the well-known "inverse square law". The NXT however approaches a linear law over a limited range, as is illustrated by the comparative curves in figure 7.

The effect of this linear law is that people near to the loudspeaker are not deafened, while people who are farther away can still hear clearly. Public address systems will benefit greatly, and the area of the living room in which you get good stereo sound will expand. In an ideal world, it may even be that you will be able to get the TV loud enough to hear clearly without disturbing the neighbours.

While meaningful accurate comparative measurements are not at present available, it is clear that less amplifier power is required to give sufficient sound level over a listening area than would be required with conventional loudspeakers.

Another fundamental difference between NXT and conventional loudspeakers is that while the sound radiation from a conventional loudspeaker is focused and, in the technical sense, coherent, the radiation from an NXT panel is diffuse. While this might appear to be a drawback, what it means in reality is that interference to sound quality caused by room boundaries is much reduced. This effect minimises the peaks and troughs normally associated with sound reflecting from the walls of the room.

This also means that hanging one of these flat panel loudspeakers on the wall like a picture will not cause unpleasant resonances, although it will cause a reduction in sound level of about 3dB, due to the loss of radiation from the rear of the panel. And hanging the panels on the wall will be a reality, as the panels can be as thin as 2mm and any area from 25 square metres to 100 square metres.

### Listening tests

In the listening room, varied program material was played including some CDs I brought along myself. As I sat in the normal listening position that one would pick for hifi loudspeakers I could not immediately hear any difference between the NXT flat panel speakers being demonstrated and any true hifi standard loudspeaker system. At that stage the most impressive thing was that there were no big bulky boxes in evidence.

On more careful consideration, I reckoned that the clarity and sense of openness in the sound was better than I would normally expect even from a good set of loudspeakers. I suspect that this is a characteristic of the NXT panels, but I cannot say for sure until I hear a set in a room which is less acoustically good than the demonstration room.

I was encouraged to walk around the room to hear how the sound intensity changes as you move up closer to the loudspeakers. In fact, it changes very little, so that with the four channel home theatre demonstration, you could hear all four channels over most of the room. The loudspeaker you were standing next to did not drown out the sound from the other channels. This sounds absurd, but the reason, at least in part, is that as you get close to a large flat-panel loudspeaker, a lot of the sound being radiated from it goes

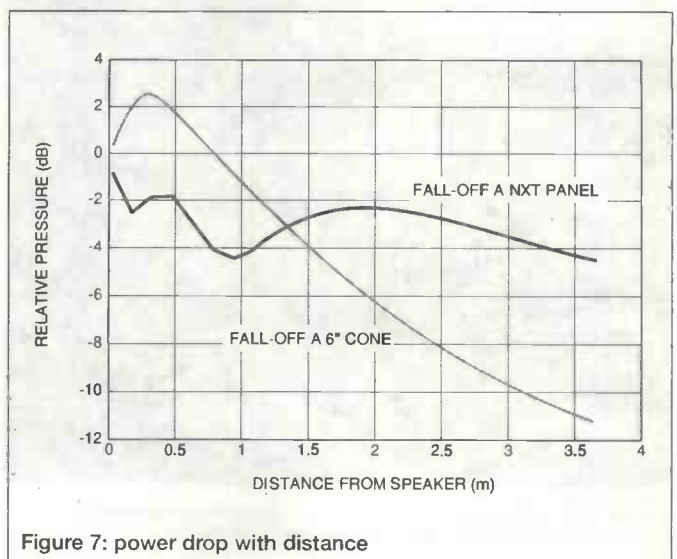
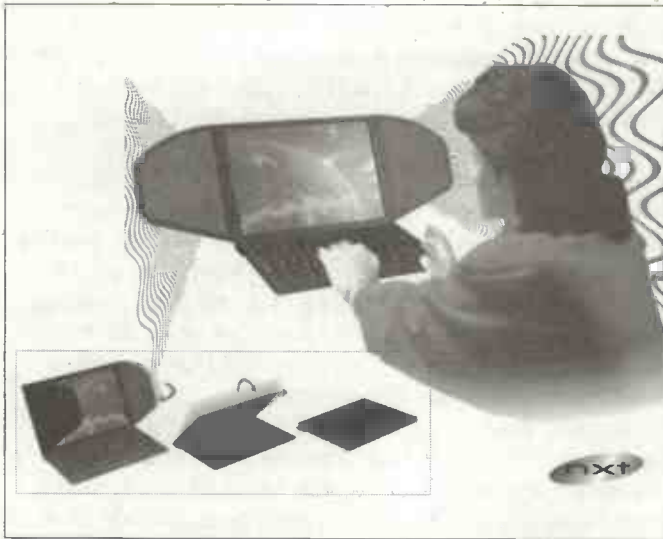


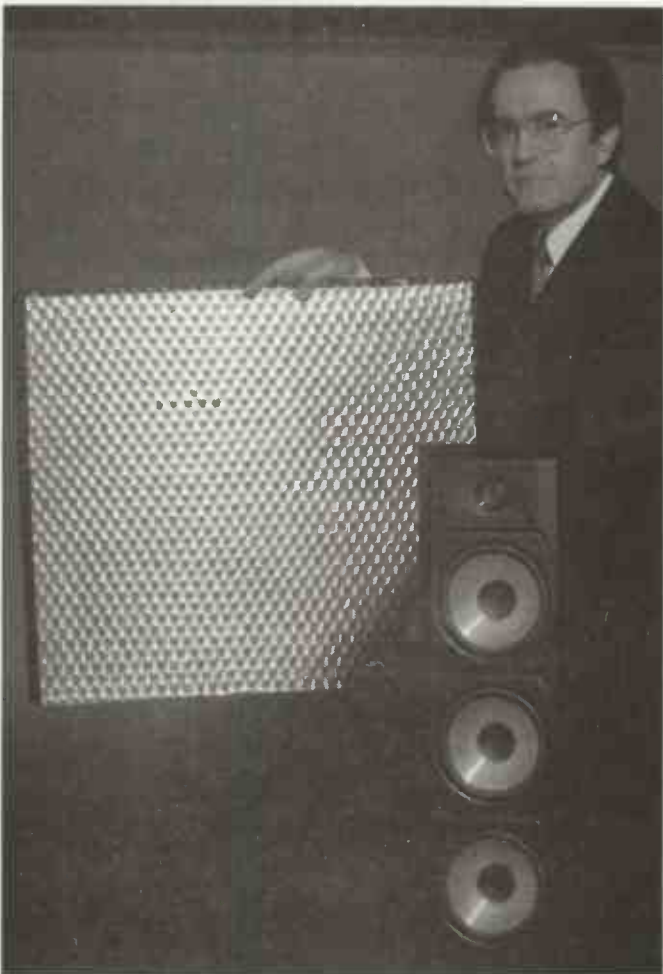
Figure 7: power drop with distance



I don't believe your ears! Design for a fold-out laptop with thin panel speakers.

past you and does not reach your ears. It is also partly a function of the very complex vibrational mode.

One of the many effects of this is that if you are using NXT flat panel speakers as part of a public address system, the microphone can get close to the loudspeakers before feedback occurs, because the sound intensity at a point does not rise in the same way that it does when you approach a small area piston-type loudspeaker. Other implications of this effect are discussed below.



Chief Executive Farad Azima with an improbable-looking but remarkable-sounding NXT flat speaker panel.

I was given a flat panel speaker to handle while it was actually working. The model I handled was rectangular and roughly 1 metre by 0.5 metre, and being made almost entirely of a secret composite material of about the same weight as corrugated cardboard (and indeed appeared similar in structure) was very light, and as I turned it round I noticed very little change in sound level or quality until it was almost edge-on to my ears. There was very little sound vibration to feel, even at a reasonable listening level, though the quality of the sound was affected by where I held the panel. Holding it in a way that would disturb its complex vibrational pattern could noticeably impair the sound quality. The transducer which excites the vibrations in this panel was only noticeable as a slight ripple in the surface. Unsurprisingly, given the extreme complexity of the vibrational mode, it was off-centre rather than central as you would expect with a piston-type loudspeaker.

One part of the demonstration which made an impression upon me was the use of a mock ceiling tile in the foyer for an announcement. I first heard it while I was in the listening room, through the open door, and for something that was plainly audible under these circumstances it was not exceptionally loud when I stood right underneath the NXT tile. This really brought home to me the point about how much the very even volume dispersion will be able to improve the quality of public address systems.

### Loudspeaker applications

Although the first application which may come to many peoples minds is for flat panel hifi loudspeakers for domestic use, a likely application to come first is that of multimedia laptop computers. The loudspeakers in laptop computers are inevitably small, with an inevitably shrill tone. The picture here shows a possible application, with flat panel loudspeakers as pull out ears from the sides of the display.

In fact, it may turn out to be possible to make displays with the right mechanical characteristics to work as the loudspeakers. Yes, the plural was deliberate. If two drivers are used, one to each side of the screen, then although the whole panel will radiate the sound from each driver, the sound straight from the driver will reach the ear before that which has travelled across the panel before being radiated. This timing information has been shown to give the ear directional cues, hence stereo.

Obviously, public address or, more correctly, sound reinforcement with little tendency towards feedback will be a great boon, the other aspect of the acoustic characteristic, that of less reduction of sound intensity with distance, is equally valuable. What it means is that fewer loudspeakers are needed to give audible sound over a wide area. A particular plus point from many peoples point of view is that there is not a specially loud area just under a roof loudspeaker.

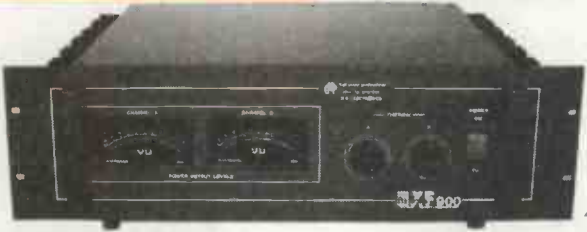
Recently we ended up leaving a bar in which the only unoccupied tables were those directly under loudspeakers, but the bar staff would not turn the sound any lower otherwise some people couldn't hear it. NXT loudspeakers, in place of the occasional ceiling tile, would have gone a long way towards solving this problem. A ceiling tile as a sound source will likely be welcomed in airport waiting rooms and the like, ensuring that all can hear the announcements without the need to deafen those near the loudspeakers.

Of course, if unobtrusive loudspeakers can look like ceiling tiles, then so can microphones. Bugging in plain sight might be the next fashion in international espionage



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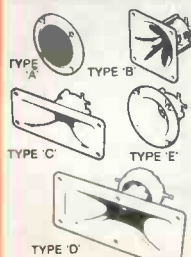


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The Japanese intend to go a large step better. In overcrowded Japan, space is at a premium, and a company which makes pre-formed bathrooms - the whole thing, washbasin, floor and all - is now planning to make pre-formed wall panels which will be NXT type loudspeakers. Then the stereo speakers will not occupy any room space - just connect the hifi system to the wall and listen in comfort. Of course, sound will also be radiated from the other side of the panel, into the adjoining room, but I do not doubt that when the time comes there will be an answer to this - perhaps a second panel to cancel the sound from the first in one direction only.

This brings me to another application. With the drive for quieter machinery, it is likely that active sound deadening will be incorporated, within the next few years into a number of products. The less directional response at high frequencies will make the NXT panel more effective as an active sound cancellation source. While it is unlikely that the distribution pattern of the NXT loudspeaker will exactly match the source of noise, it is likely to do so reasonably over a wider angle and thus be more effective than an ordinary loudspeaker.

### Electrical characteristics

The energy transfer from the loudspeaker to the air is complex and fairly efficient. It is also similar over a wide range of frequencies. The effect of this is that there are no mechanical effects of the sort which make the graph of the impedance of an ordinary loudspeaker far from smooth. The curves supplied look like simple resistance plus the inductance of the moving coil transducer.

This means, of course, that it is very likely that fancy loudspeaker cables will be less relevant, and that amplifier distortion will be lower because the impedance being driven is so much nearer to a plain resistance.

Why should loudspeaker cables matter less? Well there has for some time been controversy as to whether loudspeaker cables do have a significant effect on sound, but it is increasingly accepted that some difference between cables does exist, and it seems plausible that the differences are caused by resistance, inductance, and capacitance reducing the ability of the amplifier to damp resonances of the loudspeaker. A loudspeaker which has a resistive impedance and little in the way of resonances is less likely to be affected by a little extra impedance between it and the amplifier.

There are two ways to excite the NXT panel using moving coil drivers, and these are illustrated in figures 8 and 9. The first is an inertial magnet driver in which the mass of the magnet must be sufficient that the majority of the vibration is transferred to the panel and not to the magnet, while the other sort of driver is a clamped driver which bends the panel. This has a much higher mechanical impedance. It would also be possible to drive an NXT panel with a piezo-electric transducer, but this would not match well with ordinary hifi amplifiers.

In any event, the magnitude of vibration of a panel is typically a few microns over the middle frequency range, well within the elastic limit of the material. Thus, the panel itself adds negligible distortion to the signal. Also, the magnet and coil move very little relative to each other, so that distortion caused by any unavoidable non-uniformity of magnetic field is minimised.

Figure 10 shows second and third harmonic from a typical conventional loudspeaker compared with that from a typical NXT.

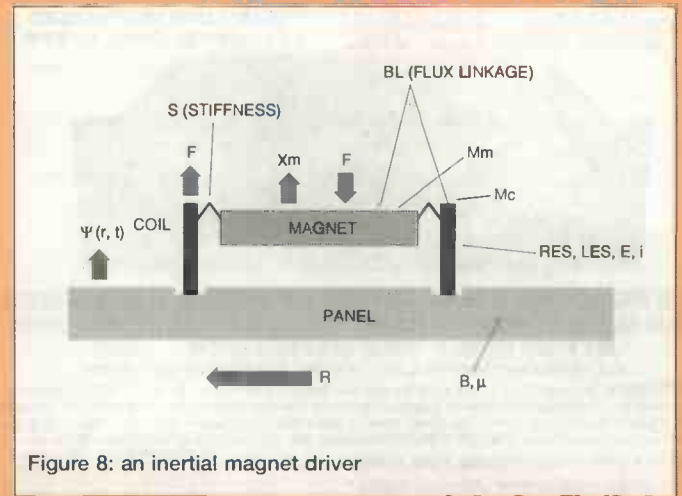


Figure 8: an inertial magnet driver

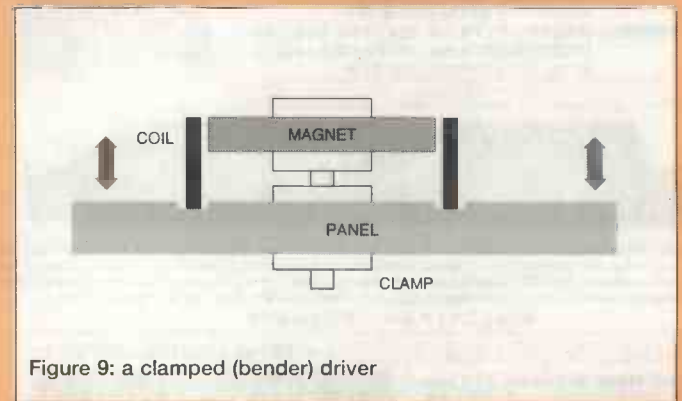


Figure 9: a clamped (bender) driver

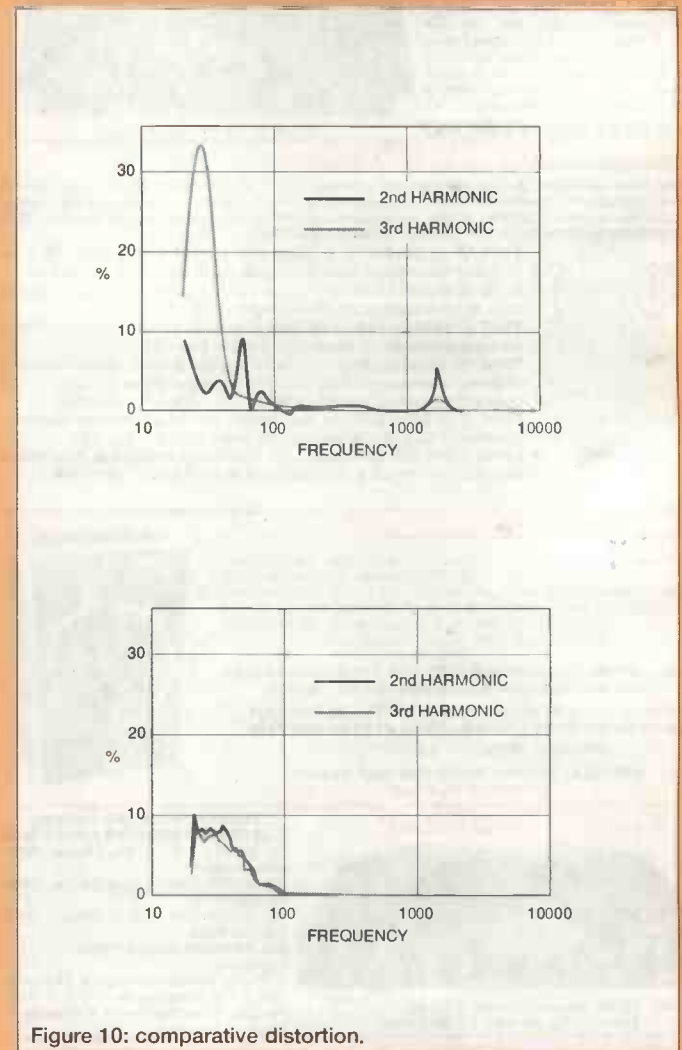


Figure 10: comparative distortion.



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## Commercialisation

NXT have licensed their sister companies Mission and Wharfedale to make loudspeakers with this technology, but they are also licensing other, unrelated, companies worldwide, such as NEC and the pre-formed wall panel manufacturers mentioned above. They have recently licensed Samsung. A cross-licensing agreement has also been signed with United States company Noise Cancellation Technologies (NCT), with NCT, which has developed its own piezo-electric Flat Panel Transducer technology, sublicensing the joint intellectual property in the automotive and transportation sectors allied to noise cancellation issues, while NXT expands its sub-licensing activities in all other fields. Each company will be able to include the other's technology in its own sub-licences

What the licensee gets is design software, and the right to use the technology in a particular product area. Without the software it would be effectively impossible to design an NXT type loudspeaker, and even with the software it may be difficult first time round. The NXT team have been able to advise licensees on how to get the results they need on their introduction to the new technology.

They have also suggested a machining technique. It is necessary for the correct functioning of the loudspeakers that the edge is free to vibrate normally. Cutting methods which cause irregularities on the edge, or which melt the edge of the material to form a stiffer rim around the cut, interfere with the correct functioning of the panel. NXT has found that cutting with high pressure water jets is most effective.

The folks at NXT reckoned that products incorporating the next flat panel technology might be available as early as July 1997, perhaps in the USA. The first application on the market is quite likely to be - yes - a multimedia laptop PC. The first hifi applications may be available by the end of 1997.

The design and the tuning of the manufacturing process to produce loudspeakers that work well may be much more difficult than for conventional loudspeakers, but it is also likely that the unit costs in volume production will be much less than for conventional speakers, at least for the higher quality applications. Maybe this will not initially translate to lower prices, but rather to higher ones due to the novelty value. In the long run, however, I expect top quality loudspeakers which I can place on the wall, or in the wall, or even *instead of* the wall, to be available prices comparably lower than the traditional loudspeaker technology.



NXT speakers with their lightweight nature and superior sound quality, are a natural match for all multimedia computing applications, in particular notebooks and PDAs.



NXT speakers integrated with rear parcel shelf of a car, acting as a structural member. The nature of NXT sound provides uniform sound distribution in the car environment without any hot spots.

Below: NXT's table of applications for the first products expected on the market

Application	Response	Sensitivity	Characteristics
SonTile™	100Hz-12kHz	87db	Unique voice intelligibility; concealed speaker mounting; lightweight; exceptional sound distribution; very low installation cost.
Multimedia and laptops	200Hz-12kHz	84dB	Much superior to conventional speakers computers fitted to laptops and mm computers
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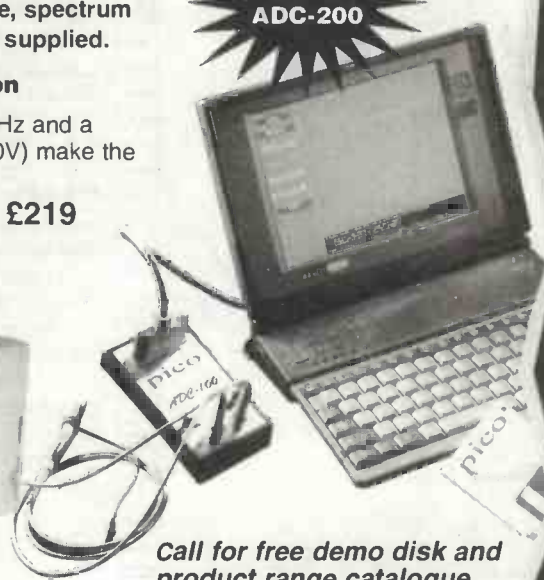
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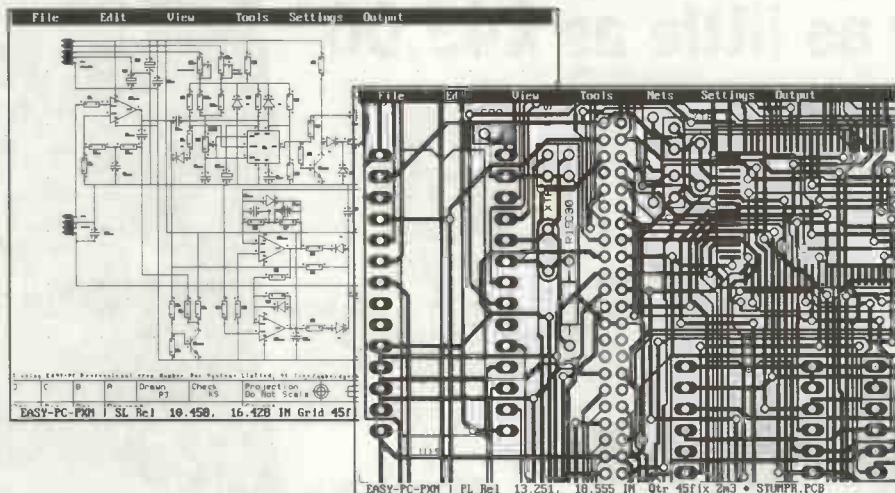
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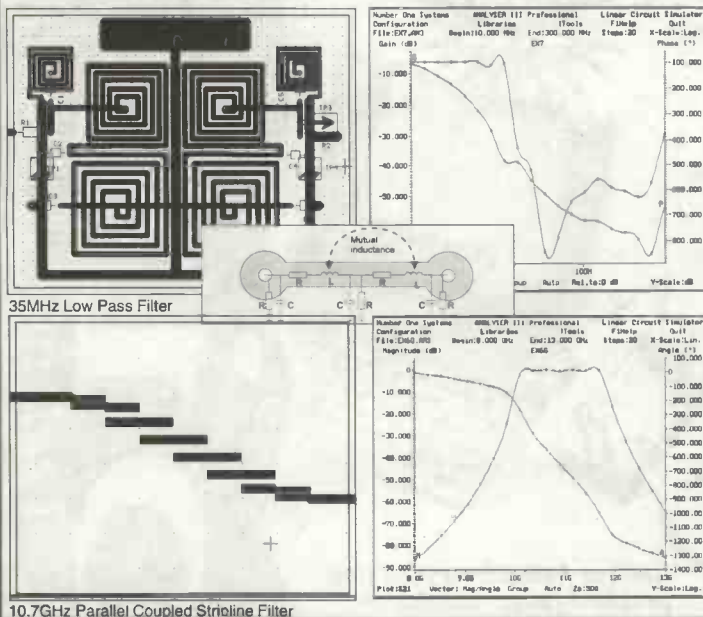


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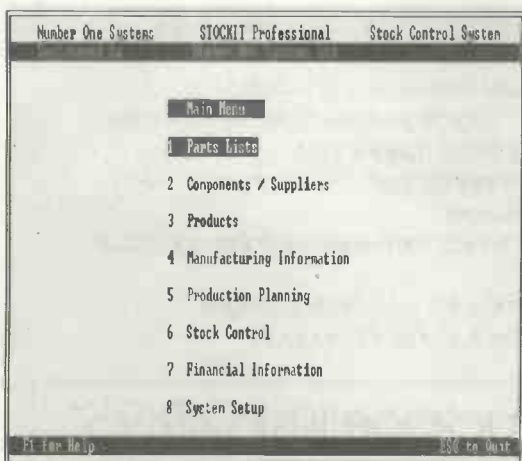
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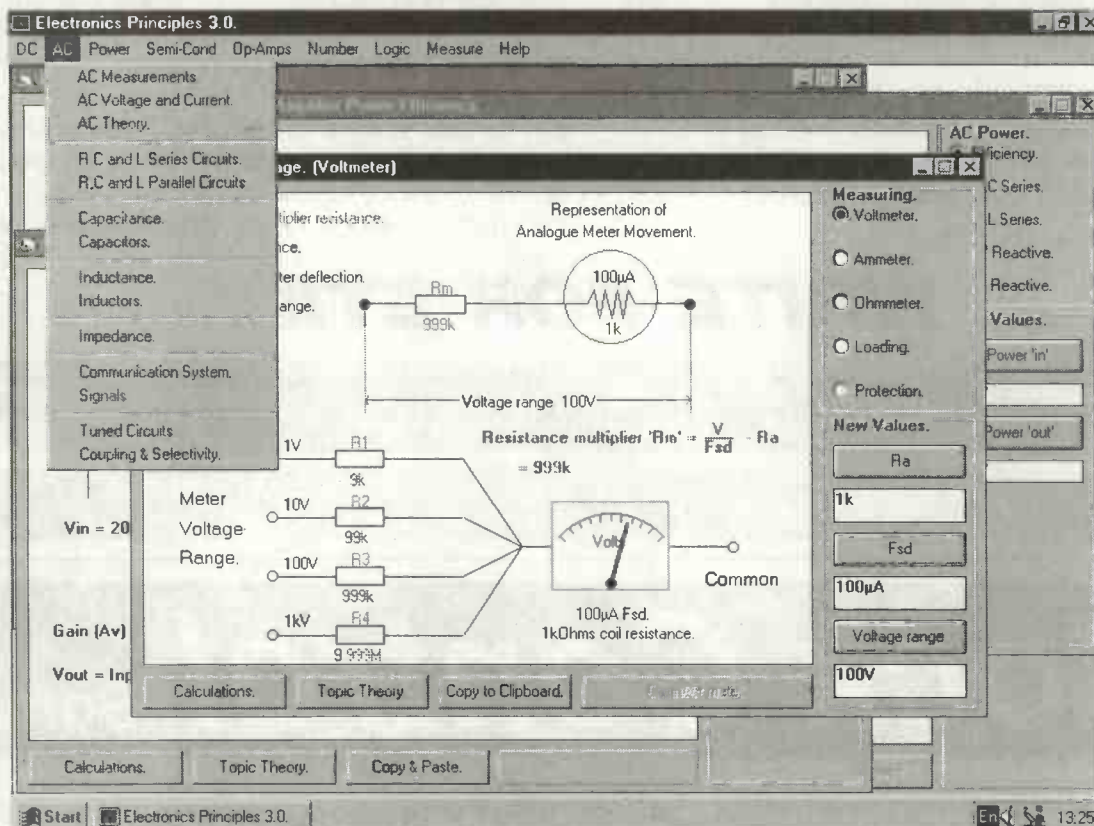
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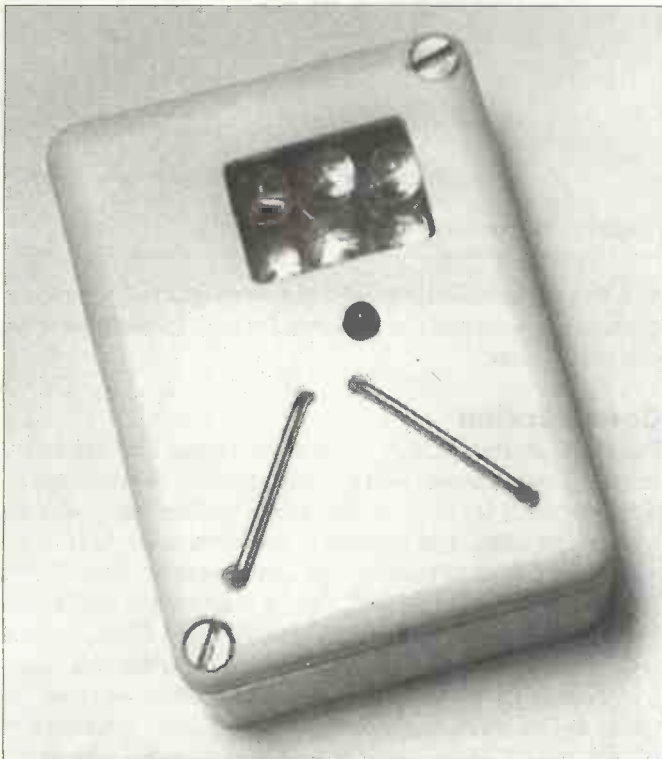


# Low power, light-powered

By Terry Balbirnie

# Continuity Quick-Tester

*Hold it up to a light  
- and presto!  
Needs no batteries.*



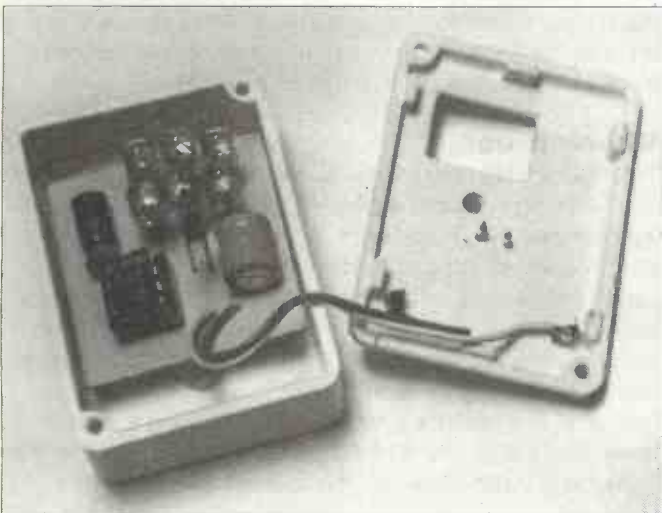
**A** continuity tester is a device that indicates a low resistance path. It would be useful having one in the home or workshop for testing fuses and filament lamps, to identify switch and relay contacts, to look for breaks in pieces of wire or PCB tracks and to find faulty connections in plugs and sockets. You could also use one to check situations where there should not be continuity - for example, where a blob of solder has bridged adjacent PCB tracks.

