ETI
ELECTRONICS TODAY INTERNATIONAL

11 39
65 DISK BOX
66
68 71

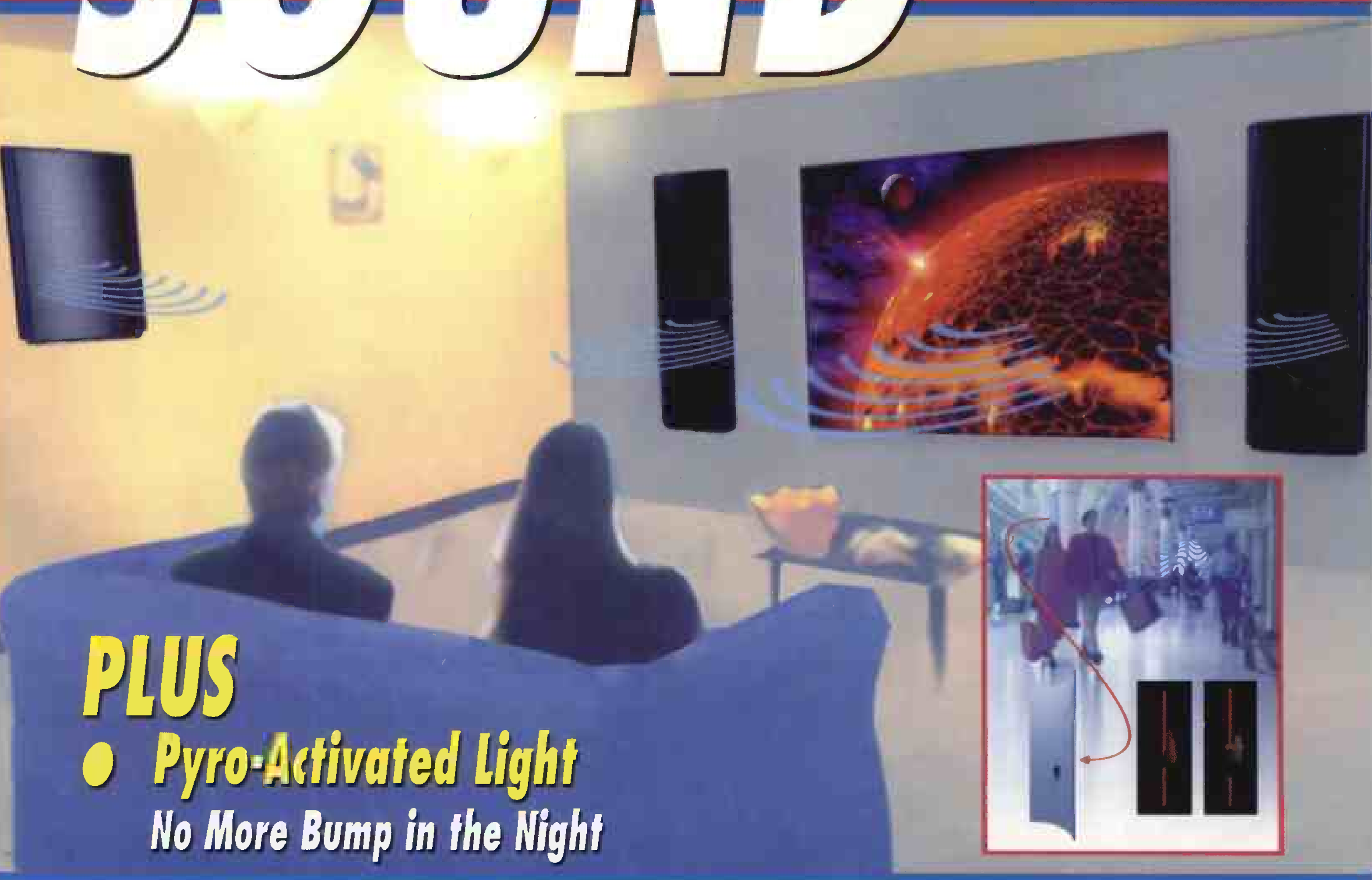
WIN Two Tickets for the Air Tattoo
See Page 47

VIRTUAL pH METER
For PC computers

PIC PROGRAMMER REVISITED
More features, easier to operate

WALL OF SOUND

THE NEW LOUDSPEAKERS WILL BE HEARD AND NOT SEEN



PLUS
- **Pyro-Activated Light**
  No More Bump in the Night
- **Light-powered Continuity Quick-Tester**
- **Handy Moisture Meter**

9 770142 722146 06

FOR ENTHUSIASTS BY ENTHUSIASTS
NEXUS

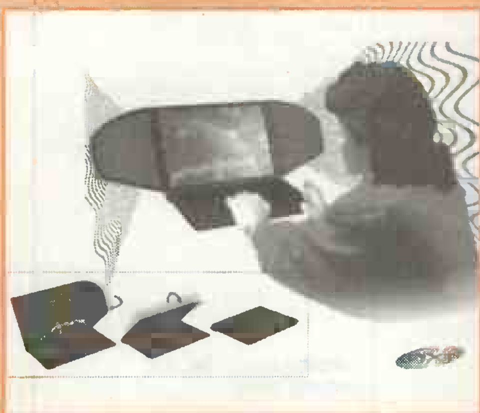
VOLUME 26 No. 6 £2.35 USA $4.95

Contents

Volume 26 No.6

& Features Projects

Next Issue 20th June 1997



Regulars

DIGITAL MULTIMETERS

CM2300 DIGITAL MULTIMETER

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

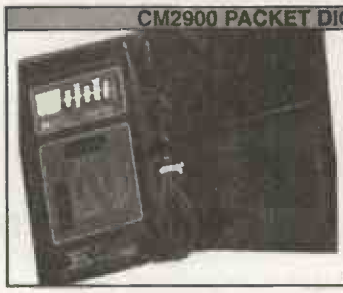
ORDER CODE: CM2300
PRICE: 975p

CM2400T DIGITAL MULTIMETER WITH TEMP MEASUREMENT

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

ORDER CODE: CM2400T
PRICE: 1450p

CM2900 PACKET DIGITAL MULTIMETER



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

ORDER CODE: CM2900
PRICE1150p

CM2700 AUTORANGING DIGITAL MULTIMETER

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

ORDER CODE: CM2700
PRICE: 4050p

CM3230 DIGITAL CAPACITANCE METER

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

ORDER CODE: CM3230
PRICE: 3950p

CM3900A DIGITAL MULTIMETER

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

ORDER CODE: CM3900A
PRICE: 2900p

CM3920 DIGITALMETER WITH TEMP MEASUREMENT

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

ORDER CODE: CM3920
PRICE: 4100p

8 Way Preprogrammed Universal Remote Control

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

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

Order Code: 8 WAY
Price: 1450P + VAT

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PLEASE PHONE US FOR TYPE NOT LISTED HERE AS WE ARE HOLDING 30,000 ITEMS AND QUOTATIONS ARE GIVEN FOR LARGE QUANTITIES

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TV and video parts sold are replacement parts.
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WE STOCK TV AND VIDEO SPARES, JAPANESE TRANSISTORS AND TDA SERIES. PLEASE RING US FOR FURTHER INFORMATION.

SATELLITE POWER SUPPLY REPAIR KITS

ALBA	CODE
SAT660	SATPSU2

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

BRITISH TELECOM	CODE
SVS300	SATPSU17

BUSH	CODE
IRD150	SATPSU12
IRD155	SATPSU19

CHURCHILL	CODE
D3MAC DECODER	SATPSU7

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

FERGUSON	CODE
SRD 5, SRD16	SATPSU1
SRV1	SATPSU2
SRDE4	SATPSU11

FINLUX	CODE
SR5700	SATPSU12

GOODMANS	CODE
ST700	SATPSU1

GRUNDIG	CODE
STR1	SATPSU1
GIRD200, FIRD3000	SATPSU2

MANHATTAN	CODE
850, 950	SATPSU1

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

MIMTEC	CODE
SOPRENSON TYPE PSU ONLY	SATPSU15

NETWORK	CODE
9000, 9200	SATPSU2

NOKIA	CODE
SAT1500	SATPSU2

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

PHILIPS	CODE
STU802/05M	SATPSU1
STU801	SATPSU2

THOMSON	CODE
SRS4	SATPSU2

TOSHIBA	CODE
SAT99, TU-SDU200	SATPSU1

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

PACE SATELLITE TUNERS

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

PACE SWITCH MODE TRANSFORMERS

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

SATMETER

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

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

LED INDICATOR: VERTICAL/HORIZONTAL
POWER AMPLIFIER: 18 DB

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

ORDER CODE: TOOL 22 PRICE: 8500p

SATELLITE LNB'S

MAKE & MODEL	ORDER CODE	PRICE
Cambridge AE22/AE5 0.8dB standard 10.95-II.70 GHz Gold Range	LNB1	2160p
Cambridge AE14 Universal LNB 10.7-11.7/11.7-12.75 GHz	LNB2	2500p
Cambridge AE21/AE5 Single O/P Switching LNB 1.0dB Standard	LNB3	2050p
Cambridge AE19/AE6 Single O/P Switching LNB 1.0dB Enhanced	LNB4	2050p
Cambridge AE23/AE12 0.8dB Enhanced 10.7-11.8GHz Gold Range	LNB5	2160p
Cambridge AE8 Dual O/P H-V Separate Enhanced	LNB6	4000p

MAKE & MODEL	ORDER CODE	PRICE
Cambridge AE7 Twin O/P H+V Both Enhanced	LNB7	4000p
Cambridge AE2 Dual O/P H-V Separate Enhanced	LNB8	3550p
Grundig Super Universal 'Anis' 10.7-12.75 GHz 0.8dB	LNB9	2600p
Grundig Universal 'Anis' 10.7-12.75 GHz 1.0dB	LNB10	2250p
Cambridge AE1 Twin O/P H+V Both Standard	LNB11	4000p

FUSES

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

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

CERAMIC PLUG TOP

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

20mm CERAMIC TIME LAG

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

38mm CERAMIC TIME LAG

CURRENT RATING	ORDER CODE	PRICE
10A	FUSE48	815P

32mm CERAMIC SLOW BLOW

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

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

TRANSISTORS

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

PART	PRICE
BD647	50P
BD649	50P
BD675	40P
BD676	40P
BD677	38P
BD678	40P
BD679	40P
BD680	40P
BD681	45P
BD682	45P
BD705	50P
BD707	50P
BD709	50P
BD711	50P
BD736	50P
BD826	50P
BD828	50P
BD839	55P
BD897	50P
BD899	50P
BD977	50P
BDX33	60P
BDX37	100P
BDX44	100P
BDX47	75P
BDX54C	75P
BDX62C	150P
BDX63C	175P
BDX64C	175P
BDX65	80P
BDX66C	175P
BDX67C	275P
BDX71	70P
BDX77	175P
BDX87C	175P
BDX88C	150P
BDW24	55P
BDW93	50P
BDW94	50P
BDY29	225P
BDY56	225P
BDY58	500P
BDY90	125P
BDY92	100P
BF137	35P
BF187	30P
BF181	18P
BF183	20P
BF195	7P
BF199	8P
BF200	16P
BF225	30P
BF240	16P
BF245	25P
BF254	15P
BF255	12P
BF256	18P
BF257	18P
BF259	18P
BF262	25P
BF270	18P
BF273	15P
BF311	21P
BF336	20P
BF337	20P
BF338	20P
BF362	30P
BF367	13P
BF371	17P
BF421	18P
BF422	21P
BF423	25P
BF455	12P
BF458	19P
BF462	50P
BF471	28P
BF472	28P
BF479	30P
BF494	16P
BF495	16P
BF595	16P
BF596	16P
BF615	30P
BF617	30P
BF760	4OP
BF763	40P
BF870	22P
BF871	22P
BF960	38P
BF961	35P
BF964	38P
BFQ232	75P
BFQ252A	60P
BFR90	85P
BFR91	99P
BFT43	30P
BFX29	20P
BFX84	20P
BFX85	20P
BFX87	15P
BFX88	15P
BFX89	60P
BFY50	14P
BFY51	24P
BFY52	14P
BFY56	25P
BFY64	25P
BFY90	45P
BLY48	85P
BR100	14P
BR103	37P
BR303	85P
BSX20	15P
BU105	80P
BU108	100P
BU109	80P
BU110	90P
BU111	100P
BU124	60P
BU125	100P
BU126	65P
BU128	125P
BU133	125P
BU137	150P
BU180	100P
BU184	100P
BU204	65P
BU205	70P
BU206	100P
BU207	150P
BU208	70P
BU208A	75P
BU208AT	200P
BU208B	200P
BU208D	130P
BU209	90P
BU225	120P
BU226	120P
BU312	90P
BU325	55P
BU326A	75P
BU406	60P
BU406D	85P
BU407	55P
BU407D	75P
BU408	60P
BU408D	75P

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

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

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

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

RECTIFIER DIODES

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

TRANSISTORS

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

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

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

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

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

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

SERVICE AIDS

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

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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-enclampsia 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...

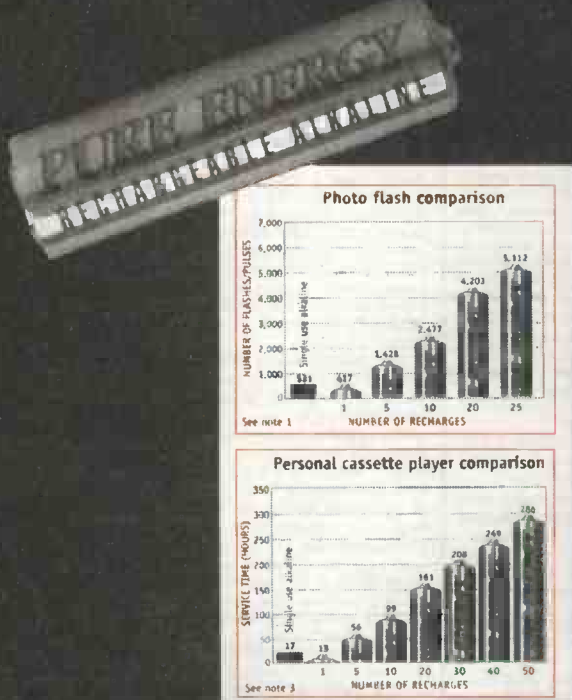
Mercury-free batteries ready to change the market

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 Kordesch, 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 the 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-tiop 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.

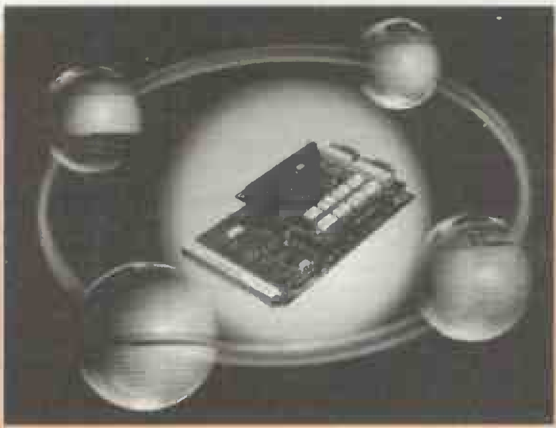
The batteries will be on retail sale. Further enquires to Allied Battery Technologies, 14 Bates Industrial Estate, Wycombe Road, Stokenchurch, Bucks HP14 3RJ.

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.

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 higer 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 kernal 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 unitl 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.

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.

It 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 hifi items to see if the styling is compatible with other respected models on the market, as hifi 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.

