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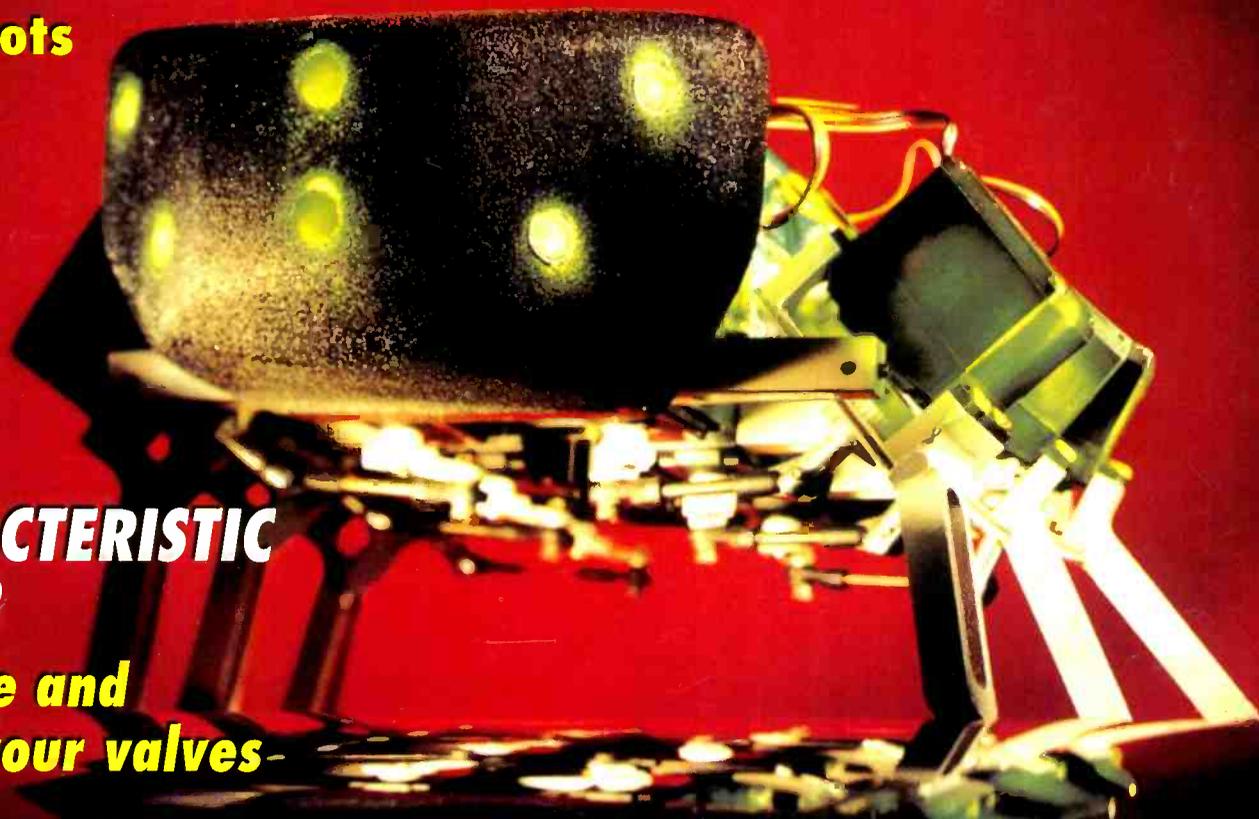
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Fast Fivers - A Process Timer

Speed Controlling DC Motors

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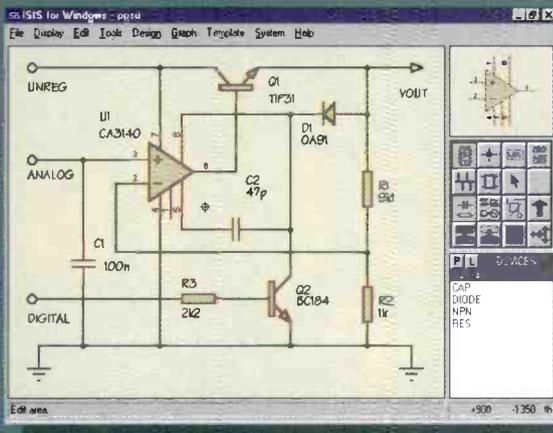
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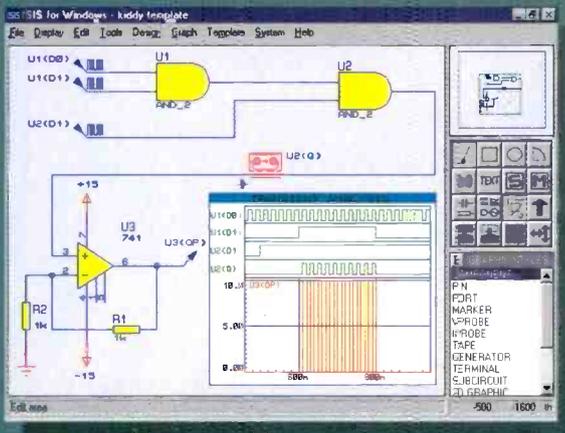
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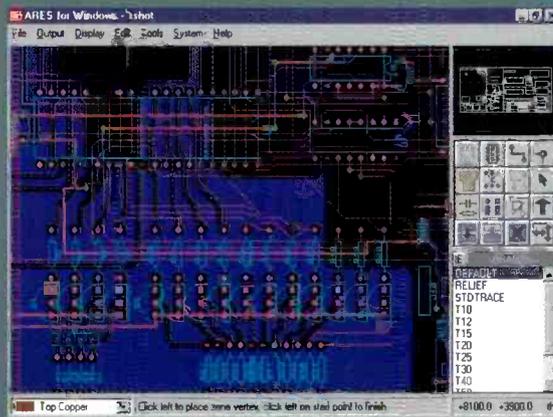
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EWV January 1997

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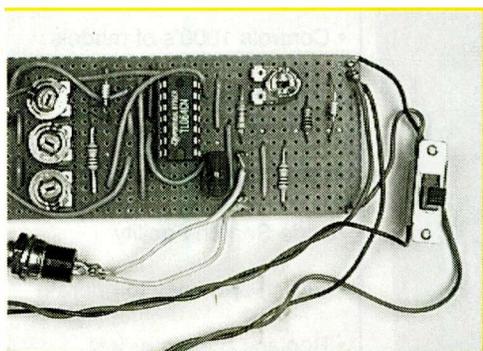
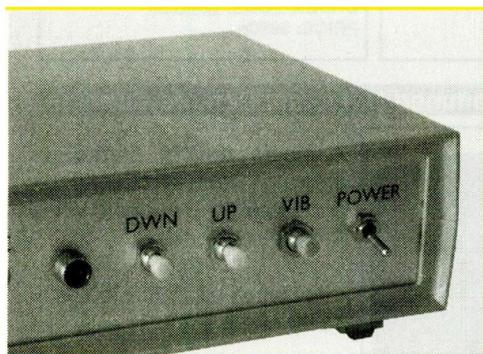
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The Secret of the Machines

Artificial intelligence is gradually moving into many corners of modern life. Could artificial intelligence be self-teaching - could it learn to out-think mankind? Douglas Clarkeson looks at the evidence.

11

Digital Voice Modulator

Robert Penfold's 'voice-box' is based on the HT-8950 voice modulator chip. You can add three levels of pitch-shift, up and down, and a 'robot voice' for machine-men, with added vibrato if you want it. There are mic and line inputs, and operation from long-life HP7 batteries.

23

Brake Light Checker

Functioning brake-lights are arguably even more important on a trailer or caravan than they are on a car. Terry Balbirnie's self-test system warns if caravan and trailer brake lights fail to work when they are needed.

30

Higher Education Special

If you are a school leaver - or just want to new direction in your career - now is the time to decide whether to dedicate the next few years to Higher Education, and where. ETI looks at some established college courses in Electronics and offers some advice about applying.

39

Speed Control in DC Motors - Part one

David Ponting's gift reel-to-reel high-quality tape recorder was absolutely free - all he had to do to put it in working order was create a constant-speed capstan motor drive suitable for both sides of the Atlantic. So began the experiments to find the best control circuit.

45

Ham Radio Today

All the best for Radio Amateurs

50

Valve Characteristic Tester - Part One

Now that valves are popular again in audio amplifiers, pre-amplifiers and filters, Peter Kenyon has designed is a portable unit which helps with matching valve pairs and checking on valve characteristics.

55

Fast Fivers - A Process Timer (4)

This is the Egg Timer of the Future, says Owen Bishop. It can time up to three consecutive stages of a process, a multistage process lasting for half-an-hour or (for a bit more dosh) to seven stages or more.

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Terry Balbirnie goes back to basics on Ohm's Law

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DIGITAL MULTIMETERS

CM2300 DIGITAL MULTIMETER



FEATURES:

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

ORDER CODE: CM2300
PRICE: 975p

CM2400T DIGITAL MULTIMETER WITH TEMP MEASUREMENT

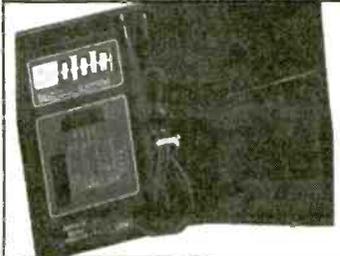


FEATURES:

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

ORDER CODE: CM2400T
PRICE: 1450p

CM2900 PACKET DIGITAL MULTIMETER



FEATURES:

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

ORDER CODE: CM2900
PRICE: 1150p

CM3900A DIGITAL MULTIMETER

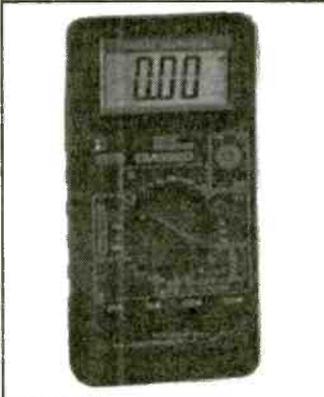


FEATURES:

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

ORDER CODE: CM3900A
PRICE: 2900p

CM3920 DIGITAL METER WITH TEMP MEASUREMENT



FEATURES:

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

ORDER CODE: CM3920
PRICE: 4100p

CM2700 AUTORANGING DIGITAL MULTIMETER



FEATURES:

- 3.75 LCD DISPLAY WITH DECIMAL POINT
- 33 SEGMENT BAR GRAPH DISPLAY
- OVERRANGE INDICATOR
- 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/500V
- AC VOLTAGE: 320mV/3.2V/32V/320V/600V
- DC CURRENT A: 320 μ A/3200 μ A/32mA/320mA/10A
- AC CURRENT A: 320 μ A/3200 μ A/32mA/320mA/10A
- RESISTANCE: 320 Ω /3.2K Ω /32K Ω /320K Ω /3.2M Ω /32M Ω

ORDER CODE: CM2700
PRICE: 4050p

CM3230 DIGITAL CAPACITANCE METER



FEATURES:

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

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| | | | | | |
|--|--|---|--------------------------------|---|---|
| ALBA | CODE | ECHOSTAR | CODE | MIMTEC | CODE |
| SAT660 | SATPSU2 | SR5500 EARLY PSU WITH ADJ 6500, SR7700, SR8700 | SATPSU12 SATPSU13 | SOPRENSON TYPE PSU ONLY | SATPSU15 |
| AMSTRAD | CODE | FERGUSON | CODE | NETWORK | CODE |
| SRD510, SRD520, SRD540, SRD550 SRDR45 SRD500 SRX320, SRX340, SRX345, SRX350 SRX100 SRD600 SAT250, SR950, SRD700, SRD950, SRX1002, SRX2001, SRX301, SRX501, SRX502 SRD2000 | SATPSU3 SATPSU4 SATPSU5 SATPSU6 SATPSU14 SATPSU16 SATPSU18 | SRD 5, SRD16 SRV1 SRDE4 | SATPSU1 SATPSU2 SATPSU11 | 9000, 9200 | SATPSU2 |
| BRITISH TELECOM | CODE | GRUNDIG | CODE | NOKIA | CODE |
| SVS300 | SATPSU17 | STR1 GIRD200, FIRD3000 | SATPSU1 SATPSU2 | SAT1500 | SATPSU2 |
| BUSH | CODE | FINLUX | CODE | PACE | CODE |
| IRD150 IRD155 | SATPSU12 SATPSU19 | SR5700 | SATPSU12 | PRD800, PRD900, PSR800, PSR900 MRD920, SS9000, SS9010, SS9200, SS9210, SS9220 D100, D150, MSS100 APOLLO, MSS200, MSS300 MSS500, MSS1000 | SATPSU1 SATPSU2 SATPSU6 SATPSU8 SATPSU9 SATPSU10 |
| CHURCHILL | CODE | GOODMANS | CODE | PHILIPS | CODE |
| D3MAC DECODER | SATPSU7 | ST700 | SATPSU1 | STU802/05M STU801 | SATPSU1 SATPSU2 |
| | | MASPRO | CODE | THOMSON | CODE |
| | | SRE250S/1, SRE350S/1 SRE250S, SRE350S, SRE450S | SATPSU1 SATPSU2 | 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 |

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|--------------------|----------|-------|
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| PACEPRD800, PRD900 | PRD800 | 550p |

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INPUT IMPEDENCE: 75 Ohm
MAX.INPUT SIGNAL: -10 DBM

LED INDICATOR: VERTICAL/HORIZONTAL
POWER AMPLIFIER: 18 DB

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

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SATELLITE LNB'S

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

FUSES

| CURRENT RATING | TIME LAG (20MM) | | QUICK BLOW (20MM) | |
|----------------|-----------------|-------|-------------------|-------|
| | ORDER CODE | PRICE | ORDER CODE | PRICE |
| 100mA | FUSE36 | 75p | FUSE37 | 60p |
| 160mA | FUSE01 | 75p | FUSE17 | 60p |
| 250mA | FUSE02 | 75p | FUSE18 | 60p |
| 315mA | FUSE03 | 75p | FUSE19 | 60p |
| 400mA | FUSE04 | 75p | FUSE20 | 60p |
| 500mA | FUSE05 | 75p | FUSE21 | 60p |
| 630mA | FUSE06 | 75p | FUSE22 | 60p |
| 800mA | FUSE07 | 60p | FUSE23 | 60p |
| 1A | FUSE08 | 60p | FUSE24 | 60p |
| 1.25A | FUSE09 | 60p | FUSE25 | 60p |
| 1.6A | FUSE10 | 60p | FUSE26 | 60p |
| 2A | FUSE11 | 50p | FUSE27 | 60p |
| 2.5A | FUSE12 | 50p | FUSE28 | 60p |
| 3.15A | FUSE13 | 55p | FUSE29 | 50p |
| 4A | FUSE14 | 55p | FUSE30 | 50p |
| 5A | FUSE15 | 60p | FUSE31 | 50p |
| 6.3A | FUSE16 | 60p | FUSE32 | 50p |