## Using a meter

Of course, if you have a multi-tester you could set this to a low resistance range and use it for the purpose. A low reading would indicate continuity. Using a meter would be fine if it was always to hand and if it was to be used by an experienced person. However, someone who did not have the necessary knowledge would not be able to set the range correctly and they might have difficulty interpreting the reading. To have an instrument specially made for the job is definitely a good idea. The traditional type has the disadvantage of being battery-operated - as it will probably be used only occasionally, the battery is likely to be found missing just when you need to make a test (having been "borrowed" for something else), or gone flat from being left on or just from old age.

## Testing - with a difference

This continuity tester is different because it does not use batteries and has no on/off switch. This is because it uses light as an energy source! Even artificial room lighting will be sufficient to make it work. Normally, the tester will be left in a position where light can reach it, such as on a window sill, and it will then be available for instant use. If it has been kept in the dark - in a drawer, for example, it will be ready to operate in a minute or two. This circuit is principally a one-shot device intended to give one test at a time. This is because, after providing a positive result, there is a delay before it will respond again. This "dead" time will depend on the brightness of the ambient light - in normal room lighting it will be about one or two minutes but in bright daylight it may only be a second or two. There is a trick which enables several tests to be made in quick succession and this will be explained at the end.



The circuit will respond to resistances from zero to about 200 ohms. This makes it suitable for checking lamp filaments (whose cold resistance will be a few ohms or tens of ohms), many transformer windings, chokes and relay coils in addition to "straight" continuity tests. It will even identify a good diode (because this will show continuity when connected one way but not the other). The Continuity Quick-Check is very versatile and, no doubt, readers will find other uses for it.

The object to be tested is used to bridge a pair of wire rails arranged in the form of an inverted "V" on top of the box. A red LED will then flash to show continuity. Most fuses, switch tags, bulbs and connectors will bridge the rails quite easily. Where this is not possible, a pair of extension leads may be made, as described at the end.

### How it works

The circuit for the Continuity Quick-Check is shown in figure 1. The components labelled D1 - 6 are silicon photodiodes (LEDs). However, in this circuit they are used as photovoltaic cells. When light shines on them, they develop a small voltage between their ends. This voltage will be some 0.2V to 0.4V over a wide range of light levels. The ability of this type of device to deliver current is very limited and will depend on the brightness of the light reaching it. In sunlight, for example, it may reach 1mA or more. In room lighting it will fall to 2mA or less. Photovoltaic cells make a convenient and compact power source when only a small current is needed. Conventional solar cells appear to be available only in larger sizes and since several of them would be needed, the finished device would be rather large. Also, they do not respond as well as the specified devices in room lighting. Note that not all photodiodes will work in this circuit, and it is essential to use the type shown in the parts list unless you are prepared to experiment.

The photodiodes are connected in series. Thus, the voltage across the set will be six times greater than that across one. With an average value of 0.3V, this will provide a nominal 1.8V. This charges capacitor C1, which is then used to power the rest of the circuit. If the LEDs are shaded so that light can no longer reach them, the charge stored in C1 cannot easily drain back through the diodes. This might appear to be possible because they are forward biased (see figure 1). However, each one needs about 0V6 across it to conduct (that is, 3V6 for the set of six) but the maximum voltage across the capacitor is only 2V4 (with 0V4 across one photodiode) or thereabouts. The photodiodes can therefore "pump" charge into the capacitor but, once there, it can only escape by leakage or, of course, by being used. In the prototype unit, the capacitor self-discharges in 30 minutes approximately. After having charged up, the tester will therefore be capable of working for some time even in darkness.

When the rails are bridged by a low resistance, the positive end of C1 will be connected to IC1 input, pin 5, and establishes a supply to it. This component is an LED flasher/oscillator and C2 is the capacitor needed to make the circuit oscillate (provide pulses). There is also a voltage-doubling effect whereby the pulses applied to light-emitting diode, LED1, are of double supply voltage (nominally 3V6). Note that no series resistor is necessary here because current limiting takes place on the chip. LED1 will continue to flash until C1 has discharged to about 1V. Below this, the ic stops working and also (taking into account the voltage doubling effect) there will be insufficient to operate the LED. Normally, the charge arriving will be much less

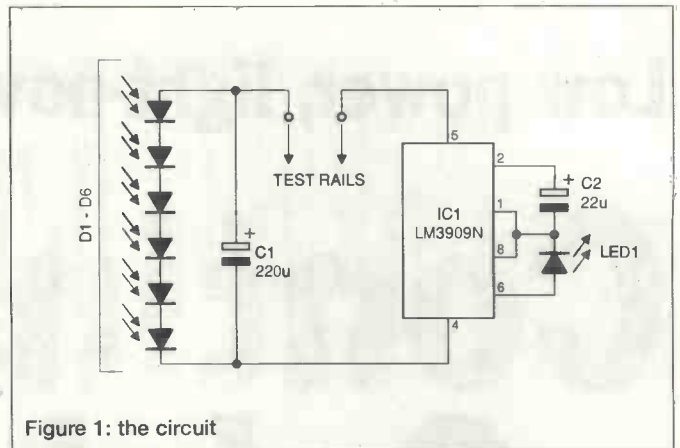


Figure 1: the circuit

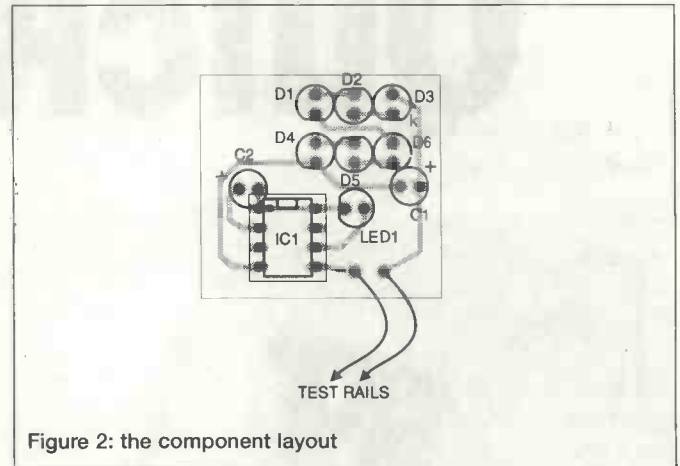


Figure 2: the component layout

than that being drawn so that C1 will be substantially discharged during each test - hence the need for recovery time referred to earlier.

### Construction

The PCB component layout is shown in figure 2. Begin by mounting the ic socket and photodiodes D1 - 6 (these are simply labelled "1" to "6" in the diagram). Take care, because it is easy to solder one or more of them the wrong way round and this would prevent the circuit from working. The cathode (negative) of each ("k" in the diagrams) is identified by a slightly shorter lead and by a "flat" on the body. Add the LED, again, taking care over the polarity. Note that, although a standard LED will work, a high-brightness type will give better results. Both capacitors are electrolytics - check the polarity. Solder short pieces of light-duty stranded wire to the pads labelled "test rails". Insert the ic into its socket with the correct orientation. Since this is a CMOS device, it can be static sensitive - it is wise to touch something earthed (such as a water tap) before handling the pins.

### Check it out

The PCB should now be checked before it is mounted in the box. Keeping the wires separated, place it on a table so that light reaches the photodiodes. Allow about two minutes for the capacitor to charge sufficiently for a test to be made. Touch the wires together. The LED should flash a few times showing that there is a low-resistance path between them. If this test does not work, allow more time for the capacitor to charge or use brighter light.

If all is well, the box may be prepared. Begin by measuring the positions of the photodiodes and LED on the PCB. Mark these places on the lid and make holes to





correspond. The two wire rails should now be cut out. In the prototype, pieces of paper clip were used with their ends bent through right-angles. Small holes are drilled in the lid so that, when the ends of the wires are passed through, they form an inverted "V". Leave a small space between each rail and the lid of the box. The wires from the PCB should now be soldered to one end of each rail on the inside. Paper clip material is not the easiest to solder to, and care must be taken to use sufficient heat to make good electrical connections without melting the plastic. If necessary, the ends may be locked in position using a little quick-setting epoxy-resin adhesive or they may be carefully bent over. The PCB may be secured inside the box using an adhesive fixing pad and raised as necessary so that the LED protrudes slightly through its hole.

Short pieces of wire with a small crocodile clip on one end and a test probe on the other will be useful for checking items where it would be difficult bringing them into direct contact with the test rails. The crocodile clips are simply clipped on to the rails. This method will be useful when checking the continuity of PCB tracks.

### Multiple tests

There may be times when several tests need to be made in quick succession. This may be done by holding the unit within 1ft (30cm) of an ordinary, say 60W, light bulb for two or three seconds each time. This will make the unit ready for use again almost instantly. Note that when using the tester, the best sources of light are daylight and tungsten filament bulbs. Fluorescent light is rather poor for the purpose.

All components for the Continuity Quick-Check were obtained from Maplin.

## PARTS LIST

### Capacitors

- C1 220u 10V radial electrolytic  
C2 22u 10V radial electrolytic

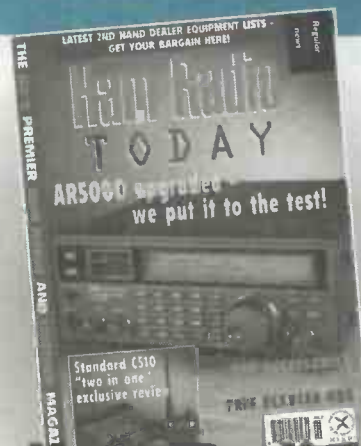
### Semiconductors

- IC1 LM3909N  
D1 - 6 SFH2030 silicon photodiodes,  
Maplin order code CY90X  
LED1 3mm high-brightness red LED

### Miscellaneous

- PCB materials, 8-pin dil socket, plastic box.

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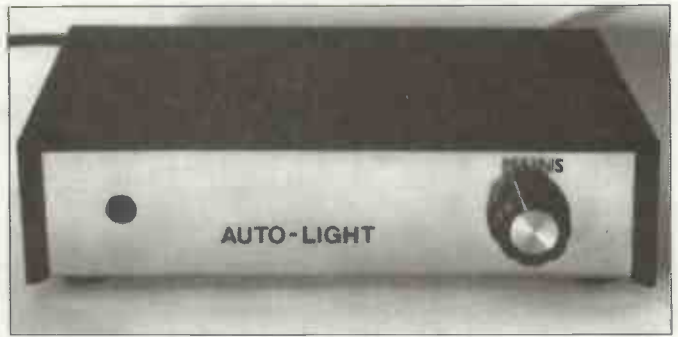
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4002	74HC03	£0.21	74LS53	£0.20	ADM691AN	£6.48	TEA1781DP	£5.03	BAT85	£0.17	AC126	£0.40	BC337	£0.10	BDX33C	£0.56
4006	74HC04	£0.17	74LS75	£0.30	ADM695AN	£6.48	TEA5115	£3.11	BY126	£0.13	AC127	£0.50	BC337-25	£0.10	BDX34C	£0.50
4007	74HC08	£0.21	74LS76	£0.25	ADM699AN	£3.58	TU061CP	£0.35	BY127	£0.10	AC128	£0.40	BC338	£0.10	BDX53C	£0.47
4008	74HC10	£0.16	74LS83	£0.31	CA741CE	£0.26	TU062CP	£0.60	BY133	£0.10	AC187	£0.48	BC338-25	£0.10	BDX54C	£0.50
4009	74HC11	£0.20	74LS85	£0.35	CA747CE	£0.39	TU064CN	£0.72	OA47	£0.20	AC188	£0.48	BC348B	£0.14	BF180	£0.31
4010	74HC14	£0.22	74LS86	£0.20	CA3046	£0.37	TU071CP	£0.39	OA90	£0.07	AC171	£3.84	BC357	£0.25	BF182	£0.31
4011	74HC20	£0.28	74LS90	£0.48	CA3059	£1.33	TU072CP	£0.40	OA91	£0.10	AD149	£1.67	BC393	£0.73	BF185	£0.58
4012	74HC27	£0.16	74LS92	£0.35	CA3080E	£0.73	TU074CN	£0.50	OA200	£0.56	AD161	£0.92	BC414C	£0.13	BF194	£0.31
4013	74HC30	£0.22	74LS93	£0.42	CA3130E	£0.87	TU081	£0.33	OA202	£0.59	AD162	£0.92	BC441	£0.40	BF194B	£0.19
4014	74HC32	£0.20	74LS107	£0.23	CA3140E	£0.51	TU082CP	£0.54	Zeners 2.7 to 33V	BC107	£0.17	BC461	£0.46	BF195	£0.19	
4015	74HC34	£0.25	74LS109	£0.21	CA3189E	£1.22	TU084CN	£0.50	400mW	BC107B	£0.17	BC463	£0.29	BF244	£0.35	
4016	74HC73	£0.40	74LS112	£0.24	LA3242E	£1.12	TU094CN	£3.17	1.5W	BC108	£0.14	BC478	£0.12	BF244B	£0.40	
4017	74HC74	£0.23	74LS113	£0.21	DG2121CJ	£1.55	TU705ACP	£1.62	Bridge Rectifiers	BC108B	£0.16	BC479	£0.32	BF244C	£0.35	
4018	74HC75	£0.40	74LS114	£0.21	DG2121CJ	£1.55	TU7271	£0.54	1.5A 50V	BC108C	£0.15	BC490	£0.24	BF257	£0.33	
4019	74HC76	£0.20	74LS122	£0.31	EL2030CN	£5.67	TU7272	£0.88	1.5A 200V	BC109	£0.17	BC516	£0.22	BF259	£0.33	
4020	74HC85	£0.24	74LS123	£0.31	ICL7106	£2.95	TMP01FP	£5.60	1.5A 400V	BC109C	£0.19	BC517	£0.20	BF337	£0.40	
4021	74HC86	£0.22	74LS125	£0.27	ICL7611DCP	£1.06	ULN2003	£0.52	1.5A 600V	BC114	£0.19	BC527	£0.20	BF355	£0.38	
4022	74HC107	£0.40	74LS126	£0.25	ICL7621	£1.70	ULN2004A	£0.48	1.5A 800V	BC115	£0.41	BC528	£0.20	BF383	£0.13	
4023	74HC123	£0.33	74LS132	£0.21	ICL8038	£4.89	ULN2803	£0.90	1.5A 1kV	BC116	£0.41	BC537	£0.20	BF451	£0.19	
4024	74HC125	£0.24	74LS133	£0.36	ICM7555	£0.32	ULN2804A	£1.64	3A 200V	BC118	£0.41	BC546B	£0.08	BF459	£0.33	
4025	74HC126	£0.46	74LS136	£0.23	ICM7555	£0.98	ULN2806	£1.20	3A 400V	BC132	£0.36	BC546C	£0.08	BF469	£0.36	
4026	74HC132	£0.37	74LS139	£0.40	ICM7555	£0.98	XR2026	£5.37	3A 600V	BC134	£0.36	BC547C	£0.09	BF492	£0.29	
4027	74HC133	£0.29	74LS139	£0.24	LM1651	£1.72	ZN4142	£2.72	6A 200V	BC135	£0.36	BC547C	£0.09	BF494	£0.31	
4028	74HC138	£0.35	74LS145	£0.56	LM272M	£1.36	ZN416E	£1.99	6A 800V	BC136	£0.25	BC548	£0.08	BF498	£0.32	
4029	74HC139	£0.31	74LS147	£1.26	L298	£6.37	ZN416E	£1.99	10A 400V	BC141	£0.27	BC549C	£0.10	BF500	£0.30	
4030	74HC151	£0.33	74LS148	£0.64	L298	£6.37	EPROM's	25A 200V	BC142	£0.31	BC550C	£0.10	BF511	£0.25		
4031	74HC155	£0.27	74LS151	£0.25	L6219	£4.48	2716	£4.74	25A 600V	BC143	£0.34	BC556A	£0.08	BF522	£0.28	
4033	74HC154	£0.85	74LS153	£0.25	LF347N	£0.46	2732	£4.84	Thyristors	BC149	£0.21	BC557B	£0.08	BS170	£0.21	
4034	74HC157	£0.40	74LS154	£0.70	LF351N	£0.43	2764-25	£4.20	C106D	BC154	£0.36	BC557C	£0.08	BS170	£0.23	
4035	74HC158	£0.23	74LS155	£0.25	LF353N	£0.42	27C64-25	£3.44	PO102AA	BC157	£0.12	BC558C	£0.08	BSW66	£1.35	
4040	74HC160	£0.64	74LS156	£0.36	LF353N	£0.42	27C010	£5.74	TIC116D	BC159	£0.17	BC559C	£0.08	BU126	£1.32	
4041	74HC161	£0.28	74LS157	£0.22	LM301A	£0.35	27128-20	£4.08	TIC126D	BC160	£0.28	BC560A	£0.09	BU205	£1.41	
4042	74HC162	£0.45	74LS158	£0.21	LM301A	£0.35	27C128-20	£4.08	BC170	BC170	£0.16	BC560B	£0.09	BU208A	£1.24	
4043	74HC163	£0.27	74LS158	£0.22	LM308N	£0.58	27S62-20	£4.85	ZO105DA	BC171	£0.16	BC637	£0.21	BU326A	£1.40	
4044	74HC164	£0.35	74LS161	£0.48	LM318	£0.98	27S62-20	£3.68	TIC206D	BC171B	£0.16	BC638	£0.09	BFX84	£0.31	
4046	74HC165	£0.35	74LS162	£0.44	LM318	£0.98	27S62-20	£3.68	TIC266D	BC172	£0.13	BC639	£0.21	BU508A	£0.98	
4047	74HC173	£0.38	74LS163	£0.32	LM319N-14	£0.90	27S62-20	£3.42	TIC266D	BC172	£0.13	BC640	£0.13	BU508D	£1.44	
4048	74HC174	£0.27	74LS164	£0.32	LM324	£0.24	RAM	4164-15	BT408-600B	BC172B	£0.13	BCY70	£0.22	BU526	£1.74	
4049	74HC175	£0.35	74LS165	£0.48	LM335Z	£1.52	6116-10	£1.90	TIC266D	BC177	£0.18	BCY71	£0.18	BU806	£1.06	
4050	74HC192	£0.72	74LS170	£0.30	LM339N	£0.24	6264-10	£3.15	Diac, SL Switch	BC178	£0.18	BCY72	£0.20	BUT11A	£1.30	
4051	74HC195	£0.32	74LS173	£0.24	LM348N	£0.31	6256-10	£2.80	DB3, 32V	BC179	£0.20	BC179	£0.18	BD124P	£1.30	
4052	74HC240	£0.37	74LS174	£0.24	LM358N	£0.25	6256-10	£4.22	BR39	BC179A	£1.30	BC179A	£0.17	BD135	£0.78	
4053	74HC241	£0.37	74LS175	£0.24	LM377	£2.57	511000-8	£8.54	Transistors	BC182	£0.11	BC182	£0.11	BF136	£1.26	
4054	74HC242	£0.48	74LS190	£0.60	LM380N	£0.88	514256-8	£6.80	2N1613	BC182A	£0.11	BC182A	£0.11	BF1740	£1.60	
4055	74HC244	£0.42	74LS191	£0.24	LM381N	£2.64	A/D Converters	2N1711	BC182B	BC182B	£0.12	BC182B	£0.12	MJ2501	£1.60	
4060	74HC245	£0.46	74LS192	£0.60	LM392N	£0.79	Data Acquisition	2N218A	BC182B	BC182B	£0.08	BC182B	£0.08	MJ11015	£1.80	
4063	74HC249	£0.25	74LS193	£0.56	LM392N	£0.79	AD420AN	£25.38	2N2219A	BC183	£0.08	BC183	£0.08	MJ11016	£2.56	
4066	74HC253	£0.25	74LS195	£0.24	LM393N	£0.21	AD575JN	£8.75	2N2222A	BC183L	£0.08	BC183L	£0.08	MJE340	£0.40	
4067	74HC257	£0.25	74LS196	£0.24	LM393N	£0.21	AD574AJN	£18.48	2N2646	BC184	£0.08	BC184	£0.08	MJE350	£0.48	
4068	74HC259	£0.57	74LS197	£0.24	LM394N	£0.21	AD775JN	£18.48	2N2904A	BC184	£0.08	BC184	£0.08	MPSA05	£0.14	
4069	74HC273	£0.35	74LS221	£0.40	LM348N	£0.31	AD7226KN	£25.69	2N2905A	BC184L	£0.08	BC201	£0.40	MPSA06	£0.12	
4070	74HC299	£0.64	74LS240	£0.32	LM358N	£0.25	AD755AKN14.04	£1.04	2N2907A	BC184L	£0.08	BC202	£0.40	MPSA13	£0.12	
4071	74HC356	£0.45	74LS241	£0.32	LM377	£2.57	AD7828KN	£0.33	2N2907A	BC204C	£0.72	BC203	£0.40	MPSA42	£0.17	
4072	74HC365	£0.34	74LS242	£0.32	LM380N	£0.88	ICL7109CPL	£7.75	2N2926	BC206C	£0.72	BC204	£0.40	MRF475	£1.78	
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4075	74HC368	£0.25	74LS244	£0.32	LM390N	£0.72	LM3911A	£2.30	2N3055	BC208	£0.72	BC222	£0.58	PIP30C	£0.37	
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4082	74HC423	£0.37	74LS258	£0.24	LMC6032IN	£1.55	ZN4488E	£7.50	2N3703	BC213	£0.08	BC243B	£0.50	PIP42C	£0.52	
4085	74HC453	£0.42	74LS266	£0.14	LP311N	£0.74	NEW		2N3704	BC213B	£0.08	BC244A	£0.53	PIP47	£0.48	
4086	74HC563	£0.48	74LS273	£0.32	LP324N	£0.67	Microcontrollers		2N3705	BC213C	£0.08	BC244C	£0.53	PIP48	£0.62	
4089	74HC564	£0.48	74LS279	£0.25	LP339N											



# Infra-red Activated

# Auto Light



**Robert Penfold's auto light switch is driven by a low-sensitivity, low-power pyro detector to provide movement-sensitive indoor lighting for night-time wanderers.**

**T**his project will be of interest to anyone who has got up in the middle of the night and stumbled around looking for the light switch. It is essentially the same as an outside security light, but it has much lower sensitivity as it is only intended for indoor use. Simply moving around near the sensor results in the controlled light being switched on. You can climb the stairs with your Once switched on, the light remains on for about one minute after the last activation of the sensor. This delay is sufficient to ensure that the light does not get a bout of the "flickers", but it is short enough to prevent the light from staying on for long periods of time when no one is present. The delay time is easily altered to suit individual requirements.

Like security lights, this unit uses a passive infra-red detector, but as only a limited range is required it does not use any form of lens system. Even so, a range of a few metres can be achieved. One disadvantage of using a lens-free detector is that the angle of view is not very large. However, this will not normally be of any great significance, and good results should still be obtained provided the unit is installed in a suitable place. Of course, a lens system can be used if either high

sensitivity or a wide angle of view are essential, but a lens should not normally be required. This type of sensor is activated by the body-heat of someone moving within its area of coverage. An advantage of this type of sensor is that it is not easily "fooled", and false alarms are rare occurrences. Something like a moth flying around the room will not activate the light!

## The pyro-sensor

The infra-red sensor, or "pyro" sensor, as this type of component is normally called, is a ceramic device. It is in some respects similar to a Piezo-electric component such as a crystal microphone, and consists of a slice of ceramic material with an electrode on each surface. However, rather than the twisting of the ceramic material producing a voltage across the electrodes, it is heat that produces an output signal. Normal semiconductor infra-red detectors are sensitive to wavelengths of around 900nm, which is close to the visible red part of the spectrum. Pyro sensors operate at much longer wavelengths of around 1 to 20 micrometres. In other words, pyro sensors carry on where ordinary infra-red devices leave off.