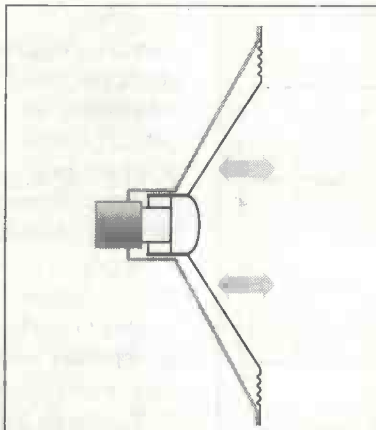


Figure 1: the piston action of a conventional loudspeaker

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 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 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.

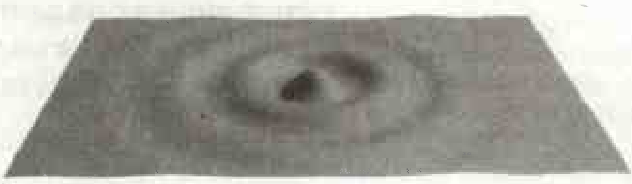


Figure 2: the vibration pattern typical of an electrostatic loudspeaker

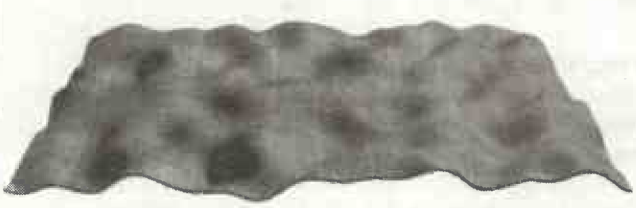


Figure 3: the vibration pattern typical of an NXT loudspeaker

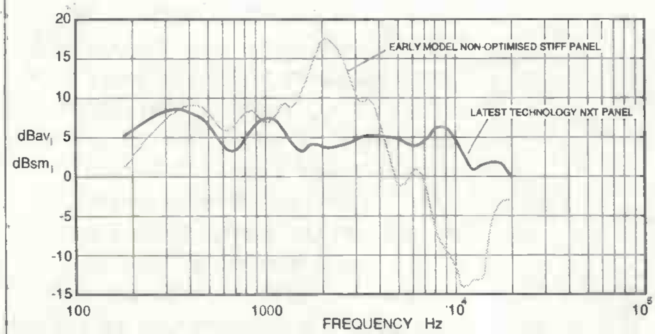


Figure 4: the frequency response of an early panel compared with a later, optimised, design

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 sheer 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 predicable 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.

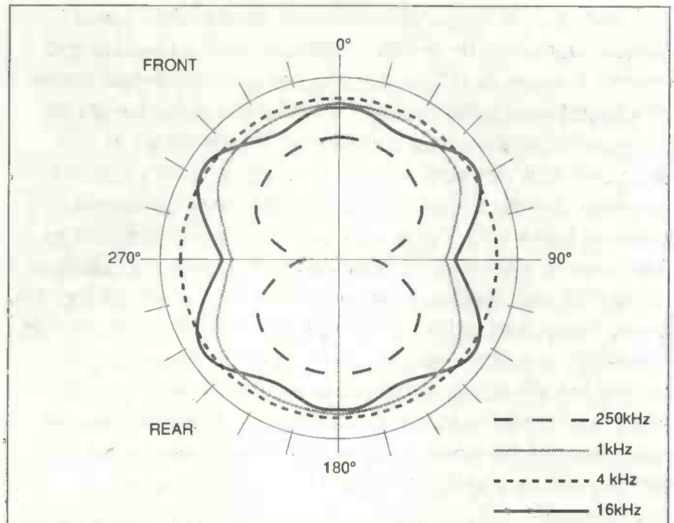


Figure 5: the radiation pattern for an NXT panel

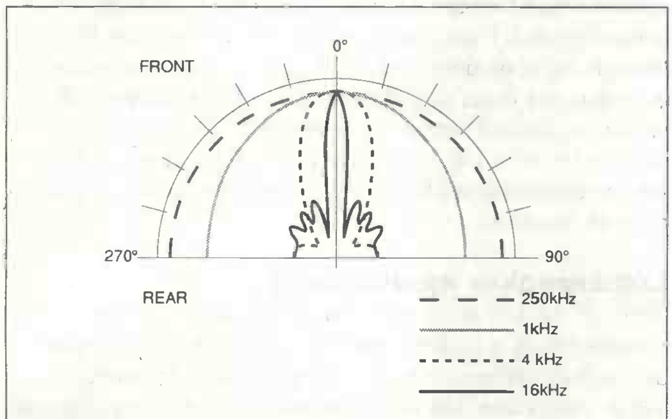


Figure 6: the radiation pattern typical of a 6.5-in cone loudspeaker in a baffle

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 ampiifier 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

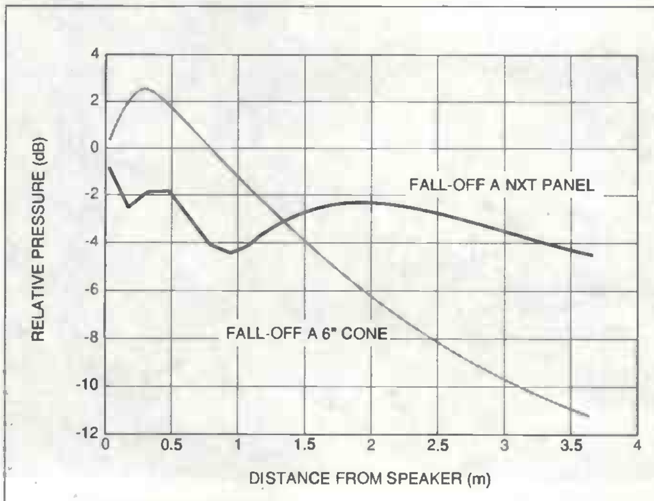
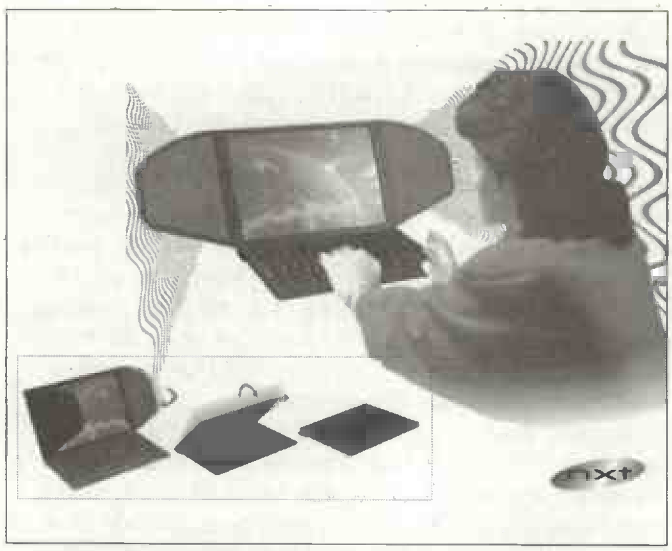


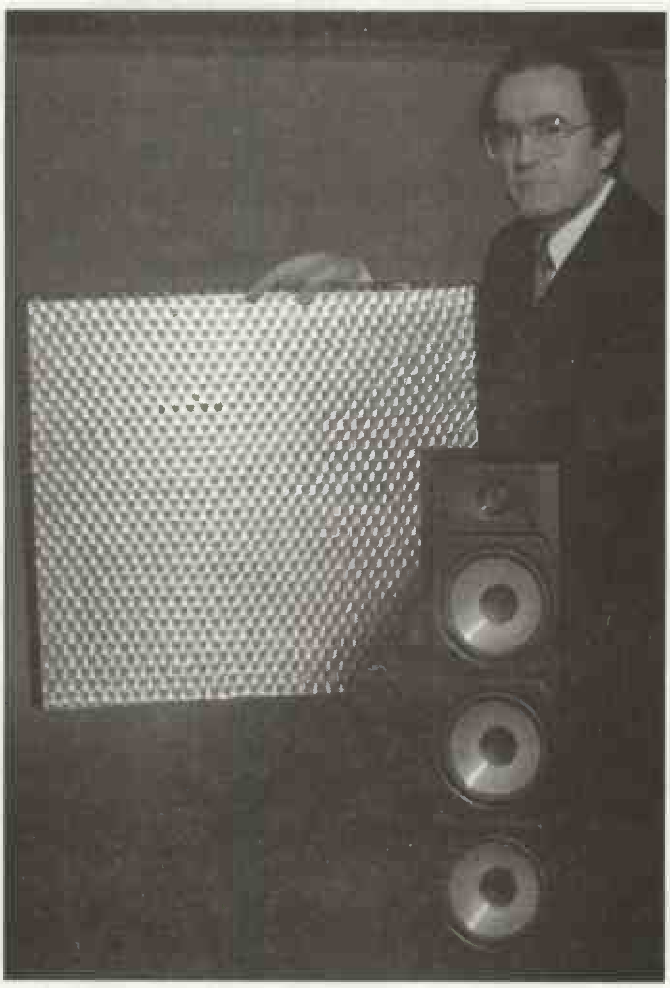
Figure 7: power drop with distance



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

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.

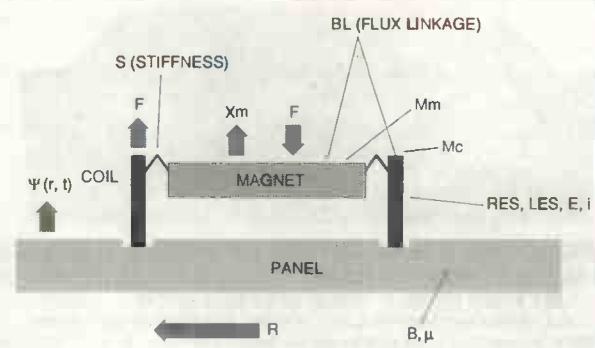


Figure 8: an inertial magnet driver

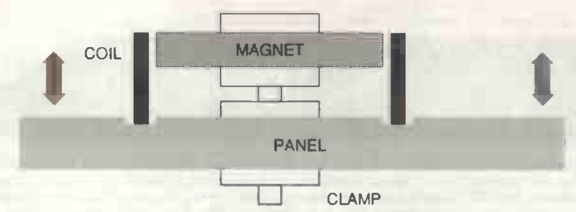


Figure 9: a clamped (bender) driver

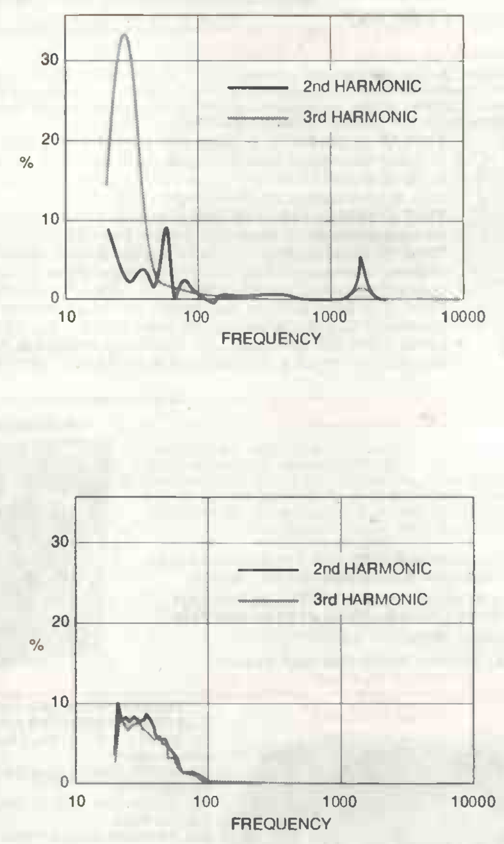


Figure 10: comparative distortion.

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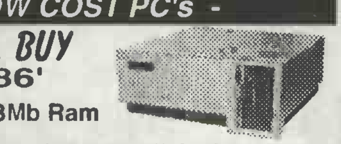

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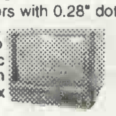

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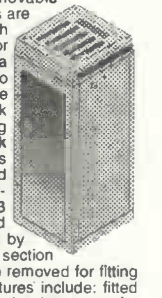

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Commercialisation

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 automative 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

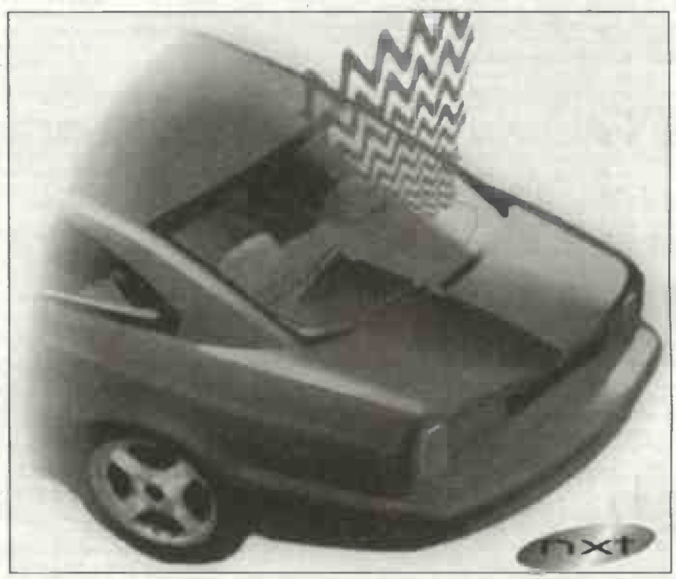
What the licensee gets is design software, and the right to use the technology in a particular product area. Without the software it would be effectively impossible to design an NXT type loudspeaker, and even with the software it may be difficult first time round. The NXT team have been able to advise 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 mulitimedia 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
Stereo audio (.6msq)	100Hz-18kHz	88dB	High quality stereo sound, slimline, matched to decor
SoundField™	120Hz-18kHz	87dB	Exceptional ambient sound field creation, most suitable for rear channel AV; cinema and domestic
SoundVu™	60Hz-18kHz	88dB	Unique performance and combination of diffuse soundfield loudspeaker with video screen; large audience coverage.