CERAMIC PLUG TOP

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

20mm CERAMIC TIME LAG

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

38mm CERAMIC TIME LAG

| CURRENT RATING | ORDER CODE | PRICE |
|----------------|------------|-------|
| 10A | FUSE48 | 815P |

32mm CERAMIC SLOW BLOW

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

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| AC125 | 30P | BD647 | 50P | BU409 | 85P | BUX48A | 150P | MPSA14 | 15P | 2N3533 | 100P |
| AC126 | 30P | BD649 | 50P | BU412 | 175P | BUX5 | 800P | MPSA20 | 15P | 2N3585 | 650P |
| AC127 | 30P | BD645 | 40P | BU413 | 175P | BUX80 | 180P | MPSA42 | 15P | 2N3702 | 9P |
| AC128K | 40P | BD676 | 40P | BU414B | 250P | BUX81 | 160P | MPSA43 | 15P | 2N3703 | 9P |
| AC141K | 45P | BD677 | 38P | BU415A | 170P | BUX84 | 50P | MPSA44 | 40P | 2N3704 | 9P |
| AC176 | 22P | BD678 | 40P | BU426A | 70P | BUX85 | 50P | MPSA55 | 12P | 2N3705 | 9P |
| ACY18 | 48P | BD679 | 40P | BU433 | 120P | BUX86 | 30P | MPSA56 | 12P | 2N3706 | 9P |
| ACY19 | 48P | BD680 | 40P | BU500 | 100P | BUX87 | 50P | MPSA57 | 15P | 2N3707 | 9P |
| AD149 | 60P | BD681 | 40P | BU500D | 225P | BUX98A | 350P | MPSA92 | 20P | 2N3710 | 12P |
| AF126 | 50P | BD682 | 45P | BU505 | 90P | BUY18S | 150P | MPSA93 | 20P | 2N3711 | 12P |
| AF139 | 30P | BD705 | 50P | BU505D | 90P | BUY47 | 150P | MPSU10 | 200P | 2N3771 | 85P |
| BC107 | 8P | BD707 | 50P | BU505DF | 90P | BUY57 | 125P | MPSU45 | 550P | 2N3772 | 90P |
| BC108 | 8P | BD709 | 50P | BU506 | 100P | BUY69A | 200P | MPSU56 | 400P | 2N3773 | 100P |
| BC109 | 8P | BD711 | 50P | BU506D | 70P | BUY71 | 250P | MPSU60 | 350P | 2N3792 | 150P |
| BC109C | 10P | BD736 | 50P | BU506DF | 120P | BUZ10 | 65P | MRS10 | 35P | 2N3797 | 18P |
| BC140 | 20P | BD826 | 50P | BU508A | 70P | BUZ11 | 200P | MR856 | 36P | 2N3819 | 30P |
| BC142 | 20P | BD828 | 50P | BU508AF | 90P | BUZ11A | 175P | OC28 | 350P | 2N3820 | 70P |
| BC143 | 20P | BD839 | 55P | BU508APH | 80P | BUZ14 | 550P | OC29 | 250P | 2N3823 | 40P |
| BC147 | 8P | BD897 | 50P | BU508D | 90P | BUZ20 | 225P | OC35 | 350P | 2N3866 | 110P |
| BC149 | 8P | BD899 | 50P | BU508DF | 115P | BUZ21 | 250P | OC36 | 250P | 2N3903 | 11P |
| BC159 | 8P | BD977 | 50P | BU508DR | 130P | BUZ24 | 350P | OC45 | 50P | 2N3906 | 11P |
| BC160 | 30P | BDX33 | 60P | BU508V | 110P | BUZ25 | 450P | OC200 | 180P | 2N3924 | 375P |
| BC171 | 10P | BDX37 | 100P | BU508VF | 100P | BUZ32 | 25P | R2008B | 100P | 2N3927 | 375P |
| BC172 | 10P | BDX44 | 100P | BU526 | 75P | BUZ36 | 800P | R2010B | 100P | 2N4031 | 25P |
| BC173 | 14P | BDX47 | 75P | BU536 | 100P | BUZ44A | 525P | S2000A3 | 175P | 2N4033 | 25P |
| BC178 | 14P | BDX54C | 75P | BU546 | 125P | BUZ45A | 800P | S2000AF | 175P | 2N4036 | 29P |
| BC179 | 14P | BDX62C | 150P | BU603 | 125P | BUZ50B | 500P | S2055A | 175P | 2N4220 | 175P |
| BC182 | 7P | BDX63C | 175P | BU606D | 225P | BU53A | 800P | S2055AF | 200P | 2N4347 | 130P |
| BC182L | 7P | BDX64C | 175P | BU608D | 120P | BUZ71 | 75P | S2530A | 100P | 2N4391 | 60P |
| BC183 | 7P | BDX65 | 80P | BU626 | 120P | BUZ71AF | 100P | S2800M | 100P | 2N4392 | 60P |
| BC183L | 7P | BDX66C | 175P | BU705 | 130P | BUZ72A | 150P | TIP29 | 15P | 2N4393 | 55P |
| BC184 | 7P | BDX67C | 275P | BU706DF | 175P | BUZ72AF | 100P | TIP29A | 22P | 2N4399 | 200P |
| BC184L | 7P | BDX71 | 70P | BU706F | 150P | BUZ73A | 150P | TIP29C | 25P | 2N4401 | 12P |
| BC212 | 7P | BDX77 | 175P | BU724A | 100P | BUZ76A | 110P | TIP29E | 40P | 2N4403 | 12P |
| BC212L | 7P | BDX87C | 175P | BU801 | 70P | BUZ80 | 200P | TIP30 | 25P | 2N4416 | 120P |
| BC213 | 7P | BDX88C | 150P | BU806 | 70P | BUZ80AF | 200P | TIP30C | 20P | 2N4420 | 75P |
| BC213L | 7P | BDW24 | 55P | BU807 | 60P | BUZ83 | 200P | TIP31A | 22P | 2N4427 | 75P |
| BC214 | 7P | BDW93 | 50P | BU807F | 75P | BUZ90A | 27P | TIP31C | 24P | 2N4920 | 50P |
| BC214L | 7P | BDW94 | 50P | BU808DF | 300P | BUZ91A | 400P | TIP32 | 24P | 2N4922 | 30P |
| BC237 | 7P | BDY29 | 225P | BU810 | 110P | BY448 | 200P | TIP32A | 21P | 2N4923 | 30P |
| BC238 | 7P | BDY56 | 225P | BU824 | 450P | BYT11 | 25P | TIP32C | 28P | 2N5038 | 175P |
| BC239 | 7P | BDY58 | 500P | BU826 | 120P | C106D | 28P | TIP33 | 50P | 2N5061 | 20P |
| BC300 | 20P | BDY90 | 125P | BU826A | 160P | COY80 | 40P | TIP33C | 60P | 2N5088 | 20P |
| BC301 | 20P | BDY92 | 100P | BU902 | 110P | IRF120 | 225P | TIP34 | 65P | 2N5109 | 100P |
| BC302 | 20P | BF137 | 35P | BU903 | 110P | IRF130 | 475P | TIP34C | 65P | 2N5116 | 175P |
| BC303 | 20P | BF167 | 30P | BU910 | 80P | IRF140 | 550P | TIP35C | 65P | 2N5154 | 150P |
| BC304 | 25P | BF181 | 18P | BU912 | 100P | IRF150 | 550P | TIP36C | 65P | 2N5160 | 600P |
| BC327 | 7P | BF183 | 20P | BU920 | 100P | IRF240 | 425P | TIP42A | 20P | 2N5179 | 40P |
| BC328 | 7P | BF195 | 7P | BU922 | 110P | IRF250 | 375P | TIP41C | 22P | 2N5192 | 50P |
| BC337 | 7P | BF199 | 8P | BU930 | 130P | IRF300 | 600P | TIP42A | 20P | 2N5241 | 500P |
| BC338 | 7P | BF200 | 16P | BU932 | 175P | IRF340 | 325P | TIP42C | 22P | 2N5245 | 45P |
| BC441 | 28P | BF225 | 30P | BU941 | 250P | IRF350 | 750P | TIP47 | 30P | 2N5294 | 40P |
| BC446 | 18P | BF240 | 16P | BU2508A | 130P | IRF10 | 650P | TIP48 | 40P | 2N5296 | 30P |
| BC477 | 18P | BF245 | 25P | BU2508AF | 130P | IRF10 | 150P | TIP50 | 60P | 2N5320 | 50P |
| BC516 | 22P | BF254 | 15P | BU2508D | 130P | IRF520 | 150P | TIP51 | 80P | 2N5322 | 55P |
| BC537 | 25P | BF255 | 12P | BU2508DF | 150P | IRF530 | 150P | TIP52 | 80P | 2N5401 | 10P |
| BC546 | 8P | BF256 | 18P | BU2520AF | 225P | IRF540 | 200P | TIP54 | 85P | 2N5416 | 40P |
| BC547 | 8P | BF257 | 18P | BU2520DF | 225P | IRF610 | 150P | TIP102 | 70P | 2N5448 | 12P |
| BC548 | 8P | BF259 | 18P | BU2525A | 325P | IRF611 | 150P | TIP105 | 65P | 2N5457 | 45P |
| BC549 | 8P | BF262 | 25P | BU2525AF | 325P | IRF620 | 180P | TIP106 | 65P | 2N5458 | 55P |
| BC550 | 8P | BF263 | 25P | BU2527AF | 400P | IRF630 | 150P | TIP107 | 65P | 2N5460 | 55P |
| BC556 | 14P | BF273 | 15P | BUF405A | 200P | IRF640 | 350P | TIP110 | 40P | 2N5461 | 75P |
| BC557 | 7P | BF311 | 20P | BUH315 | 200P | IRF642 | 200P | TIP111 | 40P | 2N5462 | 45P |
| BC558 | 8P | BF336 | 20P | BUH15D | 250P | IRF650 | 200P | TIP112 | 35P | 2N5484 | 55P |
| BC559 | 8P | BF337 | 20P | BUH515 | 200P | IRF710 | 150P | TIP112H | 50P | 2N5551 | 12P |
| BC560 | 8P | BF338 | 20P | BUH515D | 250P | IRF720 | 200P | TIP115 | 50P | 2N5671 | 350P |
| BC563 | 20P | BF362 | 30P | BUH517 | 275P | IRF730 | 150P | TIP116 | 30P | 2N5672 | 400P |
| BC568 | 20P | BF367 | 13P | BUH517D | 175P | IRF740 | 150P | TIP117 | 30P | 2N5680 | 55P |
| BC640 | 20P | BF371 | 17P | BUH715 | 425P | IRF820 | 150P | TIP120 | 37P | 2N5884 | 175P |
| BCY33 | 200P | BF421 | 18P | BUV93 | 375P | IRF830 | 160P | TIP121 | 35P | 2N5886 | 325P |
| BCY34 | 200P | BF422 | 21P | BUK444 | 200P | IRF840 | 150P | TIP122 | 30P | 2N6031 | 250P |
| BCY70 | 16P | BF423 | 25P | 500B | | IRF9140 | 1000P | TIP125 | 30P | 2N6049 | 55P |
| BCY71 | 16P | BF455 | 12P | BUK444 | 200P | IRF9150 | 150P | TIP128 | 40P | 2N6059 | 150P |
| BCY72 | 16P | BF458 | 19P | 800B | | IRF9511 | 150P | TIP127 | 35P | 2N6098 | 50P |
| BD115 | 30P | BF462 | 50P | BUK445 | 200P | IRF9520 | 150P | TIP130 | 30P | 2N6099 | 45P |
| BD124P | 50P | BF471 | 28P | 600B | | IRF9530 | 400P | TIP131 | 30P | 2N6107 | 40P |
| BD131 | 25P | BF472 | 28P | BUK446 | 400P | IRF9531 | 200P | TIP132 | 30P | 2N6109 | 40P |
| BD132 | 25P | BF479 | 30P | 800B | | IRF9540 | 300P | TIP136 | 40P | 2N6211 | 400P |
| BD133 | 50P | BF494 | 16P | BUK455 | 200P | IRF9541 | 200P | TIP137 | 55P | 2N6248 | 150P |
| BD135 | 20P | BF495 | 16P | 600B | | IRF9610 | 150P | TIP162 | 110P | 2N6284 | 250P |
| BD136 | 20P | BF525 | 16P | BUK456 | 200P | IRF9620 | 150P | TIP141 | 65P | 2N6287 | 225P |
| BD137 | 20P | BF596 | 16P | BUW81A | 150P | IRF9622 | 200P | TIP143 | 75P | 2N6292 | 40P |
| BD138 | 20P | BF615 | 30P | BUW81A | 1900P | IRF9630 | 325P | TIP145 | 50P | 2N6385 | 120P |
| BD139 | 20P | BF617 | 30P | BUW82 | 1900P | IRF9640 | 375P | TIP146 | 70P | 2N6403 | 160P |
| BD140 | 20P | BF670 | 40P | BU511A | 200P | IRF9640 | 375P | TIP147 | 80P | 2N6427 | 25P |
| BD144 | 90P | BF763 | 40P | BU512A | 200P | IRF9630 | 325P | TIP150 | 90P | 2N6476 | 250P |
| BD157 | 38P | BF870 | 22P | BU514A | 500P | IRF9640 | 375P | TIP151 | 60P | 2N6488 | 90P |
| BD168 | 30P | BF871 | 22P | BU523 | 225P | IRFP140 | 250P | TIP2955 | 50P | 2N6491 | 90P |
| BD175 | 30P | BF960 | 38P | BU548A | 175P | IRFP150 | 300P | TIP3055 | 50P | 2N6547 | 300P |
| BD177 | 30P | BF961 | 35P | BUT11A | 55P | IRFP240 | 300P | TIPL760 | 100P | 2N6609 | 375P |
| BD179 | 32P | BF964 | 38P | BUT11AF | 55P | IRFP250 | 400P | TIPL762A | 200P | 2N6660 | 375P |
| BD181 | 45P | BFQ232 | 75P | BUT12 | 80P | IRFP350 | 325P | TIPL763A | 200P | 2N6675 | 175P |
| BD182 | 60P | BFQ252A | 60P | BUT13 | 310P | IRFP450 | 400P | TIPL791A | 80P | 2N6678 | 225P |
| BD184 | 60P | BF900 | 85P | BUT18 | 80P | IRFP460 | 775P | TS61 | 15P | 4N35 | 50P |
| BD187 | 30P | BF910 | 99P | BUT18AF | 80P | IRFP9140 | 1450P | TS90 | 15P | | |
| BD201 | 33P | BF143 | 30P | BUT30V | 1700P | IRFP9240 | 500P | TS93 | 20P | | |
| BD202 | 38P | BFX29 | 20P | BUT56A | 100P | IRFPC50 | 600P | ZTX107 | 11P | | |
| BD203 | 42P | BFX84 | 20P | BUT76A | 80P | IRFRC20 | 250P | ZTX108 | 11P | | |
| BD204 | 42P | BFX85 | 20P | BU190 | 1300P | IRFZ20 | 65P | ZTX109 | 12P | BY127 | 8P |
| BD222 | 31P | BFX87 | 15P | BU192 | 1200P | IRFZ42 | 275P | ZTX121 | 20P | BY133 | 8P |
| BD225 | 31P | BFX88 | 15P | BU198 | 1500P | IRFZ44 | 275P | ZTX300 | 10P | BY164 | 40P |
| BD232 | 31P | BFX89 | 60P | BUV20 | 650P | MJ900 | 200P | ZTX301 | 16P | BY179 | 35P |
| BD233 | 30P | BFY50 | 14P | BUV21 | 400P | MJ10001 | 200P | ZTX302 | 10P | BY184 | 32P |
| BD234 | 32P | BFY51 | 24P | BUV23 | 475P | MJ1001 | 200P | ZTX303 | 20P | BY206 | 11P |
| BD235 | 28P | BFY52 | 14P | BUV24 | 350P | MJ2501 | 100P | ZTX304 | 10P | BY207 | 20P |
| BD236 | 30P | BFY56 | 25P | BUV25 | 110P | MJ2955 | 55P | ZTX320 | 20P | BY227 | 19P |
| BD237 | 21P | BFY64 | 25P | BUV26 | 150P | MJ3000 | 100P | ZTX501 | 13P | BY228 | 28P |
| BD238 | 24P | BFY90 | 45P | BUV27 | 150P | MJ3001 | 100P | ZTX502 | 10P | BY298 | 15P |
| BD239 | 30P | BLY48 | 85P | BUV28 | 110P | MJ4032 | 175P | ZTX503 | 18P | BY299 | 18P |
| BD240 | 40P | BR100 | 14P | | | | | | | | |