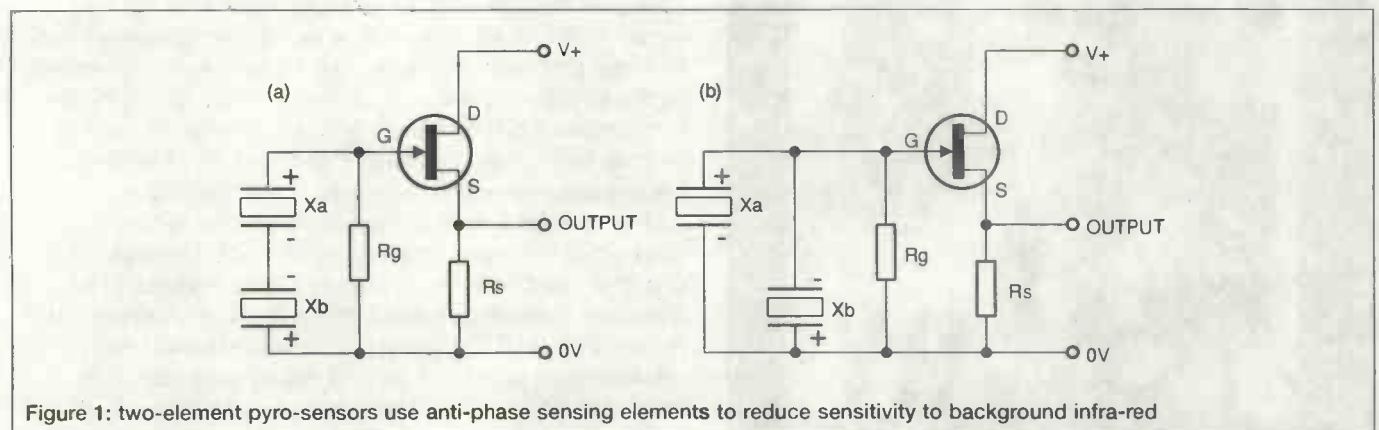


Figure 1: two-element pyro-sensors use anti-phase sensing elements to reduce sensitivity to background infra-red

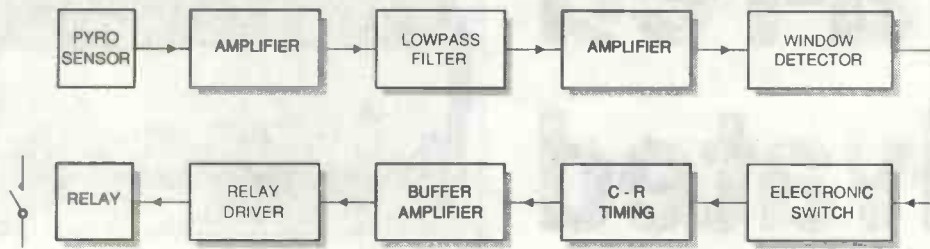
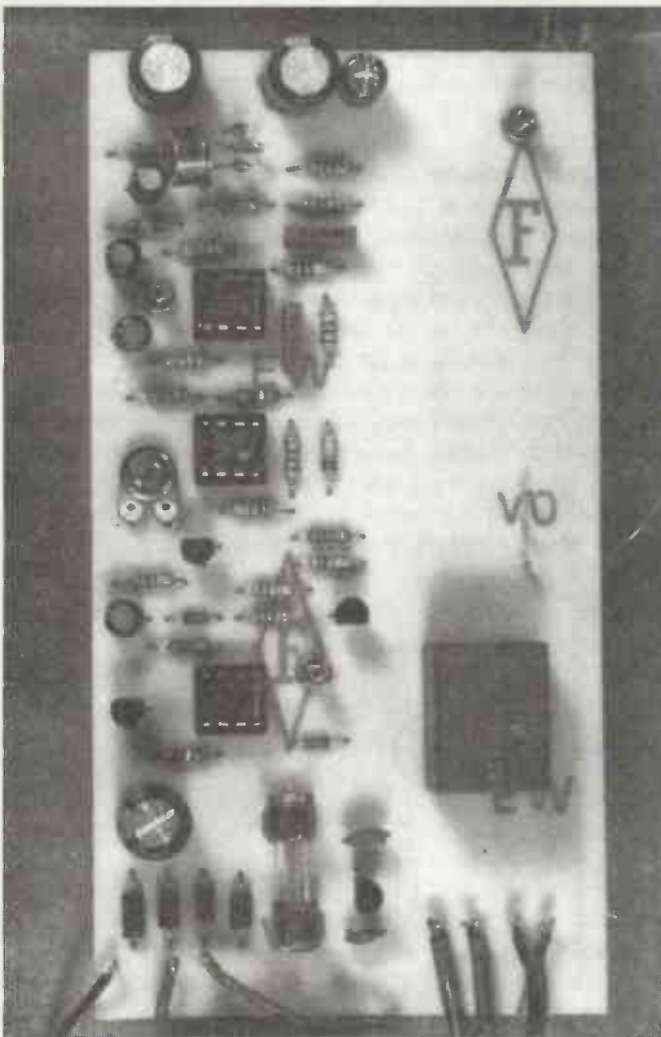


Figure 2: the block diagram for the auto-light

Most pyro sensors have two sensing element connected out-of-phase. Some data sheets show the two elements connected in series (figure 1a), while others show them connected in parallel (figure 1b). In either case the effect is much the same, with the output from one element tending to cancel out the signal from the other element. This may seem to be of little practical value, but you have to bear in mind that the purpose of a pyro sensor is not to detect a steady level of infra-red. It is designed to detect a moving infra-red "target", and in normal use the infra-red "light" is swept across the sensor as the detected person moves across the field of view. The infra-red signal is therefore detected by one element and then the other. This gives a positive signal from the first element followed by a negative signal from the second element, or vice versa.



In either event, the result is a strong output signal from the sensor. The point of using two sensing elements is that it provides a cancelling effect on any changes in the background infra-red level, which will affect both elements simultaneously, it but provides good sensitivity to anyone crossing the field of view. As a result, it is possible to achieve high sensitivity with only very infrequent spurious triggering.

Practical pyro sensors invariably include a jfet buffer amplifier, which provides a relatively low output impedance despite the high output impedance of the sensing elements. The load resistor for this amplifier is sometimes included in the sensor, but in most cases it is a discrete component. The gate bias resistor is invariably built into the sensor. A pyro sensor has a strictly limited frequency response which typically extends from about 0.3 hertz to around 3 hertz. The low frequency response is limited by the value of the bias resistor in the buffer amplifier.

The high frequency response is limited by the time it takes for the sensing elements to heat up and cool down. The slices of ceramic material are made very thin in order to maximise the high frequency capabilities, but an upper limit of a few hertz is the best that can be achieved. In practice this very limited response is adequate, and is actually well matched to the frequency of the signals generated in this application.

### System operation

Figure 2 is the block diagram for the automatic light. The output level from the pyro sensor will usually be extremely small, and may sometimes be under one millivolt peak to peak. A large amount of amplification is therefore needed in order to provide reliable operation of the main circuit. The output signal from the sensor is therefore boosted by two high gain amplifiers. These provide an output level of a few volts peak to peak even if the output signal from the pyro sensor is very weak. With such a high level of gain there can be major problems with noise. This noise is in part generated by the amplifiers, but it is to a large extent produced by the pyro sensor. It can be greatly reduced by lowpass filtering, and the filter cut-off frequency can be set very low due to the low signal frequencies involved in this application.

This enables a large amount of attenuation to the obtained at the mains frequency of 50 hertz. Direct pick-up of mains "hum" from mains powered lighting seems to be absolutely minimal, but it is difficult to avoid a small amount of stray pick-up in the wiring. The lowpass filtering avoids problems with spurious triggering due to stray pick-up of "hum" and noise spikes in the input wiring.



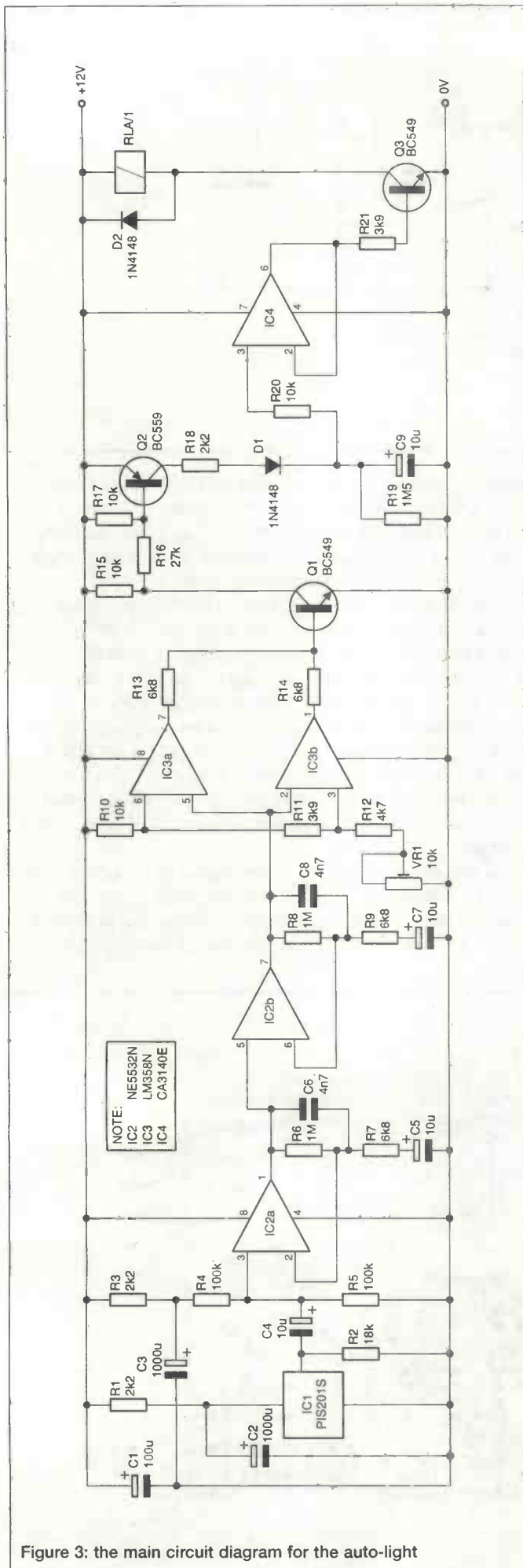


Figure 3: the main circuit diagram for the auto-light

The output potential from the second amplifier is normally about half the supply voltage, but it varies around this level when the unit is activated. A window discriminator detects when the voltage potential of the amplifier strays by about one volt or more from its quiescent level. It then turns on an electronic switch which in turn drives a C-R timing circuit. This circuit has a fast attack time so that the light is switched on almost at once when the unit is activated. Its decay time is very much longer so that once the light is switched on it does not switch off again for about half a minute. If the unit is activated before the voltage on the timing capacitor has decayed, the charge voltage will be boosted to its maximum level again. In this way the time that the light is switched on is controlled by a combination of the timing circuit and whether or not the unit continues to be activated.

The timer stage feeds into a buffer amplifier which ensures that loading on the timing capacitor does not significantly affect the circuit's decay time. The output of the amplifier controls the relay via a simple driver stage. A normally open relay contact connects power through to the controlled lamp while the relay is switched on.

### Circuit operation

Figure 3 shows the main circuit diagram for the auto-light. The circuit for the mains power supply unit and the other mains wiring is shown separately in figure 4. Taking figure 4 first, IC1 is the pyro sensor, and it is a type which requires a discrete load resistor (R2). The circuit should work well with any similar pyro detector, but R2 should obviously be omitted if a sensor having an integral load resistor is used. C4 couples the output from IC1 to a two stage non-inverting mode amplifier based on IC2. The two sections of IC2 are used in identical amplifiers which each provide a voltage gain of about 150. The lowpass filtering is provided by C6 and C8, which provide increased feedback and reduced gain at frequencies of more than a few hertz. Biasing for these direct coupled stages is provided by R4 and R5. With such high gain there is a risk of feedback through the supply lines causing low frequency oscillation. Both IC1 and the bias circuit for IC2 are fed from the positive supply line via a decoupling network which has a long time-constant, and this avoids problems with low frequency instability.

IC3 is used in a conventional window discriminator which has R10, R11, R12, and VR1 to produce the two reference voltages. VR1 enables the reference voltages to be adjusted to suit the exact output voltage of IC1 under standby conditions. The output of IC3a goes high if the upper reference level is exceeded, and the output of IC3b goes high if output of IC2b drops below low lower reference potential. In either instance, Q1 is switched on, and it in turn switches on Q2. C9 is then rapidly charged via R18 and D1, but when Q2 switches off again D1 ensures that no current can flow back into Q1 and Q2. The only significant discharge path for C9 is through the high value of R19. The voltage on C9 is used to control switching transistor Q3 via a simple voltage follower (IC4). Q3 drives the relay coil, and the relay remains switched on while the voltage on C9 remains at more than about 0.6 volts. It takes roughly one minute for the charge on C9 to decay from its maximum level to the point where the relay switches off, but this time is easily changed as it is proportional to the value of R19. For example, changing the value of R19 to 750k gives a hold-on time of about 30 seconds.

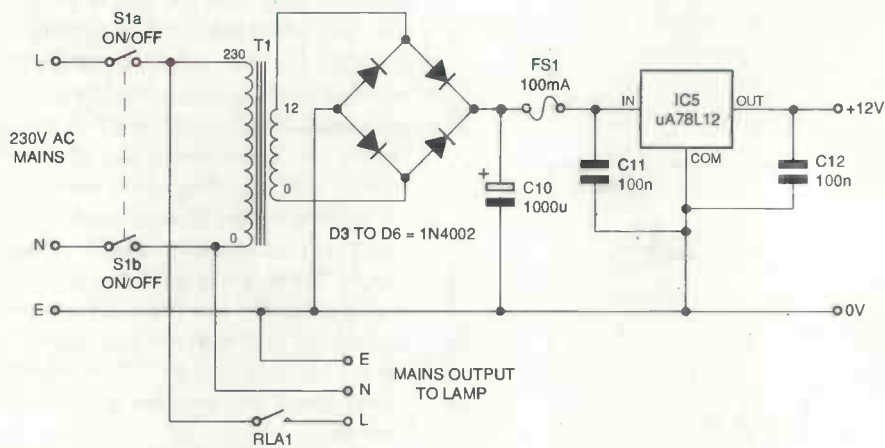


Figure 4: the circuit diagram of the mains power supply

The mains power supply unit (figure 4) has T1 to provide isolation from the mains and a voltage step-down. D3 to D6 form a bridge rectifier which full-wave rectifies the output from T1. Smoothing is provided by C10, and IC5 then provides regulation and electronic smoothing of the output. IC5 incorporates current limiting which protects the supply in the event of an overload, and further protection is provided by fuse FS1. The current consumption of the main circuit is only a few milliamps under standby conditions, but it rises to around 45 milliamps when the relay is switched on.

### Construction

The component overlay for the printed circuit board appears in figure 5. This board is reasonably simple to construct, but there are one or two points that require some amplification. As far as the electrical characteristics are concerned, any relay that has a coil resistance of about 300 ohms or more and a 12 volt coil is suitable for use in this circuit. The only other proviso is that it must have at least one normally open contact having adequate ratings for this application. This

means a contact rating of at least 230 volts AC and one amp. On the other hand, only the specified relay on an exact equivalent will fit this printed circuit design properly. This makes it extremely difficult to use an alternative relay, and I would strongly advise against doing so.

The CA3140E used for IC4 has a PMOS input stage, and consequently requires the normal anti-static handling precautions. The most important of these is to fit the device in a holder, and it is not a bad idea to use holders for the other DIL integrated circuits even though they are not static-sensitive. The CA3140E should be supplied in some form of anti-static packaging, and it should be left in this until it is time for it to be fitted into its holder. Try not to handle the pins any more than is really necessary when fitting this device, and avoid any obvious sources of static charges.

One way of arranging the general layout of the unit is with the circuit board mounted on the rear panel of the case and the pyro sensor "looking" through a window cut in the front panel. If this approach is used the pyro sensor can be

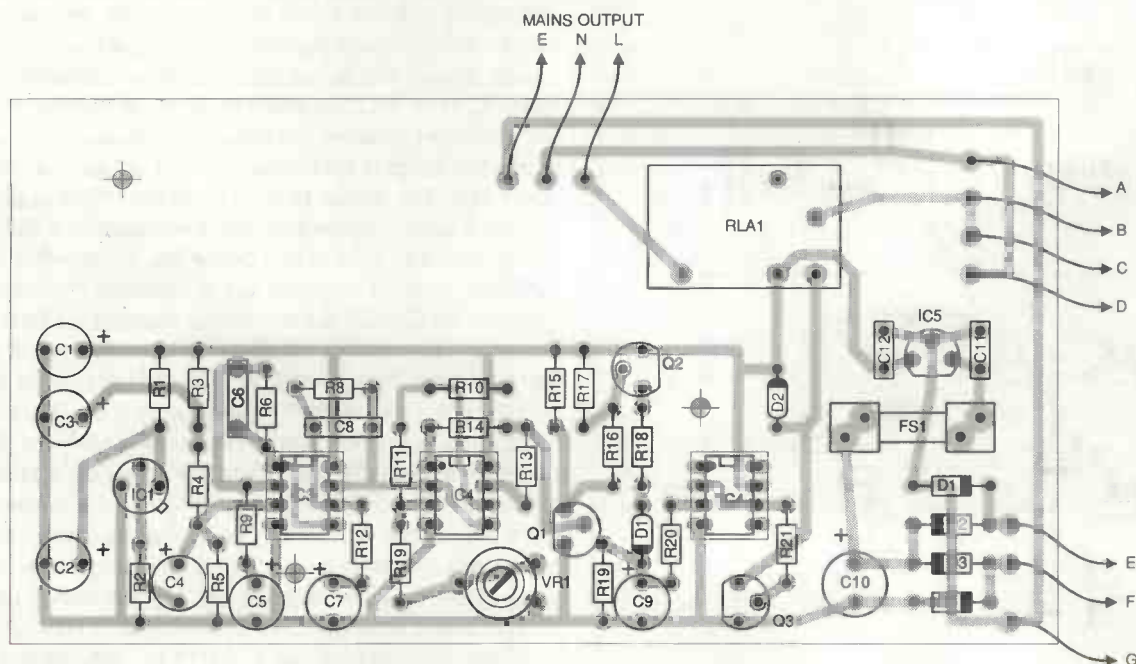


Figure 5: the component layout for the auto-switcher





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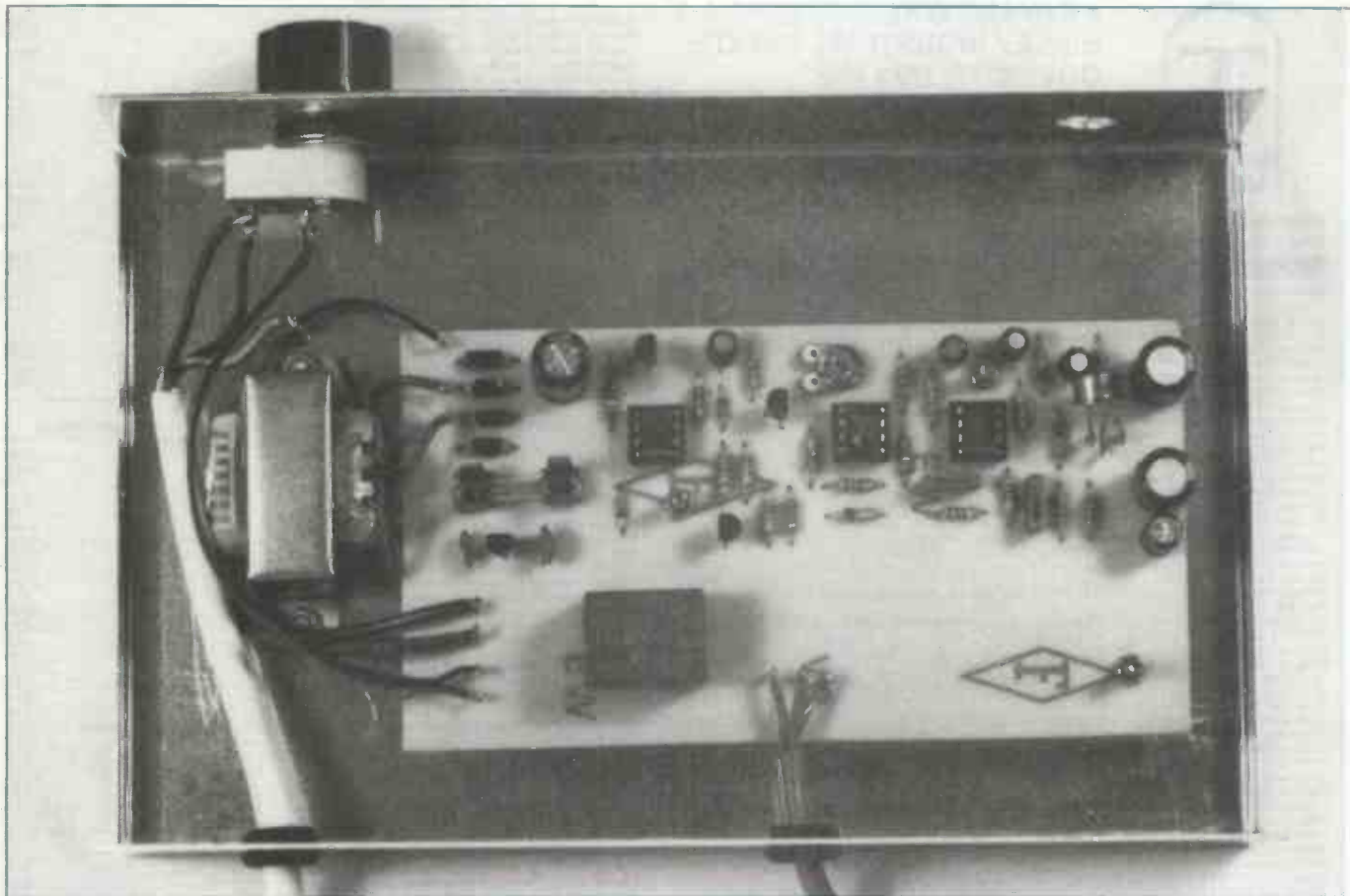
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mounted on the circuit board in the usual fashion. For optimum result it should be twisted slightly so that its window is precisely horizontal. The alternative approach is to have the printed circuit board mounted on the base panel of the case. The pyro sensor still "looks" through a window cut in the front panel of the case, but the sensor will obviously have to be mounted on perpendicular to the circuit board. Probably the easiest way of doing this is to first fit three solder pins to the board in place of the sensor. It should then be easy to fit the sensor on to the pins so that it is perpendicular to the board. Avoid touching the pyro sensor's window as this could reduce its sensitivity. If you should accidentally touch the window use a soft cloth to clean away any finger marks.

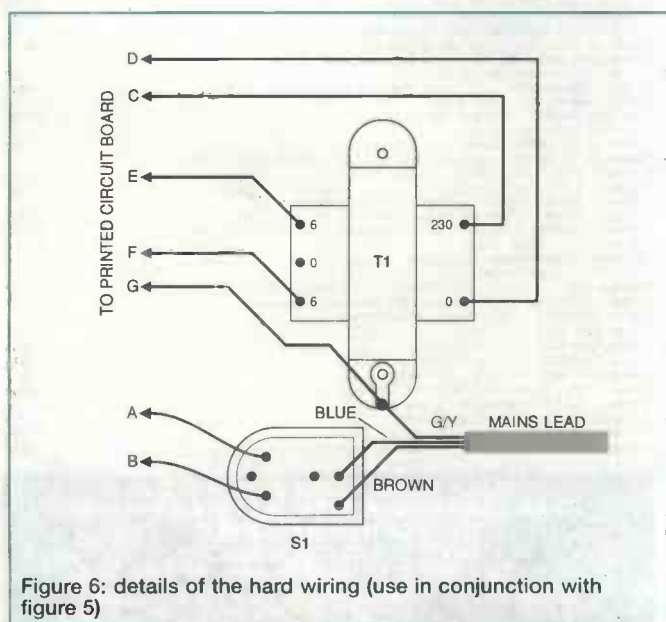


Figure 6: details of the hard wiring (use in conjunction with figure 5)

The fuse is mounted on the board via a pair of fuse-clips. The clips must be the type that has two pins, and not the single pin variety. C5 and C7 must be good quality electrolytic capacitors, or the biasing of the amplifier may be well off centre. Tantalum capacitors are ideal, but good quality electrolytic capacitors should suffice. In other respects construction of the printed circuit board is perfectly straightforward, but be careful to fit the diodes and rectifiers the right way round as mistakes here could cause damage to some of the components. Fit single sided solder-pins to the board at the points where connections will be made to the mains transformer, etc.

As this project connects to the dangerous mains supply it is essential that it is housed in a metal case that is reliably earthed to the mains earth lead. The case must also be a type which has a screw fitting lid or cover, and not one that has a clip-on lid that provides easy access to the mains wiring. Although it is not particularly complex, this project is definitely not suitable for beginners and it should only be undertaken by those who have the necessary experience. The general layout used is not overly important, but it is advisable to have on/off switch S1 and mains transformer T1 situated as far away from the pyro sensor as possible. A solder-tag fitted on one of the mains transformer's mounting bolts provides a chassis connection point. As some tracks of the printed circuit board carry the mains supply it is essential that the board is mounted securely. It is also essential that it is held about 10 millimetres or more clear of the case. Plastic stand-offs can be used, but I prefer 6BA or metric M3 screws plus spacers for boards that carry the mains supply.

The size of the window for the pyro sensor is not critical, but in theory a small hole gives longer operating range, and a larger hole produces shorter range with a wider angle of



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view. In practice small windows seem to give poor results, and it seems to be better to use a hole having a diameter of around 10 to 20 millimetres. Of course, if the sensor is mounted very close to the front panel, a much smaller hole will be required. It might be worthwhile making a large cut-out in the front panel, and pieces of card having apertures of various sizes can then be tried over the cut-out to determine the aperture which provides the best results in your particular set-up. Ideally some transparent material should be used to "glaze" the cut-out, but material that is transparent to visible light might not be transparent to long wavelength infra-red. It might be necessary to experiment a little in order to find a suitable window material. The lamp can be hard wired to the circuit board or connected to the unit via a mains socket mounted on the case. This depends on whether the lamp will always be used

with this unit or if it will sometimes be used on its own. The hard wiring method is used on the prototype and this is the more simple method to implement. It simply requires a hole for the mains output lead to be drilled in the rear panel of the case. A hole is also needed for the mains input lead. Both holes should be fitted with grommets to protect the leads.

Fitting a mains socket on the case is slightly awkward as a large and irregular cut-out is required. The shape of the cut-out must be determined by taking measurements from the socket itself. The cut-out can be produced using a miniature round file, Abrafile, fretsaw, etc. With this type of thing it is always advisable to cut just inside the perimeter of the required cut-out, and then enlarge the hole to precisely the required size and shape using a file. The fixing screws supplied with the sockets are unlikely to be of much use in this case and should be replaced with M3 bolts about 12 to 25 millimetres long. Together with a couple of M3 nuts these should enable the socket to be firmly fixed to the front panel. Details of the hard wiring are provided in figure 5, which should be used in conjunction with figure 4. This wiring is very simple indeed, but as the mains supply is involved it is essential to proceed with due care. Thoroughly checked the finished wiring for errors. A mains transformer having a single 12 volt secondary winding is required, but most modern mains transformers either have twin secondary windings or a centre-tapped winding. Probably the best choice is a transformer having a 6-0-6 volt secondary winding, with the centre-tap being left unused. The wiring diagram assumes that this type of transformer will be used.

It is possible for the mains transformer to heat up the air within the case, causing turbulence which will give spurious triggering. The easiest solution to this problem is to use some tissue paper or other wadding inside the case, between T1 and IC1, so that they are largely sealed off from one another. Make sure that the wadding does not block IC1's view.

**Mains voltage is potentially dangerous. Constructors who are not experienced in fitting mains circuitry should seek the assistance of an experienced mains constructor.**

### Adjustment and use

The easiest way of giving VR1 a suitable setting is with the aid of a multimeter. First cover the sensor with (say) some Bostik Blue-Tack so that you can make measurements and adjust VR1 without activating the unit. After the circuit has had several seconds to settle down, measure the output voltage at pin 7 of IC2. Next monitor the voltage at pin 6 of IC3, and adjust VR1 to set it one volt higher than the voltage at pin 7 of IC2. If you do not have access to a multimeter, temporarily connect a resistor of about 27k in value across R19. This will shorten the hold-on time to only about one second. Trial and error can then be used to find a setting for VR1 that gives good freedom from spurious triggering.

When installing the unit, bear in mind that it is most sensitive to someone crossing the field of view, and least sensitive to someone moving directly towards or away from the unit. It is a matter of installing the unit where it will work effectively, and not simply mounting it on any wall or shelf that happens to be handy. There seems to be no major problem with optical feedback, but it would not be a good idea to have the unit aimed at the light it is controlling.