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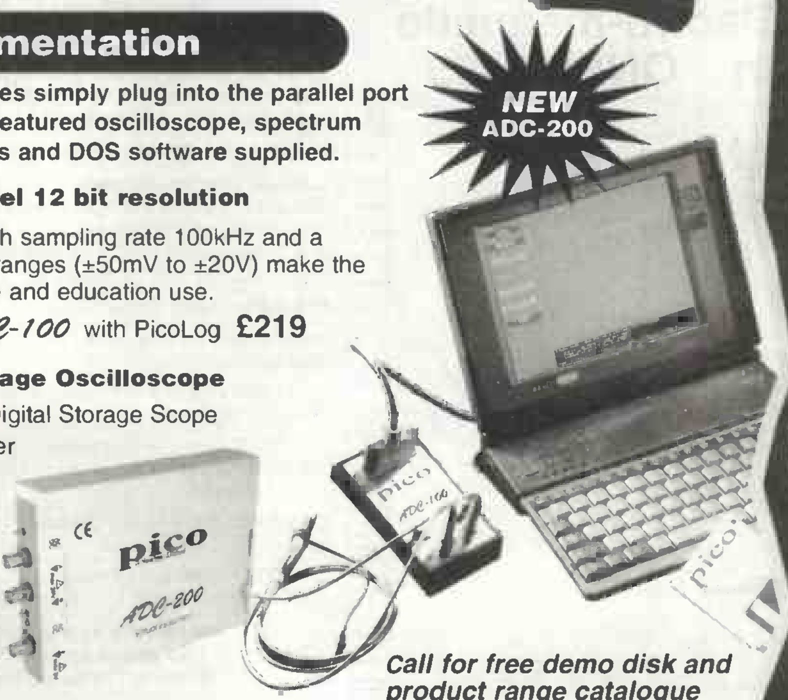

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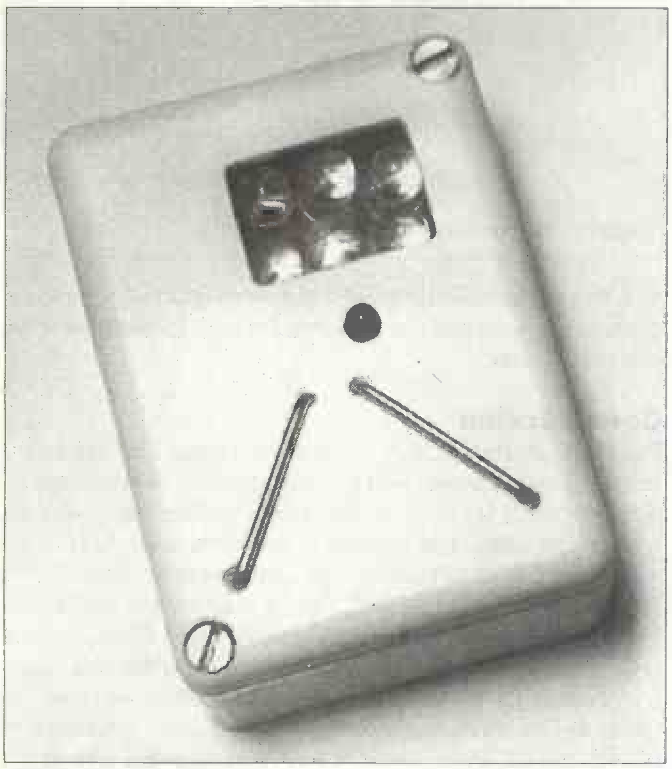
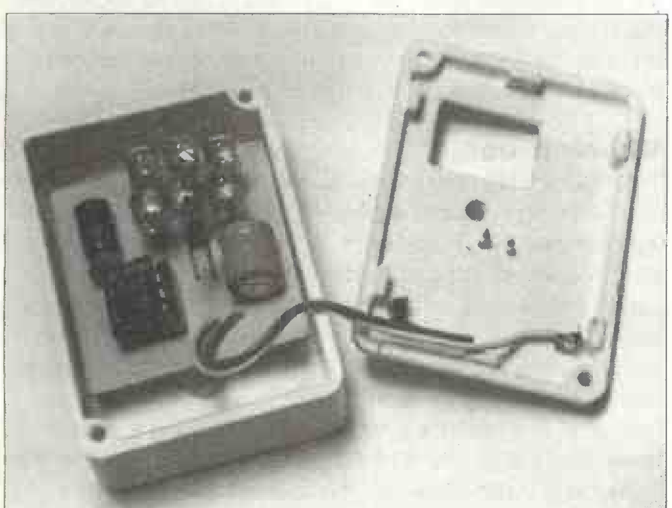
Low power, light-powered

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

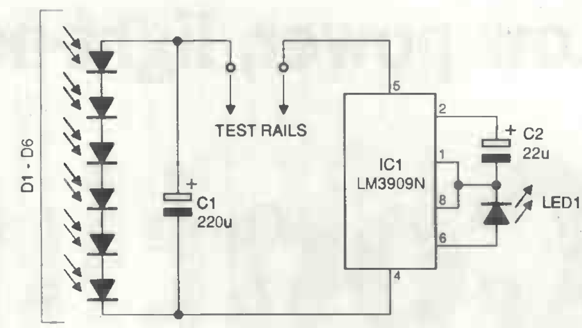


Figure 1: the circuit

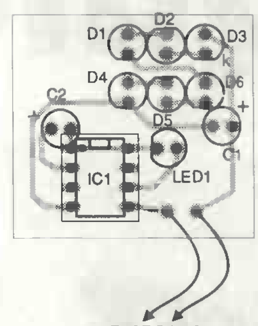


Figure 2: the component layout

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 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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4049	£0.22	74HC175	£0.35	74LS165	£0.48
4050	£0.26	74HC192	£0.72	74LS170	£0.30
4051	£0.38	74HC195	£0.32	74LS173	£0.24
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NE555N	£0.25	79L15	£0.28
NE556N	£0.36	79L24	£0.30
NE565	£1.84	ADM666AN	£3.44
NE566N	£0.90	L200CV	£1.30
NE567N	£0.39	L296	£6.87
NE571N	£2.47	L387A	£3.24
NE592	£0.62	LM2940CT	£2.30
NE5532N	£0.60	LM317T	£0.50
NE5534N	£0.64	LM323K	£2.84
NE5539N	£4.35	LM334Z	£1.35
NE5560N	£2.31	LM337T	£0.68
OP07CN	£1.42	LM338K	£5.52
OP27CN	£2.90	LM723	£0.29
OP77GP	£2.36	LP2950CZ	£2.70
OP90GP	£3.11	REF01CP	£3.44
OP97FP	£2.43	REF02CP	£4.66
OP113GP	£3.44	REF12Z	£1.28
OP176GP	£2.09	REF195GP	£4.72
OP177GP	£1.89	REF25Z	£1.24
OP200GP	£5.60	REF50Z	£1.22
OP213FP	£5.20	TL431CP	£0.45
OP275GP	£2.57	ZN423	£1.55
OP282GP	£2.27	ZN458B	£1.89
OP283GP	£5.20		
OP290GP	£5.40		
OP297GP	£5.74		
OP400GP	£11.81		
OP495GP	£8.69	**Diodes**	
RC4136	£1.00	1N914	£0.06
SAA1027	£4.46	1N916	£0.06
SG3524N	£0.96	1N4001	£0.06
SG3543	£6.88	1N4002	£0.07
SL486	£2.88	1N4003	£0.07
SSM2015P	£12.32	1N4004	£0.07
SSM2017P	£3.38	1N4005	£0.07
SSM2131P	£4.19	1N4006	£0.08
SSM2141P	£4.21	1N4007	£0.08
SSM2142P	£6.16	1N4148	£0.05
SSM2143P	£3.78	1N4149	£0.06
TBA120S	£0.90	1N5400	£0.09
TBA800	£0.70	1N5401	£0.09
TBA810S	£0.64	1N5402	£0.10
TBA820M	£0.40	1N5404	£0.11
TDA1170S	£2.48	1N5406	£0.12
TDA2002	£1.04	1N5407	£0.14
TDA2004	£3.11	1N5408	£0.15
TDA2030	£1.18		

BA157	£0.10	2N6491	£1.58	BC327-25	£0.10	BD708	£1.04
BA158	£0.10	2SB548	£0.30	BC328	£0.10	BD807	£0.80
BA159	£0.10	2SD1730	£1.44	BC328-16	£0.10	BDX32	£1.78
BAT85	£0.17	AC126	£0.44	BC337	£0.10	BDX33C	£0.56
BY126	£0.13	AC127	£0.50	BC337-25	£0.12	BDX34C	£0.50
BY127	£0.18	AC128	£0.40	BC338	£0.10	BDX53C	£0.47
BY133	£0.10	AC187	£0.48	BC338-25	£0.10	BDX54C	£0.50
OA47	£0.28	AC188	£0.48	BC348B	£0.14	BF180	£0.31
OA90	£0.07	ACY17	£3.84	BC357	£0.25	BF182	£0.31
OA91	£0.10	AD149	£1.67	BC393	£0.73	BF185	£0.58
OA200	£0.56	AD161	£0.92	BC414C	£0.13	BF194	£0.31
OA202	£0.29	AD162	£0.92	BC441	£0.40	BF194B	£0.19
Zeners 2.7 to 33V		BC107	£0.16	BC461	£0.46	BF195	£0.19
400mW	£0.08	BC107B	£0.17	BC463	£0.29	BF244	£0.35
1.3W	£0.14	BC108	£0.14	BC478	£0.32	BF244B	£0.40
Bridge Rectifiers		BC108B	£0.16	BC479	£0.32	BF244C	£0.35
1.5A 50V	£0.19	BC108C	£0.15	BC490	£0.24	BF257	£0.33
1.5A 200V	£0.20	BC109	£0.17	BC516	£0.22	BF259	£0.33
1.5A 400V	£0.22	BC109C	£0.19	BC517	£0.17	BF337	£0.40
1.5A 600V	£0.22	BC114	£0.19	BC527	£0.20	BF355	£0.38
1.5A 800V	£0.27	BC115	£0.41	BC528	£0.20	BF423	£0.13
1.5A 1kV	£0.24	BC116	£0.41	BC537	£0.20	BF451	£0.19
3A 200V	£0.36	BC118	£0.41	BC546B	£0.08	BF459	£0.33
3A 400V	£0.40	BC132	£0.36	BC546C	£0.08	BF469	£0.36
3A 600V	£0.33	BC134	£0.36	BC547B	£0.09	BFX29	£0.29
6A 200V	£0.70	BC135	£0.36	BC547C	£0.09	BFX84	£0.31
6A 800V	£0.59	BC140	£0.25	BC548C	£0.08	BFX85	£0.32
10A 400V	£1.39	BC141	£0.27	BC549C	£0.10	BFY50	£0.30
25A 200V	£1.68	BC142	£0.31	BC550C	£0.10	BFY51	£0.25
25A 600V	£1.80	BC143	£0.34	BC556A	£0.08	BFY52	£0.28
Thyristors		BC149	£0.21	BC557B	£0.08	BS107	£0.21
C106D	£0.36	BC154	£0.36	BC557C	£0.08	BS170	£0.23
PO102AA	£0.30	BC157	£0.12	BC558C	£0.08	BSW66	£1.35
TIC116D	£0.66	BC159	£0.17	BC559C	£0.08	BU126	£1.32
TIC126D	£0.77	BC160	£0.28	BC560A	£0.09	BU205	£1.41
Triacs		BC170	£0.16	BC560B	£0.09	BU208A	£1.24
ZO105DA	£0.42	BC170B	£0.16	BC637	£0.21	BU326A	£1.40
TIC206D	£0.65	BC171	£0.11	BC638	£0.21	BU500	£1.54
TIC226D	£0.94	BC171B	£0.16	BC639	£0.21	BU508A	£0.98
BTA08-600B	£0.99	BC172	£0.13	BC640	£0.13	BU508D	£1.44
TIC236D	£0.96	BC172B	£0.13	BCY70	£0.22	BU526	£1.74
Diac, Si. Switch		BC177	£0.18	BCY71	£0.20	BU806	£1.06
DB3, 32V	£0.20	BC178	£0.18	BCY72	£0.20	BUT11A	£1.30
BRY39	£1.30	BC179	£0.18	BD124P	£6.86	BUT11AF	£1.30
Transistors		BC179A	£0.17	BD135	£0.21	BUX84	£0.78
2N1613	£0.31	BC182	£0.11	BD136	£0.21	IRF540	£1.26
2N1711	£0.26	BC182A	£0.11	BD137	£0.23	IRF740	£1.80
2N1893	£0.29	BC182B	£0.12	BD138	£0.22	MJ2501	£1.60
2N2218A	£0.28	BC182L	£0.08	BD139	£0.25	MJ3001	£1.80
2N2219A	£0.25	BC182LB	£0.08	BD140	£0.25	MJ11015	£2.45
2N2222A	£0.18	BC183	£0.08	BD150C	£0.82	MJ11016	£2.56
2N2646	£1.12	BC183L	£0.08	BD165	£0.42	MJE340	£0.40
2N2904A	£0.25	BC183LB	£0.08	BD166	£0.35	MJE350	£0.48
2N2905A	£0.25	BC184	£0.08	BD187	£0.39	MPSA05	£0.14
2N2907	£0.20	BC184L	£0.08	BD201	£0.40	MPSA06	£0.12
2N2907A	£0.20	BC186	£0.33	BD202	£0.40	MPSA13	£0.12
2N2926	£0.16	BC204C	£0.72	BD203	£0.40	MPSA42	£0.17
2N3053	£0.27	BC206B	£0.72	BD204	£0.40	MRF475	£7.28
2N3054	£0.85	BC207B	£0.74	BD222	£0.58	TIP29C	£0.31
2N3055	£0.58	BC208	£0.72	BD225	£0.42	TIP30C	£0.37
2N3439	£0.62	BC209A	£0.72	BD232	£0.50	TIP31C	£0.41
2N3440	£0.50	BC212	£0.08	BD237	£0.32	TIP32C	£0.41
2N3702	£0.09	BC212L	£0.08	BD238	£0.44	TIP33C	£0.72
2N3703	£0.10	BC212LB	£0.08	BD240C	£0.37	TIP41A	£0.44
2N3704	£0.10	BC213	£0.08	BD243B	£0.50	TIP42C	£0.52
2N3705	£0.10	BC213B	£0.08	BD244A	£0.53	TIP47	£0.48
2N3706	£0.10	BC213LC	£0.08	BD244C	£0.53	TIP48	£0.62
2N3771	£1.44	BC214	£0.08	BD245C	£1.18	TIP50	£0.53
2N3772	£1.51	BC214L	£0.08	BD246	£1.18	TIP121	£0.48
2N3773	£1.70	BC225	£0.15	BD246C	£1.18	TIP122	£0.48
2N3819	£0.42	BC237B	£0.09	BD283	£0.61	TIP125	£0.46
2N3820	£0.66	BC238B	£0.09	BD284	£0.61	TIP127	£0.40
2N3904	£0.10	BC238C	£0.09	BD400	£0.79	TIP132	£0.46
2N3905	£0.10	BC239C	£0.10	BD441	£0.41	TIP137	£0.56
2N3906	£0.10	BC250A	£0.15	BD442	£0.37	TIP142	£1.30
2N4036	£0.34	BC251	£0.13	BD534	£0.47	TIP147	£1.12
2N5245	£0.80	BC252	£0.13	BD535	£0.50	TIP2955	£0.97
2N5296	£0.57	BC261B	£0.30	BD536	£0.65	TIP3055	£0.70
2N5321	£0.57	BC262B	£0.24	BD581	£0.62	VN10KM	£0.48
2N5322	£0.57	BC267B	£0.30	BD597	£0.92	ZTX300	£0.16
2N5401	£0.11	BC307	£0.10	BD646	£0.52	ZTX500	£0.16
2N5551	£0.11	BC308	£0.10	BD648	£0.52		
2N6107	£0.60	BC319C	£0.13	BD650	£0.53		
		BC327	£0.10	BD707	£0.42		

No Minimum Order Value

	Electrolytic Radial					Electrolytic Axial						
µF	16v	25v	40v	63v	100v	16v	25v	40v	63v	100v	250v	450v
0.47	---	---	---	£0.05	---	---	---	---	---	---	---	---
1.0	---	---	---	£0.05	£0.05	---	---	---	£0.13	---	---	£0.22
2.2	---	---	---	£0.05	---	---	---	---	£0.13	---	---	£0.30
4.7	---	---	£0.05	£0.05	£0.05	---	---	---	£0.13	---	---	£0.41
10	£0.05	£0.05	£0.05	£0.05	£0.09	£0.12	---	£0.12	£0.13	£0.17	£0.40	£0.51
22	£0.05	£0.05	£0.05	£0.07	£0.11	£0.12	£0.13	£0.14	£0.15	£0.21	£0.52	£1.06
33	£0.05	---	£0.05	---	---	---	---	---	---	---	---	---
47	£0.05	£0.05	£0.07	£0.10	£0.19	£0.13	£0.13	£0.15	£0.19	£0.32	£0.57	---
100	£0.06	£0.06	£0.10	£0.13	£0.26	£0.14	£0.16	£0.19	£0.26	£0.44	---	---
220	£0.08	£0.09	£0.13	£0.25	---	£0.19	£0.20	£0.27	£0.39	£0.48	---	---
330	£0.09	---	£0.19	---	---	---	---	---	---	---	---	---
470	£0.12	£0.17	£0.24	£0.33	---	£0.24	£0.28	£0.43	£0.53	---	---	---
1000	£0.15	£0.33	£0.34	---	---	£0.33	£0.43	£0.59	£1.08	---	---	---
2200	£0.27	£0.55	£0.70	---	---	£0.53	£0.66	£1.11	£1.55	---	---	---
3300	---	£0.94	---	---	---	---	---	---	---	---	---	---
4700	£0.67	£1.05	---	---	---	£0.86	£1.11	---	---	---	---	---