TRANSISTORS

| PART | PRICE | PART | PRICE | PART | PRICE | PART | PRICE | PART | PRICE | PART | PRICE |
|---------------------------|-------|---------------|-------|----------------------|-------|------------|-------|------|-------|--------------------|-------|
| IC SOCKETS | | | | | | | | | | | |
| 8 PIN | 4P | 1A/50V | 18p | TIC116C | 59p | 8156 | 300p | 4075 | 13p | 7430 | 25p |
| 14 PIN | 5P | 1A/100V | | W01 | | 8224 | 240p | 4076 | 42p | 7437 | 28p |
| 16 PIN | 6P | WO2 | 19p | TIC116D | 70p | 8226 | 240p | 4077 | 13p | 7438 | 30p |
| 18 PIN | 9P | WO4 | 21p | 8A/400V | | 8250 | 750p | 4078 | 13p | 7442 | 38p |
| 20 PIN | 10P | LA/400V | | TIC126D | 75p | 8251 | 200p | 4081 | 13p | 7447 | 60p |
| 22 PIN | 12P | LA/600V | 23p | 12A/400V | | 8253 | 160p | 4082 | 13p | 7450 | 22p |
| 24 PIN | 13P | WO3 | 28p | TIC126M | 90p | 8257 | 220p | 4085 | 36p | 7451 | 10p |
| 28 PIN | 13P | 1A/800V | | 12A/600V | | 8271 | 340p | 4086 | 30p | 7454 | 25p |
| 40 PIN | 15P | BR81D | 33p | C1060 | 28p | 8279 | 270p | 4089 | 75p | 7473 | 25p |
| ZENER DIODES | | | | | | | | | | | |
| 400m | WATT | BR84D | 37p | 4A/400V | | 8283 | 400p | 4093 | 18p | 7481 | 90p |
| 2V7 TO 39V | 5P | BR86D | 43p | BR103 | 37p | 8284 | 440p | 4094 | 44p | 7482 | 60p |
| 1.3 | WATT | 2A/600V | | BR303 | 85p | 8287 | 260p | 4094 | 58p | 7485 | 25p |
| 2V7 TO 39V | 9P | BR88D | 43p | BT106 | 180p | 8288 | 650p | 4098 | 50p | 7489 | 75p |
| VOLTAGE REGULATORS | | | | | | | | | | | |
| 7805 | 25P | BR32 | 43p | BT119 | 100p | 82C206PLCC | 500p | 4099 | 42p | 7493 | 35p |
| 7806 | 25P | 2A/200V | 43p | 17088 | 200p | 8748 | 700p | 4501 | 26p | 7495 | 48p |
| 7808 | 25P | BR84D | 37p | 17089 | 200p | 8755 | 800p | 4502 | 36p | 74132 | 42p |
| 7812 | 25P | 2A/400V | | SG 264 | 800p | 8126 | 95p | 4504 | 35p | 74141 | 55p |
| 7815 | 25P | BR251 | 150p | SG613 | 1500p | 8128 | 110p | 4505 | 80p | 74145 | 70p |
| 7818 | 25P | 25A/100V | | CMOS IC's | | | | | | | |
| 7824 | 25P | BR252 | 165p | COMPUTER IC's | | | | | | | |
| 7905 | 25P | 24A/200V | | 4000 | 13p | 4010 | 13p | 4506 | 58p | 74157 | 45p |
| 7906 | 30P | BR254 | 185p | 4001 | 13p | 4011 | 13p | 4507 | 30p | 74160 | 50p |
| 7908 | 30P | 25A/400V | | 4002 | 13p | 4012 | 13p | 4508 | 67p | 74HC SERIES | |
| 7912 | 30P | BR255 | 165p | 4006 | 100p | 4006 | 34p | 4510 | 32p | 74HC03 | 14p |
| 7915 | 30P | 24A/200V | | 4007 | 200p | 4007 | 13p | 4512 | 38p | 74HC08 | 18p |
| 7918 | 30P | BR256 | 185p | 4008 | 140p | 4009 | 20p | 4514 | 65p | 74HC10 | 20p |
| 7924 | 30P | 25A/600V | 200p | 4009 | 210p | 4010 | 21p | 4515 | 65p | 74HC11 | 14p |
| 78L05 | 24P | BR258 | 240p | 4010 | 210p | 4011 | 13p | 4517 | 100p | 74HC14 | 26p |
| 78L08 | 24P | 25A/800V | | 4011 | 210p | 4012 | 13p | 4518 | 36p | 74HC20 | 19p |
| 78L12 | 24P | BR351 | 185p | 4012 | 13p | 4013 | 13p | 4519 | 28p | 74HC27 | 20p |
| 78L15 | 24P | 35V/100V | | 4013 | 13p | 4014 | 13p | 4520 | 35p | 74HC31 | 19p |
| 78L18 | 24P | BR352 | 200p | 4014 | 13p | 4015 | 13p | 4521 | 86p | 74HC33 | 24p |
| 79L05 | 35P | 35V/200V | | 4015 | 13p | 4016 | 13p | 4522 | 18p | 74HC34 | 24p |
| 79L08 | 35P | BR354 | 220p | 4016 | 13p | 4017 | 13p | 4523 | 30p | 74HC35 | 24p |
| 79L12 | 35P | 35V/400V | | 4017 | 13p | 4018 | 13p | 4524 | 38p | 74HC36 | 24p |
| 79L15 | 35P | BR356 | 230p | 4018 | 13p | 4019 | 13p | 4525 | 41p | 74HC37 | 28p |
| LM309K | 100P | 35V/600V | | 4019 | 13p | 4020 | 13p | 4526 | 41p | 74HC38 | 35p |
| LM317T | 100P | BR358 | 260p | 4020 | 13p | 4021 | 13p | 4527 | 41p | 74HC39 | 35p |
| LM323K | 350P | 35V/800V | | 4021 | 13p | 4022 | 13p | 4528 | 65p | 74HC40 | 33p |
| 78H09KC | 800P | BY164 | 40p | 4022 | 13p | 4023 | 13p | 4529 | 40p | 74HC46 | 29p |
| 79H12KC | 700P | 1.5A/100V | | 4023 | 13p | 4024 | 13p | 4530 | 140p | 74HC107 | 33p |
| 79HGKC | 800P | BY176 | 40p | 4024 | 13p | 4025 | 13p | 4531 | 29p | 74HC123 | 35p |
| L.E.D.'s 3mm | | | | | | | | | | | |
| RED | 5p | TRIACS | | 26LS32 | 75p | 4025 | 13p | 4532 | 140p | 74HC125 | 32p |
| YELLOW | 8p | TIC206D | 60p | 2716 | 100p | 4026 | 60p | 4533 | 60p | 74HC126 | 33p |
| GREEN | 8p | 4A/400V | | 2732 | 200p | 4027 | 18p | 4534 | 30p | 74HC132 | 33p |
| 5mm | 5p | TIC225D | 69p | 2732A | 220p | 4028 | 29p | 4535 | 40p | 74HC133 | 33p |
| RED | 8p | 6A/400V | | 2764 | 150p | 4029 | 34p | 4536 | 40p | 74HC137 | 52p |
| YELLOW | 8p | TIC226D | 68p | 27C64 | 200p | 4030 | 34p | 4537 | 100p | 74HC138 | 33p |
| GREEN | 8p | 8A/400V | | 27128 | 150p | 4032 | 52p | 4538 | 140p | 74HC147 | 42p |
| RECTANGULAR LED's | | | | | | | | | | | |
| 5mm x 2.5mm | 5p | TIC235D | 85p | 27256-25 | 150p | 4033 | 60p | 4539 | 50p | 74HC153 | 32p |
| RED | 8p | 12A/400V | 105p | 27512 | 300p | 4034 | 76p | 4540 | 170p | 74HC154 | 90p |
| YELLOW | 8p | 16A/400V | | 4116 | 40p | 4035 | 42p | 4541 | 180p | 74HC157 | 34p |
| GREEN | 8p | TIC253D | 190p | 4164-15 | 80p | 4038 | 46p | 4542 | 55p | 74HC158 | 44p |
| 5mm x 2.5mm | | | | | | | | | | | |
| RED | 5p | 20A/400V | 205p | 4164-12 | 90p | 4040 | 30p | 4543 | 55p | 74HC161 | 44p |
| YELLOW | 8p | TIC263D | | 41256-15 | 80p | 4041 | 36p | 4544 | 48p | 74HC162 | 44p |
| GREEN | 8p | 25A/400V | | 41256-12 | 110p | 4042 | 30p | 4545 | 40p | 74HC163 | 44p |
| BRIDGE RECTIFIER | | | | | | | | | | | |
| W005 | 16p | 2N5061 | 20p | 41464-12 | 150p | 4043 | 36p | 4546 | 48p | 74HC164 | 44p |
| THYRISTORS | | | | | | | | | | | |
| W005 | | | | | | | | | | | |
| W005 | | | | | | | | | | | |

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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New semiconductor design centre

Fears expressed over decline in science students

Cypress Semiconductor Corporation is making a multi-million pound investment in one of the largest microchip design centres in the UK, in Basingstoke, Hampshire. The new centre will design various semiconductor products including SRAMS, CPLD and FCT logic chips. Working with Cypress design centres in North America and Asia the UK centre will participate in the company's 24-hour, round-the-clock design projects. At the end of one working day, a project can be handed over to another centre in a different time zone. As many as 60 new design posts will be created. Cypress is working with educational establishments in the UK to encourage the training of future electronics design engineers. Fears have been expressed that a decrease in the number of good science students will have an adverse effect on recruitment in the UK where there have traditionally been high levels of expertise in semiconductor design. "This is particularly important in the light of falling numbers of school pupils studying subjects such as physics," says design centre director David Rees. "When young people are thinking about their future career paths, we need to be sure that they understand the advantages and opportunities available to engineering graduates."



David Rees of Cypress Semiconductor: concern about school leavers

Cypress Semiconductor's product lines include static rams, eproms and specialty memories; programmable logic devices (PLDs), data communications products and personal computer chipsets, timing devices and USB microcontrollers. The company has a World Wide Web site at <http://www.cypress.com>.

Free licenses for Radio Amateurs under 21

The Radiocommunications Agency has announced that Amateur Radio Licences will be issued free of charge to all qualified users under the age of 21 from 1st July 1997. New applicants registered on or after 1st July will be issued free of charge, and existing licence holders will not be charged this year providing their expiry falls on or after that date.

Technology Minister John Battle said: "The Agency has taken this step to encourage more young people into amateur radio. Radio in its many forms has made a massive impact this century on all aspects of our life. We should do all we can to help young people develop an interest in one of the key technological areas for the next century."

There is widespread concern that the attractions of home computing, and also the falling standards that many fear have taken place in education, have combined to discourage younger people from taking up amateur radio. Another factor is that miniaturisation and integration have made high level radio electronics now inaccessible to most Amateurs, even with higher qualifications, so that amateur radio's contribution to the cutting edge of radio has been shifted to experimental or low power areas, and out of what many see the mainstream.

The Novice Licence was launched in 1991 to help young people enter Amateur Radio in easier stages. In 1996 the Radio Society of Great Britain (RSGB) announced that it was to concentrate on keeping prices down and extending services to encourage Amateurs to pursue their hobby. The saving of the £15-per-year License fee will help younger people who are not earning or earning low wages. Amateur radio has also been a major factor in bringing youngsters into Electronics.

For more information contact the Radiocommunications Agency
Tel. 0171 211 0158.

Old PCB retirement scheme in Basingstoke

Cradle-to-Grave electronics Capital of the UK, Basingstoke is now the home of a new recycling scheme aimed at recovering and reprocessing valuable electronic parts instead of allowing their wasteful disposal in landfill sites. The electronics take-back scheme is launched by Project Integra, the waste management strategy, in conjunction with Intex Logistics of Horndean, and local firm PW Recycling. Electronic scrap will be collected and stripped down to recover re-useable ics and other components before the PCBs are refined for their residual value of tin, lead, copper, gold and other metals. The plastic casings will also be analysed for type and then broken down for re-sale to the plastics industry. If the trial is a success, a similar scheme could be set up countrywide.

OVERSEAS READERS

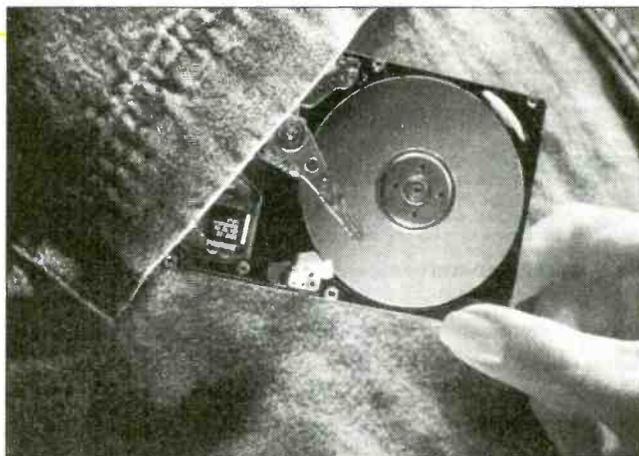
To call UK telephone numbers, replace the initial 0 with your local overseas access code plus the digits 44.