## PARTS LIST for the IR Auto Light

### Resistors

(All 0.25 watt 5% carbon film)

R1,3,18	2k2 (3 off)
R2	18k
R4,5	100k (2 off)
R6,8	1M (2 off)
R7,9,13,14	6k8 (4 off)
R10,15,17,20	10k (4 off)
R11,21	3k9 (2 off)
R12	4k7
R16	27k
R19	1M5
VR1	10k min hor preset

### Capacitors

C1	100u 16V radial elect
C2,3	1000u 16V radial elect
C4,5,7,9	10u 25V radial elect
C6,8	4n7 polyester, 7.5mm lead spacing
C10	1000u 25V radial elect
C11,12	100n ceramic

### Semiconductors

IC1	PIS201S or similar pyro sensor
IC2	NE5532N
IC3	LM358N
IC4	CA3140E
IC5	uA78L12 12V 100mA positive regulator
Q1,3	BC549 (2 off)
Q2	BC559
D1,2	1N4148 (2 off)
D3,4,5,6	1N4002 (4 off)

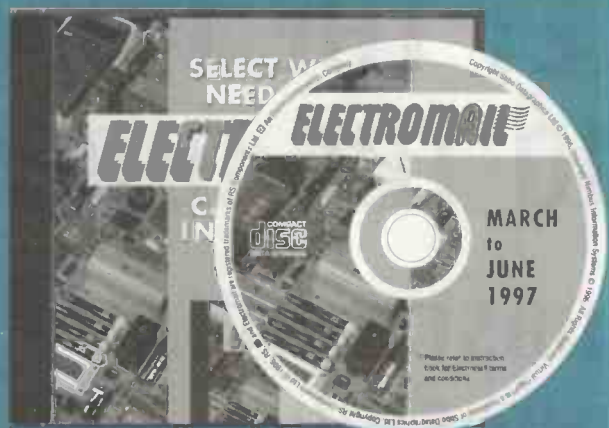
### Miscellaneous

RLA1	12 volt 300R or more coil resistance, single changeover contact rated at 230V ac and 1A or more (Maplin YX97F recommended)
FS1	20mm 100mA "quick-blow" fuse
T1	Standard mains primary, 12 volt 100mA secondary (or 6V - 0 - 6V 100mA secondary with centre-tap ignored)
S1	Rotary DPST mains on/off switch
	Metal case about 203 x 127 x 51mm, printed circuit board, mains lead and plug fitted with 2A fuse, pair of 20mm fuse-clips, 8-pin DIL holder (3 off), control knob, wire, solder, etc.





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# PIC Programmer Re-Visited

**Robin Abbott has developed a more powerful and updated version of the popular ETI PIC programmer**

**I**n the June 1995 issue of Electronics Today International, I presented a PIC programmer which at the time was highly successful. It used a single PIC16C57 and a handful of other components to implement a programmer capable of programming all 12 and 14 bit core PICs in standard DIP packages which were available at the time. Several hundred of these programmers have been built, either in the original form, or in kit form from Forest Electronics. The programmer was designed at the time to be as cheap as possible, and consequently it lacked certain advantages that might be available in a more sophisticated model. For instance:

18pin, 28pin and 40pin devices were all programmed in their own individual sockets, therefore a constructor requiring to use all 3 types of device would require 3 relatively expensive ZIF sockets for large scale programming. Although In-Circuit Programming (also known as In Service Programming (ISP)) was supported, PIC16C84 devices could not be erased in circuit as at the time Microchip had not published the serial programming specification for these devices.

At the time the programmer was designed to be expandable, and in fact many PIC devices released since the programmer was designed are able to be programmed, changing only the initialisation file used in the PC. However the newer 8 pin devices - the 12C508 and 12C509 cannot be programmed by the original programmer as they use a different algorithm from other devices in the series.

To overcome these disadvantages, and to bring the programmer up to date I have redesigned the original programmer to produce a new version with the following features:

- The programmer is now fitted with a single 40 pin multi-width ZIF socket which can accommodate the following PIC device types: 12C50X (8 pin), 16C55X (18 pin), 16C6x, 16C7x, 16C8X, 16F8X, and PIC14000 (with an adapter), in fact, all the current serially programmed 12 and 14 bit core PIC devices in packages with 40 pins or less.

- The programmer supports in-circuit programming of all serially programmed devices, including in-circuit erasure of the 16C8X series.

- The programmer is on a board approximately 2/3 the size of the original programmer.

- The new version is based itself around a PIC, either the 16C84, 16C56, 16C58, 15C556, or 16C558 PIC's may be used.



- The programmer operates on a serial link to a PC running either Windows 3.1 or Windows '95. I particularly dislike programmers (or indeed any peripherals) which use the parallel port, most PC's are only fitted with one parallel port and therefore need either a printer switch or an additional parallel card, parallel cables are also considerably more expensive, and are physically inflexible.

- The programmer supports standard HEX files produced by the Microchip MPASM assembler, or other assembler environments such as the FED PICDESIM assembler/simulator.

- The new programmer also switches Vdd to the chip being programmed (the original programmer always maintained Vdd).

- The programmer supports reading and programming of the eeprom data areas in those PICs which have an eeprom data area.

- The programmer supports Program Readable Identities (PRIDs). This allows the programmer to write a serial number to the program store in the PIC in the form of RETLW instructions which may be read by the application program. The serial number may be unique for each chip programmed with each application, or may be defined as the code checksum, or as a random number.

The only feature offered by the original programmer which is not provided in this version is support for programming in parallel mode. This mode is only used with the 16C5X series devices which are now becoming more expensive than more capable serially programmed devices, thus the 16C556 can be used as replacement for the 16C56 (with some minor code modifications), but has 4 times as much RAM as the 16C56, and is about 10% cheaper (at current UK distributor prices).





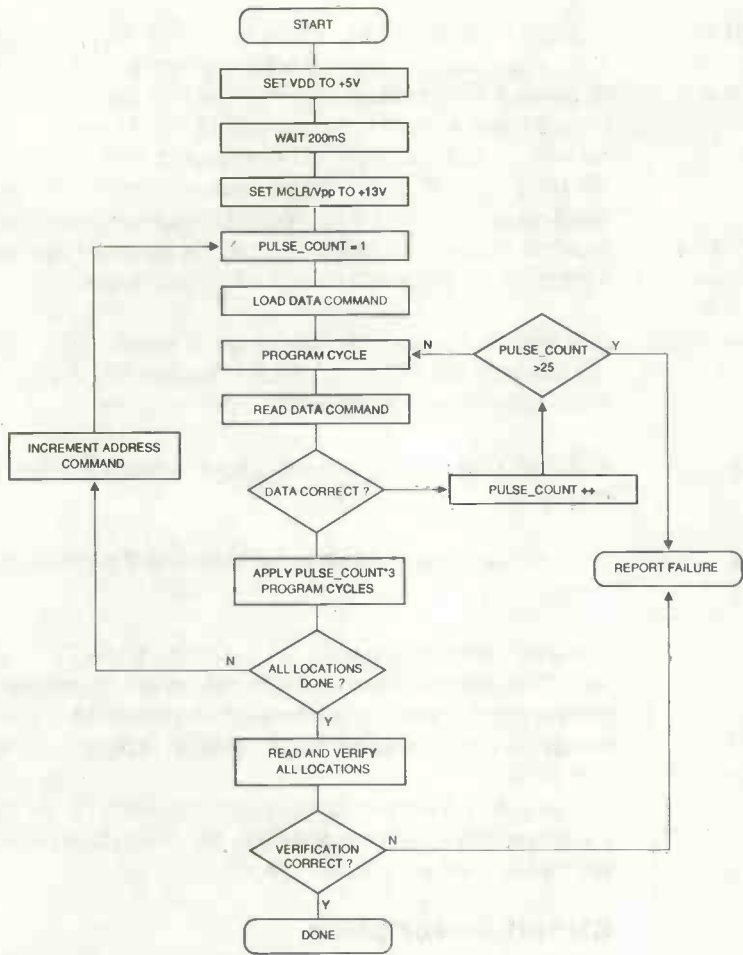


Figure 2: programming algorithm

further 16 clocks which are used to clock data into or out of the chip to the 14 bit wide program store (The first and last clocks are unused). For example figure 1 shows the signals applied to a PIC to read the contents of location 0 in the program store.

There are 6 commands used to program the PIC. When Vpp is raised the address pointer is positioned to location 0. The load Data and Read Data input or read data for the current programming address respectively. Increment address moves the address location to the next address. The Begin and End programming commands start and end a programming pulse. Finally the load configuration command positions the address pointer at the configuration area (described below). The eeprom devices have additional commands to erase the eeprom device, and to program and read the eeprom data area.

The programming algorithm used is a fast program/verify/overprogram method, similar to fast algorithms used for standard eproms. Each location is programmed with a short pulse, and read to verify it. If the location fails then it is programmed again. When the location is correctly verified, then the location is programmed again with three times as many pulses as that required to program it in the first place. The algorithm is shown in figure 2.

Please note that the Microchip programming specification requires that the programming

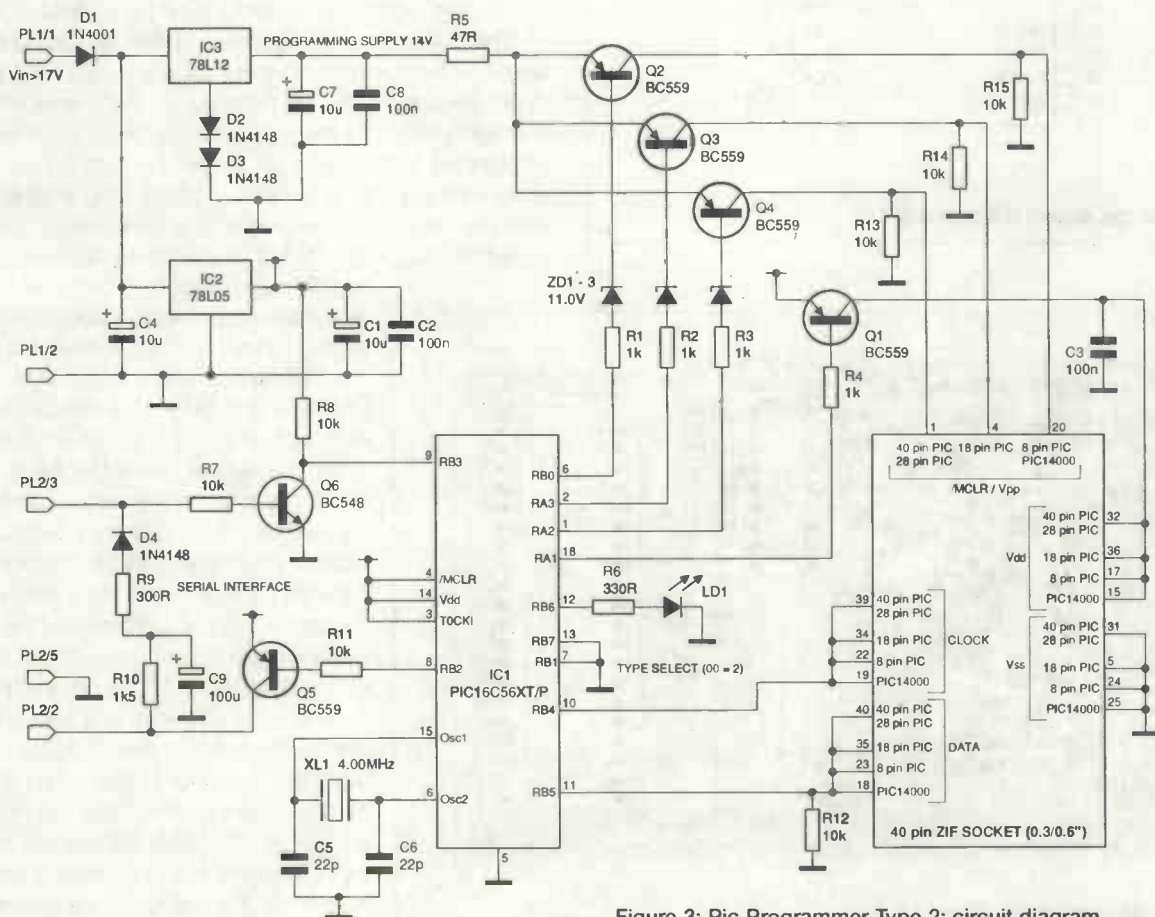


Figure 3: Pic Programmer Type 2: circuit diagram

should be performed at  $V_{dd}=5V$ , and verified at both 4V and 6V to ensure that the device has programmed correctly. This programmer only verifies at  $V_{dd}=5V$ , and therefore is classified by Microchip definition as a development programmer.

### Configuration fuses

Each PIC device has a configuration fuse which defines its operation in the application circuit. Any PIC programmer must allow the configuration fuse values to be set. The configuration fuses allow the following device features to be set:

1. Oscillator type, as one of the following items:  
LP - Low power crystal oscillator, for instance 32768 kHz  
XT - Crystal Oscillator  
RC - Resistor/capacitor based oscillator  
HS - High speed crystal oscillator (more than 4MHz)

2. Code Protect (CP) bit. When set the CP bit forces the PIC, when read, to return a scrambled version of the code to prevent unauthorised copying. The PIC cannot be programmed in this state, however EEPROM versions may be erased. User words may be written or read when the CP bit is set. CAUTION - some devices (particularly the most recent PICs) have non-erasable code protect fuses, thus the expensive /JW variant may be rendered useless for further development once the CP fuse is set.

3. Brown Out Enable Bit. This is set to enable the brown out circuit in the PIC. This circuit holds the PIC in reset if the supply voltage drops below a pre-set level.

4. Watch Dog Enable. This bit is set to enable the watch dog timer.

5. Power up timer. This bit is set to enable the power up timer.

The user words may be set to any value as specified by the user. They may be used to define the version of software, or to provide a serial count for each individual chip. User words cannot be read by the application program running in the PIC.

The user words and configuration fuse may be set by the programmer PC host software, the dialog box used to set these is shown in screen shot 1.

### Circuit Description

The circuit diagram is shown in figure 3.

The programming algorithm is implemented in IC1 - a PIC16C56, 16C556, or 16C84. This device also includes the serial interface software, and drives an LED which is illuminated when the subject PIC is being read or written.

The power supply requires a stable 5V supply for  $V_{dd}$ , and 13V for the programming supply  $V_{pp}$ . The 13V supply is obtained by a 78L12, boosted by two signal diodes in the earth return of the regulator (the output voltage is referenced to the earth pin of the regulator). The programming supply is applied to the chip through a 47R resistor - R5, and switched to any of 3 pins of the ZIF socket by Q2, Q3 or Q4. The switching of these transistors

is achieved through 11 V zener diodes - when the output of the controller PIC is high (+5V) the voltage differential between the PIC output and the transistor base is insufficient to bias the zener diode into conduction and the transistor is turned off, when the output is low the zener diode conducts and the transistor conducts. This type of circuit is necessary because the PIC outputs have static protection diodes forward conducting to  $V_{dd}$ , and without the zener the transistor would be permanently turned on by these diodes. Q1 switches +5V to the programmed PIC.

The serial interface is a cheap and simple 2 transistor circuit based around Q5 and Q6. The input of the circuit is driven by the output of the PC which in the idle state is at -12V. D4, R9 and C9 filter the input from the PC to provide a negative supply for the output of the interface which

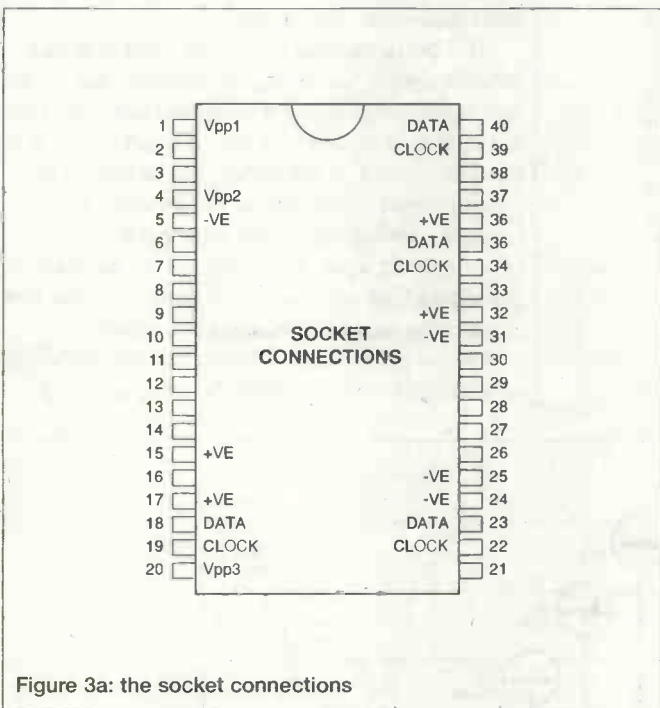


Figure 3a: the socket connections

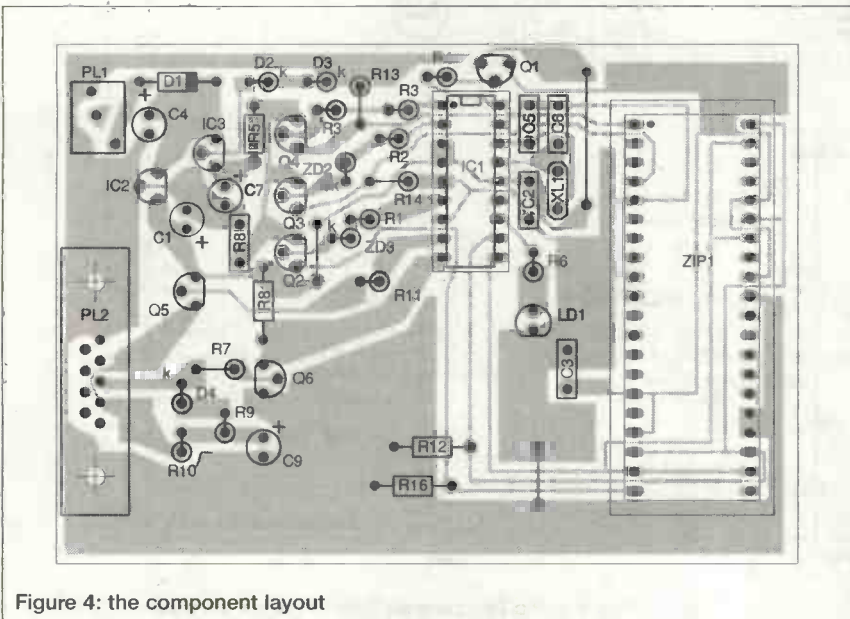


Figure 4: the component layout



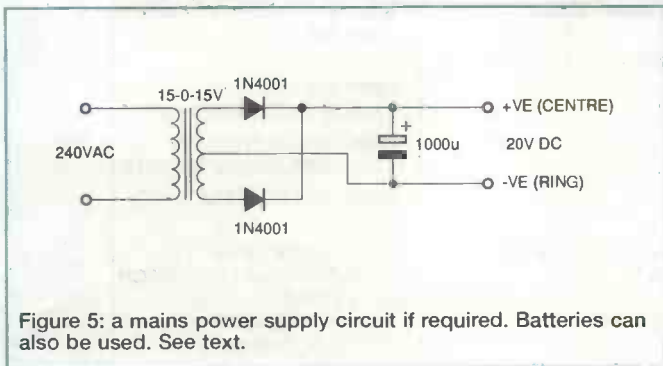


Figure 5: a mains power supply circuit if required. Batteries can also be used. See text.

is required to swing between -1V and +1V for the input of the PC. This circuit has proved to operate very well in practice, however on a very small number of PC's the input impedance is too low, and R10 may be reduced to 1k, or lower.

There are five different PIC pin-outs driven by this circuit. 18 pin devices, 28 pin devices and 40 pin devices are all programmed in the top of the ZIF socket. 8 pin devices and the PIC14000 are programmed in the bottom of the socket (The PIC14000 requires an adapter - see later section). Figure 3a shows the socket positions for the various devices programmed.

The two pins RB6 and RB7 are connected to ground to indicate to the controller PIC the type of programmer that is in use, this is because the same software load is actually used for a number of different programmer types.

### Construction and test

Figure 4 shows the PCB overlay. Construction is straightforward, there being no special components or assembly required.

There are three links which should be fitted to the board first. Follow with the horizontally mounted resistors, D1, and then the IC sockets. The 40 pin ZIF socket should be fitted into an IC socket. Mount (in order) the vertical resistors, diodes, and capacitors, and finally the sockets and other components.

Once construction is complete the board may be tested. Do not fit IC1 at this stage.

The power supply required is 17V or greater. In practice power consumption of the programmer is so low that two 9V batteries may be used as a supply, or a 12V battery eliminator (they usually have an off load voltage in excess of 20).

Figure 5 shows the circuit diagram of a suitable mains power supply. If using a mains power supply, inexperienced mains constructors should ask for assistance from someone with mains experience.

Connect power to the circuit and check that the power supply on pins 5 and 14 of the socket for IC1 is +5V. Check that the power supply on the emitter of TR2 is about 13V, finally check that there is no significant voltage on any pin of the ZIF socket. Disconnect power and insert IC1, reconnect power, and the LED should flash five times which is a power up check implemented in the PIC.

The cable connection between the programmer and the PC is three-wire. Figure 6 shows the cable connections required for a self built cable, however any standard PC cable may be purchased. The programmer software will operate on any of the serial ports on a standard PC.

PROGRAMMER	PC CONNECTOR TYPE:			
	9 - WAY FEMALE	9 - WAY MALE	25 - WAY FEMALE	25 - WAY MALE
PL1				
2	3	2	2	3
3	2	3	3	2
5	5	5	7	7

Figure 6: serial cable connections from the programmer to the host PC

If you have a terminal emulator then set up your terminal emulator to the correct port which you are using for the programmer. Set the emulator to run 9600bps, no parity, no flow control, 8 bits, one stop bit. In Windows terminal this is the menu option under Settings / Communications. Enter a capital D, the programmer should respond with 'L' which is the 'OK' report from the programmer. Enter an 'F' character and LD1 should illuminate. Enter 'K' and LD1 will go out. Finally check that all the pins on the ZIF socket are close to 0V.

Now install and run the host software to check the programmer with some real devices. Initial programming for all device types should be performed with erasable devices in case of problems with the construction.

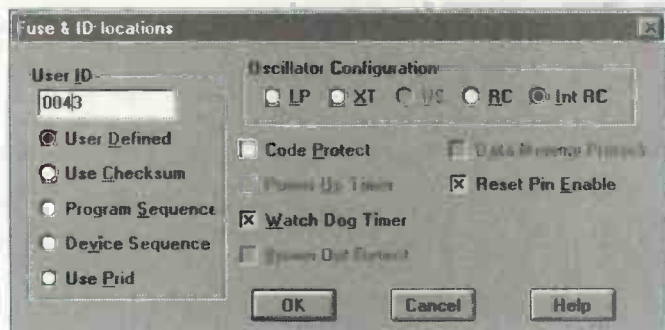


Figure 7: screen shot sample from the software

### PC host software

The host software is installed by from Windows 3.1 or Windows '95 by running the program "INSTALL.EXE" on the supplied disk. This is achieved from Windows Program Manager by selecting the File, Run menu option, and then typing A:\INSTALL.EXE in the command line edit box. In Windows '95 use the start button then the run option and type A:\INSTALL.EXE in to the box. The software may be installed in any directory on your hard disk, but defaults to installation in a directory called "C:\PICPROG". Once installed then double click the icon called PICPROG to start the program. Figure 7 shows a screen shot of the PC program when running.

Once running the Options / Communications menu option may be used to connect to the programmer. The programmer software is supplied with a guide to its use, and with help files.

### Programmer interface specification

For those users who wish to produce their own host software for the programmer this section defines the protocol used for the serial interface to the programmer.

COMMAND LETTER	FUNCTION	INPUT DATA	RETURNED DATA
A	SET MODE	SINGLE BYTE MODE DATA - SEE TEXT	ACKNOWLEDGEMENT BYTE
B	READ ENTIRE PIC	NONE	SIZE* WORDS + ACKNOWLEDGEMENT BYTE
C	READ CONFIGURATION WORD	NONE	CONFIGURATION WORD + ACKNOWLEDGEMENT BYTE
D	CHECK PROGRAMMER	NONE	ACKNOWLEDGEMENT BYTE - 'L'
E	PROGRAM 4 WORDS AT THE CURRENT LOCATION, MOVE THE CURRENT LOCATION ONWARD 4 WORDS	4 WORDS + SINGLE BYTE CHECKSUM	SINGLE BYTE COUNT OF OVERPROGRAM PULSES FOR ALL 8 WORDS + ACKNOWLEDGEMENT BYTE 'F' IF PROGRAM FAILED
F	ENTER PROGRAMMING MODE, SET CURRENT LOCATION TO 0	NONE	ACKNOWLEDGEMENT BYTE
G	PROGRAM USER WORDS	4 WORDS + SINGLE BYTE CHECKSUM	ACKNOWLEDGEMENT BYTE
H	CHECKSUM ENTIRE PIC AND CONFIGURATION WORD, EXCLUDES USER WORDS	NONE	16 BIT CHECKSUM IN LOW-HIGH FORMAT +ACKNOWLEDGEMENT BYTE
I	SET PIC PROGRAM OR EEPROM DATA SIZE	SIZE OF PROGRAM AREA IN LOW-HIGH FORMAT. LOW BYTE MUST ALWAYS BE ZERO EXCEPT FOR EEPROM DATA AREA WHEN LOW AND HIGH BYTES MUST BE IDENTICAL AND SET TO THE 8 BIT SIZE OF THE EEPROM	ACKNOWLEDGEMENT BYTE
J	READ USER WORDS	NONE	4 USER WORDS + ACKNOWLEDGEMENT BYTE
K	LEAVE PROGRAMMING MODE	NONE	ACKNOWLEDGEMENT BYTE
L	PROGRAM CONFIGURATION FUSES	SINGLE CONFIGURATION WORD + SINGLE BYTE CHECKSUM	ACKNOWLEDGEMENT BYTE
M	INCREMENT PROGRAM LOCATION (ONLY NEEDED TO STEP PAST CONFIGURATION IN PARALLEL DEVICES WHEN PROGRAMMING DATA - SEE TEXT)	NONE	ACKNOWLEDGEMENT BYTE
N	BLANK CHECK PIC	NONE	RETURN 'L' IF THE PIC IS BLANK, 'F' IF IT IS NOT BLANK
O	BULK ERASE EEPROM DEVICE PROGRAM AND DATA	NONE	ACKNOWLEDGEMENT BYTE
P	READ EEPROM DATA	NONE	SIZE* WORDS + ACKNOWLEDGEMENT BYTE
Q	PROGRAM 4 BYTES AT THE CURRENT EEPROM DATA LOCATION, MOVE THE CURRENT LOCATION ONWARD 8 BYTES	4 BYTES SENT AS WORDS IN PIC PARALLEL FORMAT, FOLLOWED BY A SINGLE BYTE CHECKSUM	ACKNOWLEDGEMENT BYTE

\* SIZE IS PROGRAMMED BY THE SETSIZE COMMAND ('I')

Figure 8: table of commands and responses used by the programmer

Please note that the interface for this programmer is different to the original project, the programmers may be differentiated in host software by sending a D character to the programmer, the original programmer will respond with a 'K', this programmer will respond with an 'L'.

Communication to the programmer relies on a command/acknowledgement protocol driven by the host machine. Commands are given as a letter from 'A' to 'Q', and any bytes required by the command follow the command letter. The programmer responds with any bytes to be sent as a result of the command followed by an acknowledgement byte. The acknowledgement byte is either an 'L' or an 'F'. 'L' indicates the command was successfully obeyed, 'F' indicates that an error occurred such as a checksum failure on data sent to the programmer. Commands may take up to 100ms before the acknowledgement byte is returned, and if this time expires

then an error may assume to have occurred, the time-out in the prototype was set to 1s.

To initialise the programmer from any state then this sequence should be followed: Send 'D' 18 times, wait 1S and discard any bytes returned from the programmer. Send 'K' and wait for the acknowledgement - 'L', the programmer is now guaranteed to be in a waiting state. This sequence needs to be followed only at the beginning of an application program.

Figure 8 shows the list of commands which can be sent to the programmer, and the expected responses. The following paragraphs describe commands in more detail.