Ceramic Mini Disc
1.0,1.2,1.5,1.8,2.2,2.7,3.3,3.9,4.7,5.7,6.8,8.2
1.0pF to 22nF 100V £0.06
47nF & 100nF 50V £0.07

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

Dipped Ceramic Multilayer
10,22,33,47 and multiples.
10pF to 100nF 100V £0.10
220nF 100V £0.14
330nF 100V £0.16
470nF 100V £0.22
1.0µF 100V £0.29
Full Technical Specification available

Resistors - Please State Value Required

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

per 100 of one value only

Preset Resistors - Please State Value Required

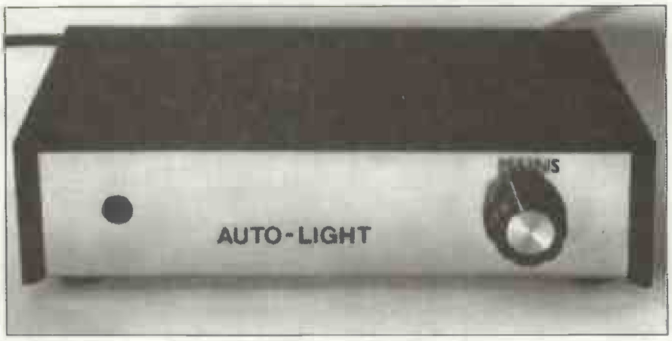
Enclosed, 10mm Square Horz / Vert.	100Ω - 1M0 0.15W	£0.15 Each
Skeleton, 10mm Dia. Horz / Vert.	100Ω - 1M0 0.1W	£0.11 Each
Sub-min, 6mm Dia, Horzontal	E3 200Ω-1M0 0.1W	£0.19 Each
Multiturn, 10mm Square, Top Adjust.	E3 100Ω-1M0 0.5W	£1.00 Each
Multiturn, 19mm Long, End Adjust.	E3 50Ω-2M0 0.5W	£0.64 Each

Potentiometers - Please State Value Required

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

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

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.

This 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.

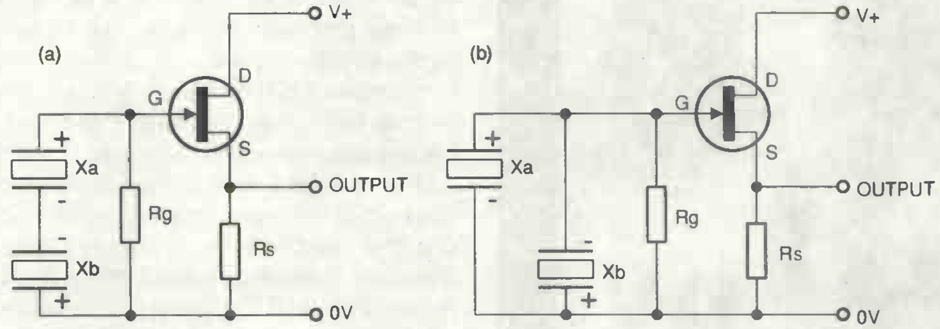


Figure 1: two-element pyro-sensors use anti-phase sensing elements to reduce sensitivity to background infra-red

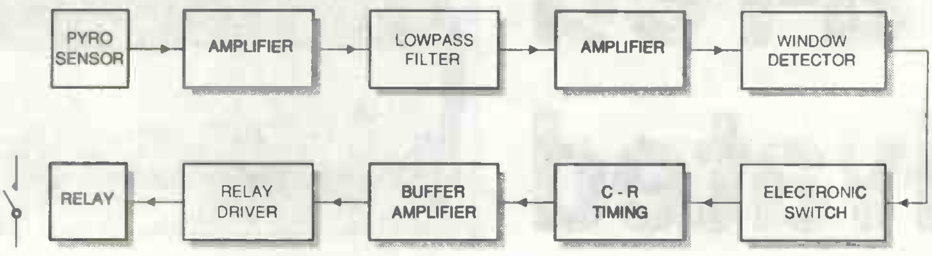
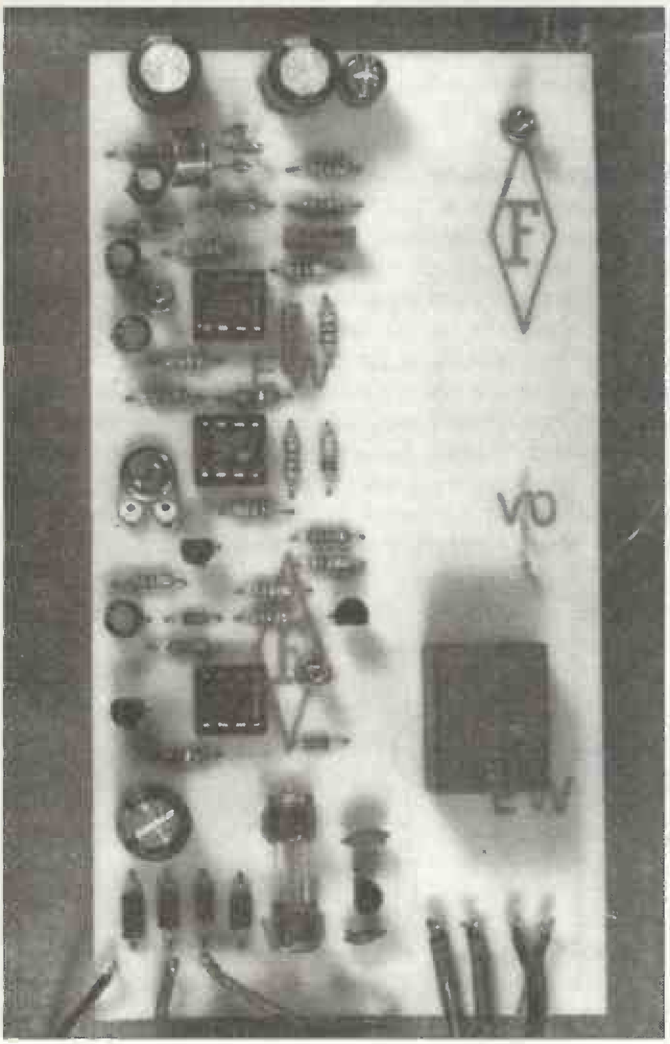


Figure 2: the block diagram for the auto-light

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.

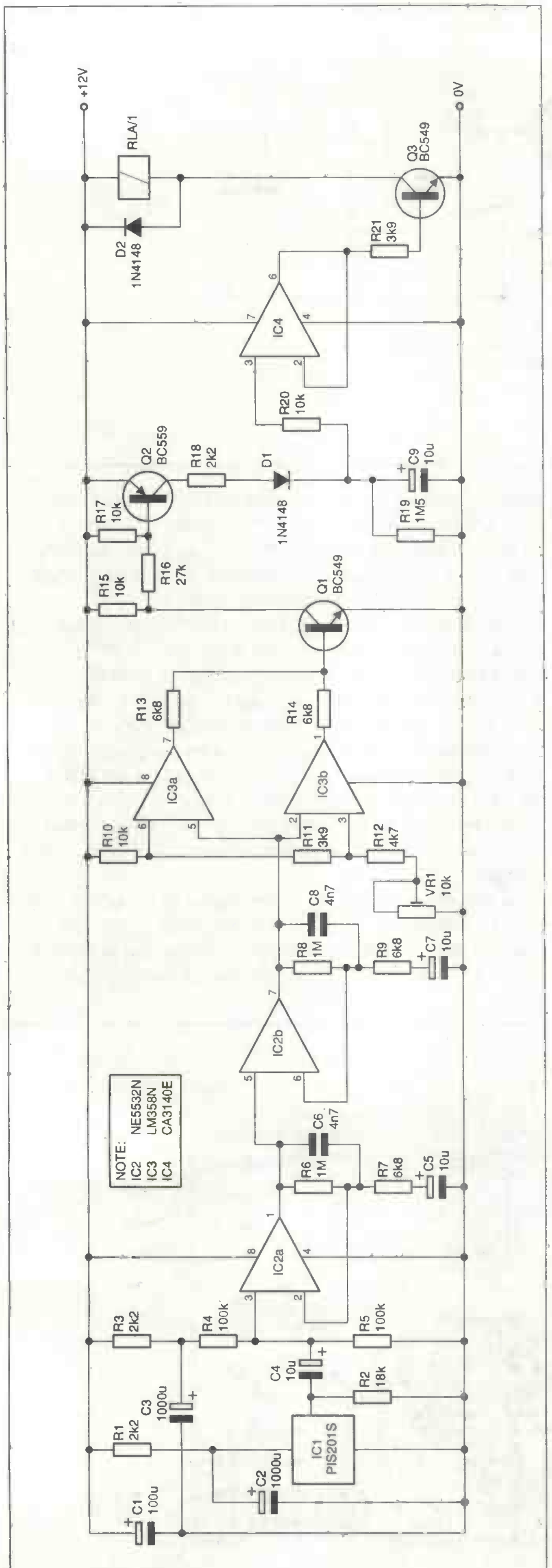


Figure 3: the main circuit diagram for the auto-light

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.

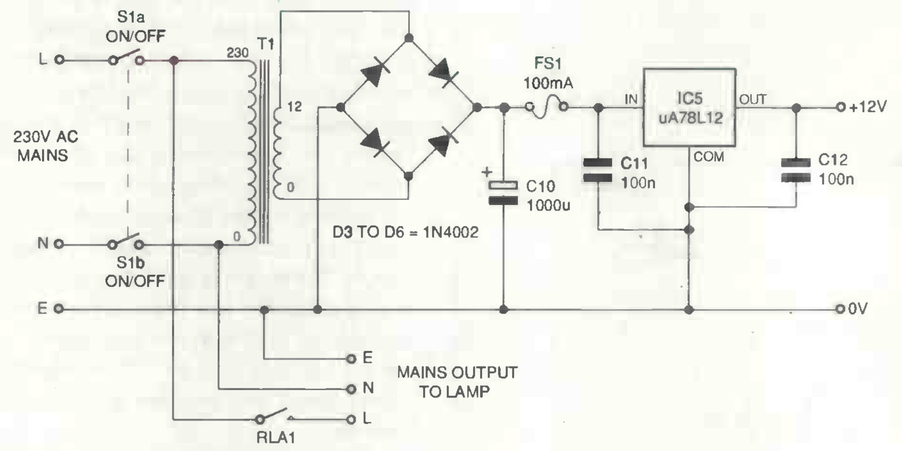


Figure 4: the circuit diagram of the mains power supply

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 even 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 to 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 his 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

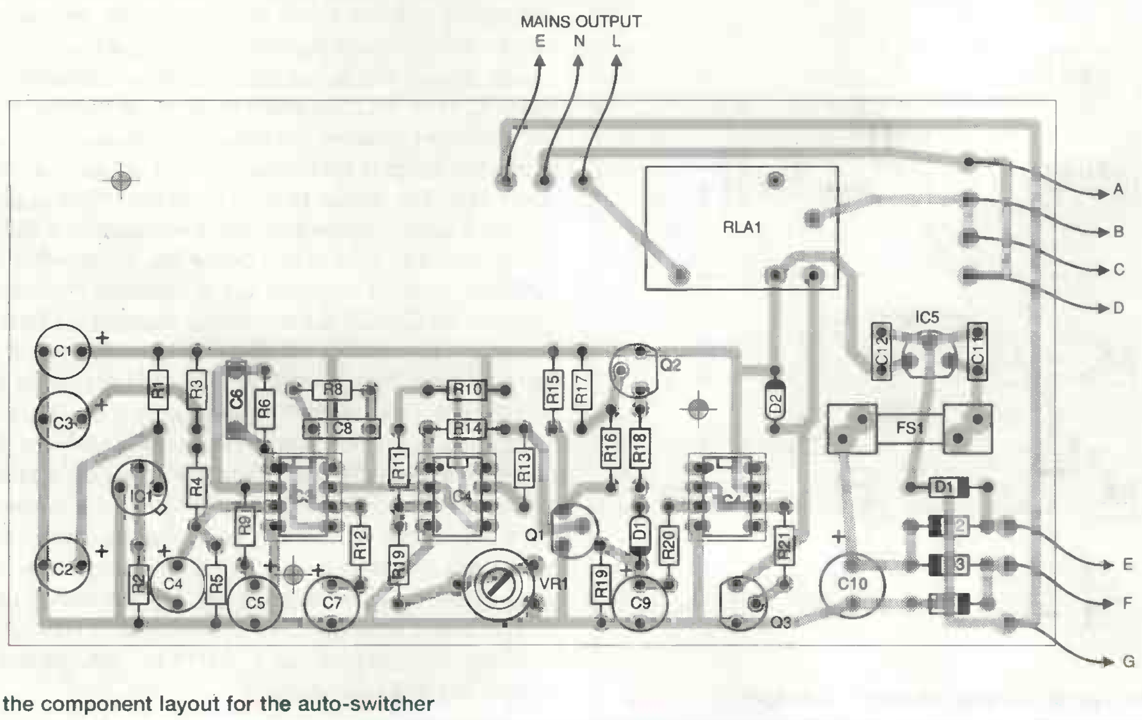


Figure 5: the component layout for the auto-switcher

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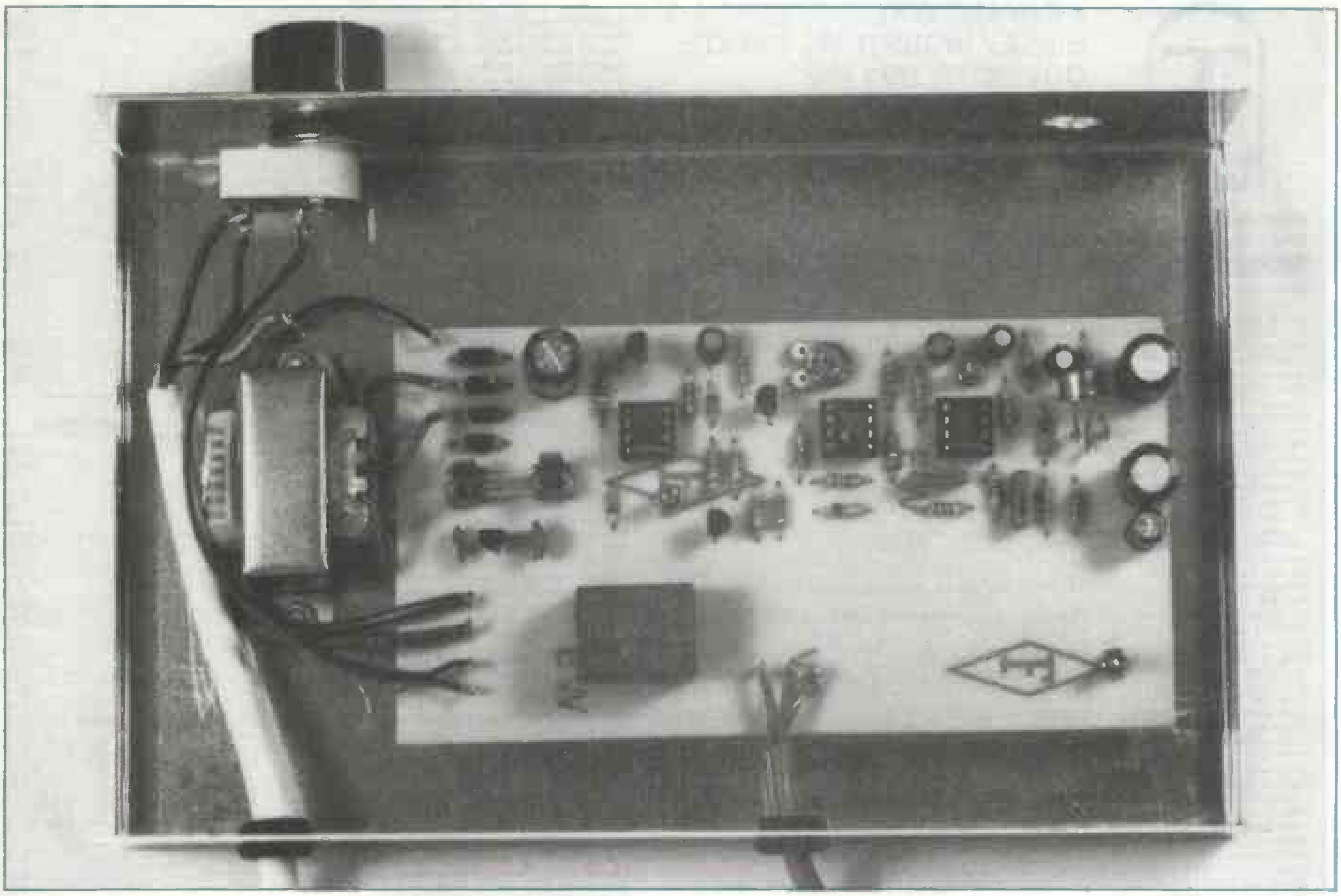