The World's first 5 GB laptop disk drive

IBM have produced a laptop hard disk drive not much bigger than the palm of a child's hand, but able to hold a record-breaking 5 billion bytes (5.1 gigabytes) of data.

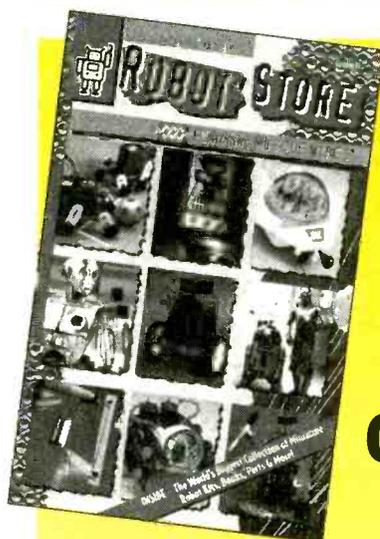
The IBM 2.5 in Travelstar 5GS can store 50 years' worth of a typical daily newspaper, or about 1 million printed pages - a stack of paper as tall as a 62-story building. (No wonder newspaper libraries are looking at compact data storage.)

Whereas the Travelstar 5GS, which is about two-thirds of an inch (17 mm) thick, will go into premium notebook computers. Aimed mainly at notebook users who don't want to store their newspaper collection, the compact drive will allow users to take advantage of space-demanding applications such as long multimedia presentations, games with advanced graphics and video conferencing. The main contributor to this compact storage is IBM's new MRX (magneto-resistive extended) drive-head technology. No bigger than the head of a pin, the MRX head component sends out stronger signals than older heads, enabling it to reach and write larger volumes of information. "MRX is a major step beyond the older-generation magneto-resistive head technology," said Bob Scranton, vice president of technology at IBM's Storage Systems Division.



Another IBM 2.5 in disk drive with MRX head technology sets a new density record, storing the most data per square inch of any disk drive: 2.64 billion bits. The Travelstar 4GT is only half an inch (12.5 mm) thick and it destined for new ultra-portable laptops. The 4GT is also designed to be the most rugged 2.5 in disk drive, based on its non-operational shock rating. (This is the measurement of how much force is applied to the drive before it no longer functions fully.)

IBM expects to ship the drives to OEMs (Original Equipment Manufacturers) in July, and manufacturers including Dell Computer, Gateway 2000 and IBM expect to have them on the market in their notebook computers this year.



Robot Store Catalogue

Robot builders can now obtain the Mondotronics Robot Store catalogue no. 13, "The World's Biggest Collection of Miniature Robot Kits, Books, Parts and More".

The current catalogue features touching and seeing robots, programmable robots, robot muscle wires, many gear and motor kits, and the MicroBench (tm) Pic-driven 24-channel user-definable I/O workbench, able to take downloaded programs and run independent of the main computer. Also new this time is the Soccer'bot Kit, six-legged football-playing robots. No soldering with this kit.

For a catalogue with more information contact Mondo-tronics Inc., 524 San Anselmo Ave. 107-13, San Anselmo CA 94960. Tel. (USA) 415 455 9330 Fax 415 455 9333 email info@mondo.com. Web site: www.IRobotStore.com.

Maritime radio is handed over by the RA

Responsibility for maritime radio operator exams and certification, maritime radio performance specifications and type approval of maritime radiocommunications equipment, including compliance with the Electromagnetic Compatibility Directive, has been transferred from the Radiocommunications Agency to the Marine Safety Agency of the Department of Transport as of 30 June 1997.

Announcing the changes, Minister for Science, Energy and Industry Mr John Battle said: "This transfer will bring a number of benefits to the maritime community and marine radio industry, including rationalisation of seafarer training and certification in the UK. It will also allow resources to be better used and aid consistency in decision taking through single Agency participation in specific on-setting work at European level."

Parliamentary Under-secretary of State for Transport Glerda Jackson said, slightly more succinctly: "This transfer represents a rationalisation of the functions carried out by the two Agencies, resulting in a 'one-stop shop' for manufacturers of radio equipment and mariners wishing to become qualified in seafaring competencies."

The MSA will also take over the power to revoke an Authority to Operate held by an individual. The RA will continue to be responsible for licensing of maritime radio use under the Wireless Telegraphy Act 1949, the enforcement of licence conditions, and investigation of reports of radio interference.

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

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

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

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

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

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PORTABLE X RAY MACHINE PLANS Easy to construct plans on a simple and cheap way to build a home X-ray machine! Effective device, X-ray sealed assemblies, can be used for experimental purposes. Not a toy or for minors! £6/set. Ref FXP1.

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

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

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

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

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

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

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

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

ULTRA HIGH GAIN AMP/STETHOSCOPIC MIKE/SOUND

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

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ANTI DOG FORCE FIELD PLANS Highly effective circuit produces time variable pulses of acoustical energy that dogs cannot tolerate £6/set Ref F/DOG2

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

PHASOR BLAST WAVE PISTOL SERIES PLANS Handheld, has large transducer and battery capacity with external controls. £6/set Ref F/PS4

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

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

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

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

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

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

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

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

1 WATT FM TRANSMITTER KIT Supplied with piezo electric mic. 8-30vdc. At 25-30v you will get nearly 2 watts! £15 ref 1009.

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

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HELPING HANDS Perfect for those fiddly jobs that need six hands, 6 ball and socket joints, magnifier. £7.99 ref Y057A

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

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

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

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

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

MAGNETIC MARBLES They have been around for a number of years but still give rise to curiosity and amazement. A pack of 12 is just £3.99 ref G/IR20

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

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

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

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

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

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

FUTURE PC POWER SUPPLIES These are 295x135x60mm, 4 drive connectors 1 mother board connector. 150watt, 12v fan, iec inlet and on/off switch. £12 Ref EF6

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

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

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

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

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

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

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

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

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

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

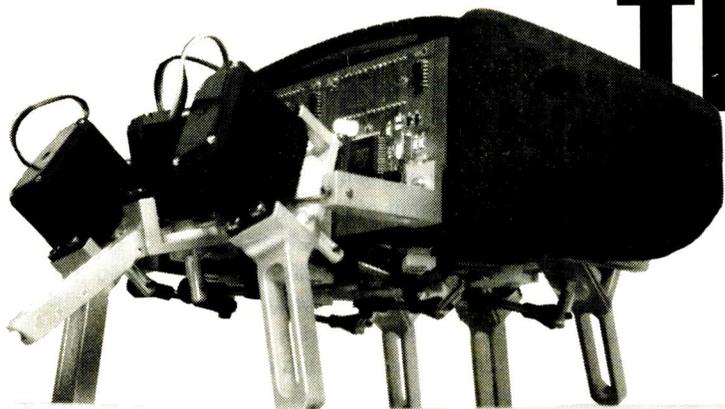
9-0-9V 4A TRANSFORMERS, chassis mount. £7 ref LOT19A.

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

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The Secret

Robots are playing an increasingly pivotal part in modern life. Now some people fear that they will become a 'new species' that will take us over. Douglas Clarkson examines the evidence.

of the Machines

Artificial intelligence is a rapidly expanding component of our society. As an integral component of economic competitiveness, market economies prosper by utilisation, for example, of industrial robots in car assembly lines. There are so many issues raised, for example, by Professor Kevin Warwick's book *March of the Machines* that it is difficult to know where to begin in sampling its many messages. Also, the work of Professor Warwick's group at Reading University tends to handle topics in a constructive way - finding ways and means to develop a specialist wheelchair for the disabled. There are indications, however, within the world military sector, of massive investment and development of 'intelligent systems' to wage war. This means that by no means all R & D is communicated to the public at large.

Professor Warwick's book is deliberately slanted to be read by someone with no background in science, so its technical and scientific content is deliberately limited. This can be something of a disappointment for those able to find their way around publications with more technical content.

Professor Warwick, shown with one of the 'Seven Dwarfs' in figure 1, has in a way singled out identity in a particular aspect - autonomous units, each with an apparent identity of its own - in order to isolate and demonstrate the potential for machine independence and development. Books like *March of the Machines* are more perhaps designed to stimulate a debate than provide definitive predictions about the future. The book airs several key questions - none more important than an understanding of the Nature of Self.

The nature of Self

A central question in the study of machine intelligence relates to the nature of human consciousness. There are expressions of belief that the human brain is no more than a complex telephone exchange which is connected across various interfaces to a higher energy or non physical spiritual force. There is also the viewpoint that 'neurons are us' - we are no more and no less than our vast tangled web of brain cells. This is the viewpoint of 'strong' Artificial Intelligence, which maintains that, if the human identity is no more than a complex collection of miniature electrical circuits, then it should eventually be able to copy this and replicate human faculties. Also, according to this theory, even circuits of intermediate

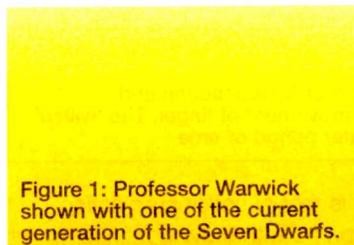
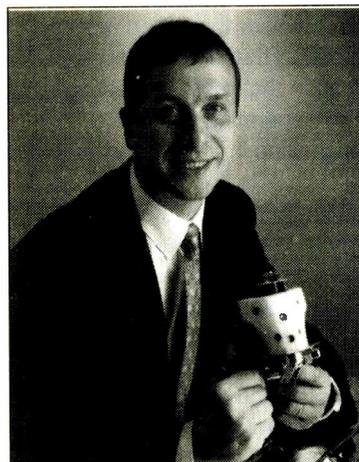


Figure 1: Professor Warwick shown with one of the current generation of the Seven Dwarfs.



complexity would have some degree of human type characteristics.

According to the belief in the higher spiritual force theory of consciousness, or 'magic' theory, it will never be possible to develop a 'self aware' robotic machine because the element of higher human development - will and consciousness - cannot be replicated in purely physical form. It is in the progression of machine 'cleverness', however, that many in this field anticipate an apparent attribute or mimic of machine self awareness. It will, however, be a clever deception.

The mind of the mathematician

The Artificial Intelligence community is too busy designing, programming and training AI systems to spend much of their time engaging in philosophical thought of the nature of awareness and consciousness. But they do prompt mathematicians like Roger Penrose to put a shot across the bows of the barge of 'strong AI' - that bastion of belief that considers that consciousness is no more than the activation of vast arrays of neural connections in our brain. Twinned with this belief is the assumption that if a connected system can be made to process algorithms as complex as those taking place in the human brain, then it too will be conscious. Penrose's book, *The Emperor's New Mind* is effectively a move back to the common sense approach that consciousness is something quite separate and different from simulated sensory spikes in silicon. In tracing through observations across diverse fields of mathematics, physics, neurophysiology and computing, Professor Penrose presents some interesting observations.

One of these is that in identification of the 'road map' of sensory mappings in the brain, where, for example, the area is activated that causes the right arm to move, this will be done without the wish to move the left arm being aroused. In one conscious patient, the right arm in fact tried to stop such 'involuntary' motion taking place.

While the site selected was the origin of nerve pathways to control the arm, it was not the centre which controlled the 'will' to undertake such activity.

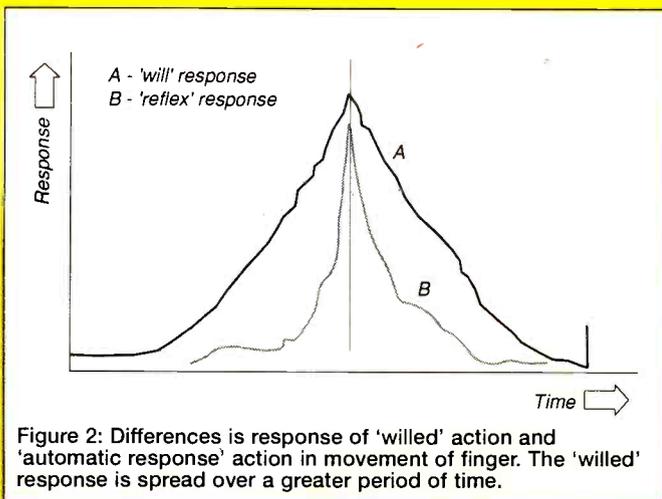


Figure 2: Differences in response of 'willed' action and 'automatic response' action in movement of finger. The 'willed' response is spread over a greater period of time.

Another subtle observation is that of anticipated action - such as wiggling a finger compared with moving a finger in response to a buzzer or a light signal. The differences in response are indicated in figure 2, where the 'willed' action takes place over a longer time period than the 'response' action. This is perhaps an indication that more interesting differences could be detected by separating actions originating in 'will' and those originating in 'reflex' and 'response'?

One very interesting observation of general interest is the phenomenon of 'blindsight'. Where the retinal function is intact but damage occurs to the visual cortex so that vision is lost over part of the visual field, some sensory awareness can in fact be retained since visual data is also routed to other centres in the brain. This was proved by a patient with this problem correctly 'guessing' simple geometrical shapes presented in the visual field that was 'missing'. This suggests therefore, that the brain is undertaking some sort of image assessment and characterisation that is not directly related to seeing objects.

Leastways, Professor Penrose gives us plenty to think about. It is an indication that the pendulum is moving steadily away from a Newtonian model of the universe and with it strong artificial intelligence concepts of the nature of human consciousness. Professor Penrose, however, has not actually stepped outside the stockade of 20th century physics, though he has climbed its highest tower and gazed into new territories yet to be discovered.

The march of popular science

The area of machine consciousness and emerging theories of cosmology is very much the core material of an expanding core of books appearing under 'Popular Science'. One interesting contribution is *'Who's Afraid of Schrodinger's Cat'* by Ian Marshall and Darah Zohar, which acts like a road map of old, transitional and new theories. *The Life of the Cosmos* by Lee Smolin provides a perspective on Newtonian Science and

emerging views of cosmology and related matters. *Goodbye Descartes* by Keith Devlin continues in the same vein. In a reinforcement of an earlier book, Hubert Dreyfus has recently published *What Computers Still Can't Do* to remind us that computers in the 1990s are fundamentally not really any smarter than they were in the 1970s. Are these titles evidence that thinking on artificial intelligence is really moving away from equating all human faculties to that of connected neural circuits? Most book publishers at least must think so.

The heightened debate on machine intelligence comes also at an interesting phase in science which, while fascinated as ever with the diversity of the physical world is giving some space to more esoteric topics. The Big Bang is one thing and the first three minutes was a very interesting time, but now the attention of physicists is being directed on conditions before the Big Bang. Why did it take place? This takes science into a plane of thought rather than into a profile of measuring observables. Once science sets forward questions to be asked, it tends to be persistent and not let go of them. In looking for new answers, physicists have been fundamentally influenced by their discoveries in quantum physics.