The Set mode command ('A') and the Size command ('I') should be sent before any other command is sent to the programmer. These set the type of PIC and the size of the program area. The Set mode command ('A') is followed by a single byte. The bits of this byte are as follows:



- Bit 0 - Set if the configuration register is being programmed
- Bit 1 - Set for an eeprom device (10ms program pulses)
- Bit 2 - Set if Vpp is to be applied to pin 1 of the ZIF socket
- Bit 3 - Set if Vpp is to be applied to pin 4 of the ZIF socket
- Bit 4 - Set if Vpp is to be applied to pin 20 of the ZIF socket
- Bit 5 - Set if the device contains a 12 bit core

For example the PIC16C84 has the mode command definition value 10 decimal, the PIC16C74 has the value 4, and the PIC12C508 has the value 48 decimal.

All data words written to the programmer for programming (commands 'E', 'G', and 'L') are in PIC parallel format sent as the low byte followed by the high byte. This format has the upper 8 bits of the word in the upper byte, and the lower bits in the lower byte which should be padded with 0s. Thus the hex word "1EC7" for a 14 bit device is written to the programmer as the byte "07" followed by the byte "7B". Regardless of the number of words written to the programmer they are always followed by a single byte checksum which is the 8 bit sum of the data words. If the checksum fails then the programmer will return 'F'. 12 bit core devices are written in the same 14 bit format, however the two most significant bits are always set to 0.

All data read from the programmer in response to the 'B', 'C' or 'J' commands is in the PIC parallel format as for data written, but there is no checksum. All other 8 bit data is returned as a single byte. 16 bit data is returned in the normal low byte followed by high byte format.

To program data locations the Enter Program command ('F') is given. This sets the program counter to address 0. Now 4 words can be programmed at a time using the Program Data command ('E'). Each command returns the overprogram count (a single byte) followed by the acknowledgement. The overprogram count is the total number of pulses required to initially program the 4 words. Thus if the first three words all required one pulse to initially program the word, and the fourth word required 2 initial pulses, then the overprogram count returned will be 5. After each word is programmed the internal counter is incremented ready to write the next 4 words. After the entire program area is written then the End Programming command ('K') is given. Note that for 12 bit core devices the first word after the Enter Program command is the configuration fuse.

In similar fashion the user words may be programmed by sending the Enter Program ('F') command followed by the Program ID locations command ('G'), followed by the End Programming command ('K').

The user words are programmed by sending the Enter Program ('F') command followed by increment address commands to take the program counter to the correct address (2007 Hex) and then the Program configuration fuse command ('L'), followed by the End Programming command ('K'). Note if the Code Protect fuse is set to 0 (entering protect mode) then the program command may fail due to the inability to read back the correctly programmed value. Fuses must always be programmed after the program and user words.

The User configuration fuses are programmed by sending the Enter Program ('F') command followed by (7) increment address commands ('M') to take the program counter to the correct address (2007 Hex) and then the Program configuration fuse command ('L'), followed by the End Programming command ('K'). Note if the Code Protect fuse is set to 0 (entering protect mode) then the program command may fail due to the inability to read back the correctly programmed value. Fuses must always be programmed after the program and user words.

Data eeprom is written in the same way as program eeprom, using the F, Q and K commands. Note that data sent for data eeprom is still be sent and received as 8 words in PIC parallel format even though only 8 bit bytes are being sent. Thus the byte "FF" is sent as the byte "3F" followed by the byte "03". Note for reading and programming data eeprom the size command must be used to send the size of the eeprom data area, and not the program area. Also there is no check of eeprom data after it has been written - use the read command to verify it.

### In-service programming

The in service programming facility requires a header to be constructed to connect the programmer to the device in the circuit. Figure 3 should be consulted to determine the connections from the ZIF socket to be used for each PIC type. For example to program the 16C84 in circuit, requires pins 4,5 and 35 to 37 of the ZIF socket to be wired to pins 4,5,13,14 and 15 of the 16C84 in the application circuit respectively. Use the shortest wires possible.

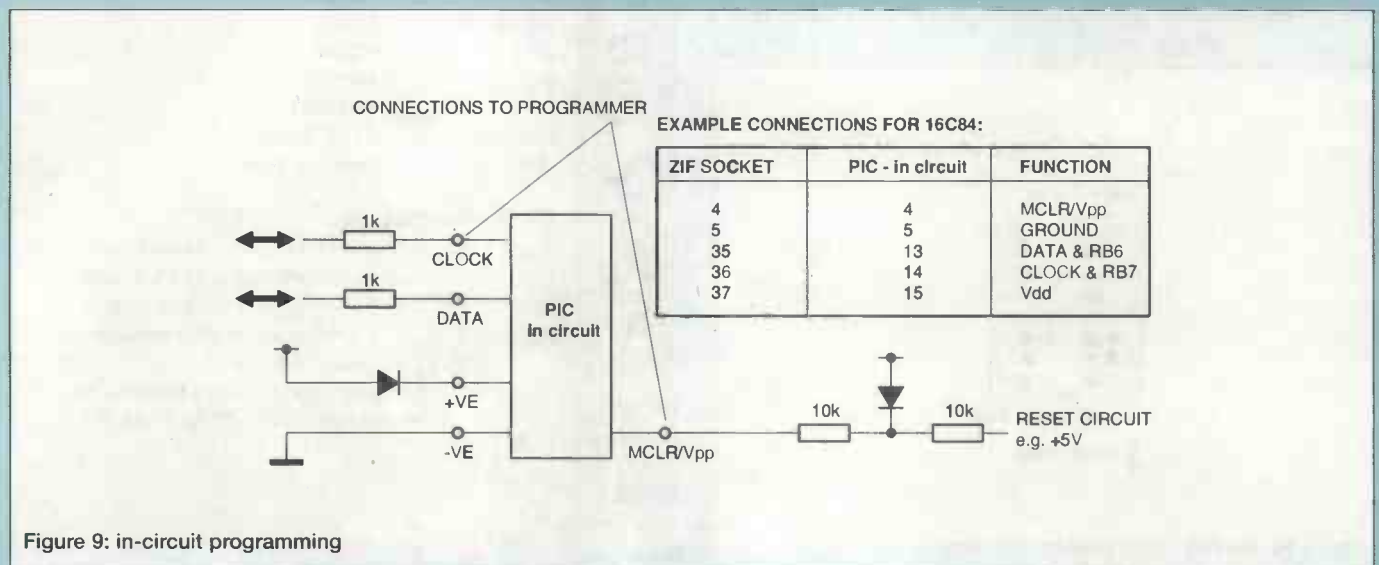


Figure 9: in-circuit programming

Figure 9 shows the wiring of the chip in circuit and the connections to the programmer. The clock and data pins of the PIC (which are usually port pins on the PIC) should be decoupled from the application circuit by 1k or greater resistors, if they can be left unused in the application so much the better. The power supply to the PIC in circuit is shown as an isolated supply by a diode, however if the application circuit can be powered then this connection is not required, however care is required in this case to check that no side effects will be generated by the PIC being programmed (all I/O pins in high impedance state, and programming waveforms on the clock and data pins). The MCLR/Vpp connection must be carefully handled to avoid the programming voltage being applied to other points in the application circuit.

### PIC 14000

A special adapter is required for the PIC14000, this can be constructed on a small piece of Vero board. This is shown in figure 10. The adapter uses a 14 pin DIL socket, and 5 wire wrap pins. The adapter is inserted in the very bottom of the ZIF socket, and the PIC14000 inserted in the DIL socket so that pin 1 of the 14000 is towards pin 1 of the ZIF socket, only pins 8 to 21 of the PIC14000 are inserted in the DIL socket.

### Finding out about PICs

The PIC data book is available from Maplin, or information may be downloaded from the internet at the Microchip Web Site: see <http://www.microchip2.com/products/micros> which allows all the datasheets to be downloaded. There are a number of good introductory texts on the PIC, for example "A beginner's guide to the Microchip PIC" from Maplin - Code AD31.

PIC-based Basic control systems including compilers are available from Parallax, or from Forest Electronics. This type of system allows rapid prototyping in BASIC, and then the program may be compiled, or re-written in assembler.

### Obtaining components

The ZIF socket is available from Farnell on 0113-263-6311, their order code is 178-238. Farnell are quite prepared to sell to individuals for home or work use.

The author is prepared to supply programmed PICs for the project as well as to supply host software. The software supplied includes the Microchip assembler and simulator, the Windows based development environment PICDE, and

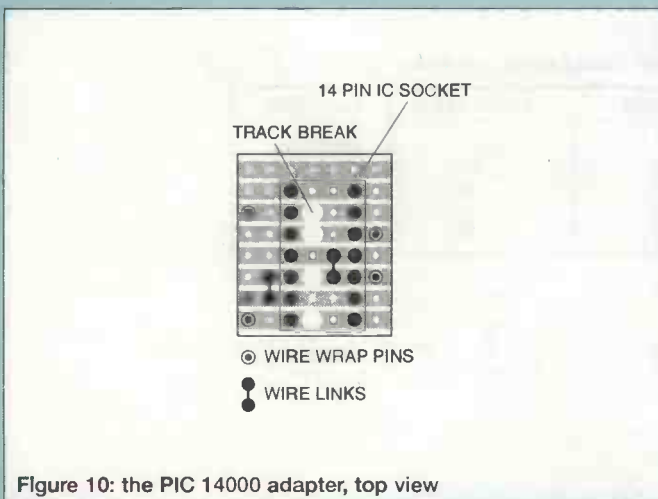


Figure 10: the PIC 14000 adapter, top view

a data sheet for the 16C84 in Acrobat format is also supplied. The host software is supplied on 3.5in High Density floppy disk suitable for use with Microsoft Windows version 3.1 or 3.11 and Windows '95. To receive the programmed PIC and the software send an SAE and a cheque for £20.00 to **Robin Abbott, 37 Plantation Drive, Christchurch, Dorset, BH23 5SG**. The author is also happy to answer any queries on the use of the programmer, but please put them in writing.

A complete kit of parts including PCB, PIC and ZIF socket is available from Forest Electronics for £40.00+£3.00 P&P, 10 Holmhurst Avenue, Christchurch, Dorset. BH23 5PQ. 01425-270191. Please DO NOT direct any technical queries regarding this article to Forest Electronics, but to the author directly.

Note: **Farnell Electronic Components:** Farnell E C have a minimum order charge of £10 for cash orders before VAT. If the 40-pin ZIF socket, which is not otherwise widely available, is combined with XL1, this should meet Farnell's minimum order requirements. XL1 is also available elsewhere. For Sales, phone 0113 263 6311 and say that you are a cash order (cheque or credit card), not an account.

There is no postal charge for normal delivery.

PARTS LIST for the PIC Programmer

<b>Resistors</b>	
All 1% 0.25 W	
R1-4	1k
R5	47R
R6	330R
R7,8,11-15	10k
R9	300R
R10	1k5
<b>Capacitors</b>	
C1,4,7	10uF 25V electrolytic radial
C2,3,8	100nF disc ceramic
C5,6	22pF disc ceramic
<b>Semiconductors</b>	
IC1	See Text
IC2	78L05
IC3	78L12
TR1-5	BC559
TR6	BC548
D1	1N4001
D2-4	1N4148
ZD1-3	11.0V Zener
LD1	Red led, 5mm
<b>Miscellaneous</b>	
XL1	4MHz resonator Farnell part number 170-230 £1.20 ex VAT
PL1	Power socket PCB mounted
PL2	9 pin D-socket PCB mounted IC socket DIL, 18 pin
ZIF socket	40 pin multi-width Farnell part number 178-238 £9.87 ex VAT.
PCB	Rubber feet for PCB



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ETI and RIAT 97 are giving away 15 pairs of adult tickets to the first 15 readers of ETI who can correctly identify the 10 differences between the two action-filled cartoons on this page.

For enquires about RIAT 97, contact the RIAT Hot News Line on 0891 122999 or multiple-choice switchboard at 01285 713268. (Calls on 0891 numbers are charged at 50p per minute of which 15p per minute is donated to the RAF Benevolent Fund Enterprises, PO Box 1940, Gloucester GL7 4NA.) If you don't fancy your luck at spot-the-difference, want to make sure of getting to Fairford, or want to take the whole family, adult advance tickets are £16 each (£20 on the day), accompanied children (aged 15 and under) get in free. The RIAT 97 ticket hotline is 0891 122997 (credit card sales), or drop into your local Waitrose or Victoria Wine branch (who are selling advance tickets).

**Competition rules:** Entries must arrive at Nexus House on or before 12th June 1997. Winners will be notified by post following the judging. The judges' decision is final and no communication will be entered into concerning the results. Employees of Nexus Special Interest Ltd. and Swift Design Ltd., associated companies and family members are not eligible to enter. Multiple entries will not be accepted. The prize is two complimentary adult tickets to the Royal International Air Tattoo, RAF Fairford, Gloucester 19th & 20th July 1997, to be sent by post to the winners. No other goods, services or expenses will be supplied in connection with the competition. For further information about the RIAT 97 please contact the RIAT Hot News Line 0891 122999. Calls on 0891 numbers are charged at 50p per minute of which 15p per minute is donated to the RAF Benevolent Fund Enterprises, PO Box 1940, Fairford, Glos GL7 4NA. No communications can be entered into regarding the competition.

Look carefully at the two pictures. In the bottom one you will see that the artist has omitted a few details. Clearly ring the area where you think the details have been missed out on the lower picture, cut it out (or send a clear photocopy of both pictures) and send it to us to reach the ETI office at the address below **no later than Thursday 12th June 1997**. The first 15 entries to reach us that clearly identify all 10 differences correctly will receive two complimentary adult tickets to the show. So get flying!

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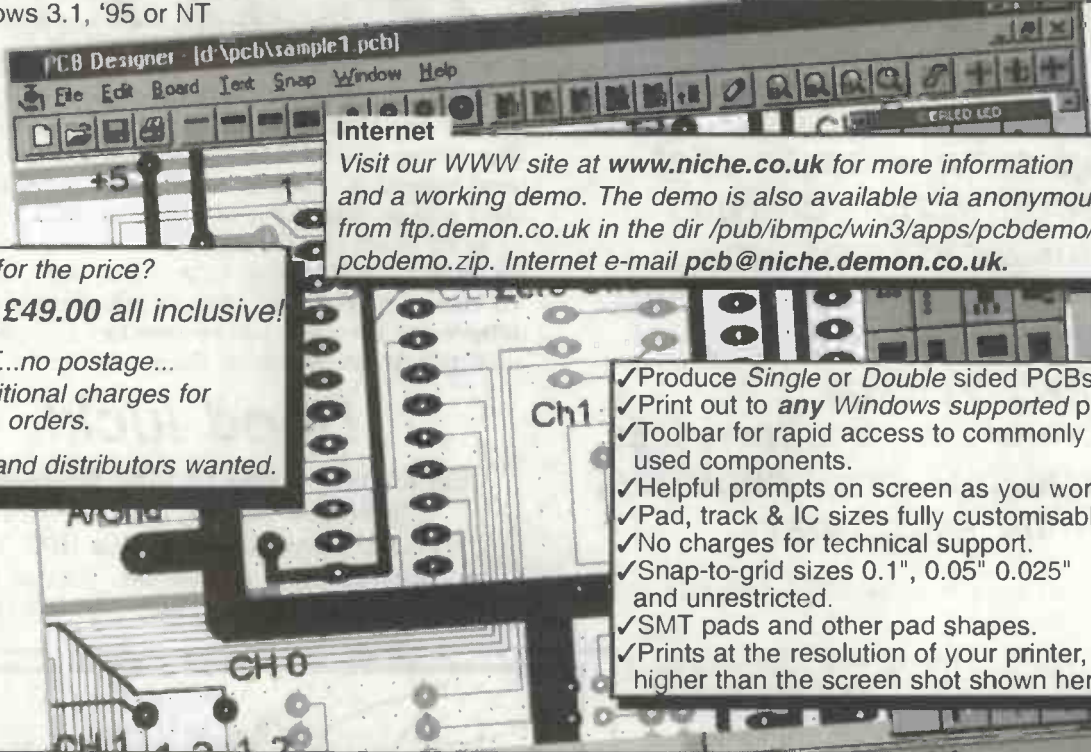


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# Fast Fivers

**Adaptable, affordable - handy circuits for around £5. By Owen Bishop**  
**3. Electronic Put-and-Take**

**P**ut-and-Take originated in medieval Germany and has been popular in one form or another ever since. The playing piece is a four-sided top, the dreidel, which has markings on each side. Players spin the dreidel in turn and then play according to which side is uppermost when it stops. In this electronic version there is a 7-segment LED which displays one of four characters:

- O Do nothing
- 1 Put one chip in the kitty
- H Take half the kitty
- A Take all the kitty

Players (two or more) draw lots or spin the dreidel to decide who is to play first. They each contribute two chips to the kitty, then play begins. The chosen player spins the dreidel (more about that later) and 'puts' or 'takes' each time until the spin gives a '0', when the turn passes to the next player. Players contribute another two chips to the kitty every time it becomes empty.

### How it works

The circuit consists of an oscillator (figure 1, IC1), a counter (IC2), a decoder (IC3) and the LED display. IC1 is actually an ic for building a phase-locked loop but there is no PLL in this circuit. We are using only one of the several useful items on this chip, the voltage controlled oscillator. The central frequency of this oscillator is determined by the values of C2 and R2, according to the equation:

$$f = 1/(C2.R2)$$

It is not just that the rate falls slowly because C1 and R1 are high-valued. The rate of fall at any instant is proportional to the charge on C1. The rate falls rapidly when S1 is first released, but falls more and more slowly as C1 discharges. We describe the rate of fall as exponential. This may sound like a dull mathematical relationship, but its effect is to add a substantial element of nail-biting suspense to the game, as we shall see later.

The stream of pulses coming from IC1 is counted by IC2, which is a 14-stage binary counter. Once again, we do not use everything that is on the chip. We need the output from two consecutive stages and, as the outputs from stages 2 and 3 are not available at the pins, we use stages 4 (pin 7) and 5 (pin 5). Given that a high voltage (close to 6V) is '1' and a low voltage (close to 0V) is '0', these outputs run through the four binary numbers 00, 01, 10 and 11, repeating until the oscillator stops. The outputs spend equal times in each state and are equally likely to stop in any one state. In this way the circuit appears to behave in a random way, just like the spinning dreidel.

The four characters have been chosen to make decoding easy. Segments b and c (figure 2) are to be switched on for all characters, so can be connected directly to the positive rail through a resistor R4. We need to decode only for segments a and c to g. This truth table shows the logic:

Inputs from IC2		Segment (logic equation in brackets)						Character
B (pin 5)	A (pin 7)	a (= A)	d (= A+B)	e (= A+B)	f (= A+B)	g (=B)		
0	0	0	0	0	0	0	1	
0	1	1	1	1	1	0	0	
1	0	0	0	1	1	1	H	
1	1	1	0	1	1	1	A	

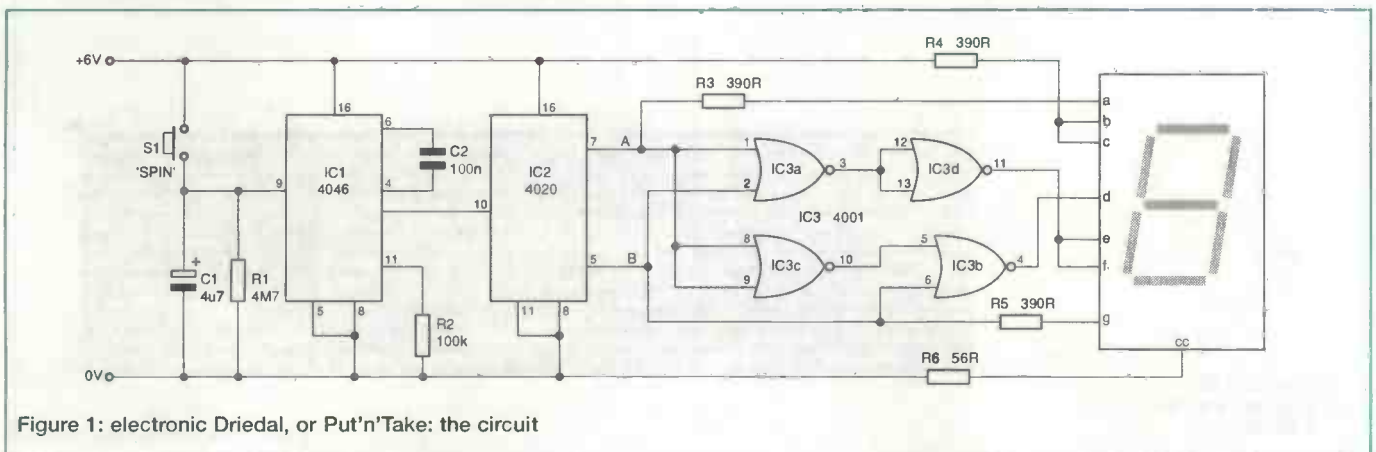


Figure 1: electronic Dreidel, or Put'n'Take: the circuit

# PARTS LIST for the Put,n,Take

## Resistors

(all 5% tolerance, 0.25W)

R1	4.7 megohm
R2	100 kilohm
R3, R4, R5	390 ohm (3 off)
R6	56 ohm

## Capacitors

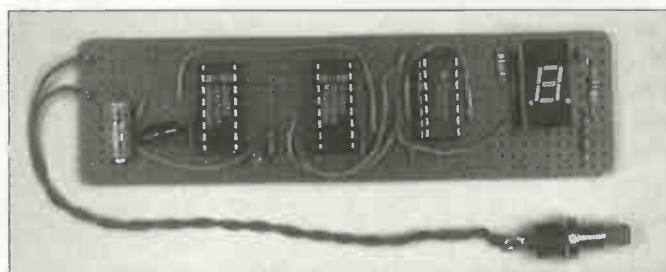
C1	4.7µF, electrolytic
C2	100nF, polyester

## Semiconductors

IC1	4046 CMOS phase-locked loop
IC2	4020 CMOS 14-stage binary counter/divider
IC3	4001 CMOS quadruple 2-input NOR gate

## Miscellaneous

S1	Push-to-make push-button
7-segment LED display, common cathode, 0.3-in (7.62mm), preferably low-current; 2.5 mm stripboard, 119mm $\times$ 30mm (46 holes $\times$ 12 strips); 1mm terminal pins (3 off); 14-pin di1 IC socket; 16-pin di1 IC sockets (2 off); battery clip or 6V battery box.	



The '+' sign represents the OR operation, while a bar over a letter or pair of letters means NOT (invert). To get 'e' and 'f' we simply NOR A with B. To get 'd' we invert A with gate 3, then NOR it with B in gate 2.

Summing up what happens during a spin, pressing S1 starts the oscillator at 100Hz but, because we dividing the rate at stages 1 to 3 before taking the outputs from stages 4 and 5, the display cycles through the set of characters just over 3 times per second (if you want it faster, decrease the value of R2). At first the display is changing a little too fast to distinguish the characters but after a few seconds we can begin to pick out the characters. Towards the end, each character remains displayed for several seconds each time. They remain longer and longer and longer ... Eventually one (but which one?) remains permanently displayed, and the payout (or in!) begins.

## Construction

Figure 3 shows the stripboard layout. The connections to the LED display follow the pattern of commonly-available types, but check this with the component catalogue, since there are other ways in which the pins are designated. Note that is essential for the display to be of the common cathode type; the common anode type does not work in this circuit. The strips are cut beneath the board as indicated by crosses on Fig 3, but note that there are NO cuts at E31, G31, F35 and H35, since we are making use of the strips for two inter-pin connections and two connections to the display. Solder blobs between adjacent strips are used to connect: B14 to C14, B24 to C24, B33 to C33, C33 to D33, D43 to E43, H33 to H33, K11 to L11 and K21 to L21. The board has connections to a 6V battery, which may be a battery box for four 1.5V cells, if preferred. S1 is connected to the 0V supply and to the pin at E1.

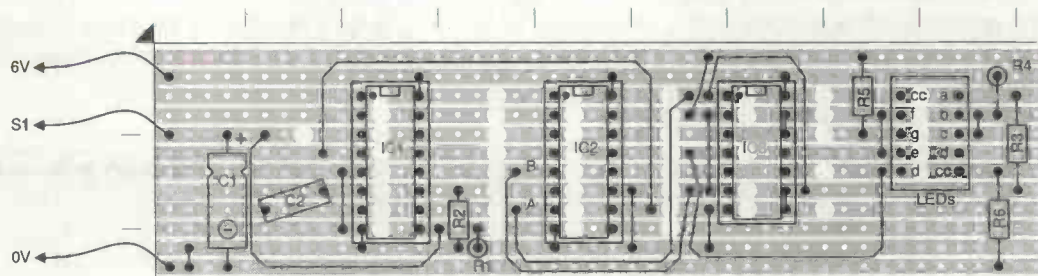


Figure 2: the segments of the LED display

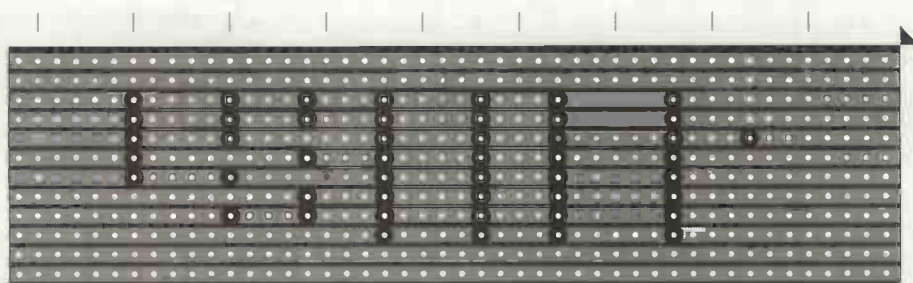


Figure 3: the stripboard layout



# Virtual pH METER for PCs

**Following the trend to PC-controlled scientific instruments, this design uses a low powered circuit operated via the serial port of the PC**

**By Ronaldo Bruno and Valentin Obac Roda  
Institute of Physics of Sao Carlos/University of Sao Paulo, Brazil**

**T**he increasing use of personal computers in the most diverse areas of activity has radically changed the face of electronic instruments. Many instruments that were self contained a few years ago, such as oscilloscopes, voltmeters, spectrum analysers and so on can these days be bought as boards to be plugged in personal computers. The display, keyboard and mouse of the PC perform the control and data visualisation of the instruments. This new trend in instrumentation is known as 'Virtual instrumentation'.

One of the drawbacks of using dedicated instrumentation boards inside the computer is the lack of portability. To move the instrument from one place to another it is necessary to move the computer or to take the board and use it in another computer. There is also a restriction in the use of laptop computers, because most instrumentation boards do not fit inside them. In this article we present a virtual instrument connected to the computer via the serial port of the PC. To increase the portability we used a low power consumption circuit fed by the serial port of the PC. The instrument that we developed is a pH and temperature meter widely used for chemical analysis, the food industry, geochemistry, water treatment, biomedical and industrial applications.

pH is a measure of the acidity or alkalinity of solutions. The pH scale ranges from 0 to 14. Seven is the neutral point, and solutions that have pH less than seven are acid solutions. The glass electrode is the most common sensor used to measure pH. In the pH range, the pH glass electrode develops a voltage proportional to the pH of the solution. The glass electrode is used in conjunction with a reference electrode. There are electrodes available, known as combination electrodes, that combine the glass electrode and the reference electrode.

The electrical response of the electrode is linear and follows the equation:

$$E = E_0 + 2,3026 RT/F$$

known as the Nernst equation, where: E is the response of the electrode in V/pH and E<sub>0</sub> is the asymmetry potential, characteristic of the electrode and varying with its age. T is the temperature in absolute degrees. F is the Faraday Constant and R is the gas constant. Figure 1 shows the response of the electrode.