mounted on the circuit board in the usual fashion. For optimum result it should be twisted slightly so that its window is precisely horizontal. The alternative approach is to have the printed circuit board mounted on the base panel of the case. The pyro sensor still "looks" through a window cut in the 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 it 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 sensors window as this could reduce its sensitivity. If you should accidentally touch the window use a soft cloth to clean away any finger marks.

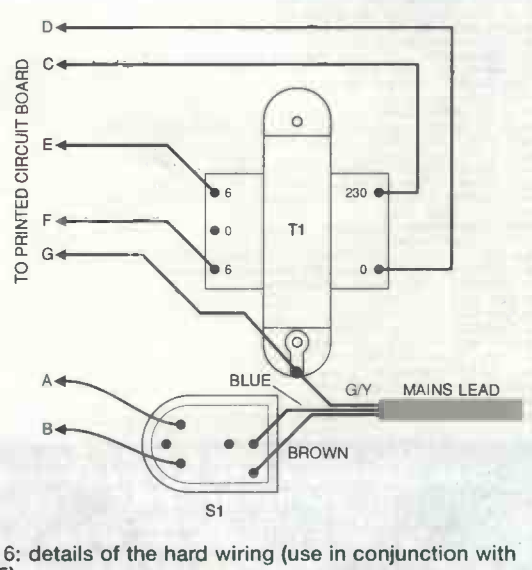

Figure 6: details of the hard wiring (use in conjunction with figure 5)

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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PIC16C74/JW Erasable	20MHz	£24.00	PIC16C556 (14 bit versn 16C56)		£4.50
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PIC16C57-04POTP	4MHz	£5.00	PIC16C57-10P OTP	10MHz	£6.00
PIC16C84-04P	4MHz	£6.00	PIC16C84-10P	10MHz	£8.00
PIC16F84-04P	4MHz	£7.00	PIC12C508-04P OTP	4MHz	£2.20
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PIC Training

Our new training course introduces PIC's painlessly with a practical emphasis.

Our training package includes

- Full introductory manual to the PIC series including use of assembler, peripherals and interrupts for the 12 bit and 14 bit controllers.
- Video introducing the PIC, and showing use of PICDESIM
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Development boards allow simple prototyping of projects.

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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 the 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.

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

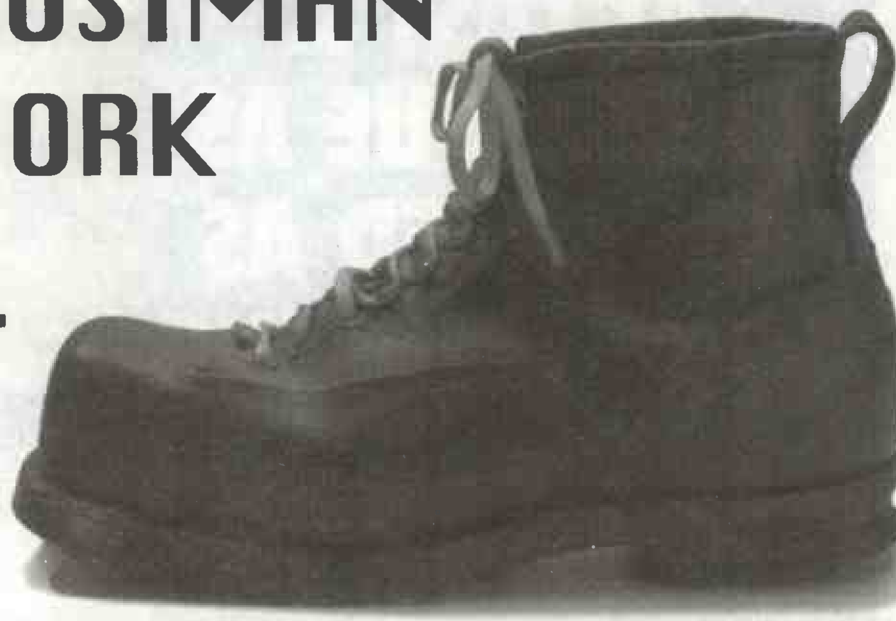
Metal case about 203 x 127 x 51mm, printed circuit board, mains lead and plug fitted with 2A fuse, pair of 20mm fuse-clips, 8-pin DIL holder (3 off), control knob, wire, solder, etc.

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.

LET THE POSTMAN DO THE WORK



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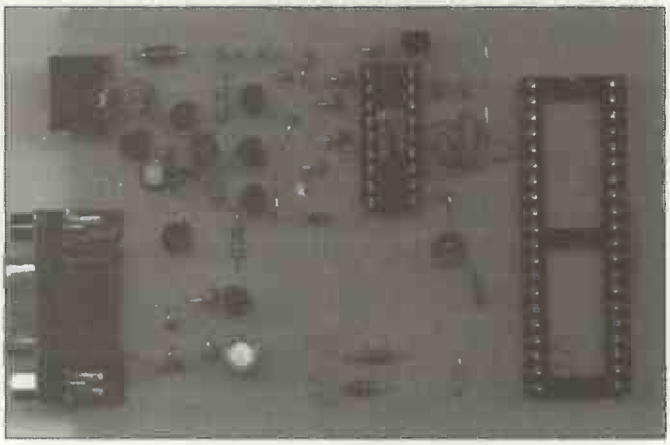
PIC Programmer Re-Visited

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



In 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. @B: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).

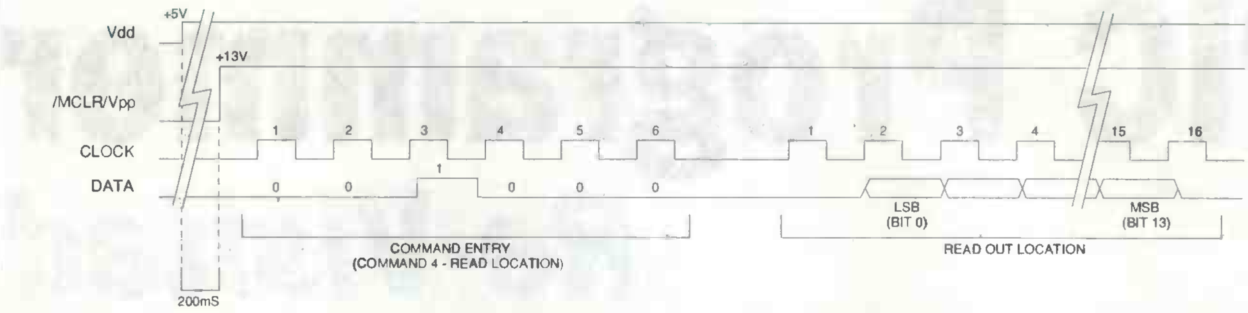


Figure 1: signals required on PIC to read the contents of the current location

PIC devices

The Microchip PIC microcontroller has proved to be highly popular in the educational and amateur markets. This is because it is cheap, easily programmed, and development tools are widely available at a reasonable price. The low and medium capability PIC devices are 12 and 14 bit core respectively. The core size refers to the width of the instruction word. As the instruction word includes the address of the file register (RAM byte) then the wider instruction word allows a bigger range of file registers to be addressed without having to page RAM, and allows jumps and subroutine calls directly to a wider range of addresses.

The instruction memory of the PIC is totally separate from the RAM area, and it is this that gives the PIC its tremendous speed in instruction execution. The next instruction may be fetched from the instruction memory at the same time as the current instruction is being executed, and all instructions (barring program jumps) are performed in 4 cycles of the external clock. This results in very fast code for which timed loop and real time software is extremely easy to program. The only disadvantage of the PIC architecture is that since the program area cannot be written from within the program then in-circuit emulators and monitors are very expensive as they normally require special bond out chips.

Table 1 presents an overview of those members of the PIC series which are programmed by this project.

Programming the PIC

The PIC devices addressed by this project are the serially programmed controllers. These devices require five pins on the device to be driven. These are the ground and positive supply lines, the programming supply voltage (Vpp), and the data and clock lines. To place the PIC into programming mode Vdd is applied, a delay of 200mS is executed, and then the Vpp pin is raised to 13V. The Vpp input pin is a shared function with the reset input pin and should be held at ground whilst waiting to program the chip, thus the chip is held in reset until Vpp is raised when the chip holds its reset state as there is no input oscillator. In the reset state all I/O pins are in the input state, thus during programming all unused I/O pins are maintained as inputs.

The clock and data lines are used to serially address the chip. Commands are 6 bits and to perform any action the command is clocked into the chip, optionally followed by a

Device	Memory Size (ROM/RAM)	I O port bits	Pins	Other Features

↑ SEE ETI AUG
VOL 26 NO 7 1997
P9

Table 1: PIC devices programmed

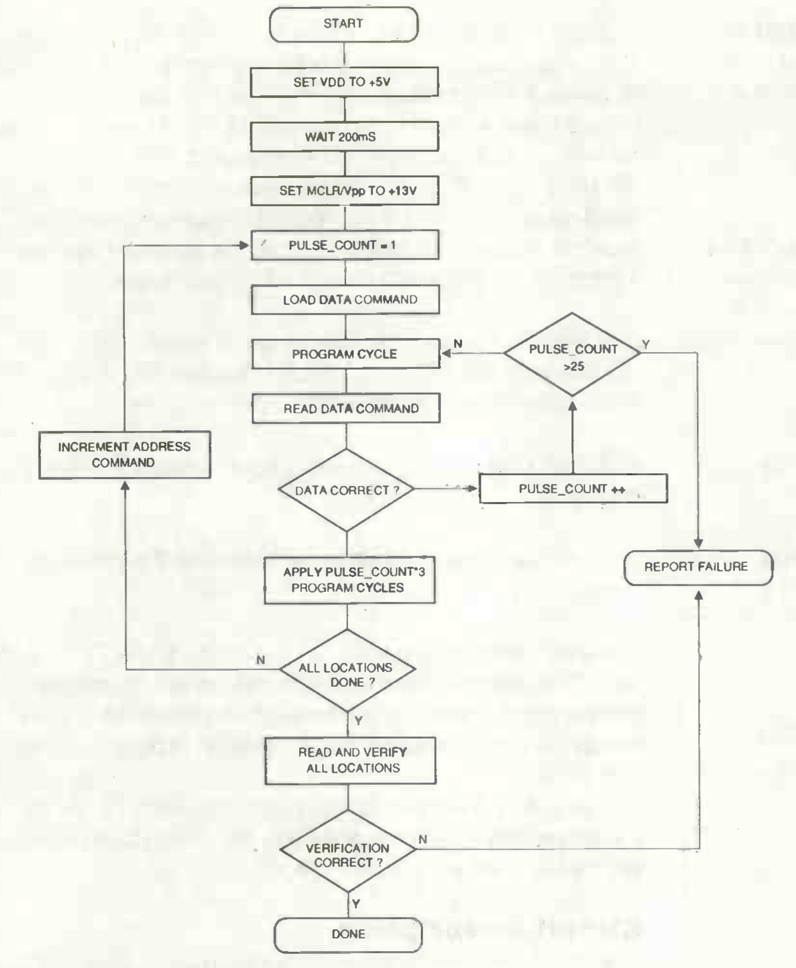


Figure 2: programming algorithm

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

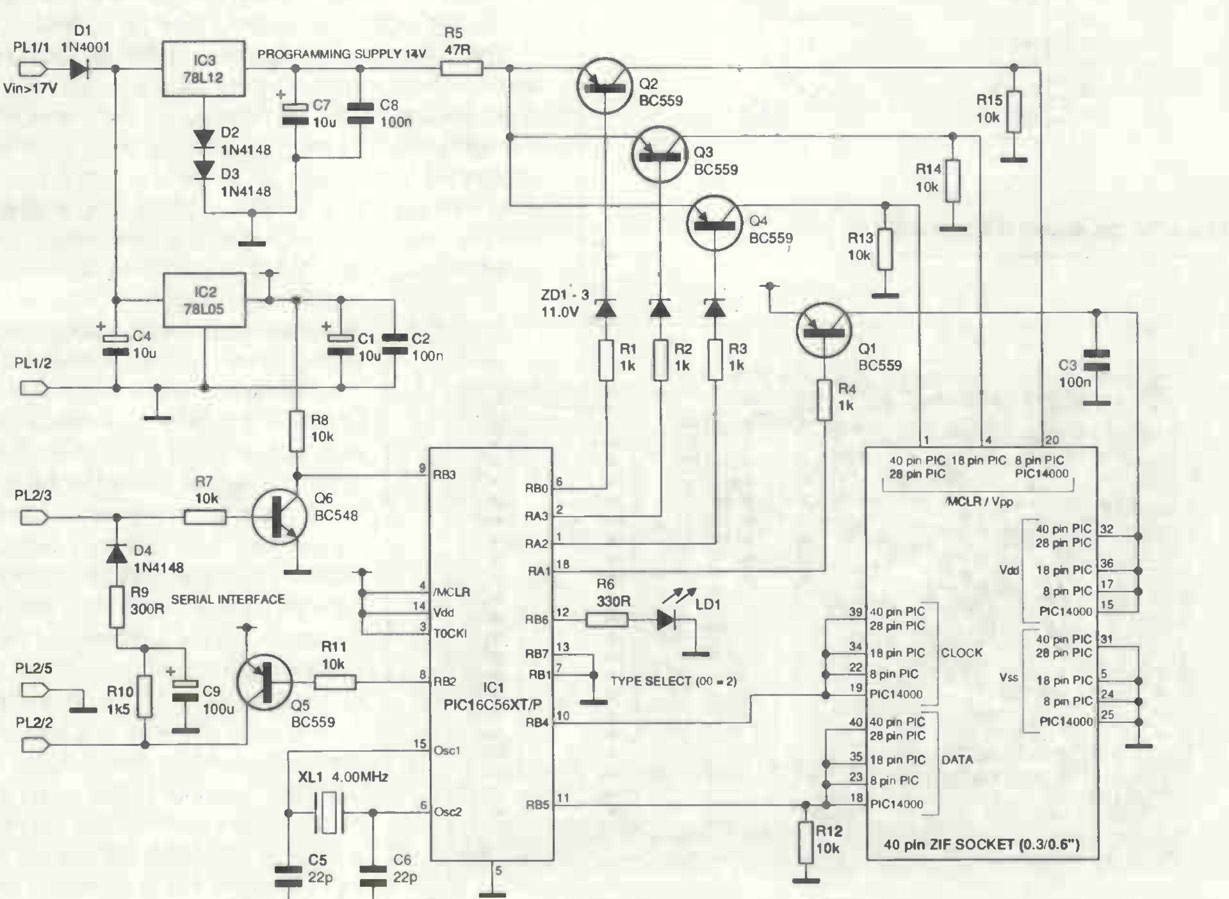


Figure 3: Pic Programmer Type 2: circuit diagram

should be performed at Vdd=5V, and verified at both 4V and 6V to ensure that the device has programmed correctly. This programmer only verifies at Vdd=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)