Concepts of Self Awareness

There are, however, some problems in basic understanding of sensory awareness. It is one thing to understand how the eye - retina - visual cortex can process a series of nerve impulses, quite another to understand how this is transformed to something that we can see. Seeing is just not a process of receiving a processed series of nerve signals - it is about an awareness of seeing. Likewise with hearing - yes, we can understand how the cochlear microphonic signal is created. The question is really: how are these signals translated into an awareness of hearing? It is this awareness of the senses - awareness of being - that remains a stubborn question and is really at the core of machine 'awareness' studies.

To thus make references to machines becoming self-aware touches on some very deep philosophical issues that certainly deserve to be addressed diligently. It is quite convenient to dismiss the whole argument and say that human beings have no real awareness of themselves and that what the human brain can do machines will one day do better.

There is also a paradox in being self-aware. The possession of self-awareness may provide, potentially, awareness of a more expansive world beyond our own immediate awareness. Thus while we are aware of ourselves, and go about our business, there is also the interaction, albeit at a subconscious level, with more expansive dimensions. So the question of self awareness on a non physical level has massive implications for future theories of Everything.

The question, however, is how can scientific diligence be extended to areas that as yet have no formal acknowledgement. We must leave that, however, to new generations of scientists to grapple with. It is certainly a paradox, however, that we may know more of the existence of black holes in distant spiral galaxies billions of light years distant than we do of our own inherent nature - self-mind-brain nature.

The drive for self-awareness

It should be borne in mind, however, that homo sapiens has primarily through genetic development acquired a highly developed sensory processing system to allow him to cope and survive in his environment. As the prime rivals and threats to his existence possessed roughly equivalent systems, but were perhaps stronger, faster or had bigger

teeth, his compliment of senses was adequate for the job. It has been argued that this trend has resulted from the need to be successful, to stand a greater chance of surviving.

Another viewpoint on this process is the interpretation that one of the prime drives of evolution appears to be the creation of species that are increasingly self aware. This is a fact noted in evolution that brain sizes have increased across numerous species including our own. One attribute of mankind's handiwork has been to seek to manifest a degree of sophistication and complexity in his technological creations. There is now even the theory that the physical constants of the universe have been so devised that life forms - such as us - can exist within it. The Anthropic Cosmological Principle by John Barrow and Frank Tipler is a book very much for the physicist and which provides a conducted tour of physical laws and relationships to provide some perspective on what they all add up to in this context.

The Higher Self model

When commentators reference the 'magic' theory, this is usually without a great degree of specificity of detail. It is described almost as a factor X which may be present in some way but, its attributes are not distinct. This does not help us try to work out in some way how consciousness may operate. By trawling through mainstream esoteric philosophies, it is possible to be slightly more specific about what this could entail.

This particular model, highlighted in figure 3, is a condensation of various esoteric traditions, some quite ancient, some more relatively recent which try to place the real human identity in some perspective.

The physical body is well known to us. According to the 'magic' theory, this is considered to be directly linked to the

etheric body, which due to its vibrational characteristics is generally invisible to us. There is also a body elemental, a structure closely linked to the needs of the physical body. This aspect has also been linked in some instances to the emotional makeup.

There are other vibrational states above the etheric which are similarly invisible. Energy is applied to the etheric body at various points of contact - the chakras - with the principle ones identified on the crown of the head, the brow, the throat, the heart, the solar plexus, the spleen and the base of the spine.

Various classification schemes may include additional centres. In this context, the physical body is very much a system sustained by energy systems which for most individuals are apparently undetectable.

A key aspect of the 'magic' theory interpretation is the interaction between the brain and etheric body and higher components. Thus an expression of will which originates above the etheric, for example, to move a finger is communicated through the etheric interface to the brain which in turn duly activates the neurons in the brain to move the finger. This level of control requires the correct part of the brain to be stimulated to undertake the required action.

Scientists have been able to use techniques such as PET (Positron Emission Tomography) and MRI (Magnetic Resonance Imaging) to identify brain activity associated with a range of processes such as reading aloud or squeezing a rubber ball. In this aspect, however, there are two paths of information. One is to cause the stimulation to take place and the other is the sensory feedback resulting from the stimulus. It is quite simple, to stimulate muscles by activating elements of the cerebral cortex. This is in fact the way in which a 'road map' of the brain's mapping system is determined. This excitation, however, does not activate the will to initiate the various motor responses - only the action.

It would be quite interesting, therefore to seek to map the points of contact of the will within the brain.

Human Sensory Extensions

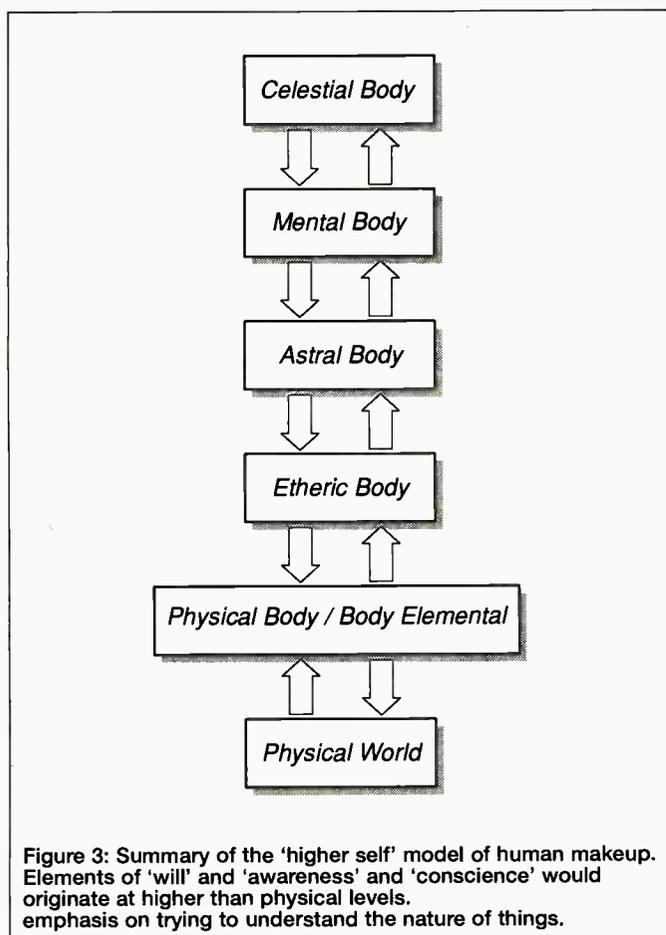
A favourite topic of science fiction writers is the concept of machines more directly participating in our neural or sensory processes. One of the most direct approaches to this is that of the cochlear implant, where external sounds are detected by conventional microphone and processed and fed along the pathway of the Organ of Corti within the cochlea where electrodes make contact with nerve fibres which in turn are connected to auditory centres in the brain. There is in fact, no direct connection between the outside world and the inner ear. This is achieved by inductive coupling.

This development is therefore very much showing the way forward. While various groups are working on the artificial retina, this is still several years away at best.

The Robots at Reading

The optimising of neural network parameters can be directly considered as a learning process. Robots developed at Reading, however, have generally a low number of effective neurons - the latest generation of the Seven Dwarfs with the equivalent of 500.

The topical third generation of Seven Dwarfs robots at Reading University, shown in a group in figure 4, have been established with the following attributes:



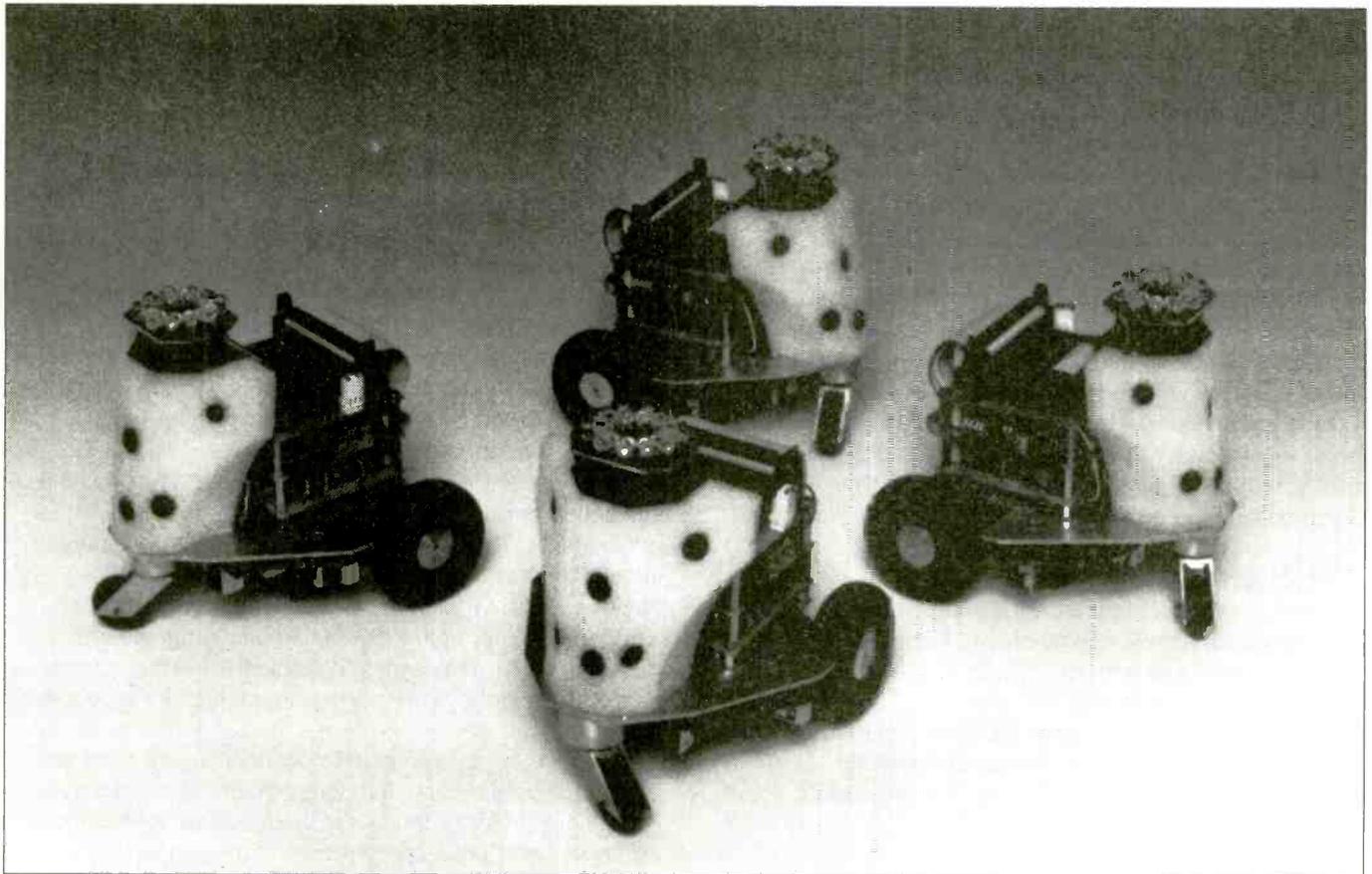


Figure 4: Group of current generation of the Seven Dwarfs (the third).

- a) avoid obstacles as determined by two front sensing ultra sound detectors
- b) dock in a recharge bay when power is required
- c) opt to be a 'leader' robot if no other robots near
- d) follow the 'leader' signal of greatest strength if not already a 'leader'

In their design, the left and right rear wheels can move independently. On top of each unit is located a mini array of infra red transmitters with infra detectors on the front portion of the unit. Each robot is provided with its own carrier frequency on which is superimposed pulses of information. A left and right side ultrasonic detector is used to provide two independent object locating signals.

An early version of Bashful is shown in figure 5.

The relevance of this set of robots is that their sensory systems, number of neural network processing elements and desired behaviour are all in balance so that they form a system that trains towards a 'smart' conclusion.

Elma is a six legged walking robot which has evolved from the previous design of Walter. Elma has sensors on her legs which allows her to detect the weight distribution along her frame. These signals are in turn routed to her processing brain which contains around 100 neurons and which maintains her stability. Elma is much more stable in walking than apparently Walter ever was. At present Elma is controlled by radio link with directions being sent to her for example to make for a given location but to avoid certain areas of the immediate area.

At present the self learning modes of neural network training is being used to train Elma to walk to that she can negotiate difficult surfaces. It is anticipated that the command system will be fully incorporated within future versions of Elma. Thus wherever Elma goes, she learns

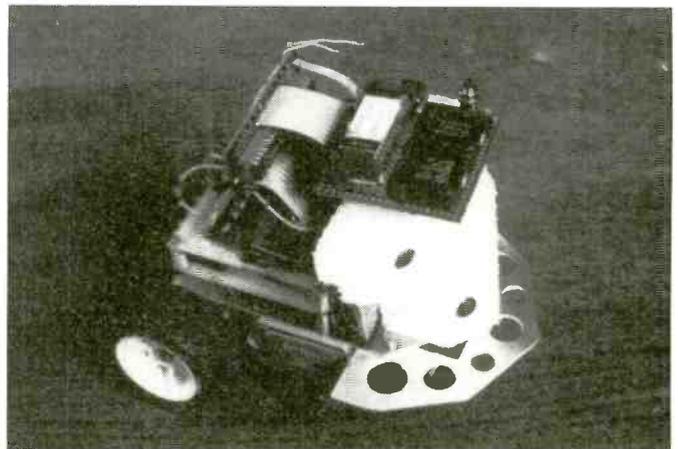


Figure 5: Close up of Bashful when he was first given a new 'neural' brain that could be simply plugged in.

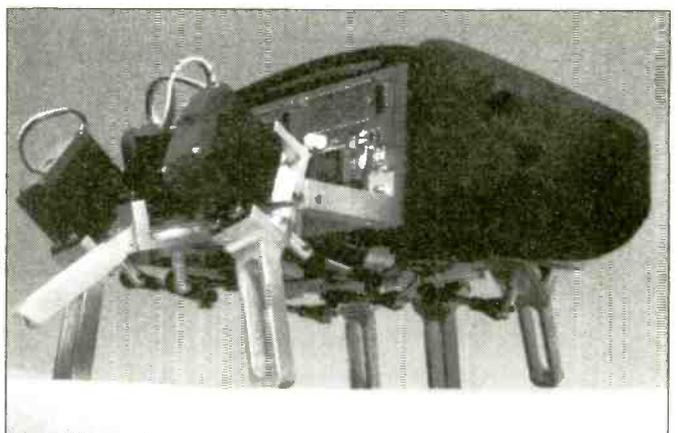


Figure 6: View of Elma, which is at present controlled remotely but which learns through training of neural network circuits to walk over difficult terrain.