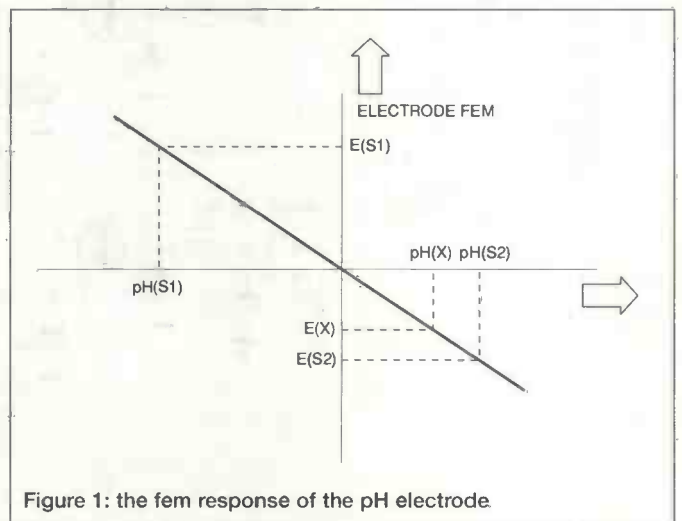


Figure 1: the fem response of the pH electrode

The internal resistance of the pH electrode is very high, around hundreds of megohms, and it is very sensitive to variations of temperature. pH meters should use a very high impedance input circuit. Before the pH measurements, the pH meter is calibrated according to the response of the electrode. This procedure is known as standardisation of the instrument. The pH meter requires the use of one or two of these standard calibration solutions according to the precision required (one- or two- point standardisation).

The Virtual pH meter that we developed has hardware controlled by a PIC microcontroller and software that runs under windows to control the instrument and visualise the data. The PC software was written in Visual Basic.

## Hardware

Figure 2 shows the schematic diagram for the circuit of the pH meter. The input circuit of the pH meter is a high impedance, low consumption operational amplifier (LF442A). A LM35 integrated sensor is the temperature sensor. An analogue switch (CD4066) creates two analogue channels, one for the pH and another for the temperature. The circuits of the power supplies and the RS232 hardware implementation were built with discrete components.

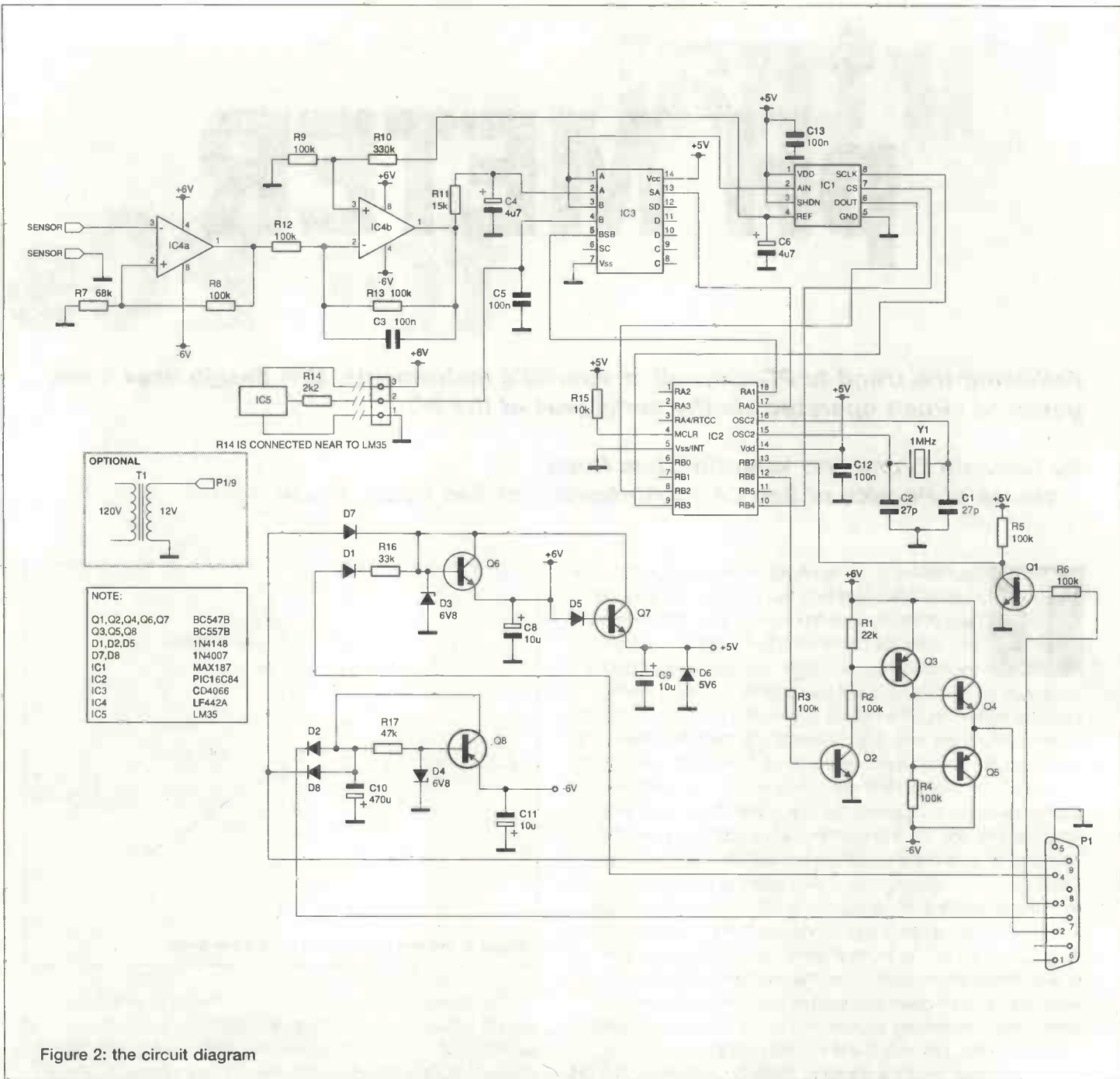


Figure 2: the circuit diagram

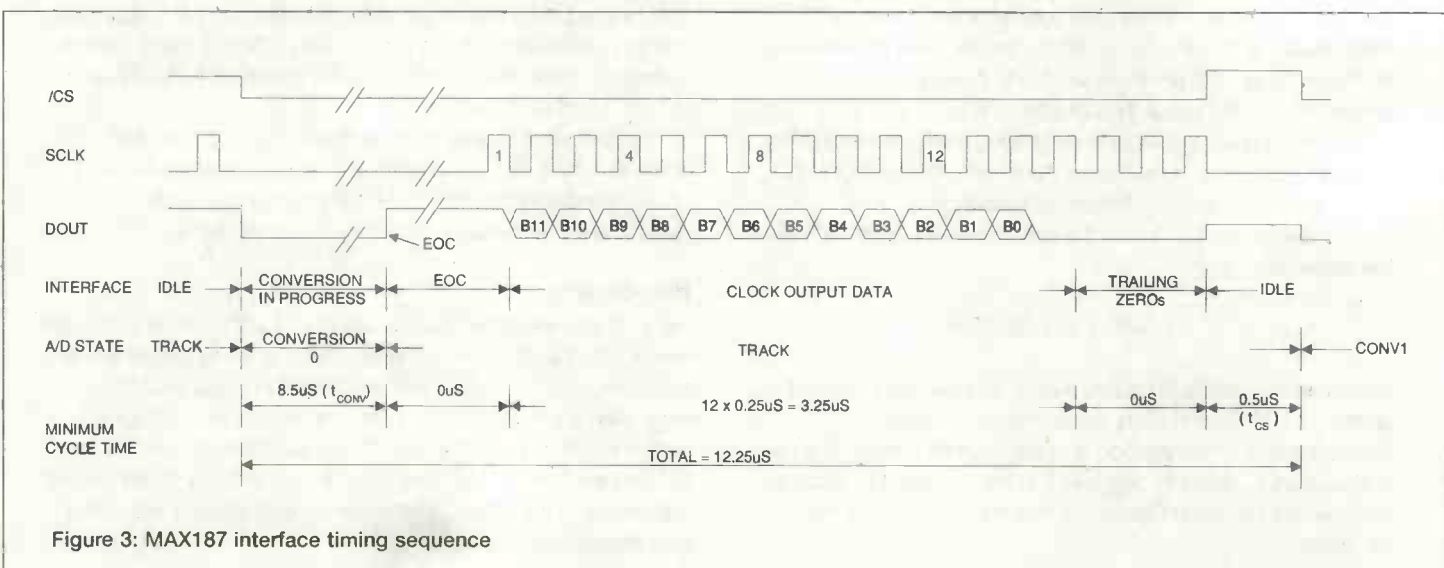


Figure 3: MAX187 interface timing sequence



The MAX187 12-bit A/D converter has a serial output, internal reference of 4.096V (available externally) and sampling rate of 75000 samplings/sec. There are no gain and offset adjustments in the A/D converter. The conversions are performed for voltages in the range 0 to 4.096V. The MAX187 has three control pins, CS, SCLK and DOUT. Figure 3 shows the converter communications protocol.

A P1C16C84 8-bit RISC microcontroller with internal eeprom controls the instrument, including the A/D converter, the analogue switches and the RS232 communication interface. The P1C16C84 has internally a ram, a real time clock counter, a watchdog timer and 13 I/O pins. The watchdog timer resets automatically the system on the occurrence of an internal program lock.

In the input circuit there are two operational amplifiers to amplify the pH sensor output to the A/D converter input. The first operational amplifier is a high input impedance, 2.5x gain, voltage follower. The output voltage of the first op amp goes, in the pH sensor range, from -1.5 V to + 1.5 V. The second op amp adds 2 V to the first op amp output, resulting in a single-polarity converted pH signal in the range of 0 to 3.5 V. An LF442 double op amp operational amplifier was used to implement the pH input circuit. The LF442 has a high input impedance of 1 terra-ohm (10 to the power of 12 ohms) and a low current consumption of 400 kA.

The transistor Q1 and the resistors R5 and R6 convert the level of the RS232 input signal (-12V to + 12V) to the 0 to 5 V range. Although the RS232 is specified to work in the -12V to + 12 V range, it can work in the -6V to + 6V range. Q2, Q3, Q4, Q5, R1, R2, R3 and R4 convert the level of the RS232 output signal from TTL (0 to 5 V) level to the -6V to + 6V range.

Finally, we have the power supply circuit, supplying the -6V, +6V and +5V voltages. The MAX187 ic works with voltages from 4.75 to 5.25V and the PIC16C84 works with voltages from 2 to 6V. For the LF442A -6V and + 6V were used, considering that it has to have outputs going up to 3.5V.

The power supply was fed from the hand shaking signals of the RS232 DTRenable and RTSenable. When the instrument is initialised, RTSenable is set to -12V and DTRenable is set to +12V. The current capacity of DTRenable and RTSenable is low, about 8mA. When the current consumption grows the available voltage drops. For this reason the circuit was conceived to minimise the power consumption. The current for the P1C16C84 working on 1MHz is 600A The MAX187 consumes 1.8 mA and the LF442 consumes 400uA. The other parts of the circuit, including the regulators and level converters consume 1 mA more. The total current consumed by the circuit is only 3.8 mA which makes the voltage on the DTRenable drop to about 9V.

Optionally, you can feed the circuit with an AC 120/12V - 100mA transformer as shown in figure 2. This can be useful if the pH meter is going to work with a dedicated system, instead of a standard PC, that has the RS232 protocol communication but doesn't have the handshaking signals.

Seek assistance from a knowledgeable person when working the mains circuits if you not an experienced mains constructor.

## Software

The software of the P1C16C84 implements basically the communications protocols of the MAX187 ND converter and of the RS232 serial interface. The serial communication is at 2400 baud, without parity, 8 data bits and one stop bit.

During the initialisation, the program waits a communication from the PC which sends the number 1 as a code to the microcontroller. During the wait loop the port pin of the PIC connected to the RS232 receive line is read continuously until data is received. When the PIC reads the number 1 it communicates with the MAX187 asking for two conversions (pH and temperature). The conversion time of the MAX187 is 8.5 us. Because we did not need to work at full conversion speed we waited a fixed time, longer than the conversion time of the MAX187, instead of waiting for its end-of-conversion signal. The 12-bit converted information is packed in two bytes. An XOR operation of the two conversion bytes generates a third byte used to detect possible communication errors. The pH and temperature values are transmitted to the PC, using six bytes of information according to the protocol shown in figure 4.

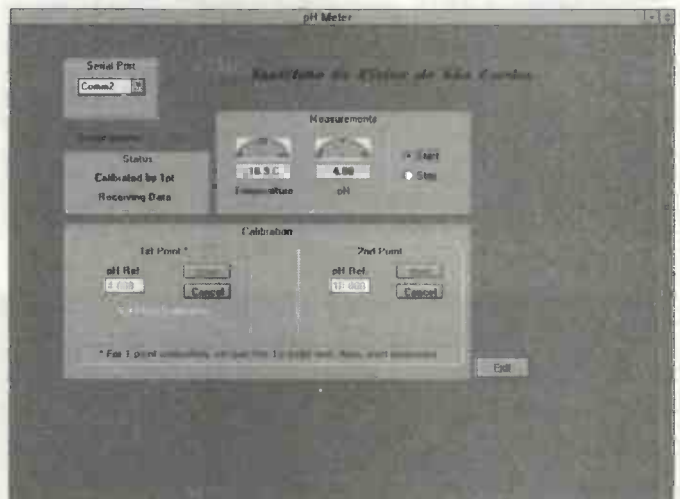


Figure 5: the virtual panel of the pH meter

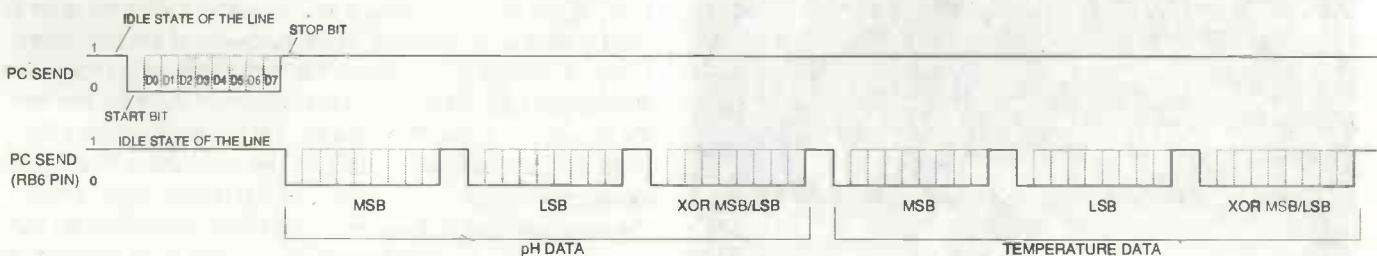


Figure 4: PC to PIC communication protocol

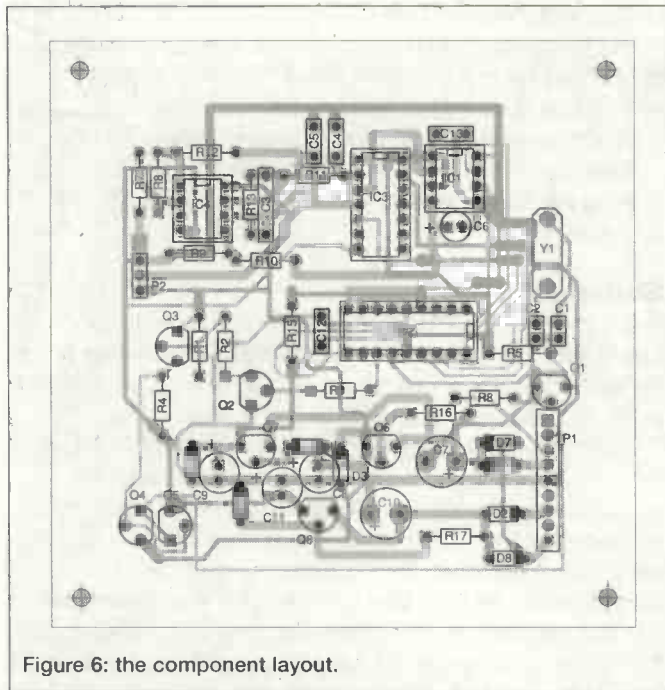


Figure 6: the component layout.

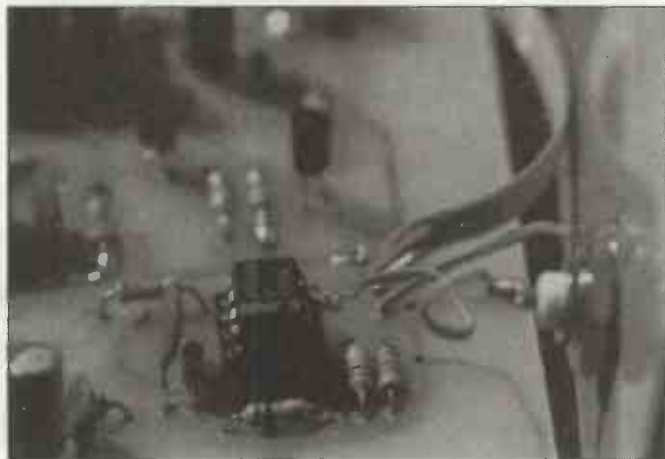
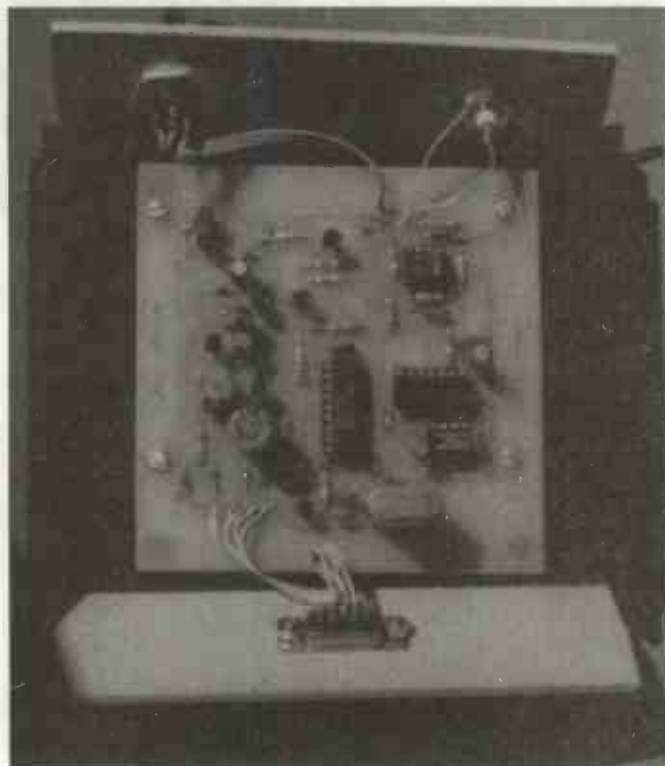


Figure 7: Above construction detail of the pH input



After sending the six bytes of information to the PC, the program returns to the initial wait loop. To avoid deadlocks, the program uses the watchdog timer of the PIC that is basically a counter driven by an internal RC oscillator. When the counter overflows, it resets the PIC, restarting the program. During the program execution on the PIC the watchdog timer counter is constantly reset. When the program enters in a deadlock, the watchdog timer counter is not set to zero and the PIC is then reset.

The software for the PC was developed in Visual Basic 3.0. The program includes routines for calibration, data visualisation and control of the instrument. Figure 5 shows a view of the screen of the instrument. Error treatment routines were included, user errors are trapped and helpful error messages are supplied. Also, when a communication fault is detected it is pointed on the screen. The program recovers automatically when the communication fault is corrected.

### Construction details

For the construction of the pH meter, a double sided PCB was used. Figure 6 shows the layout of the printed circuit boards including the component layout. To keep the input for the pH sensor high avoiding current leakage through the printed circuit, pin 3 of the LF442 operational amplifier was directly connected to the BNC connector (pH connector), as shown in figure 7. A photo of the hardware of the instrument is shown in figure 8.

To connect the pH meter to the PC, it is necessary to have a RS232 cable. You can build one connecting a DB25 female to a DB9 female following table 1, which shows the pins for each connector.

Table 1 - RS232 Cable

DB25	DB9
2	3
3	2
4	7
20	4
7	5

### Operating instructions

After installing the software, the user should choose an available serial port on the PC and connect the hardware of the instrument to the port. Avoid using COM1/COM2 or COM2/COM4 simultaneously, as this can cause conflicts. For example, if you have a mouse connected to COM1, choose COM2 for the pH meter. If you have the mouse at COM1 and a modem at COM2, choose COM4 for the pH meter and do not use the modem while using the pH meter. When the hardware setup is ready, install the PC software routines and start running the program by clicking the pH meter icon.

As shown in figure 5, we can see four distinct regions: Serial Port, Status, Measurements and Calibration. Initially we have to set the serial port according to the hardware of the instrument. The second step is to calibrate the instrument using one or two standard pH solutions. Before the calibration we have to insert the pH and temperature sensors in the standard solution. To measure the temperature standard click the button "Start" in the measurement region. After this, click the button "Stop" in the measurement region and enter in the Calibration reference first point, the pH of the standard solution. At this point you have to press "start" in the calibration region and wait until the calibration is ready, that is, when the message "1st Point Calibrated" appears on the screen.



The time necessary for the calibration varies according to the pH sensor. In general, it takes less than 30 seconds. If the instrument is calibrated with only one pH solution, the "Start" button in the Measurement region should be pressed. If a two-point calibration method is used, repeat the above calibration procedure for the second pH solution.

In the "Status" region there is available information about the operation of the system. There is a small circle that blinks, changing its colour between red and green, when the serial port is working. If the communication between the instrument and the PC fails, the Comm Monitor stops blinking until the communication problem is corrected.

The LF 442 op amp can be replaced by other dual low power high input resistance op-amps. The TL062 (Texas Instruments), RS/Electromail 638-908, Farnell TL062CN, and the MAX407 (Maxim), RS/Electromail 248-191 have the same pin configurations.

Agents for the MAX187 12-bit serial A/D converter (8-pin dll package) are:

2001 Electronic Components tel 01438 74 2001

HB Electronic tel 01204 525544

Both agents will take cash orders if the device is in stock. The list price is £10.48 ex VAT, post and packing and any credit card charges if applicable. At time of writing, HB have slightly lower charges, but 2001 have larger stocks and order more frequently.

**Farnell Electronic Components** Tel 0113 263 6311 have a minimum order charge of £10 for cash orders (cheque/credit card) before VAT. There is no postal charge for normal delivery.

The **INSTALL software for the PC** is available at the following WEB site:

<http://www.ifqsc.sc.usp.br/virtph>

or by anonymous FTP at the following address:

[www.ifqsc.sc.usp.br/pub/valentin/virtph\\_directory/pub/valentin/virtph](http://www.ifqsc.sc.usp.br/pub/valentin/virtph_directory/pub/valentin/virtph)

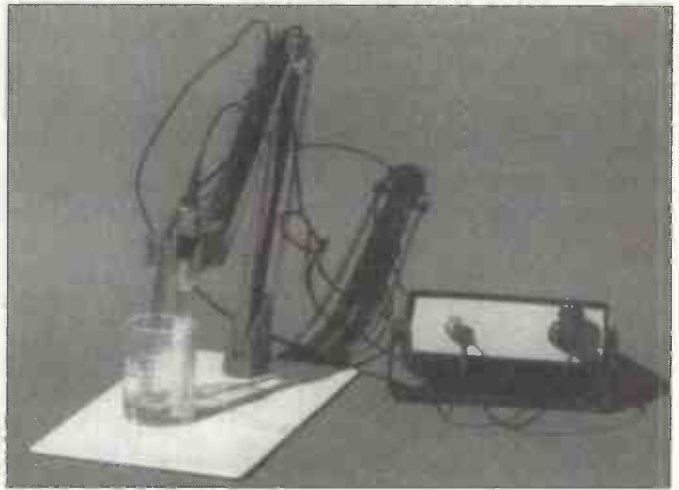
**Or contact the authors at the following address.** The authors can also send by mail additional information about the instrument, including a 3 5-in disk with the programs.

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## PARTS LIST for the pH Meter

### Resistors

All resistors are 1/8 - watt, 5%.

R1	22K
R2 to R6	100k
R7	68K
R8,R9, R12,R13	100k
R10	330k
R11	15k
R14	2k2
R15	10k
R16	33k
R17	47k

### Capacitors

C1, C2	27pF, 25 volts, ceramic disk
C3, C5, C12, C13	100nF, 25 volts, ceramic disk
C4, C6	4.7uF, 16V, radial electrolytic
C7, C10	470uF, 16V, radial electrolytic
C8, C9, C11	10uF, 16V, radial electrolytic

### Semiconductors

Q1, Q2, Q4, Q6, Q7	BC547B NPN transistor
Q3, Q5, Q8	BC557B PNP transistor
D1, D2, D5	1N4148 signal diode
D3, D4	Zener 6V8, 400mW
D6	Zener 5V6, 400mW
D7, D8	1N4007 rectifier diode
IC1	MAX187 12-bit ND converter
IC2	PIC16C84 microcontroller RS/Electromail 831-501; Farnell PIC16C84-04P
IC3	CD4066 analog switch RS/Electromail 640-908; Farnell 385-451
IC4	LF442A low power, high input impedance operational amplifier Farnell LF442CN (see below for alternatives)
IC5	LM35 integrated temperature sensor RS/Electromail 317-960 Farnell LM35DZ

### Miscellaneous

X1	1MHz Crystal RS/Electromail 307-761 Farnell 170-859
P1	DB9 Panel Male Connector
P2	Three-pin Cannon Male connector BNC connector for pH input RS-232 Cable DB25 (female) to DB9 (female) - See text.
5 x 5-in box	

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Listing: Picsoft.obj
#pragma object MPASM V01.21 6-Dec-
1996
"C:\USERS\RONALDO\PICSOFT.ASM"
#pragma interface
P 16C84
#pragma object
0 LINK101
10 START
11 LINK704 0180 0X0B
13 LINK703 3000 0X8E
14 LINK704 0080 0X81
16 LINK703 3000 0X87
17 LINK714 0060 0X6
19 LINK710 1000 0X6,3
20 LINK710 1400 0X6,4
21 LINK710 1000 0X6,6
23 LINK703 3000 0X0
24 LINK714 0060 0X5
26 LINK703 3000 0XFF
27 LINK704 0080 0X5
39 L3
39 LINK703 3000 0X2
40 LINK704 0080 0X15
42 LINK705 0800 0X15,1
43 LINK711 2000 P_ANALG
45 LINK704 0080 0X5
47 LINK703 3000 0X8E
48 LINK704 0080 0X81
50 L7
50 LINK711 2000 RXPIC
52 LINK705 0800 0X20,0
53 LINK702 3C00 0X1
55 LINK710 1800 0X3,2
56 LINK711 2800 L1
58 LINK711 2800 L7
61 L1
61 LINK711 2000 LECONV
63 LINK705 0300 0X15,1
64 LINK705 0800 0X15,0
66 LINK711 2000 P_ANALG
68 LINK704 0080 0X5
72 LINK705 0800 0X13,0
73 LINK704 0080 0X20
74 LINK711 2000 TXPIC
76 LINK705 0800 0X12,0
77 LINK704 0080 0X20
78 LINK711 2000 TXPIC
80 LINK705 0800 0X13,0
81 LINK705 0600 0X12,0
82 LINK704 0080 0X20
83 LINK711 2000 TXPIC
85 LINK705 0800 0X15,0
86 LINK710 1C00 0X3,2

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87 LINK711 2800 L1
89 LINK711 2800 L3
96 P_ANALG
97 LINK705 0700 2,1
98 LINK702 3400 0X1E
99 LINK702 3400 0X1D
100 LINK702 3400 0X1E
108 RXPIC
109 C1
109 LINK710 1C00 0X6,7
111 LINK711 2800 C2
113 LINK701 0064
114 LINK703 3000 0X8E
115 LINK704 0080 0X81
117 LINK711 2800 C1
120 C2
120 LINK711 2000 DELAY2
122 LINK711 2000 DELAY1
124 LINK703 3000 0X8
125 LINK704 0080 0X14
127 C7
127 LINK710 1C00 0X6,7
128 LINK711 2800 C4
129 LINK710 1400 0X3,0
130 LINK711 2800 C5
131 C4
131 LINK710 1000 0X3,0
133 C5
133 LINK705 0C00 0X20,1
135 LINK711 2000 DELAY2
137 LINK705 0B00 0X14,1
139 LINK711 2800 C7
141 C8
141 LINK710 1C00 0X6,7
142 LINK711 2800 C8
144 LINK701 0008
152 TXPIC
153 LINK710 1400 0X6,6
155 LINK711 2000 DELAY2
157 LINK703 3000 0X8
158 LINK704 0080 0X14
160 B5
160 LINK705 0C00 0X20,1
163 LINK710 1C00 0X3,0
164 LINK711 2800 B2
165 LINK710 1000 0X6,6
166 LINK711 2800 B3
167 B2
167 LINK710 1400 0X6,6
169 B3
169 LINK711 2000 DELAY2
171 LINK705 0B00 0X14,1
173 LINK711 2800 B5
175 LINK710 1000 0X6,6

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177 LINK711 2000 DELAY2
179 LINK701 0008
195 LECONV
196 LINK710 1000 0X6,4
198 LINK711 2000 DELAY3
201 LINK711 2000 RECDADO
202 LINK705 0800 0X0F,0
204 LINK704 0080 0X13
207 LINK711 2000 RECDADO
208 LINK705 0800 0X0F,0
210 LINK704 0080 0X12
212 LINK710 1400 0X6,4
213 LINK701 0008
220 RECDADO
221 LINK703 3000 0X8
222 LINK704 0080 0X14
224 E1
225 LINK705 0D00 0X0F,1
227 LINK710 1400 0X0F,0
229 LINK710 1C00 0X6,2
231 LINK710 1000 0X0F,0
234 LINK710 1400 0X6,3
236 LINK701 0000
237 LINK701 0000
238 LINK701 0000
239 LINK701 0000
240 LINK701 0000
241 LINK701 0000
243 LINK710 1000 0X6,3
246 LINK705 0B00 0X14,1
247 LINK711 2800 E1
248 LINK701 0008
255 DELAY1
256 LINK703 3000 0X0F
257 LINK704 0080 0X21
258 G1
258 LINK705 0B00 0X21,1
259 LINK711 2800 G1
260 LINK701 0008
262 DELAY2
263 LINK703 3000 0X1F
264 LINK704 0080 0X21
265 G2
265 LINK705 0B00 0X21,1
266 LINK711 2800 G2
267 LINK701 0008
269 DELAY3
270 LINK703 3000 0X02
271 LINK704 0080 0X21
272 G3
272 LINK705 0B00 0X21,1
273 LINK711 2800 G1
274 LINK701 0008

```



```

;#####
; Software for The pH Meter
; MAX187 e PIC16C84 CLK=1MHz
;#####
; Initialisation routine
;#####

START
    CLRF    0X0B    ;Desable
                  Interruptions

    MOVLW  0X8E    ;Programs
                  WatchDogTimer =1seg.