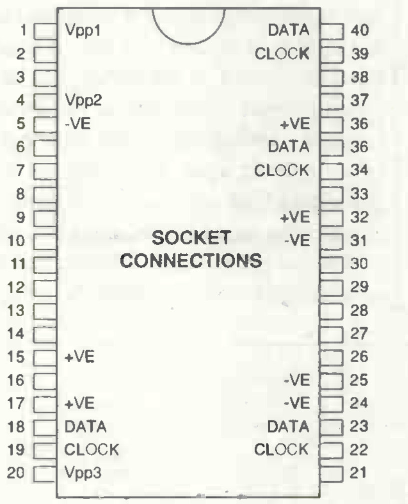


Figure 3a: the socket connections

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 Vdd, and 13V for the programming supply Vpp. 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 Vdd, 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

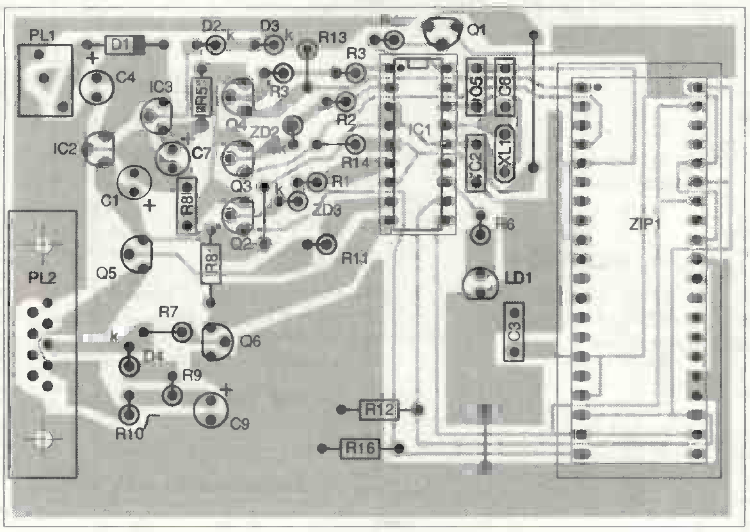


Figure 4: the component layout

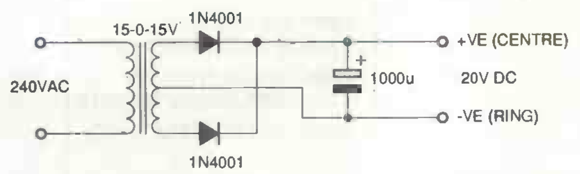


Figure 5: a mains power supply circuit if required. Batteries can also be used. See text.

PROGRAMMER	PC CONNECTOR TYPE:			
PL1	9 - WAY FEMALE	9 - WAY MALE	25 - WAY FEMALE	25 - WAY MALE
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

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.

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 /I 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.

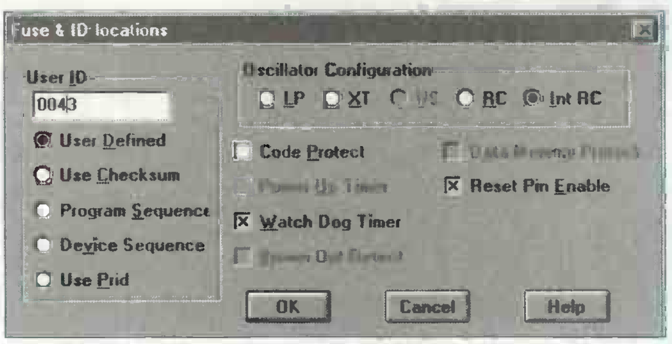


Figure 7: screen shot sample from the software

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 my 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 I 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 eepromdevice (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').

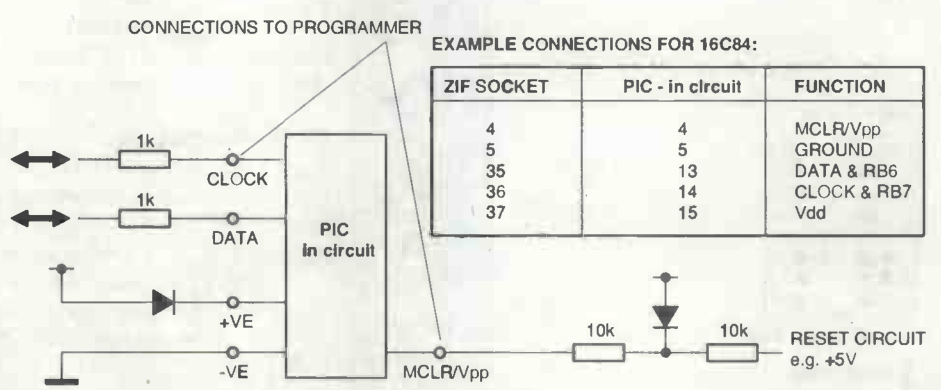
The user words are programmed by sending the Enter Program ('F') command followed by increment address commands to take the program counter to the correct address (2007 Hex) and then the Program configuration fuse command ('L'), followed by the End Programming command ('K'). Note if the Code Protect 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.



EXAMPLE CONNECTIONS FOR 16C84:

ZIF SOCKET	PIC - in circuit	FUNCTION
4	4	MCLR/Vpp
5	5	GROUND
35	13	DATA & RB6
36	14	CLOCK & RB7
37	15	Vdd

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 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.

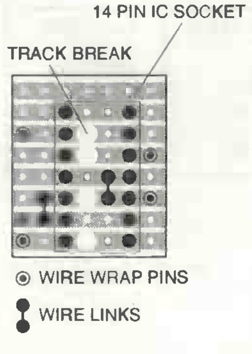


Figure 10: the PIC 14000 adapter, top view

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

Resistors

All 1% 0.25 W

R1-4	1k
R5	47R
R6	330R
R7,8,11-15	10k
R9	300R
R10	1k5

Capacitors

C1,4,7	10uF 25V electrolytic radial
C2,3,8	100nF disc ceramic
C5,6	22pF disc ceramic

Semiconductors

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

Miscellaneous

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.

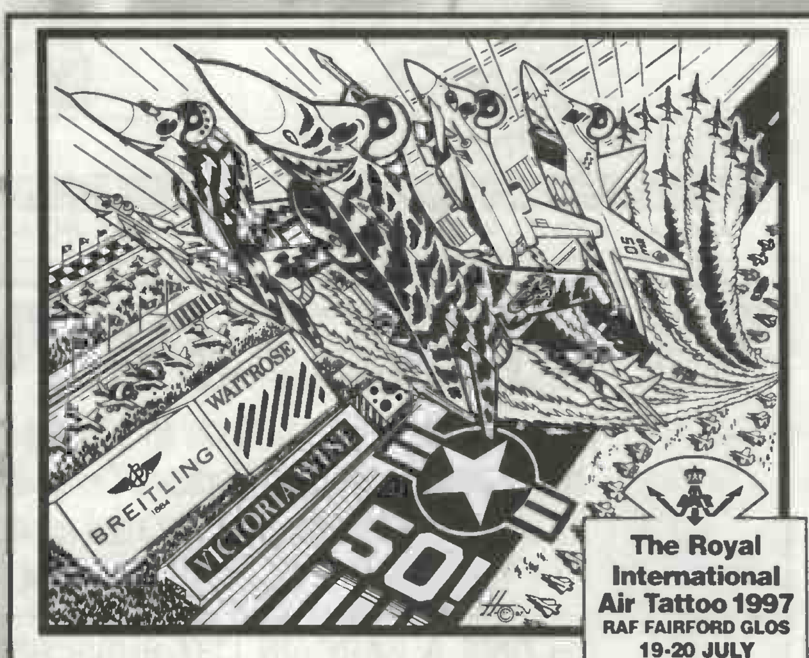
For enquires about RIAT 97, contact the RIAT Hot News Line on 0891 122999 or multiple-choice switchboard at 01285 713268. (Calls on 0891 numbers are charged at 50p per minute of which 15p per minute is donated to the RAF Benevolent Fund Enterprises, PO Box 1940, Gloucester GL7 4NA.) If you don't fancy 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).

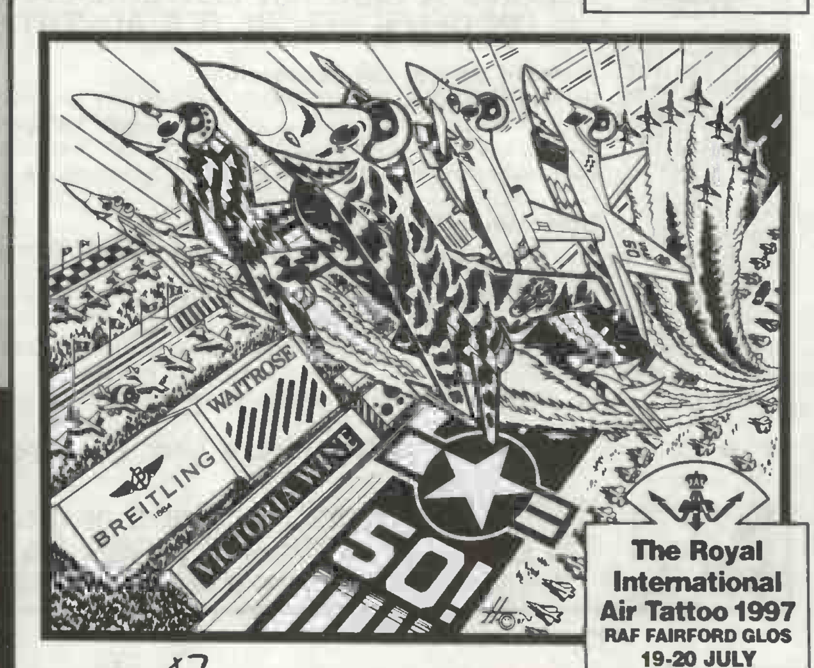
Competition rules: Entries must arrive at Nexus House on or before 12th June 1997. Winners will be notified by post following the judging. The judges' decision is final and no communication will be entered into concerning the results. Employees of Nexus Special Interest Ltd. and Swift Design Ltd., associated 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!

Good luck!

Send your entries to RIAT Competition, ETI, Nexus House, Boundary Way, Hemel Hempstead, Herts HP2 7ST by 12th June at the latest. Please clearly mark your envelope RIAT COMPETITION.





Fast Fivers

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

Put-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:

0	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 an 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 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)**					
B (pin 5)	A (pin 7)	a (= A)	d (= A+B)	e (= A+B)	f (= A+B)	g (=B)	Character
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

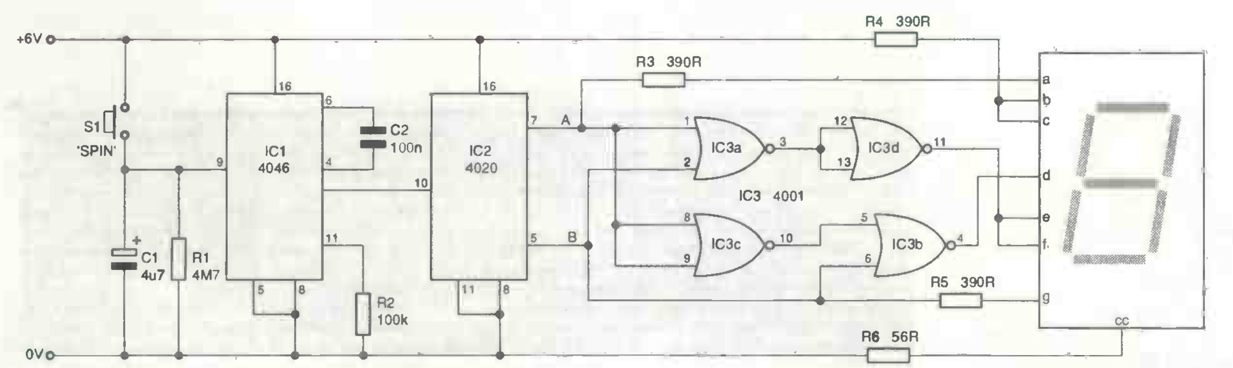


Figure 1: electronic Driedal, or Put'n'Take: the circuit

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 characters 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.

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 ◊ 30mm (46 holes ◊ 12 strips); 1mm terminal pins (3 off); 14-pin dil IC socket; 16-pin dil IC sockets (2 off); battery clip or 6V battery box.

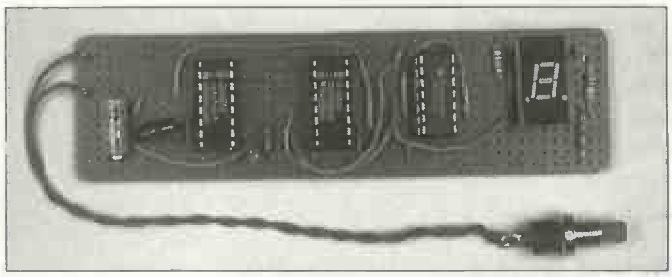


Figure 2: the segments of the LED display

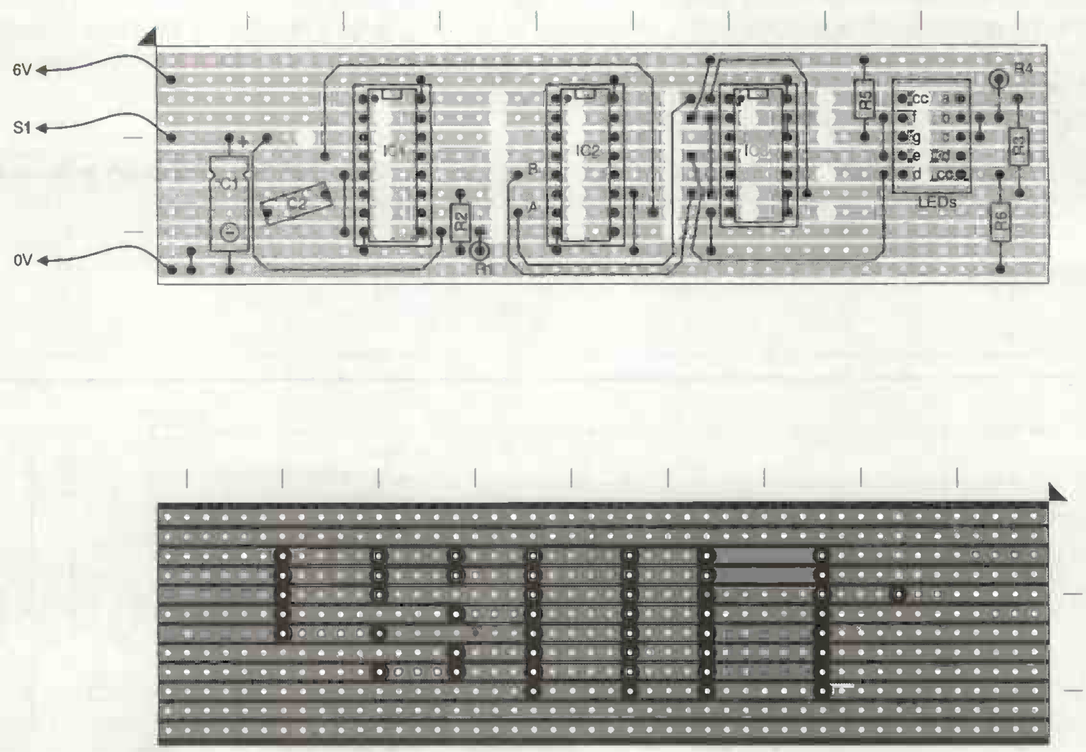


Figure 3: the stripboard layout

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

The 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 for 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:

$$E = E0 + 2{,}3026\ RT/F$$

known as the Nernst equation, where: E is the response of the electrode in V/pH and E0 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.