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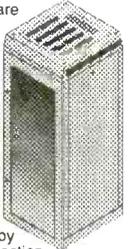


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how to walk better and is more prepared for awkward terrain that may be encountered in the future.

Elma, shown in figure 6, and also on the front cover of Professor Warwick's book, could have practical applications in working in dangerous environments - such as decommissioning nuclear power stations, mapping minefields and autonomous vehicles for space exploration, for example on the surface of Mars. European Space Agency, please take note. In a mechanical sense, Elma is considerably more complex than the Seven Dwarfs. The relevance of a device such as Elma is that it learns to cope with problems of the real world, by adapting its neural network to cope with real problems.

Neural networks and learning

It is the 'self learning' mode of neural network interaction that has principally been developed at Reading. Figure 7 indicates a typical neural network, with a row of inputs feeding forward through intermediate lines to a line of outputs. A training set of data is required to establish the function of the network. With initially random weights added, in the example of one of Professor Warwick's robots, the robot will move about, encounter other robots and other objects. Each of the lines indicated represents a specific value of weighting - with 50 defines in this particular example.

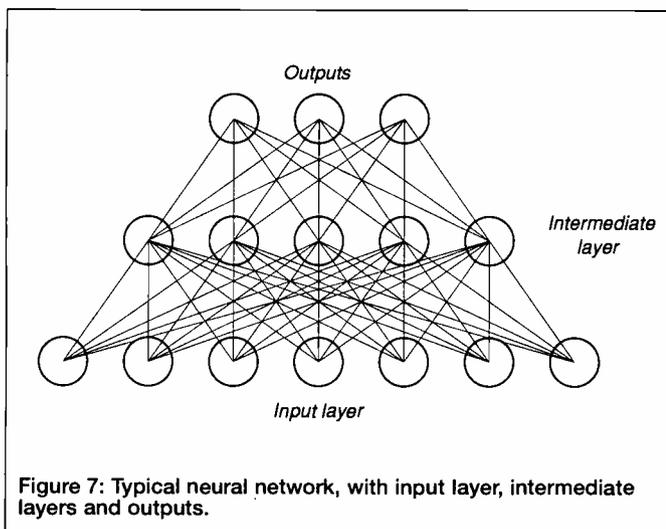


Figure 7: Typical neural network, with input layer, intermediate layers and outputs.

In time through a series of interactions with its environment, the robot will learn not to bump into things. The parameters of the weightings will tend to stabilise, for a particular robot and environment, at a given value. If after a process of learning, all the weightings are reset to the same initial set of random values, and the robot begins to learn all over again, then the final set of weightings will be comparable but not identical since the weightings will reflect exactly what happened to the robot on its way. It is also possible to reset one weighting to a random value and then observe the robot make mistakes as it relearns a more appropriate value of the weighting.

Of course, it is possible to load a set of learned parameters from one robot, transfer these to an identical but untrained robot and the new robot will behave as if it had been trained. By networking robots either in physical close proximity or, for example, across the Internet, it is possible to collate and speed up the learning process. This training across the Internet has in fact been demonstrated successfully.

Raising the AI Profile

The work at Reading has in some ways been centred on developing autonomous devices - self powered through batteries. This has allowed observation of learning modes of such devices and with also the added bonus that such devices are fun to watch and excellent for demonstrations. To the public, one inspection of the robots at close hand is worth hours of lectures on the technology of such devices. One of the achievements at Reading has been to make such technology much more visible and allow it to be captured by today's 'sound byte' media brigade, hungry, as ever, for unusual images.

In conventional approaches to design and construction of electronic systems, the unit is designed, tested and usually after a few minor modifications put into use. In the way that neural networks are developing, more complex development systems are able to adapt their network design to cope with improved power of problem-solving within a given framework. There is not only an ability to solve problems within a given framework, but there is scope to improve the power of the problem solving algorithm. This can involve optimising neural network topologies. This level of self driven enhancement within a framework of increasing complexity of function is seen also as a component of the ability of machine smartness and effectiveness to be enhanced.

So far at Reading we have the aspect of small autonomous objects responding to a very basic subset of environmental requirements and directives, really demonstrating potential usefulness rather than actual usefulness itself.

Elements of Control

In this sense, robots will remain extensions of our will. If some deranged individual develops a highly developed technology which is designed to inflict death and destruction on fellow human beings using robot technology, then this is not because the systems that wreak the havoc are self-aware and know what they are doing. As any software designer knows, however, the more complex systems become, the more liable they are to develop or manifest errors. So there is also the finite possibility that a system developed with positive intent could fail or become unsafe simply through error in its design at some level.

There is also a paradox here. If systems become self adapting and modify their neural network topology to increase complexity and general processing ability, then can such changes be validated as they take place to ensure system integrity? In this sense, the more it modifies its design to do things in a more efficient way, the more there is a potential risk of error.

AI Propaganda

There is also a discrete psychological approach to the development of robotic technology. This tends to demonstrate that after all, *homo sapiens* is nothing startling. Only a few generations of applied technology will produce machines that are much better at everything we have been trying to do.

A sober warning from Professor Warwick is that before long we will lose control of our robot inventions and they will become our masters. All things are possible. If you look carefully, however, at the vast legislative bureaucracy of the European Union, taking extreme care to define the limits of milk content in 'ice cream' then it would be unlikely that the EU would readily sanction the development and release of super robots that would dominate us.

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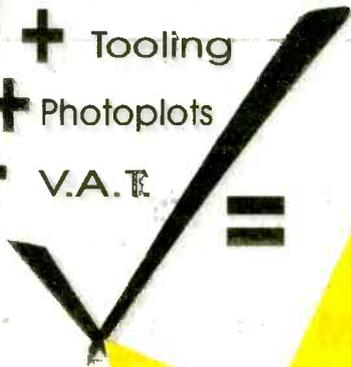
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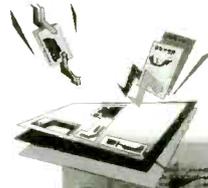
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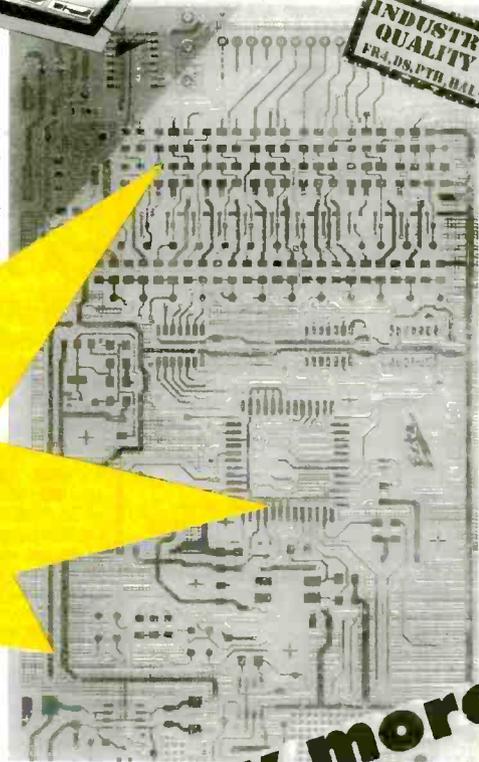


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Security

Although it was not a key remit of Professor Warwick's book, the greatest threat to the efficiency of such systems in present circumstances is to break their security and subvert their software. As disaffected groups feel resentful of the increased level of bureaucratic control of social and economic infrastructure, key computer systems may become even more a 'soft' target and one that, mistakenly, such groups could accept as justifiable. It would appear also more satisfying to subvert such systems than to destroy them.

The Really Useful Robot

It is perhaps useful to guess what a Really Useful Robot Company could develop in the future. It would be possible to program in some directives to autonomous machines. For free moving units, these could be described as:-

- do not run out of power
- do not get lost
- do not run into objects
- always take note of external commands
- undertake tasks efficiently
- fail safely in event of malfunction
- do not present a risk to other objects
- keep a log of everything that has taken place

At a level below this is the computational power to address all these issues. Such systems are becoming smarter, as increasing processing power becomes available. In terms of the effects of such systems on our society, the fact they may or may not be self aware is irrelevant. The coming reality that machines are going to get relatively smarter and smarter.

Sensory superiority

On the sensory side, with modern technology, a vast array of additional attributes can be bundled into a robot. Thus we can add equipment to detect and resolve in different parts of the electromagnetic spectrum outside the relatively narrow band of 380 nm to 720 nm. We can add x-ray spectrometer, gamma ray spectrometer, ultra violet detectors, infra red detectors. We can even add sensors via Doppler technology to determine if objects are coming towards us or going away from us. Also, as technology becomes more compact and efficient, it becomes even easier to extend the sensory armament.

Thus robots can be developed with significantly enhanced sensory systems. It is recognised, however, that the human retina/visual cortex is vastly superior in the processing of visual information compared to any machine. In its limited set of sensory inputs, the human 'machine' does exceptionally well.

Machine Profiles

While it may not be possible for a machine to experience self-awareness, it is entirely possible to provide it with sophisticated algorithms for it to operate within well defined guidelines. The general structure of an autonomous system are outlined in figure 8.

It is clear that the system would in fact be a mix of digital systems and also probably neural network components. The digital systems would provide the goal directive and components to tell how the system should respond in given circumstances. The system would require to verify its function so that it could report faults or move itself into a safe mode if required. It would require levels of security to sanction receipt of data from various sources and also security to transfer data to specific remote

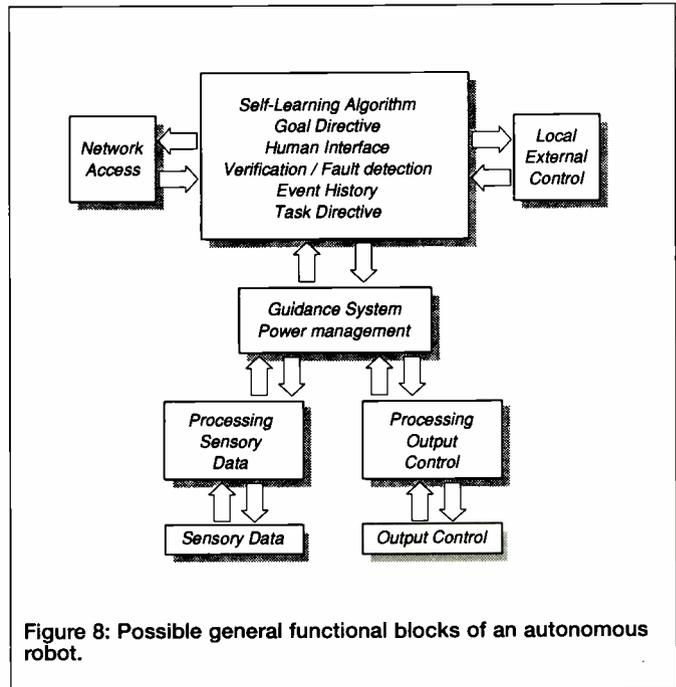


Figure 8: Possible general functional blocks of an autonomous robot.

systems. An event history could be either transmitted continuously or stored on line in order to be able to monitor system integrity or locate faults in event of failure.

Examples have been cited of robots talking to each other over the Internet. The security aspects of this would have to be looked at much more closely if it ever became commonplace. With modern processing speeds of 200 MHz, the potential data handling of such systems would be significant indeed. Technological advances with equivalent speeds of say 2000 MHz systems say in 10 years time gives even more scope to develop useful functionality.

It must be recognised, however, that the fundamental breakthrough with neural networks came about when it was realised how they could be trained. This was barely some ten years ago. While all the time incremental progress is being made in this discipline, it is quite conceivable that there are several major breakthroughs still to be experienced in this field which will allow the structuring and effective training of vastly more complex networks.

It must certainly mean that in a physical environment, smart machines will be doing physical things. To a very large extent robotic systems are already building the next generation of robots. Processes of chip manufacture and development are now so demanding that the most delicate stages of manufacture and design were long ago taken over by automated methods.

A safer society

There is no doubt that our dependence on machines will increase. So far, however (and hopefully) all these systems are very much under the control of their masters. It is our collective responsibility to ensure that this remains so. It is the complexity of our society that is pushing for increased computerisation. In the example of control of aircraft in national airspace, the trend is increasingly to hand more and more over to computers to monitor and direct flight paths. As we make such systems work harder, process more data, make more calculations per second, access data archives which expand rapidly, yes we are giving these systems a more important role in our society. This is primarily, however, because society is itself changing rapidly and these systems are being introduced to respond to this rapid technological change.

In fact key areas for additional implementation of computer/robotic technology are very clearly in evidence. They have a critical role in managing inherently unsafe systems such as a transportation systems, nuclear power plants and many procedures processing dangerous chemicals. One argument could say that without the appropriate use of such technology the future would be a more dangerous and unsafe one.

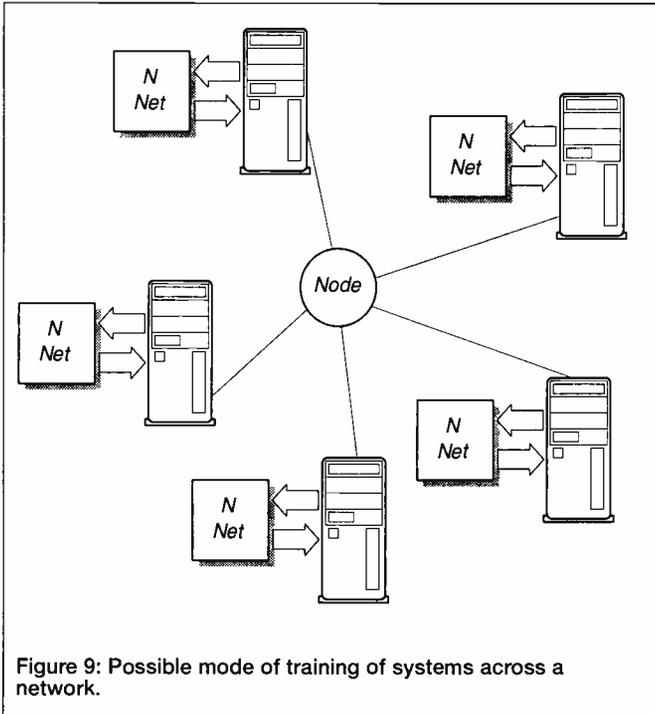


Figure 9: Possible mode of training of systems across a network.

Distributed Training of Machines

The collection of Reading robots presents an example where the small robots are moving about, learning about their environment and refining the training of their neural networks. With the high connectivity of computers today, it is relatively easy to anticipate how systems as networks can learn collectively.

Consider neural networks linked across numerous computers and which have access to a large flow of training data for the local neural networks, as shown in figure 9.