    MOVWF  0X81

    MOVLW  0X87    ;Programs Port B
    TRIS   0X6

    BCF    0X6,3   ;Initial level of the
                  SCLK signal
    BSF    0X6,4   ;Initial level of the
                  CS signal
    BCF    0X6,6   ;Initial level of
                  serial port

    MOVLW  0X0     ;Programs Port A
    TRIS   0X5

    MOVLW  0XFF    ;Desable all analog
                  inputs
    MOVWF  0X5

;#####
; Main routine: receives serial data sent by host.
; Starts 2 conversions, sending 3 bytes each
; conversion. 2 bytes (16-bit data word) and
; 1 verification byte based in a XOR of the 2 data
; bytes
; Send protocol: MSB, LSB and verification Byte.
; It sends input AN0 and then AN1 (pH and Temp)
;#####

L3    MOVLW  0X2    ;Starts analog inputs
                  counter (F15H)
    MOVWF  0X15

    MOVF   0X15,1
    CALL  P_ANALG  ;Converts counter in
                  bits from 0 to 1 at
                  port A (analog input
                  selection)
    MOVWF  0X5     ;Sends selection to
                  port A

    MOVLW  0X8E    ;Refresh OPTION
                  register
    MOVWF  0X81

L7    CALL  RXPIC  ;Waits for the Host
                  (PC) communication

    MOVF   0X20,0  ;Verifies if received
                  byte = 01h
    SUBLW  0X1     ;If positive, starts
                  conversion routines

    BTFSC  0X3,2
    GOTO  L1

    GOTO  L7      ;If received byte
                  isn't = 01h waits for
                  new communication

L1    CALL  LECONV

    DECF  0X15,1  ;Decrements F15 once
    MOVF  0X15,0

    CALL  P_ANALG ;Converts counter in
                  bits from 0 to 1 at
                  port A (analog input

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```

selection)
;Sends selection to
port A

    MOVWF  0X5

    MOVF   0X13,0
    MOVWF  0X20
    CALL  TXPIC   ;Sends MSB byte

    MOVF   0X12,0
    MOVWF  0X20
    CALL  TXPIC   ;Sends LSB byte

    MOVF   0X13,0 ;Creates verification
                  byte
    XORWF  0X12,0 ;verification byte =
                  f13 XOR f12

    MOVWF  0X20
    CALL  TXPIC   ;Sends verification
                  byte

    MOVF   0X15,0
    BTFSS  0X3,2  ;Tests analog input
                  counter ending.

    GOTO  L1

    GOTO  L3     ;restarts the main
                  routine

;#####
;Routine to convert the analog input counter in
;bits of port A
;#####
P_ANALG
    ADDWF  2,1
    RETLW  0X1E
    RETLW  0X1D
    RETLW  0X1E

;#####
;Routine to implement the RS232 serial receiv
;ing at 2400 baud
;Byte received is stored in F20h
;#####
RXPIC
C1    BTFSS  0X6,7 ;Waits for "Start
                  Bit"

    GOTO  C2

    CLRWDT
    MOVLW  0X8E    ;Clears WatchDogtimer
    MOVWF  0X81    ;Refresh OPTION
                  register

    MOVWF  0X81

    GOTO  C1

C2    CALL  DELAY2 ;Inserts a 416us
                  delay

    CALL  DELAY1  ;Inserts a "1/2"
                  delay (208us)

    MOVLW  0X8
    MOVWF  0X14    ;Loads counter (f14H)

C7    BTFSS  0X6,7 ;Reads bit at RB7
    GOTO  C4
    BSF    0X3,0  ;Places "1" in Carry
    GOTO  C5

C4    BCF    0X3,0 ;Places "0" in Carry

C5    RRF    0X20 ;Locates read bit

    CALL  DELAY2 ;Inserts a 416us
                  delay

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```

DECFSZ    0X14,1    ;Checks counting
                    ending (1-8)

GOTO      C7

C8        BTFSS     0X6,7    ;Verifies "Stop Bit"
GOTO      C8

RETURN

;#####
;Routine to implement the RS232 serial
sending at 2400 baud
;It reads a byte in F20h and then sends it
;#####

TXPIC
BSF        0X6,6    ;Sends "Start Bit"

CALL       DELAY2   ;Inserts a 416us
                    delay

MOVLW     0X8       ;Loads counter (f14H)
MOVWF     0X14

B5        RRF       0X20    ;Locates , in Carry,
                    the bit that is going
                    to be read

BTFSS     0X3,0    ;Reads bit through
                    Carry

GOTO      B2
BCF       0X6,6    ;Sends "1" at serial
                    port

GOTO      B3
BSF       0X6,6    ;Sends "0" at serial
                    port

B3        CALL      DELAY2   ;Inserts a 416us
                    delay

DECFSZ    0X14,1    ;Checks for counting
                    ending (1-8)

GOTO      B5
BCF       0X6,6    ;Sends "Stop Bit"

CALL       DELAY2   ;Inserts a 416us
                    delay

RETURN

;#####
;Routine that controls MAX187
;The MAX187 12-bit converter works with 16-bit
words made up of 2 bytes
;Data word: F13h (MSB) and F12h (LSB)
;The words are received serially (from MAX187)
at the port RB2
;The LECONV routine place the data read in the
registers F13h e F12h
;The conversion starts when CS signal goes
to low level
;(CS=0)
;#####

LECONV
BCF        0X6,4    ;Sends CS=0

CALL       DELAY3   ;Waits about 50us for
                    conversion (Tc=8.5us)

CALL       RECDADO  ;Receives the 1st
MOVF       0X0F,0   data byte and stores
                    it in f13h

MOVWF     0X13

CALL      RECDADO   ;Receives the 2nd
MOVF       0X0F,0   data byte and stores
                    it in f12h

MOVWF     0X12

BSF        0X6,4    ;Sends CS=1

RETURN

;#####
;Routine that reads one data byte from MAX187 and
stores in f05h
;#####

RECDADO
MOVLW     0X8       ;Counter (1 byte)
MOVWF     f14h

MOVWF     0X14

E1        RLF       0X0F,1  ;Rotates 13h register
                    (locates bit0 for
                    write)

BSF        0X0F,0    ;Sets bit0=1. If bit
                    at DOUT=0 then the
                    next BFC do the
                    change

BTFSS     0X6,2      ;Reads data at RB2
                    port (converter DOUT)

BCF        0X0F,0    ;Locates bit read at
                    register f13h bit=0
                    position

BSF        0X6,3      ;Sends SCLK=1

NOP
NOP
NOP
NOP
NOP
BCF        0X6,3      ;Sends SCLK=0

DECFSZ    0X14,1    ;Decrements counter e
                    jumps if reg=0

GOTO      E1
RETURN

;#####
;Delay Routines
;#####

DELAY1
MOVLW     0X0F      ;Inserts "1/2" delay
                    (208us)

MOVWF     0X21
G1        DECFSZ    0X21,1
GOTO      G1
RETURN

DELAY2
MOVLW     0X1F      ;Inserts a 416us
                    delay

MOVWF     0X21
G2        DECFSZ    0X21,1
GOTO      G2
RETURN

DELAY3
MOVLW     0X02      ;Inserts a 50us delay
                    approx.