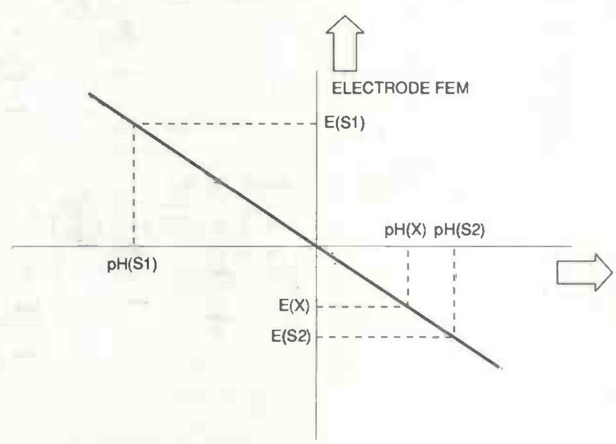


Figure 1: the fem response of the pH electrode

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.

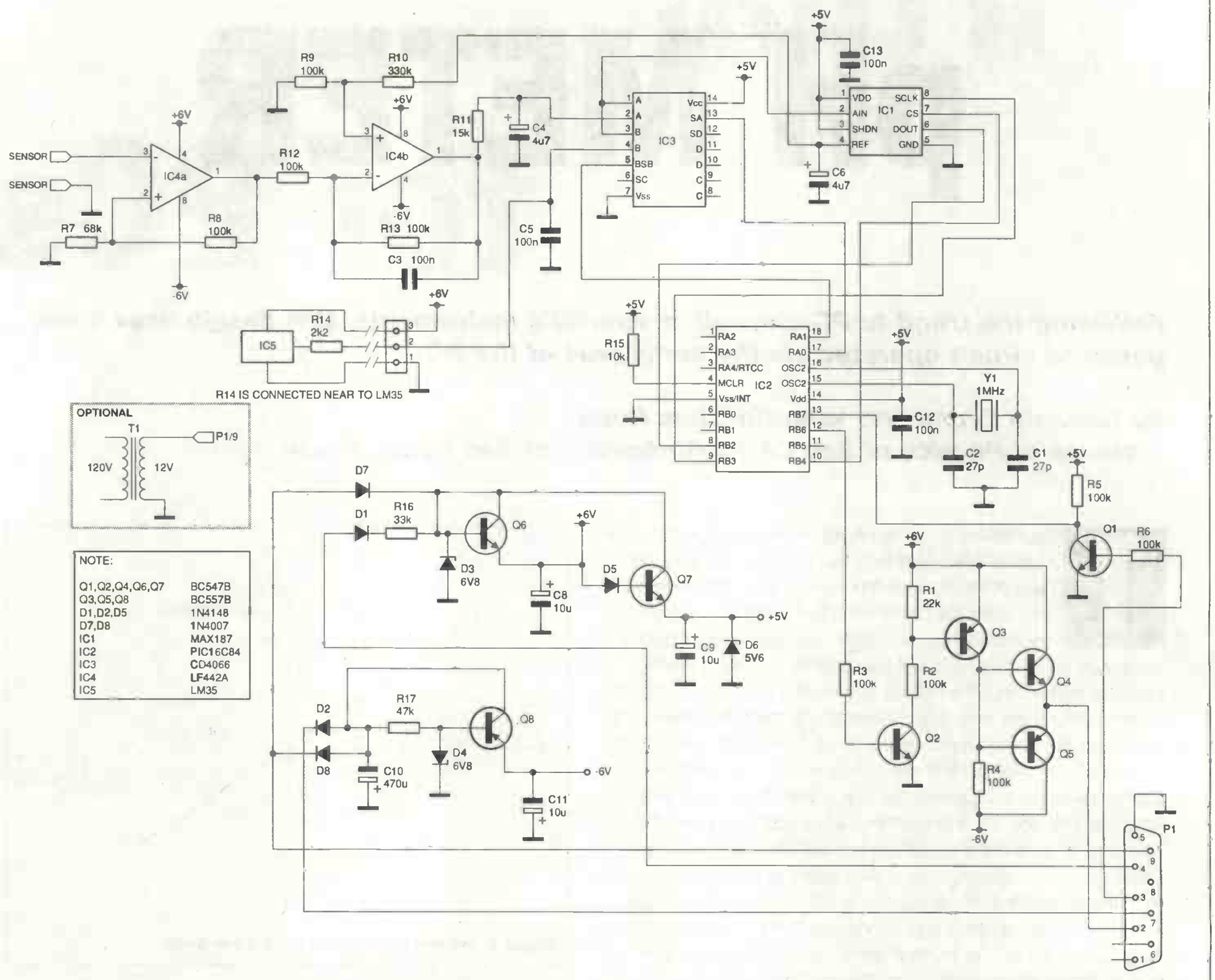


Figure 2: the circuit diagram

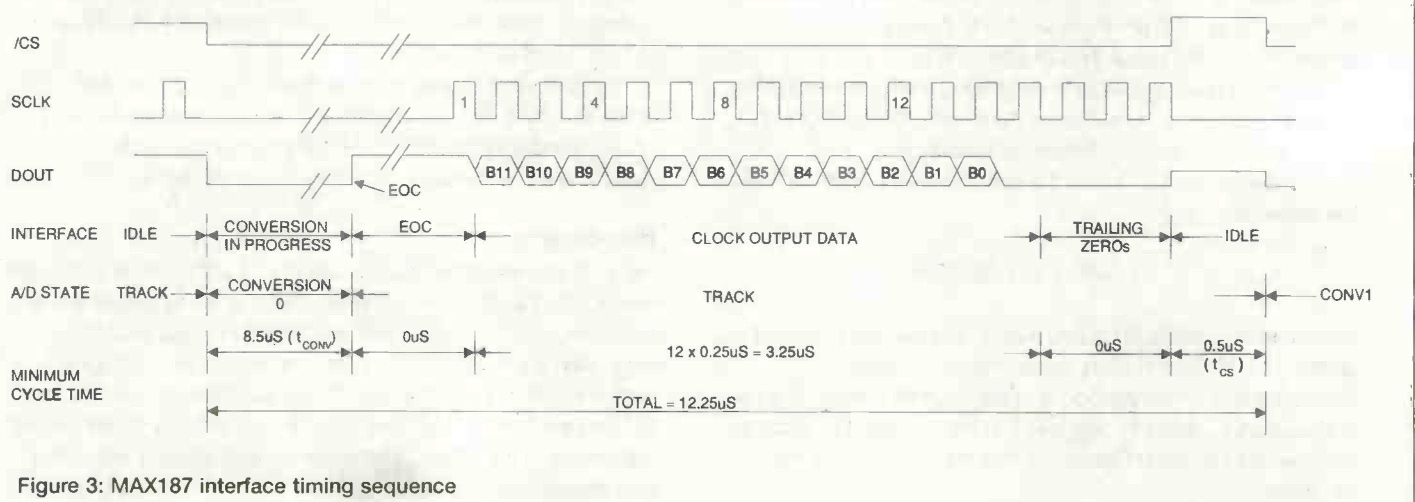


Figure 3: MAX187 interface timing sequence

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 R232 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 DRTenable 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 - l00mA 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.

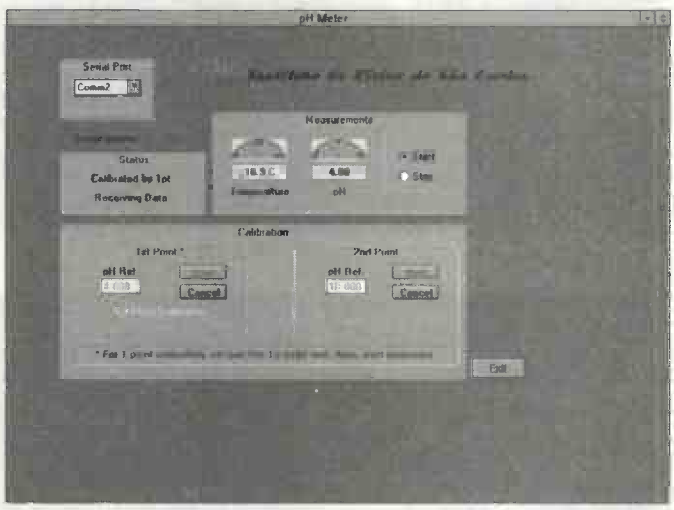


Figure 5: the virtual panel of the pH meter

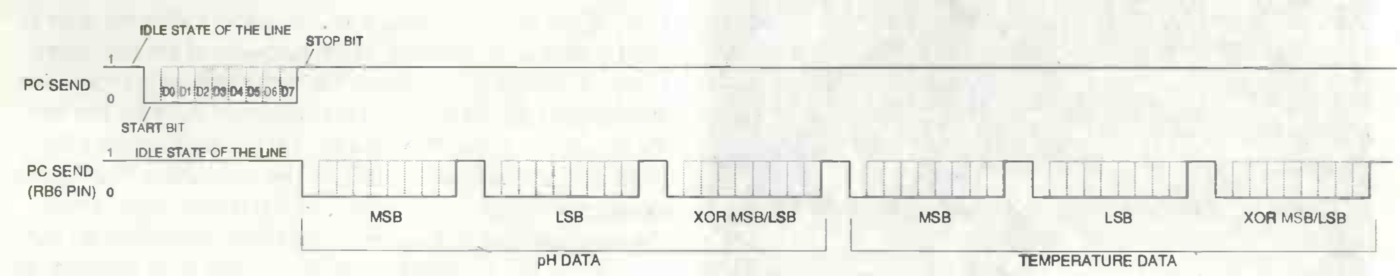


Figure 4: PC to PIC communication protocol

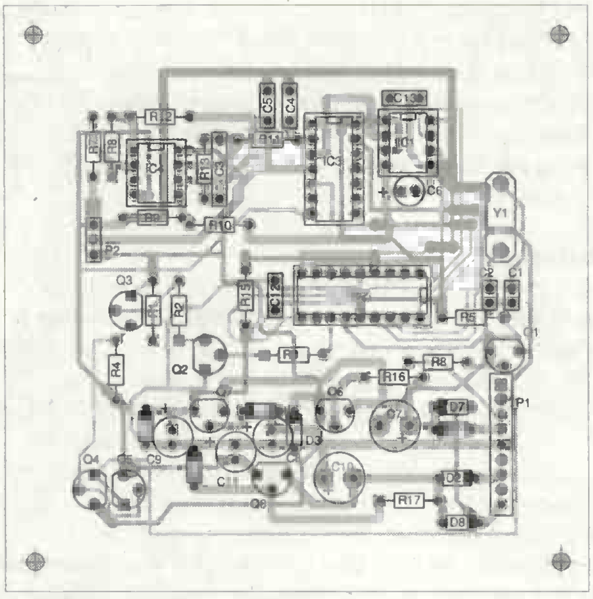


Figure 6: the component layout.

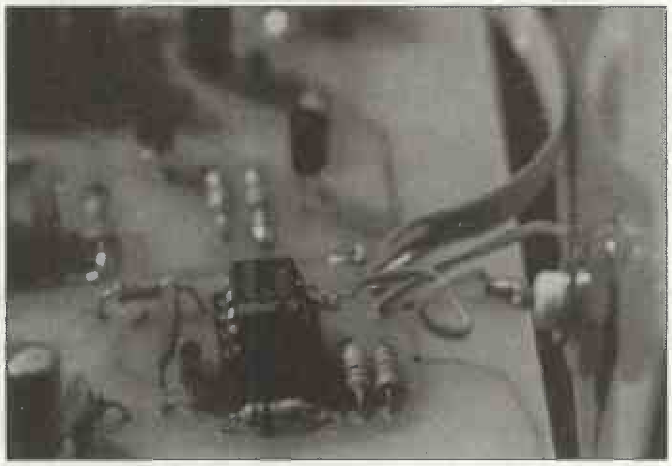
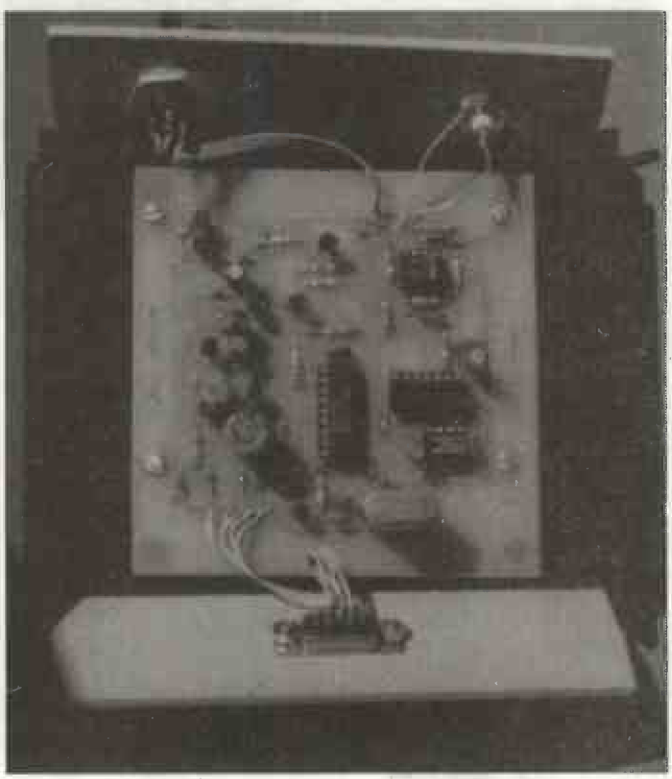


Figure 7: Above construction detail of the pH input



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 dil 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/vi rtph 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.