If all of these systems have an optimising algorithm where each system can receive its own training data set locally and also link to the network structure and input/output of other PCs, then the level of training of the PCs begins to increase as weighting factors are developed for the individual PCs and with dialogue from other systems. In this scenario it is imagined that

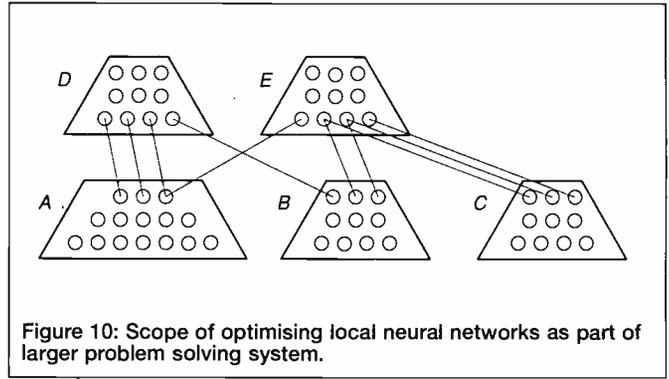


Figure 10: Scope of optimising local neural networks as part of larger problem solving system.

all these systems are configured exactly the same in their neural network configuration. The network of PC's can be considered to be increasing in smartness over the network.

As part of the 'connected' nature of the system, it would be possible for validation of the effectiveness of each local system to be checked against a reference benchmark in order to rank the systems and allow the systems to select in some way the best training data set available across the network.

If however, things are taken a stage further where each local system is given an individual autonomous task where it can optimise the internal connected structure for effective functioning. In this scenario, each local neural network has well defined input/outputs relating to physical parameters. If these are cascaded together across another layer of processing in another layer of local neural networks, as shown in figure 10, again where inputs and outputs are independently defined and have real significance, then training of these local systems can be undertaken.

An so as a thought experiment in neural network development, these systems can be considered to optimise their own internal design to solve the particular problem assigned to them - assuming the physical problem assigned to them can be split up into such local processing modules. By linking these systems in a network, they can be informed of the states of processing in the other systems. One layer would be trained at a time before the next layer was trained from the outputs of the first section. If this model is established in principle, then it is simply a case of expanding it up according to the resources of hardware and software available. This is shown as a two dimensional problem, but it could equally well be developed in three dimensions.

Systems could therefore evolve where each 'box' represents an autonomous 'smart system'. Also, the network connectivity could be superseded by an optimising 'supervisory' system to monitor the functionality of the system and make adjustments to optimise performance.

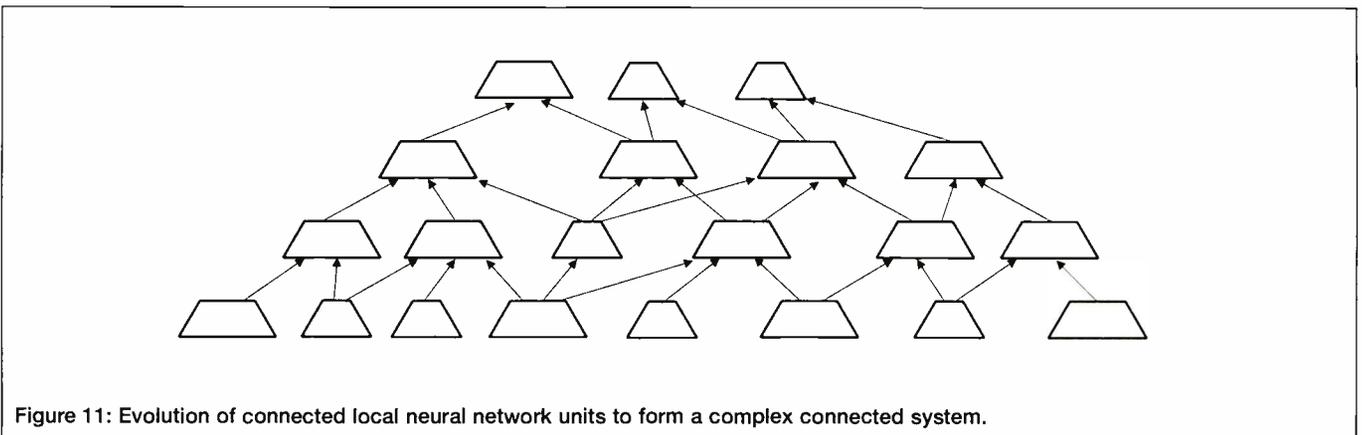


Figure 11: Evolution of connected local neural network units to form a complex connected system.

If a system such as this is to evolve 'organically', then it may require to be associated with a component of trial and error, where some configurations are abandoned while others are retained as they add efficiency to the solution. This would be a role, therefore for some aspect of genetic algorithms in the optimisation of such a system. A complex network could be developed in this way would approach the complexity of the structure of figure 11 where each cell is a relatively complex local neural network implementation. Once 'cell' could for example be a complex spoken language/command interface. Another could be a system for recognition of images.

Such a system, however, is not just a neural network. It is more like some system that has a natural property to make sense out of data, to order it by means of complex training techniques which are in the domain of conventional digital programming. This level of design requires wholly new design structures compared with conventional digital processing scenarios. No doubt this is the scenario which many in this field are seeking ways to implement. It is perhaps not the element of sheer computing power that is the daunting factor - it is the model of connectivity which is the key.

All the hard programming is in the optimising of the network and in the training. Once the network is trained, the inputs are presented and relatively simple programming feeds forward the results. At this stage, operating the network, is a relatively mechanical process. The result of the training procedures and any elements of system configuration would have been achieved

through highly advanced programming. Even if this process is driven to some sort of logical conclusion, where millions of neurons are trained together in a vast association of elements, all interconnected appropriately either with weightings in software or in on chip representations, does this represent machine self awareness? Probably not.

It would, however, represent a distillation of a vast amount of data and experience of the physical world. Such a system could be made to appear uncannily like a human being in various of its responses since this is an area in which training of some patterns of human behaviour would be relatively easy.

Does this also mean that much of the 'intelligence' of the brain is very much its sheer physical organisation. Once everything is set up, using it is very much like clockwork, as inputs feed forward through complex neuronal interconnections. After all, when we go for a walk, this is done without any conscious effort of what we are doing - it is all pre-connected. The human brain, however, is very adaptable. It learns new skills. It links to new memories. If part of it become damaged, it seeks out other functional pathways. We have yet to fully understand how it achieves this.

Socio-economic implications

Today manufacturers scour the world for sources of cheap labour. Plants are established, for example, in China, not with highly developed state of the art automated technology but where products are largely built by hand. The economics of this are still attractive, and the capital investment costs will be lower compared with setting up a highly automated production line. But with increasingly cost effective automation, there will be less demand, anywhere, for manufacturing labour. This could set in train global changes of a very unpleasant type - much more threatening to the status quo than the scenario of berserk robots. In this scenario, low skill/low labour cost economies will be particularly vulnerable to such technological change.

It is not in question that more 'smart' machines will play an increasingly important role in the future as techniques of production change the balance of people and technology. Whole new product ranges, however, will probably emerge to counter balance this trend. There are issues of safety as more and more critical systems are controlled by high technology. There are employment issues as long term established industries fade rapidly away as technological change catches up with them. It is a measure of our loss of control of technology that we are adapting our social structure to cope with technological change rather than controlling technology to serve our social needs.

The new applications

Government agencies are very interested in advances in technology to intercept and monitor all manner of modern communications. Machines could, for example, be trained to be efficient at intercepting and assessing voice and data communications and especially Internet sites which may be undesirable.

It is therefore necessary to be constructive in how this technology will be used. David Brown, in his book *Cybertrends*, maps out some potential pitfalls and ways forward for the future.

Perhaps, more importantly, it is the debate over how such technology will be used that is of more relevance.

Summary

The media interest in the Reading Robots has arisen not because the technology of the Seven Dwarfs was complex or in any way revolutionary, but because they provided a means of communicating to the onlooker the potential of robotic technology for the future.

At the same time, mixed in with this message was the implied reality that one day such robots will surpass us in 'intelligence'.

While it is accepted that robots are set on an evolutionary path of their own and this will affect the nature of our society in fundamental ways, there is plenty of current and indeed increasing scientific opinion which indicates that the 'thinking' or 'conscious' machine will never materialise. The leading edge of scientific thinking is chasing much bigger issues than the cognitive potential of silicon.

In conclusion as a contrast, perhaps it is relevant, however, to contemplate the calmness reflected in some of the larger granite carvings of Ancient Egypt, where material progress was very basic and there was greater emphasis on trying to understand the bigger picture of things.

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Digital Voice Modulator

Based on the HT-8950 voice modulator chip, Robert Penfold's 'voice-box' can add pitch-shift and vibrato to voice signals, with a 'robot voice' for would-be metal men!

This simple project is based on a single integrated circuit, but it provides a number of interesting voice effects that are generated using some basic digital signal processing. The pitch of the input signal can be shifted up or down, and in each case three levels of shift are available. A robot voice effect can also be produced, but this effect is quite strong and it can sometimes be difficult to understand what is being said. It is still a useful facility though, and will appeal to those who do not like to do things by halves. Frequency modulation (vibrato) can be added to both the pitch and robot effects. The audio quality is not in the hi-fi category since the system has only eight-bit resolution and uses a sampling rate of 8 kHz. The quality is adequate for a speech signal, though, and this project is only intended for "fun" applications such as producing sound effects for amateur dramatics productions.

The unit is economic to run as it is powered from a couple of HP7 size batteries that have an extremely long operating life. Inputs are provided at line and microphone levels, and the unit should work well with any low impedance dynamic or electret microphone. Outputs at line and microphone levels are available from separate sockets, and adding the unit into practically any set-up should therefore be very straightforward. The desired effect is selected using three pushbutton switches. One of these toggles the vibrato, and the other two cycle through the available effects in opposite directions. A front panel LED acts as a simple audio level indicator and makes it easier to obtain a suitable drive level, especially when using the unit with a microphone.

Ups and downs

There are two basic approaches to providing a shift in the pitch of an audio signal. One method involves using the heterodyne principle to raise or lower the pitch of every frequency component by an amount that is controlled by an oscillator. This method is rather like generating a single sideband radio signal and deliberately demodulating it using the wrong carrier frequency. However, this method does not necessarily involve the use of high frequencies, and the desired effect can be produced using balance mixers, high quality audio filters, and phasing techniques. Although this system provides a very



"clean" output signal it has a slight drawback in that it alters the harmonic relationship of the components in the processed signal.

For example, an input signal at 1 kHz might contain harmonics at 2 kHz, 3 kHz, 4 kHz, etc. If these are all raised in frequency by 500 Hz, the fundamental frequency would become 1.5 kHz but the first harmonic would be at 2.5 kHz. In other words, the first harmonic would no longer be at twice the fundamental frequency, and the other harmonics would be even further adrift from their correct frequencies. This would not be of importance in all applications, but it gives some "heavy metal" sounds when applied to a singing voice! Another problem with the heterodyne method is that it can only provide a very limited amount of downwards shift. This is simply because a large shift results in the lowest input frequencies being taken below 0Hz, which is obviously not possible. In reality the signal just becomes scrambled.

The second method involves recording the signal and then playing it back at the wrong speed. A higher playback speed proportionately increases the pitch of all the components in the signal, and a lower playback speed proportionately reduces the frequency of all the components. An advantage of this method is that it leaves the harmonic relationship of the individual frequency components intact. The main drawback is that it is very difficult to obtain a really "clean" output signal from a system that works in real-time. In a real-time system the input signal has to be recorded for a short period and then played back at a different speed. If the playback speed is faster than the recording speed, the playback time is shorter than the recording time. This leaves the problem of how to fill in the gaps in the output signal. A reduction in pitch gives the opposite problem with the output signal having a longer duration than the input signal. This means that some of the input signal has to be cut out in order to keep the duration of the output signal equal to that of the input signal. No matter how cleverly the sets of output samples are spliced together you can always "hear the join."

HT-8950

The chip used in this project is the HT-8950 voice modulator which is contained in a standard 18-pin DIL encapsulation (figure 1). While this device is not exactly dirt cheap, it costs very little when you consider the amount of circuitry it contains. As can be seen from the simplified block diagram of figure 2, it contains analogue to digital and digital to analogue converters as well as static RAM, an input amplifier, and a substantial amount of control logic.

The input amplifier is actually an operational amplifier that has a built-in bias circuit, and can be used in the inverting mode. This feeds into a comparator that forms part of the analogue to digital converter. The data sheet for the HT-8950 does not specify which type of conversion is used, but it is presumably a successive approximation converter. A block of static RAM is used to temporarily store the samples produced by the converter, and

then they are output to the digital to analogue converter via a data latch. Of course, the samples are clocked out to the digital to analogue converter at a higher or lower rate than they were recorded, so that the required change in pitch is obtained.

A timebase generator is included in the chip together with all the necessary control logic. An oscillator can be used to frequency modulate the timebase circuit during playback so that the vibrato effect is generated. The mode of operation is governed by seven inputs to the control logic circuit. These really break down into two groups of inputs, and one of these groups (S0, S1, and S2) is intended to provide electronic control of the chip. In this case we require manual control and it is therefore the other four inputs that are used. These inputs are at pins 15 to 18, and they have internal pull-up resistors. In use they are connected to ground via pushbutton switches. Operating the switch connected to pin 15 toggles the vibrato effect on and off. The switches connected to pins 16 and 17 enable the chip to be cycled up or down through the available modes, and the list provided below shows the order that is used. The chip defaults to the robot mode at switch-on incidentally.