MOVWF     0X21
G3        DECFSZ    0X21,1
GOTO      G1
RETURN

END

```



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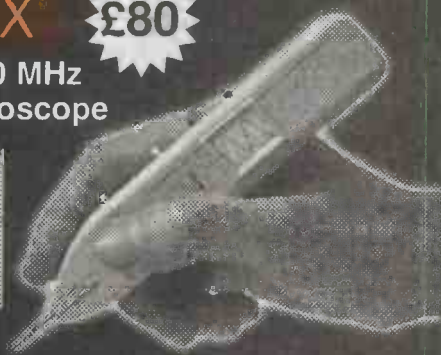
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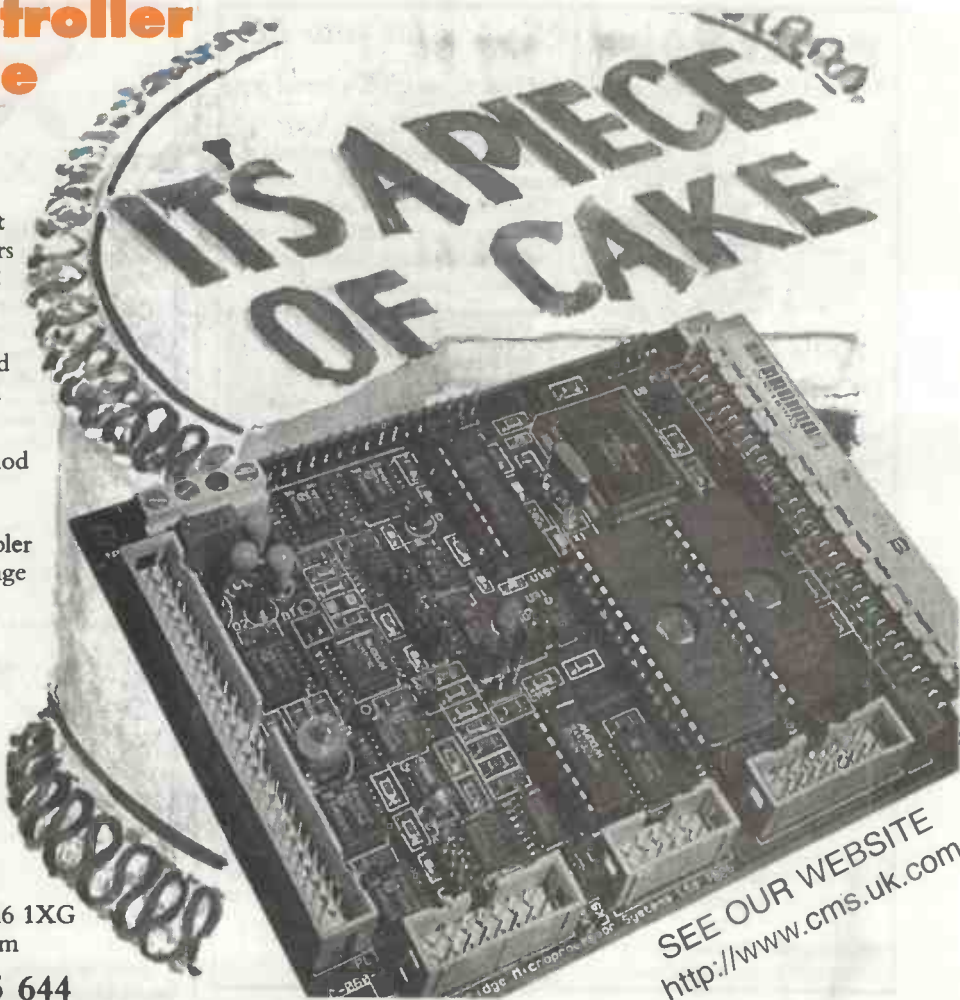
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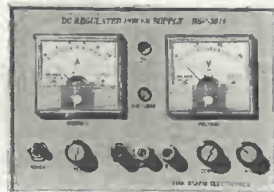
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# Handy

# Moisture

# Meter

**Going house-hunting? Raymond Haigh's inexpensive, easy-to-construct device could help you to avoid making the mistake of a lifetime.**

**D**ampness in buildings is usually costly to eradicate. Equally important, it can create conditions which promote the establishment and growth of wood rotting fungi, and this can have serious structural consequences. Levels of dampness too low to be detected by touch or sight or smell can be sufficient to cause problems of this kind, and surveyors use a moisture meter when inspecting premises. Experience and judgement are needed to interpret the significance of the readings in a given situation, but the presence of dampness is always a warning sign. Even in inexperienced hands, therefore, a simple moisture meter may alert the user to potential problems.

If you think the property you're looking over could be the house of your dreams, but you suspect that there may be "damp spots", at least you'll be made aware of the need to call in a surveyor to check it out before you buy what could become a costly nightmare.

The instrument described here is inexpensive and easy to construct: indeed, most readers will already have suitable components in their spares boxes. Calibration couldn't be simpler, and guidance is given later on how to use it. The unit will detect low levels of moisture in common building materials. It will also give a clear indication of the relative moisture content, and this feature is often invaluable in establishing the source or cause of the dampness.

### Principle of operation

Most porous, non-metallic building materials such as wood, brick, plaster and stone have a high electrical resistance when dry. As their moisture content increases, their electrical resistance reduces. This phenomenon is exploited by almost all of the moisture meters used by surveyors in order to



provide a rapid and non-destructive means of measuring dampness in buildings.

The resistances involved are quite high, above 10 megohms at very low moisture levels, and early instruments of this kind used a sensitive moving coil meter and a high voltage battery (75 - 90V) in order to obtain a reading. By connecting a transistor in a simple circuit it is possible to eliminate the need for the high voltage battery, and a more compact unit can be constructed and operated at modest cost.

### The circuit.

The circuit of the unit is given in figure 1.

The resistance of the wood or other material across the probe tips, in combination with R1 and R2, fixes the voltage on the base of Q1 and determines the current flowing through the base-emitter junction. This small current initiates a larger current flow through the collector circuit which is read on the meter placed in series with the power supply.

Pre-set resistor R2 enables the instrument to be calibrated; and pre-set R4 acts as a variable shunt across the meter so that the pointer can be set to full-scale when the probe tips are shorted together (that is, zero resistance). R5 limits the action of R4 and ensures that the pre-set is easy to adjust. The emitter resistor, R3, makes the circuit relatively immune to spreads in transistor characteristics.

The action of the circuit is extremely simple. The lower the resistance across the test probes, the greater the voltage on the base of Q1. This increases the current flowing through the transistor and the reading on the meter. The lower the resistance the higher the moisture content of the material under examination, and so the meter scale reads conventionally, from left to right.

Very little current flows when the probe tips are open circuit, (a tiny fraction of a micro-amp) and an on/off switch is not required.

### Components.

The components are widely available and non-critical, and no difficulty should be encountered in obtaining them. Almost any low-frequency, small-signal, NPN silicon transistor should be suitable for Q1. If the specified BC171 is not to hand, try a BC107, 108 or 109.

Any moving coil meter with a FSD within the range 50 to 500uA will be suitable. A Maplin

60 x 45mm pan type meter with a 100uA movement is fitted in the prototype instrument, and the values of R4 and R5 have been chosen to suit its current range and 3750 ohms internal resistance. If a more sensitive unit is fitted, R5 may have to be shorted out in order to reduce the shunt resistance. Conversely, if a less sensitive meter is used, pre-set, R4, may need increasing to 2 or even 4K7 ohms in order to secure full scale deflection with the probe tips shorted. Constructors who do not wish to modify the meter scale would be wise to install an instrument with a scale calibrated 0 - 100, as this will make it easier to interpret the readings.

The probe tips have to be sharply pointed and hard enough to resist blunting when pressed into timber, plaster or the mortar joints in brickwork. Hardened steel picture hanging pins are used for this purpose in the prototype instrument. These pins have brass heads and this makes it easy to solder them to the probe leads.

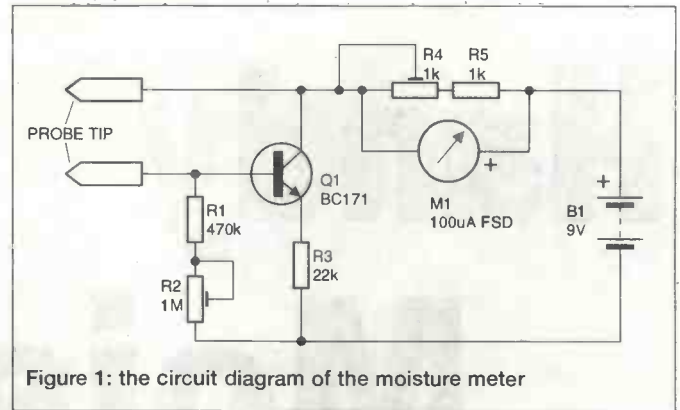


Figure 1: the circuit diagram of the moisture meter

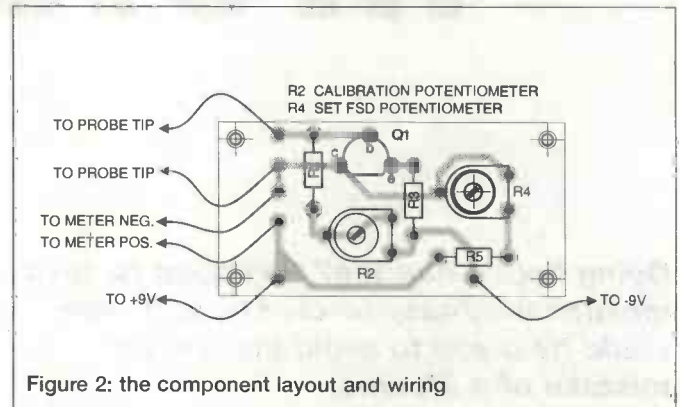


Figure 2: the component layout and wiring

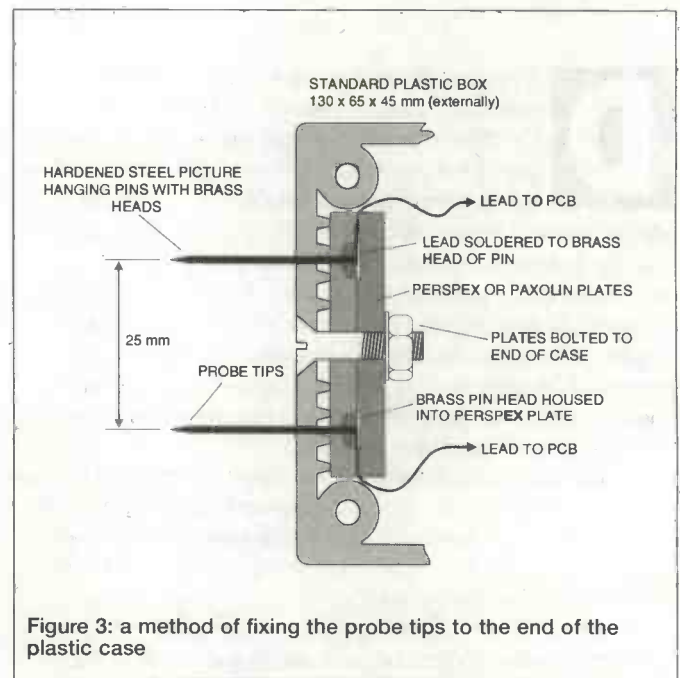


Figure 3: a method of fixing the probe tips to the end of the plastic case

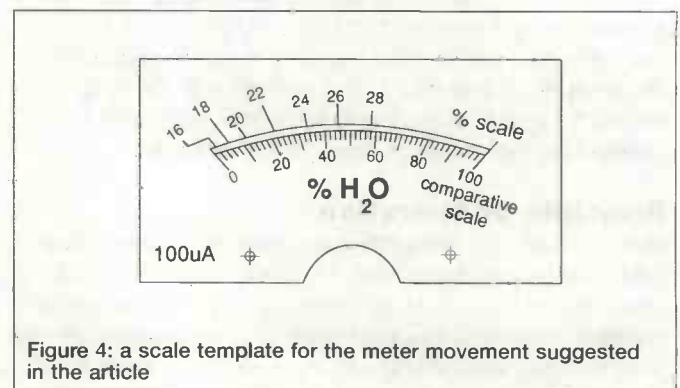
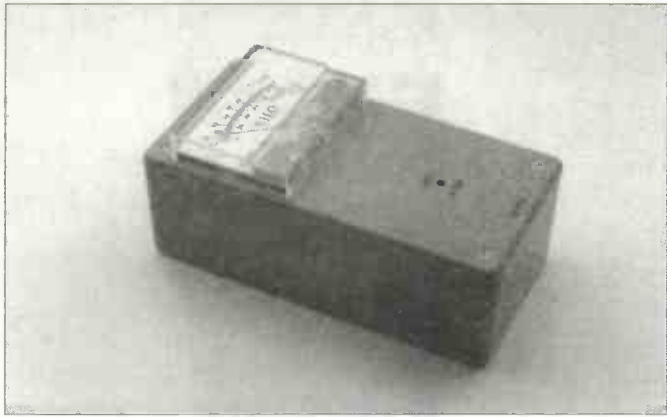


Figure 4: a scale template for the meter movement suggested in the article





## Construction.

The components are mounted on a small PCB. The component side of the board is illustrated in figure2, and the foil side in figure3. Vero pins inserted at the lead-out points ease the task of off-board wiring.

Meter, battery and PCB should be housed in a small plastic box. The arrangement adopted for the prototype is shown in a photograph. The PCB and meter are mounted on the lid, and the battery is held in place by a Paxoline partition across one end of the box. A fretsaw or coping saw can be used to form the hole for the meter.

Attach the PCB to shallow stand-offs by means of short, self-tapping screws, then Superglue the stand-offs to the lid of the box, taking care to align the holes which access the adjustment slot of R4.

The probe tips project through the end of the box, and the method of securing them is illustrated in figure 4. The probe has to be pressed fairly hard into the material under examination, and the pin fixings must be able to resist this. If the pins are a tight fit into the piece of Perspex or Paxoline, it may be possible to hold them securely in place with cyanoacrylate adhesive (Superglue) and dispense with the nut, bolt and second piece of Perspex.

## Setting up

Check the PCB for poor soldered joints or bridged tracks, and check the orientation of Q1. If all is in order, connect the meter, rotate the pre-sets to minimum resistance and connect a fresh 9V battery. The meter pointer should remain at zero.

Short the probe tips together and rotate R4 to increase the amount of resistance in circuit until the pointer is at full-scale.

Connect a 2M2 resistor across the probe tips and adjust R2 to set the meter pointer at 20 on the comparative (0-100) scale.

Check again for full-scale deflection with the probe tips shorted, and refine the adjustment of R5, if necessary. Check again for a scale reading of 20 with the 2M2 resistor across the probe.

The setting-up process is now complete and the sensitivity of the instrument has been fixed in the critical 20 - 22% moisture content region. A 620k resistor connected across the probes should now bring the pointer to 50 on the comparative scale (centre scale). This final test is desirable in order to check that the unit is functioning correctly.

If a 500uA meter, or a transistor with a low hFE, has been used, and full-scale-deflection cannot be obtained even with

R5 shorted out, try reducing the value of R3 to 10k.

Battery life is its shelf-life, but falling voltage affects the sensitivity of the unit. Check, from time-to-time, that full-scale deflection is obtained with the probe tips shorted, and adjust R4, as necessary, to ensure this.

## Calibration

With the instrument constructed and set up as described, the moisture content percentages, at various points on the 0-100 meter scale, are as tabulated below:

Moisture content percentage							
16	18	20	22	24	26	28	
Reading on 0-100 scale							
2	6	12	22	34	46	58	

Readers can use the above information to re-calibrate any suitable meter. Alternatively, if the data is pasted onto the case of the unit, it should be reasonably easy to operate it without re-calibration provided the meter has an 0-100 scale.

The calibrated scale of the meter fitted in the prototype unit is reproduced in figure5. If the specified meter is used, a photostat could be stuck to the rear of the existing aluminium scale plate with a smear of Durofix adhesive.

Gently prise off the clear acrylic meter cover, remove the two self-tapping screws which secure the aluminium plate and slide it from beneath the pointer. There is generous clearance between the pointer and the surface of the plate, and the extra thickness of the new scale will not cause problems. Sticking the new scale to the reverse of the existing enables the original meter function to be restored, without difficulty, should this be desired. Before the plate is re fixed, colour the central band of the new scale bright red, from 20 percent to maximum, as a visual reminder of the danger zone.

Moving coil meters are very delicate things and the above operation should be carried out with the utmost care so as not to damage the pointer or the bearings of the movement.

For reasons which are explained later, the calibration of the unit is inevitably approximate, as, indeed, is the calibration of all moisture-measuring instruments of this kind.

## Using the Moisture Meter

In order to check for dampness, simply press the probe tips into the timber or plaster and note the reading on the meter scale. When checking moisture levels in brickwork, press the probe into a mortar joint. If the material is too hard to permit penetration, press the probe tips firmly against the surface.

Try the unit out at home before boldly going forth to check moisture levels in someone else's property. If your house is free from dampness, the meter pointer will not shift from zero and you will have to try exterior woodwork or timber left lying around outside in order to experience a visible reading. (Pressing a finger across the probe tips should drive the pointer across the scale.) The testing procedure will, of course, leave tiny marks on surface decorations, and it is courteous and wise to obtain the approval of the house owner before using the moisture meter.

The following notes should help you to make some sense of readings you might obtain (and give you a few technical terms to help build up your 'street-cred' when talking to the experts).

(1) If the material is acceptably dry, there will be no deflection of the meter pointer. Any noticeable deflection, no matter how slight, is, therefore, an indication of dampness.

(2) The meter indicates the approximate moisture content of timbers commonly used for building purposes. Moisture content is the weight of absorbed water divided by the dry weight of the wood.

(3) The critical moisture level is 20% (12 on the 0-100 comparative scale). Above 20%, dry rot (*Serpula lacrymans*) can establish itself. Once established, it can survive with moisture contents as low as 14-15% (a slight deflection of the meter pointer).

(4) Wet rot (usually *Coniophora puteana*) requires a moisture content in excess of 40% (moving towards full-scale deflection of the meter pointer) before it can become established and develop.

(5) Timber joists and beams are built into walls. Readings on plaster or brickwork will, therefore, reveal the possibility that hidden timbers may be exposed to excessively damp conditions.

(6) The moisture meter indicates relative dampness levels in plaster, brick, concrete and stone, and this makes it a useful diagnostic tool. Rising dampness in a wall is indicated by readings close to full-scale at ground floor level petering out to near zero about one metre up.

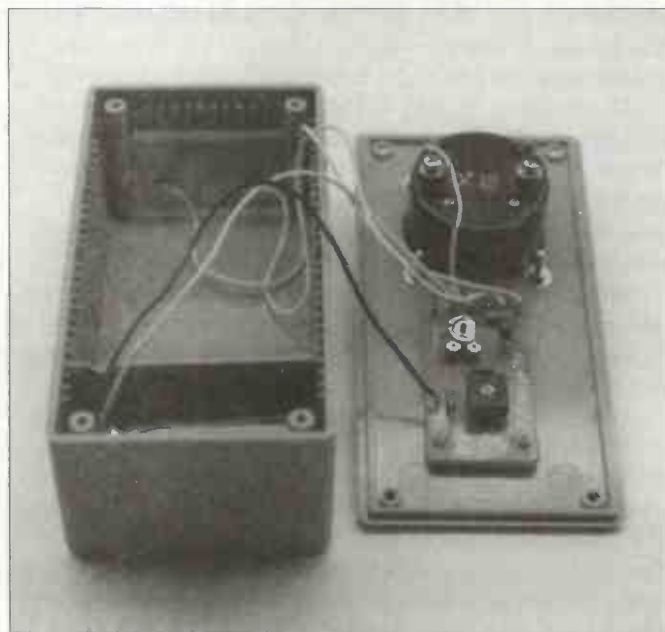
(7) Condensation may be the culprit if fairly similar readings are obtained over the entire surface of a wall.

## Limitations

Timber moisture content for a given resistance between the probe tips varies from species to species and, to a lesser extent, from tree to tree and within a single board or plank. The temperature of the wood, surface contamination, and impregnation with preservatives, also affect the readings obtained, and all of these factors combine to impose limitations on the accuracy of instruments of this kind. Resistance measuring moisture meters do, however, permit the rapid and non-destructive assessment of dampness levels, and they are standard items of equipment for surveyors who carry out detailed inspections of property.

Knowledge, skill and experience are needed to correctly interpret the significance of the readings in a given situation. In the case of a house you're only marginally interested in, however, discovering dampness could be the clincher that makes you decide not to proceed any further. If you find dampness in a property you've fallen in love with, call in an independent expert to carry out an inspection and prepare a report before you make an offer.

Provided you bear in mind the limitations of the instrument (and, perhaps, your own limitations, too) an evening spent with a soldering iron could help you to avoid making the mistake of a lifetime.



## PARTS LIST

### Resistors

All 0.25 Watt, 5% tolerance unless otherwise stated.

R1	470k
R2	1M pre-set potentiometer.
R3	22k
R4	1k pre-set potentiometer.
R5	1k
R6	2M2 1% for calibration purposes.
R7	620k 1% for calibration purposes.

### Semiconductors.

Q1	BC171
----	-------

### Meter

M1	Moving coil type, 50 - 500uA FSD. See text.
----	--

### Sundry items.

PCB making materials, Vero pins and hook-up wire. PP3 battery and connector. Plastic box. Brass-headed picture-hanging pins. Small pieces of Perspex or Paxoline. Small self-tapping screws and stand-offs. Cyanoacrylate adhesive (Superglue).



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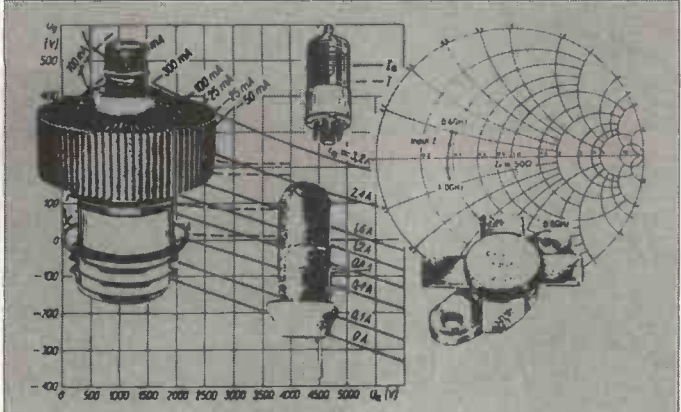
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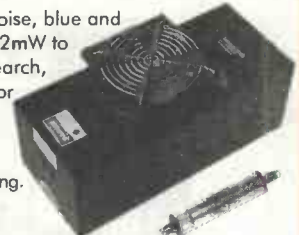


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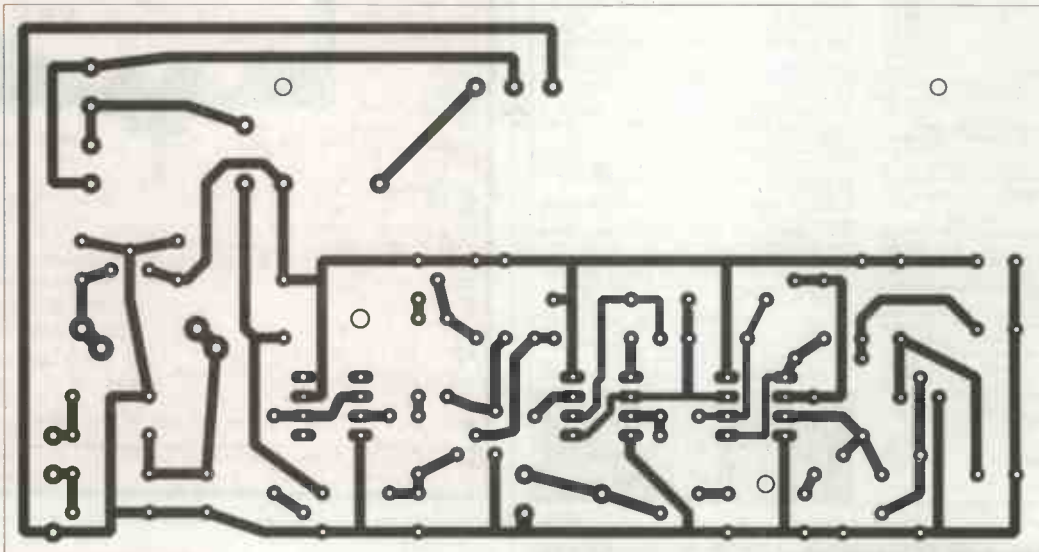
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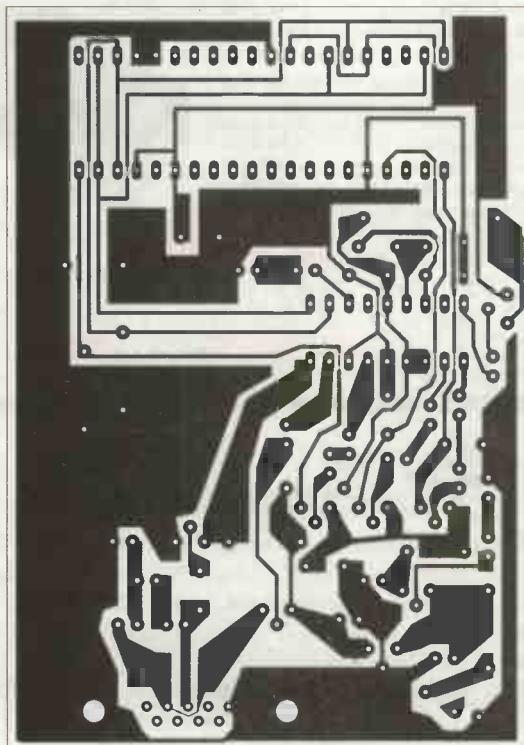
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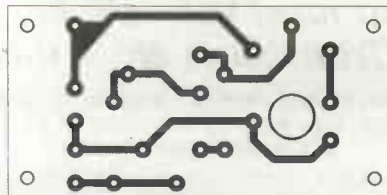
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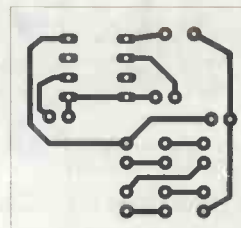
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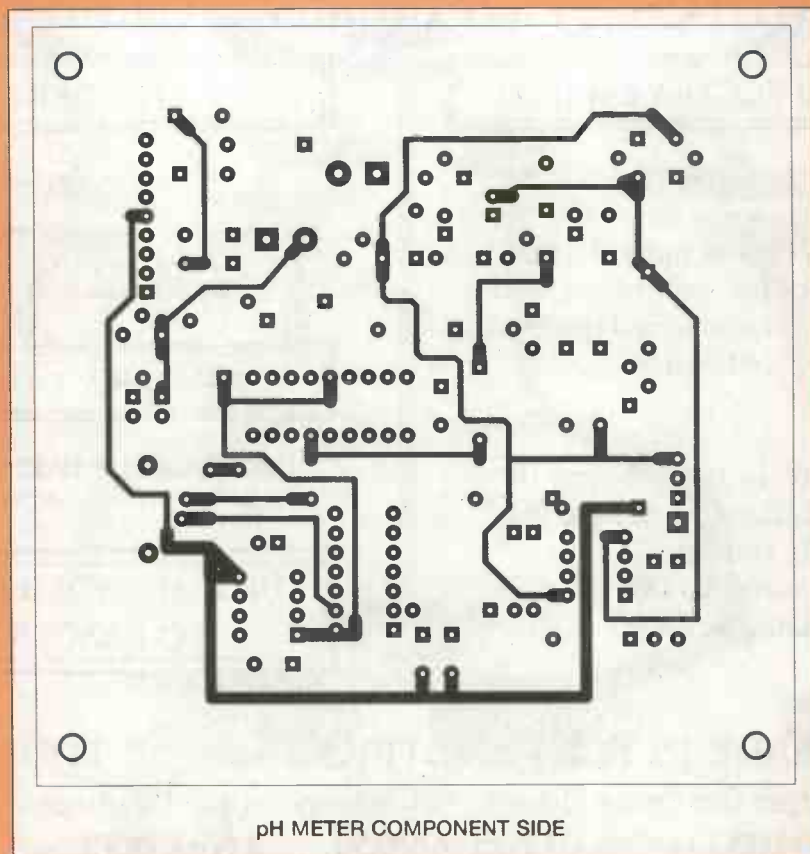
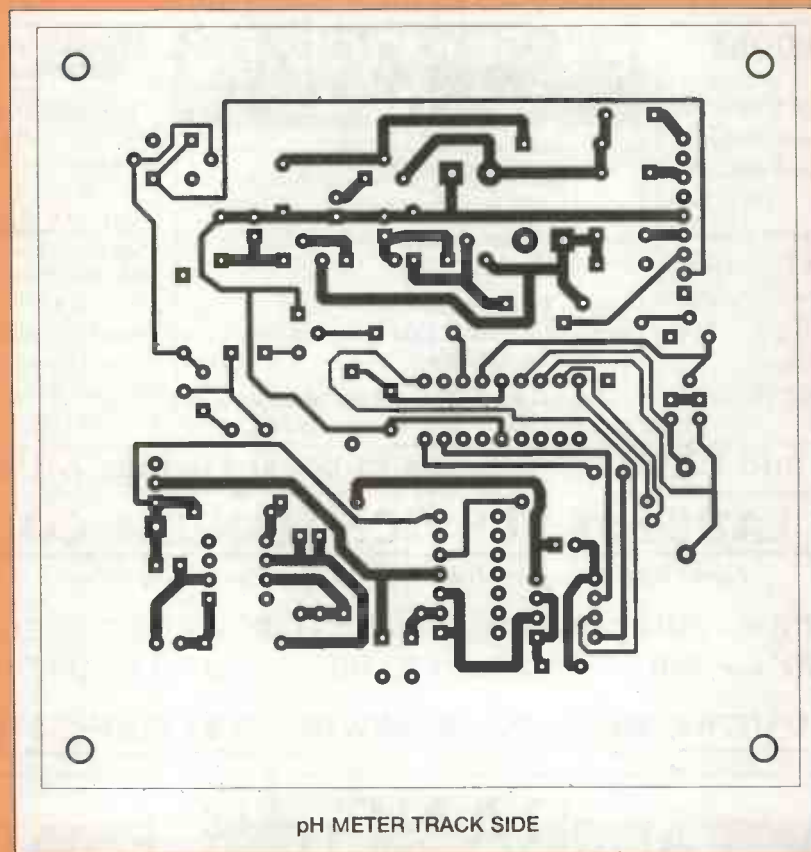
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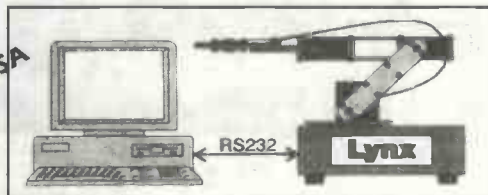
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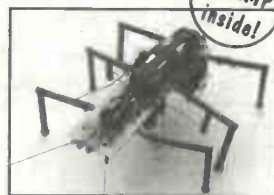


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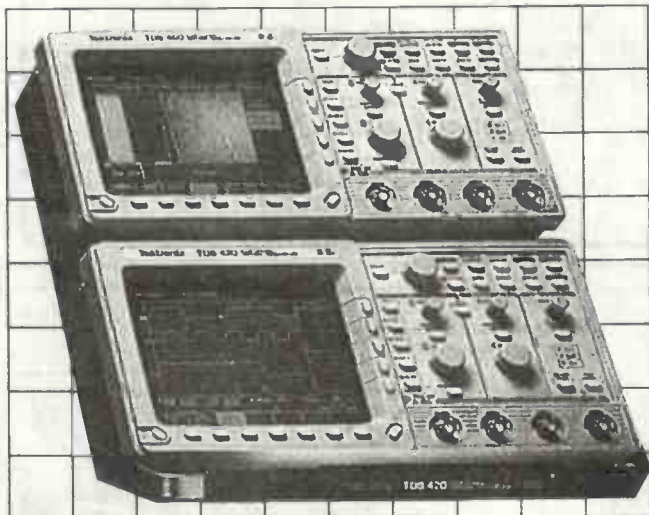
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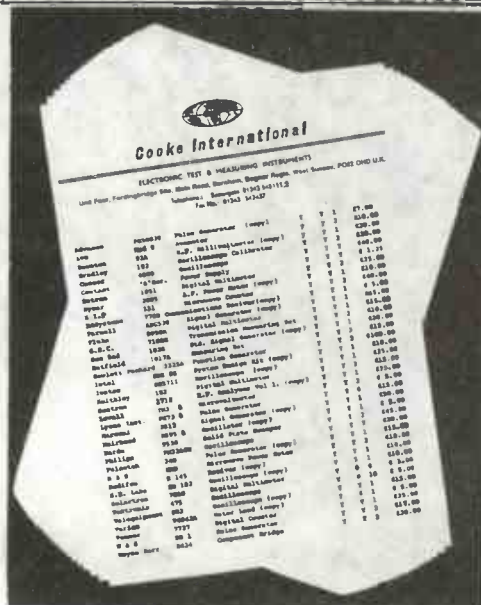
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ARRAN TECHNOLOGY . . . . .65	NO1 SYSTEMS . . . . .22
	NO NUTS . . . . .59
BK ELECTRONICS . . . . .17	
BULL ELECTRICAL . . . . .10, 12	OLSON . . . . .OBC
	OMNI ELECTRONICS . . . . .60
CMS . . . . .59	
CHELMER VALVE . . . . .65	PDSL . . . . .72
COOKE INTERNATIONAL . . .70	P H HAGAR . . . . .73
COLES HARDING AND CO . .72	PARTRIDGE
	ELECTRONICS . . . . .59
DISPLAY ELECTRONICS . . .19	PLANCENTRE
	PUBLICATIONS . . . . .72
EPT EDUCATIONAL	PICO TECHNOLOGY . . . . .21
SOFTWARE . . . . .24	PRESS AND PEEL . . . . .70
ELECTROMAIL . . . . .38	QUICK ROUTE SYSTEMS
EQT . . . . .70	(POWERWARE) . . . . .IFC
ESR COMPONENTS . . . . .28	
	ROBINSON MARSHALL . . . . .IBC,
F.K. ELECTRONICS . . . . .72	ROBOTICA . . . . .69
FOREST ELECTRONICS . . .35	
	SCIENTIFIC WIRE
GRANDATA . . . . .4, 5, 6, 7	COMPANY . . . . .72
GREENWELD	SEETRAX . . . . .67
ELECTRONICS . . . . .48	SERVICE TRADING CO . . .72
	STEWART OF READING . .60
ICS . . . . .69	
	TECHNICAL EDUCATION
JJ COMPONENTS . . . . .38	INDEX . . . . .60
JPG . . . . .65	TECHNICAL INFORMATION.67
J+N FACTORS . . . . .72	TELNET . . . . .33
LASERTECH . . . . .38, 65	VAN DRAPER . . . . .38
	VARIABLE VOLTAGE
MAURITRON . . . . .69	TECHNOLOGY . . . . .72
MILFORD	VERONICA FM . . . . .72
INSTRUMENTS . . . . .69	VISIBLE SOUND . . . . .65
NICHE SOFTWARE . . . . .48	WILSON VALVES . . . . .73



# ETI Contents Index - 1995

This index is divided into two sections: Technical and Construction, which features all articles on a constructional project or containing construction-related information, and Features, which contains our leading topic features and shorter features.

## Technical and Construction

16-channel MIDI mixer	Oct 1995
80188 SBC - 4 channel touch switch interface	Jun 1995
80188 SBC - serial ADC for virtual instrumentation (Part 1)	Jul 1995
80188 SBC - serial ADC for virtual instrumentation (Part 2)	Aug 1995
80188 single board computer (Part 2)	Feb 1995
80188 single board computer (Part 3)	Mar 1995
80188 single-board computer (Part 1)	Jan 1995
8088 interrupt-based single board computer - single-stepping	Nov 1995
8088 interrupt-based single board computer	Sep 1995
8088 interrupt-based single-board computer	Aug 1995
Active Guitar Electronics	Feb 1995
Alarming Ideas - a collection of devices mainly for PC security	Feb 1995
Analogue shutter timer for cameras	Aug 1995
Bar-code reader for the PC	Dec 1995
Basic microcontroller (Part 1)	Oct 1995
Basic microcontroller (Part 2)	Nov 1995
Basic microcontroller (Part 3)	Dec 1995
Basic microcontroller (Part 4)	Jan 1996
Basic microcontroller (Part 5)	Feb 1996
Basic microcontroller (intro)	Sep 1995
Bat simulator and sound detector	May 1995
Bicycle loop alarm	Jun 1995
Child's night light (low power)	Oct 1995
Computer controlled SMART mains control system	Feb 1995
Computer controlled SMART mains control system	Mar 1995
Computerised radio control	Nov 1995
Computing without clocks	Jul 1995
Designing a PIC micro-based project (Part 1) with alarm clock	Jul 1995
Designing a PIC micro-based project (Part 2) with alarm clock	Aug 1995
Designing a PIC micro-based project (Part 3) with alarm clock	Sep 1995
Designing a PIC micro-based project (Part 4) with alarm clock	Oct 1995
Designing a PIC micro-based project (Part 5) with alarm clock	Nov 1995
Designing a PIC micro-based project (Part 6) with alarm clock	Dec 1995
Dry battery tester	Sep 1995
Electronic cycle alarm	Dec 1995
Eprom programmer, portable	Apr 1995
Fibre optic MIDI link	Sep 1995
Fibre optic transceiver for computers and peripherals	Jul 1995
Garden shed alarm (Part 1)	Mar 1995
Garden shed alarm (Part 2)	Apr 1995
General Purpose RS232 Card with 24 lines I/O (Part 1)	Dec 1994
General Purpose RS232 Card with 24 lines I/O (Part 2)	Jan 1995
Laser Tag game - Large scale displays (last part)	Jul 1995
Laser Tag game - light gun base (Part 2)	Apr 1995
Laser Tag game - light gun control	Jun 1995
Laser Tag game - light gun control (Part 3)	May 1995
Laser Tag game - the Gunman	Mar 1995
Laser Tag game (Part 1)	Mar 1995
Message Pad "Hello Mum"	Sep 1995
Metal effects unit	Jan 1995
Mobile robot	Apr 1995
Multi-checker for home and car	Aug 1995
Multi-core cable tester	Aug 1995
NiCad battery charger	Apr 1995
Noise masker	Dec 1995
Opto-compressor gain control for public address systems	Feb 1995

Parallax Basic Stamp - making servos work for you	May 1995
Parallax Basic Stamp - applications for the pulse command	Jul 1995
Parallax Stamp - building a serial relay controller for PC	Sep 1995
Parallax Stamp - LCD based mini terminal	Apr 1995
Parallax Stamp - signal processing	Jun 1995
PCW I/O port	Mar 1995
PIC programmer	Jul 1995
PIC programmer	Jun 1995
Programmable packer timer 3-digit, using a PIC	May 1995
Solid state darkroom safelight	Jan 1995
Switch regulators (Part 1)	Jun 1995
Switch regulators (part 2)	Jul 1995
The Parabender (Part 1) parametric EQ	Dec 1994
The Parabender (Part 2) stereo EQ	Jan 1995
The Raydor (Part 1)	Feb 1995
The Raydor (Part 2)	Mar 1995
Timed mains isolating switcher	Dec 1995
Touch test continuity tester	May 1995
Twinkling star	Jan 1995
Using eproms (Part 1) : proms vs logic	Dec 1994
Using eproms (Part 2)	Jan 1995
Using PIC micros on the Arizona Microsystems PIC controller	Jun 1995
Using the PC Parallel Port	Jun 1995
Versatile bench power supply (Part 1)	Oct 1995
Versatile bench power supply (Part 2)	Nov 1995

## Features

Analysing light (feature)	Apr 1995
DC and electronically commutated electric motors	Aug 1995
Driving into the Future	Nov 1995
Electron Microscopy	Oct 1995
Electronics and the Internet	Jan 1995
Electronics in Medicine	Feb 1995
Interactive digital TV	Aug 1995
Movie Technology	Apr 1995
Nickel Metal Hydride Batteries	May 1995
Parallax Stamp review - small, low-cost control computer	Apr 1995
PC Clinic - installing sound cards	Apr 1995
PC Clinic - maintaining personal computers	Jan 1995
PC Clinic - sound boards and CD rom drives	Feb 1995
PC Clinic	Mar 1995
Shape Changing Robots	Dec 1995
Shape Memory Alloys	Jun 1995
Solar Panels ("Something for Nothing?")	Oct 1995
TEC 200 on trial - PCB-making kit/method	Jul 1995
The Ariane 5	Sep 1995
The Virtual World	May 1995
Uncovering Saturn's Secrets	Jun 1995
Walking insect robots	Mar 1995

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# C Around the Corner

This issue reports the results of the Young Electronic Designer of the Year Awards. YEDA is for full time students, mainly from the electronics disciplines, and it lays some fairly strict criteria for entrants: originality; technical competence and reliability; sound construction (and presentation); usefulness; and commercial feasibility. The young designers must consider who is going to use their design, and how practical it will be to operate. They must think about the cost of construction, where the parts are to come from, and how best to package and promote it to the eventual user. People from age 12 to 25 are encouraged to work in teams or as individuals to look at all aspects of electronics design and come up with something of their own. It is a fine and encouraging effort and a credit to the students and the sponsors, Mercury Communications, Texas Instruments and the Institution of Electrical Engineers.

In a nutshell, most of the criteria that apply to design in the wider world are the same criteria that apply to designing and publishing a project for constructors who want to build their own devices, equipment and machinery at home.

We have a slightly easier task, in fact, because most constructors are not upset if they have to do some calibration, or if the design does not include a mega-matt machine moulded heat-sealed non-reflective front panel, or even if they have to look a bit further for a specialised part (as long as we warn them, and tell them where to start looking).

But they, too, want something that works and something that will be useful or entertaining

or just intriguing. In our fraternity there is more room for the personal design, the useful widget that sits in a corner of the bench/car/attic and does something that no-one else really needs doing (but have you asked them?) in a way that is slightly different from the commercial norm. But once you have put your efforts into making your design useful, safe, reliable and maybe (but not necessarily) even attractive - not only have you met many of the criteria that determine the winners of design awards, but you may have something that others would like to build for themselves.

(There was quite a rumpus in a nearby household when the time came to replace the insulating jacket on the hot tank and the designer-in-chief suggested chucking out the widget he had built in a tobacco tin 10 years ago to monitor the hot water level. The household had come to rely on it to avoid squabbles about the hot water running out - but no-one had told him.)

If you do, we are always pleased to hear from people who have built an original-project and are thinking of writing it up. For more information, see the small ad. on page 23, or write to the editor for our Potted Project Production sheet.

Two pieces of news: author Bob Noyes reminds us that the LM3911 replacement board published last month for the Shake'n'Etch has been designed so that it can replace the discontinued LM3911 in any normal application with minimal tweaking.

The other piece of news is that negotiations for a new ETI PCB Service are far advanced, and the new service currently looks set to begin next month.

## The Challenge - Things that electronics hasn't fixed yet

I wonder if it would be possible to convert electricity to light with integrated circuits, by having a very high frequency oscillator and a microscopic antenna, and generating the light in the same way as conventional radio frequency. The laser and the LED provided part of the answer, but if you could make a nano-size transmitter and receiver for light, then an array which responded to phase and frequency suitable could, for example, function as a camera without the need for a lens. Or it could be the ultimate flat screen display, with 3D capability inherent in its functioning. But how?

## Next Month...

Volume 26 no. 7 of *Electronics Today International* will be in your newsagent on 20th June 1997 ... Robin Abbott will be describing the new Universal Serial Bus PC serial standard that can address up to 127 devices and is the contender to replace RS232 in the next few years. ... A new EEPROM programmer with personality modules for different devices from Keith Wardill ... our cryptic car-alarm look-alike ... a switched sine- and square-wave generator from Robert Penfold ... another Spiced Circuit ... the results of our EdWin competition ... and more ... *Contents are in preparation but are subject to space and availability.*



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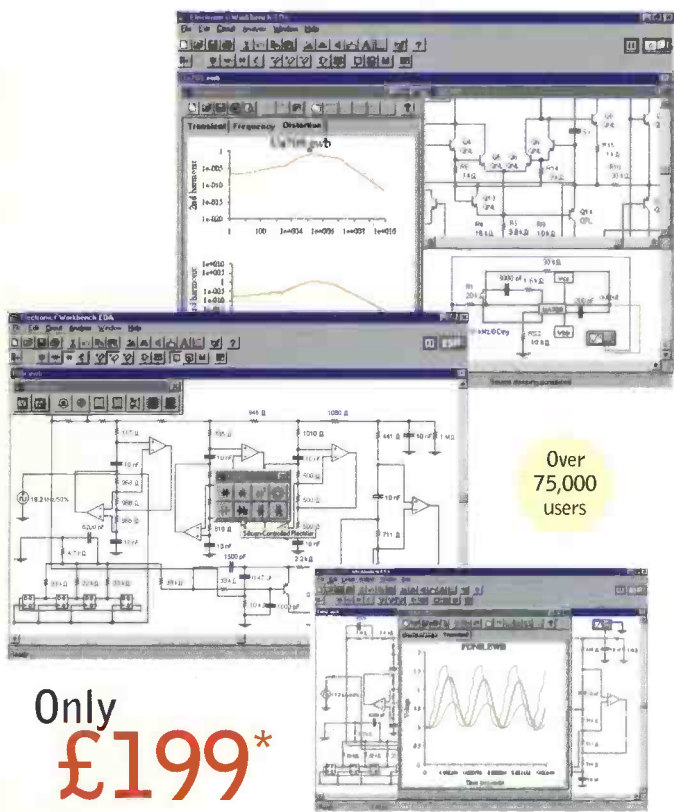
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