Prof. Valentin Obac Roda
Departamento de Fisica e Informatica/IFSC/USP
Caixa Postal 369
13560-970 - 55o Carlos (SP) - Brazil
Fax +55 16 271 3616

or by email at:

VALENTIN @ IFQSC.SC.USP.BR

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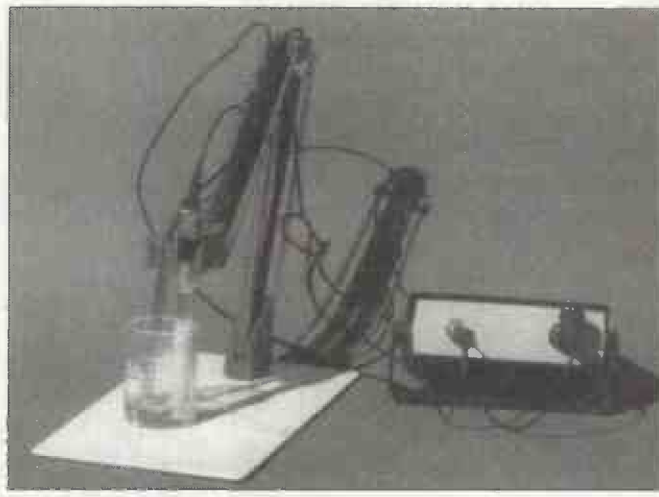

PARTS LIST for the pH Meter

Resistors

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

R1	22K
R2 to R6	l00k
R7	68K
R8,R9, R12,R13	l00k
R10	330k
R11	15k
R14	2k2
R15	10k
R16	33k
R17	47k

Capacitors

Cl ,C2	27pF, 25 volts, ceramic disk
C3, C5, C12, C13	l00nF, 25 volts, ceramic disk
C4, C6	4.7uF,16V, radial electrolytic
C7, C10	470uF, 16V, radial electrolytic
C8, C9, C11	l0uF, 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
ICl	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

```
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
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
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
                                selection)
        MOVWF       0X5         ;Sends selection to
                                port A


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

        GOTO        C1


C2      CALL        DELAY2      ;Inserts a 416us
                                delay

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

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

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
```

```
        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
B2      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
        MOVF        0X0F,0      ;Receives the 1st
                                data byte and stores
                                it in f13h
        MOVWF       0X13
        CALL        RECDADO
        MOVF        0X0F,0      ;Receives the 2nd
                                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)
                                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                     ;The following NOPs
                                are inserted to make
        NOP                     ;the SCLK signal a
                                50% duty cycle signal
        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
```

NEXUS

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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.

Dampness 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 figure1.

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.

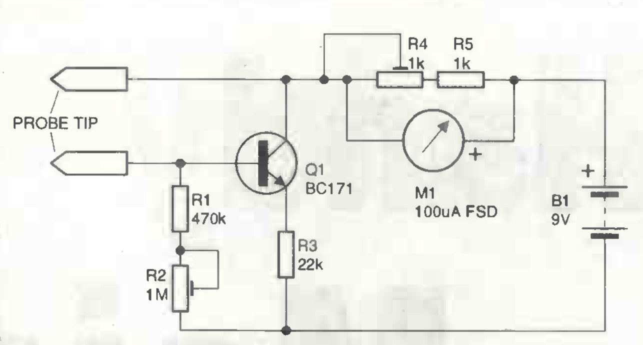


Figure 1: the circuit diagram of the moisture meter

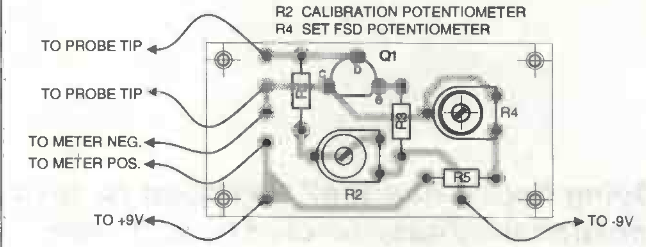


Figure 2: the component layout and wiring

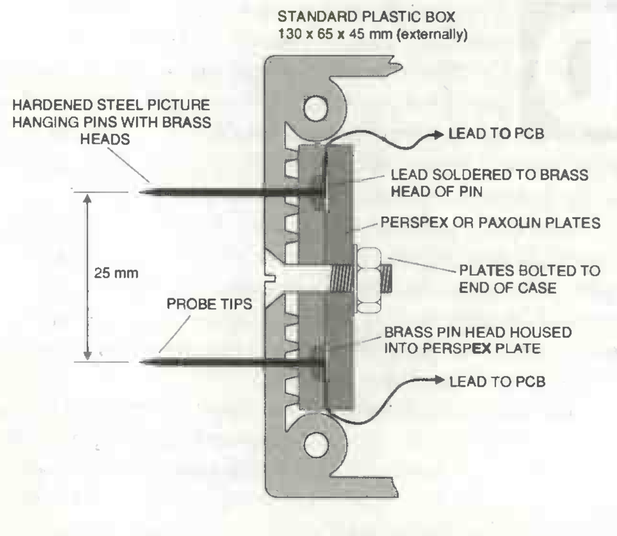


Figure 3: a method of fixing the probe tips to the end of the plastic case

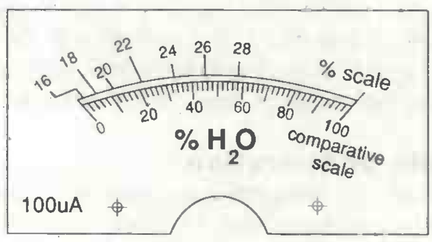


Figure 4: a scale template for the meter movement suggested in the article

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 resister 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 mater 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.

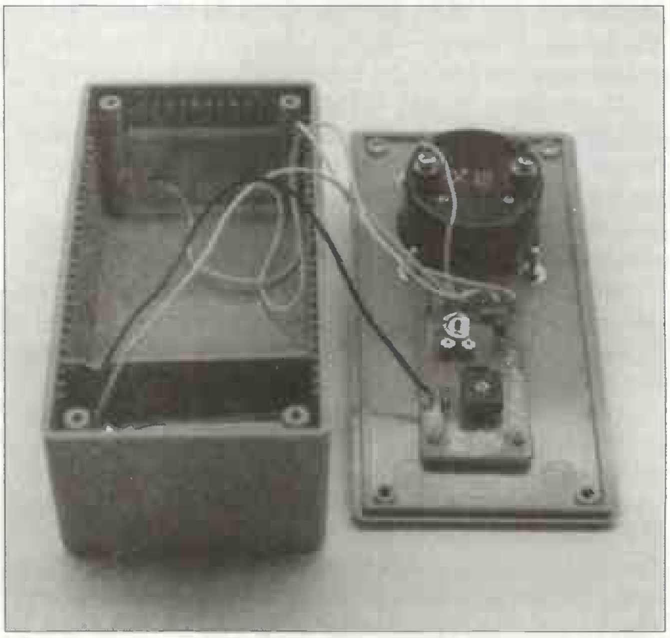
(7) Condensation may be the culprit if fairly similar readings are obtained over the entire surface of a wall.

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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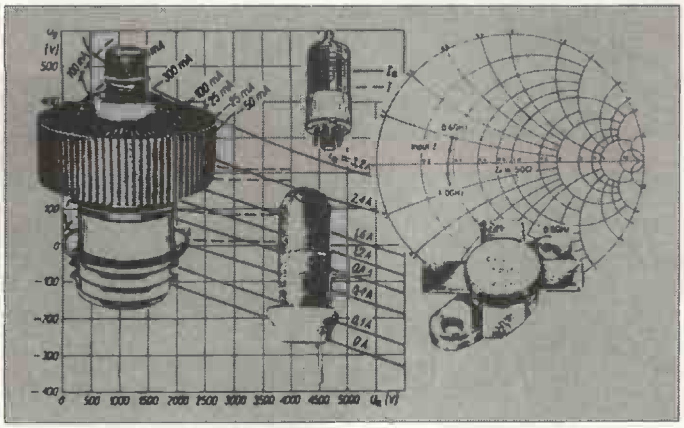

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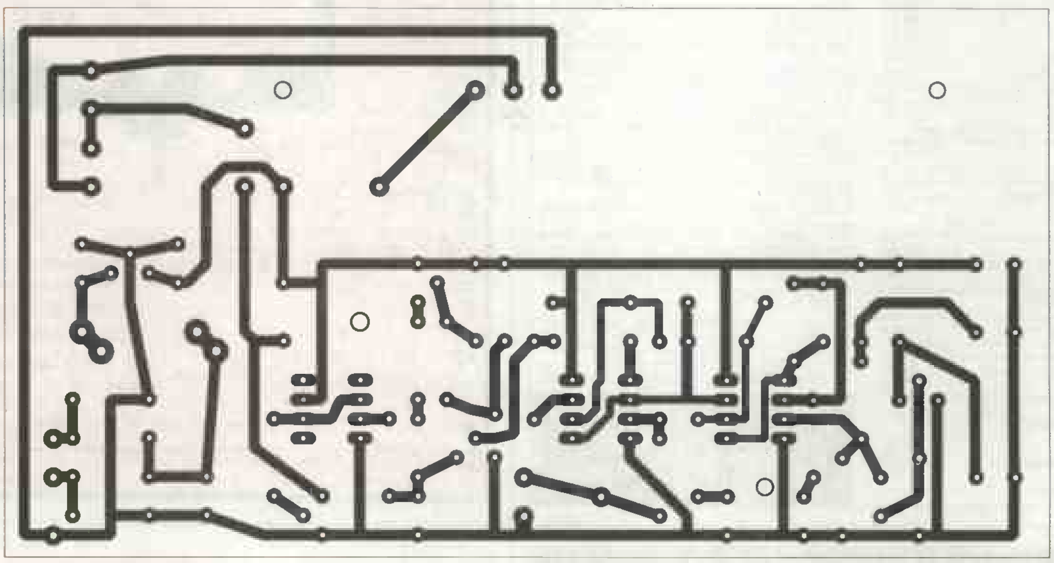
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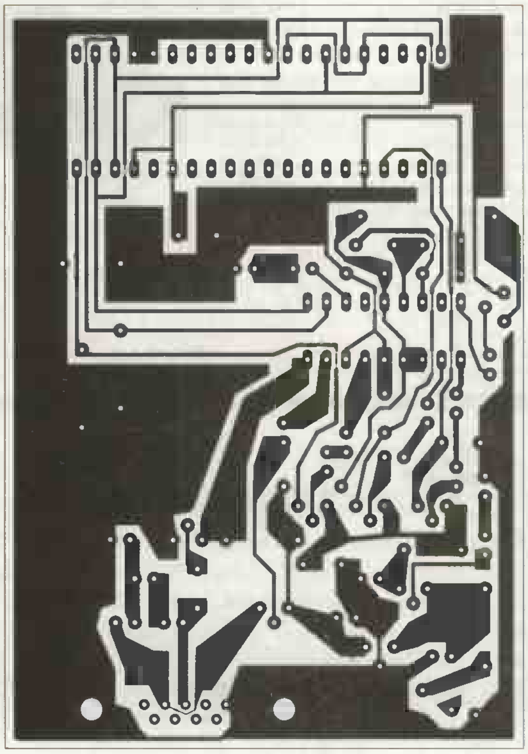
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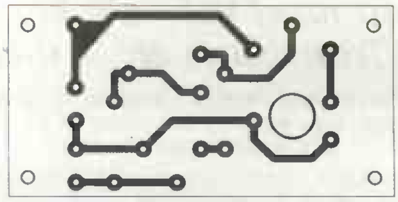
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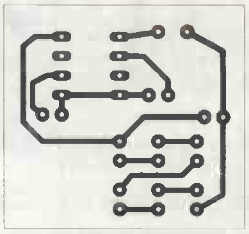
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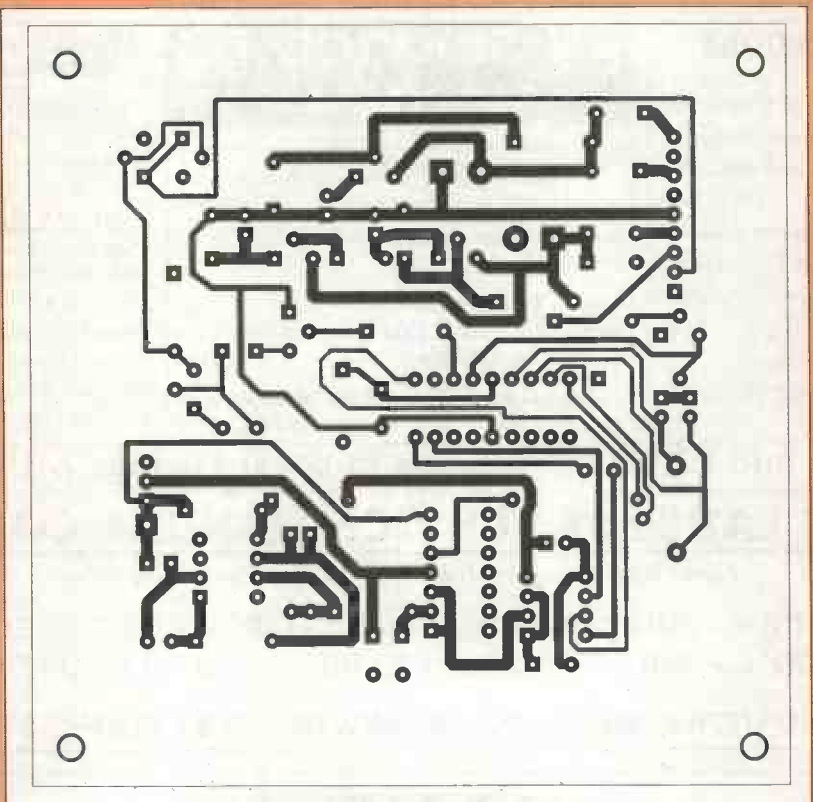

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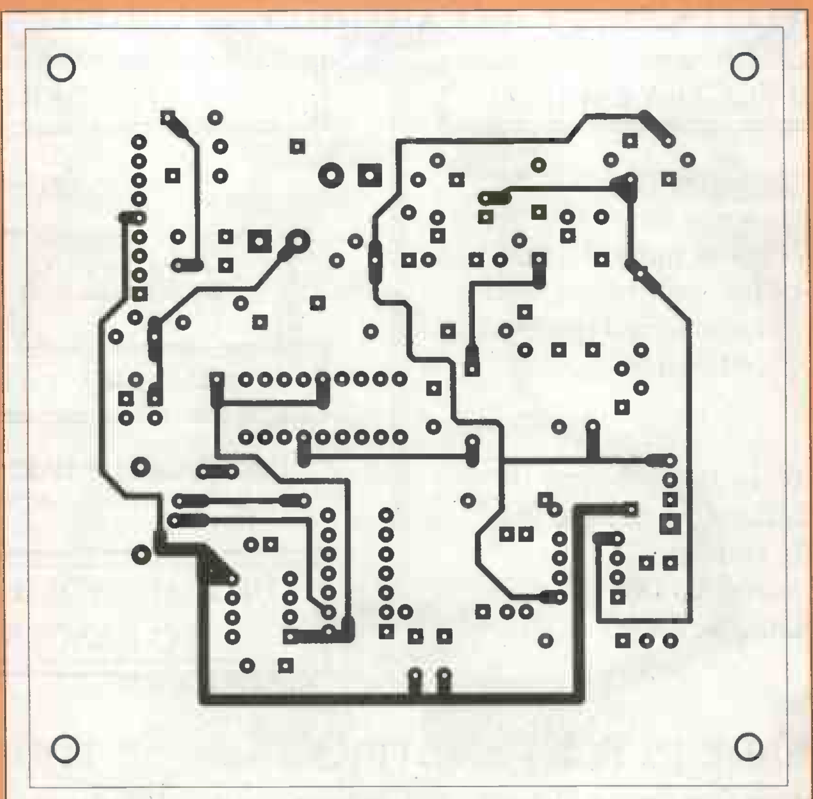

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Around the Corner

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 widgit 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.

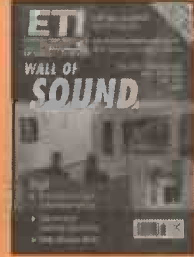
The other piece of news is that negotiations for a new ETI PCB Service are far advanced, and the new service currently looks set to begin next month.

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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