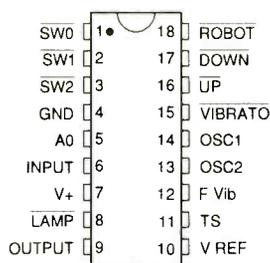


Figure 1: Pin assignments for the HT-8950 voice modulator chip

Up 2
Up 1.6
Up 1.33
Normal
Down 0.88
Down 0.8
Down 0.66
Robot

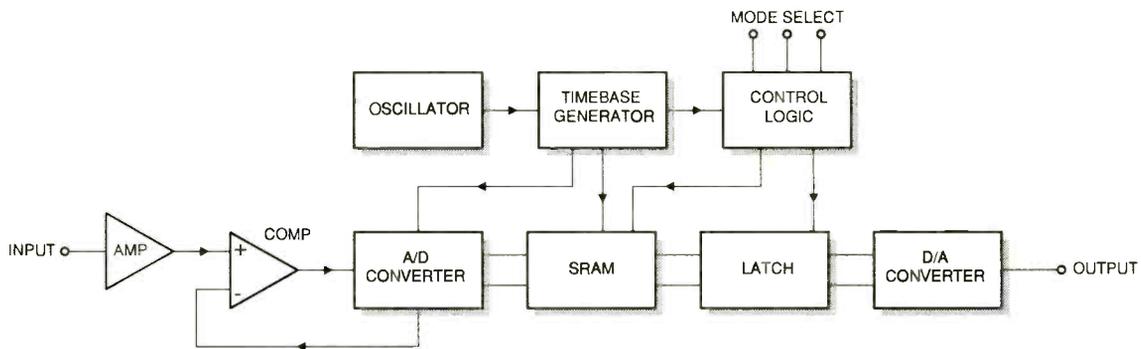


Figure 2: the block diagram for the HT-8950

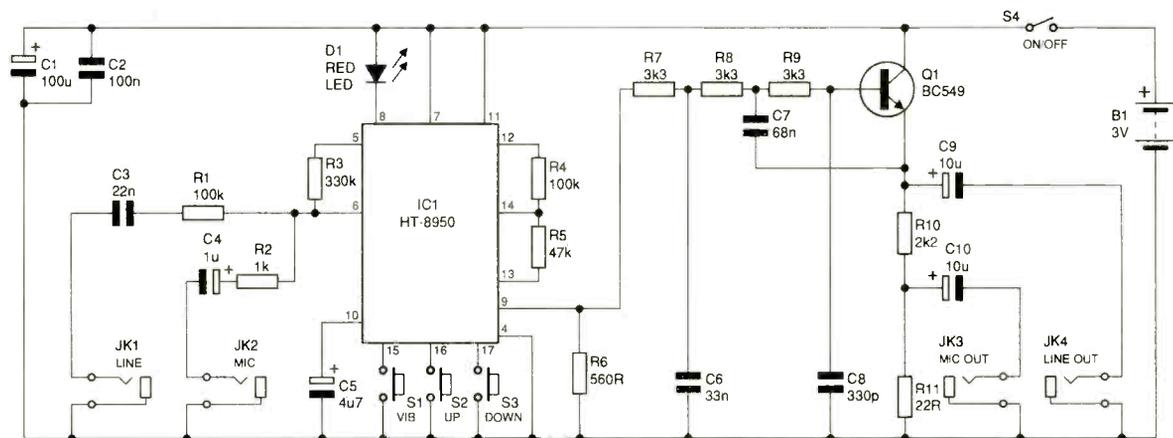
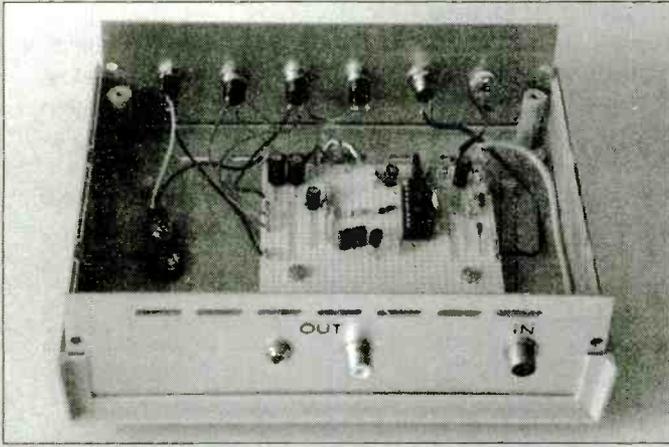


Figure 3: the full circuit diagram for the digital voice modulator



To get to the Up 1.33 mode after switching on you would therefore either press the "down" switch three times, or the "up" switch five times. Operating the switch connected to pin 18 enables the chip to be instantly switched into the robot mode, but this facility is not normally required.

Circuit operation

The full circuit diagram for the digital voice modulator is shown in figure 3. In order to provide inputs for both microphone and line levels the operational amplifier at the input of IC1 is used as a summing mode mixer. Resistor R3 is the feedback resistor and R1 plus R2 are the input resistors. The relatively high value of R1 results in a voltage gain of only 3.3 at the line input, but with an input impedance of 100k. The input amplifier mainly acts as a buffer stage for input signals at line level. R2 has a much lower value, which produces an input impedance of only about 1 k, but this is well suited to a low impedance dynamic or electret microphone. The voltage gain at this input is much higher at about 330, but this higher gain is needed due to the low output level from a low impedance microphone. Even with this much higher level of gain the microphone may have to be used quite close to the user's

mouth. Capacitor C5 is the decoupling capacitor for the internal bias circuit for the input amplifier.

Resistors R4 and R5 are part of the built-in oscillator circuits. R4 controls the vibrato frequency, and the specified value gives an operating frequency of about 8 Hz. R5 is part of the main timebase generator circuit. Switches S1 to S3 are the mode control switches. A switch on pin 18 to provide a shortcut to the robot mode has not been included, but it could easily be added if desired. The digital to analogue converter is a type that provides an output current rather than a voltage, but load resistor R6 effectively converts the output stage to normal voltage operation. The audio output signal from pin 9 is a digitised type which requires the usual lowpass filtering to remove the high frequency components. Q1 is used as an emitter follower buffer stage in a third order lowpass filter that has a cut-off frequency of about 3.5 kHz. This bandwidth is adequate for a voice signal, and is approaching the absolute maximum bandwidth supported by the sampling frequency of 8 kHz. Resistors R10 and R11 form the emitter load for Q1, and they also act as an attenuator which provides the microphone level output. This output is at about -40 decibels compared to the line output level, which should be high enough to fully drive any microphone input, but low enough to avoid overloading.

The total current consumption of the circuit is approximately 2 mA, but it increases to about two or three times this level when audio level indicator D1 is operating brightly. Each set of two HP7 batteries should last about 500 to 1000 hours. Note that the maximum operating voltage for the HT-8950 is just 4 volts, and that the absolute maximum supply rating is just 5.5 volts. Do not use a supply potential of more than 3 volts as this could cause a malfunction, and could even damage the HT-8950.

Construction

Figure 4 shows the component layout for the stripboard panel, which measures 32 holes by 24 copper strips. This is not a standard size in which stripboard is sold, and a larger piece will therefore have to be trimmed to size using a hacksaw. Then drill

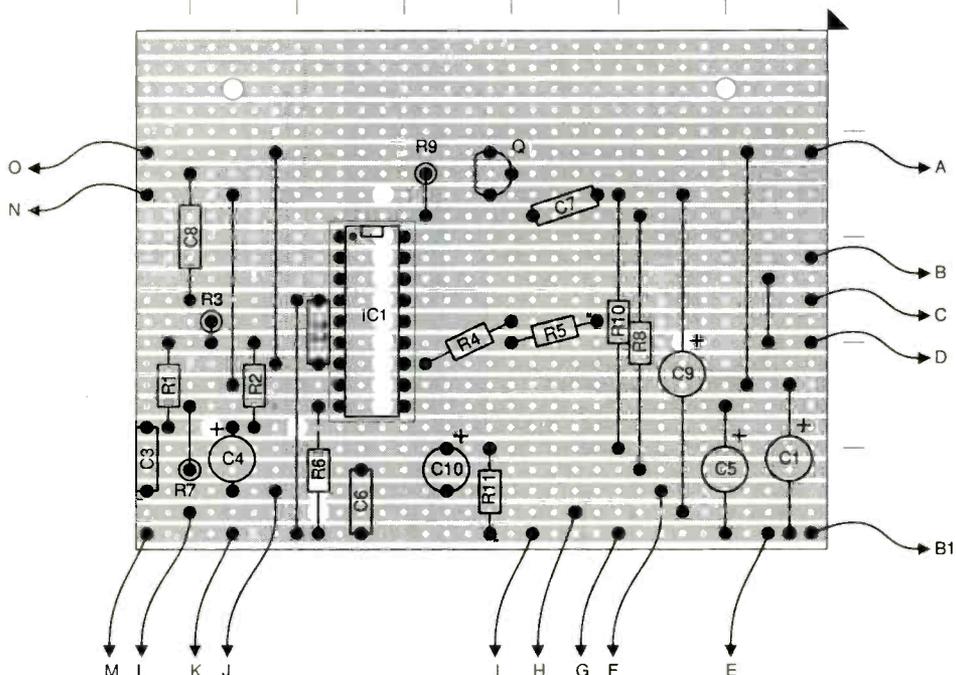


Figure 4: the component layout for the stripboard panel

the two 3.3 millimetre diameter mounting holes which will accept either metric M3 or 6BA mounting bolts. Next the breaks in the copper strips are made using either the special tool, or a hand-held twist drill bit of about 5 millimetres in diameter will do the job quite well.

The board is then ready for the components and link-wires to be added. The HT-8950 is a CMOS device and it therefore requires the standard anti-static handling precautions. As this chip is not particularly cheap it is a good idea to follow these precautions "to the letter." The most important one is to use a holder, and not to fit IC1 into the holder until the board and all the hard wiring have been completed. Until you are ready to fit IC1 into its holder it should be left in its anti-static packaging. When fitting it in place try not to touch the pins any more than is really necessary, and you should obviously keep well away from any known sources static charges.

Apart from IC1, the exact order in which the components and link-wires are fitted to the board is not too important, but it is best to work methodically rather than just fitting components at random. One or two of the link-wires are fairly long, and in order to avoid accidental short circuits they must either be kept quite taut or they must be insulated with PVC sleeving. Fit single-sided solder pins to the board at the points where connections to the off-board components such as the switches and sockets will be made. One millimetre diameter pins are needed for normal 0.1 inch matrix stripboard.

The prototype is housed in a plastic and metal instrument case which measures about 170 millimetres wide, but this is substantially larger than is really necessary. In most respects the general layout of the unit is not too critical, but the leads which connect the input sockets to the component panel must either be very short or screened cable must be used. Even when using a slightly oversized case it can be difficult to find space for everything on the front panel. It is probably better to move some or all of the sockets to the rear panel rather than cram everything on to an overcrowded front panel.

Details of the hard wiring are provided in figure 5, which should be used in conjunction with figure 4 (eg point "A" in figure 4 connects to point "A" in figure 5). I used 3.5 millimetre jack sockets for JK2 and JK3 and phono sockets for JK1 and JK4, but you can obviously use any audio connectors that match the equipment you will use with the voice modulator. A plastic holder is used for the two HP7 batteries and the connections to the holder are made by way of an ordinary PP3 style battery clip. LED indicator D1 is not driven at a particularly high average current and it is therefore advisable to use a high efficiency type. The cathode (k) terminal is usually indicated by having that lead shorter than the anode lead.

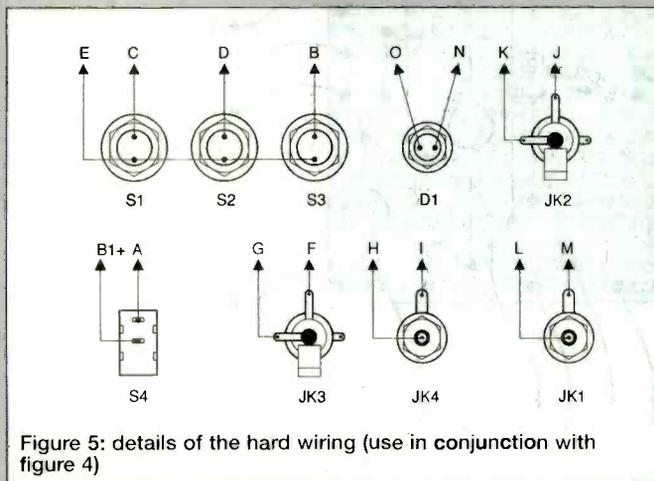
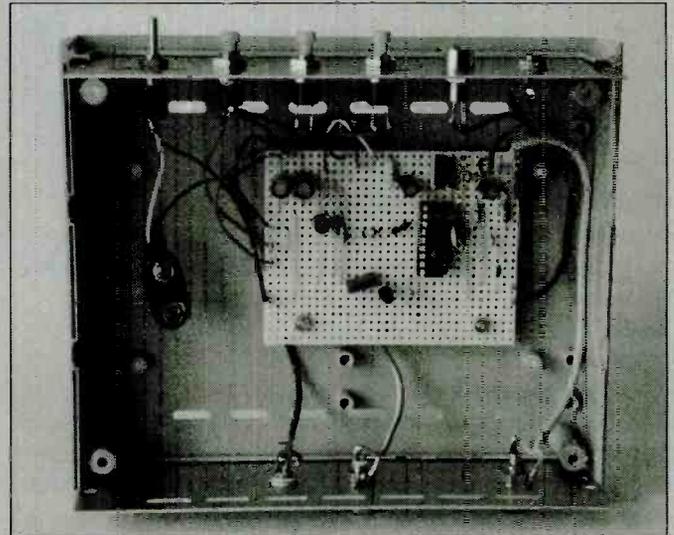


Figure 5: details of the hard wiring (use in conjunction with figure 4)

Testing and use

Mistakes are relatively easy to make when using stripboard, so it is a good idea to thoroughly check the finished unit before connecting the battery and trying it out. A good way of giving the unit an initial check is to monitor the line output using a crystal earpiece, with the input signal being provided by a microphone. At switch-on you should obtain the robot effect, and with or without the added vibrato, as you talk into the



PARTS LIST for the Digital Voice Modulator

Resistors

(All 0.25W 5 percent carbon film)

| | |
|--------|------|
| R1,4 | 100k |
| R2 | 1k |
| R3 | 330k |
| R5 | 47k |
| R6 | 560R |
| R7,8,9 | 3K3 |
| R10 | 2k2 |
| R11 | 22R |

Capacitors

| | |
|-------|-----------------------|
| C1 | 100u 10V radial elect |
| C2 | 100n ceramic |
| C3 | 22n polyester |
| C4 | 1u 50V radial elect |
| C5 | 4u7 50V radial elect |
| C6 | 33n polyester |
| C7 | 68n polyester |
| C8 | 330p ceramic plate |
| C9,10 | 10u 25V radial elect |

Semiconductors

| | |
|-----|---------------|
| IC1 | HT-8950 |
| Q1 | BC549 |
| D1 | Red panel LED |

Miscellaneous

| | |
|--------|---|
| JK1,4 | Standard jack or phono socket |
| JK2,3 | 3.5mm jack socket |
| S1,2,3 | Push to make, non-locking pushbutton switch |
| S4 | SPST min toggle switch |
| B1 | 3 volt (2 x HP7 size cells in holder) |

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| Hewlett Packard 3580A - -5Hz-50KHz | £995 |
| Hewlett Packard 3709B - Constellation Analyser with 15709A High Impedance Interface (As New) | £5750 |
| Hewlett Packard 182T with 8559A (10MHz - 21GHz) | £3750 |
| Hewlett Packard 35601A - Spectrum Analyser Interface | £1000 |
| Hewlett Packard 3585A - 40MHz Spectrum Analyser | £5000 |
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| Hewlett Packard 8595A - Network Analyser 500KHz - 1300MHz | £3250 |
| Hewlett Packard 853A + 8558B - 0.1 to 1500MHz | £3250 |
| Hewlett Packard 182T + 8558B - 0.1 to 1500MHz | £2750 |
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| Hewlett Packard 8754A - Network Analyser 4-1300MHz | £2500 |
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| Marconi 2371 - 30KHz - 200MHz | £1250 |
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| Rohde & Schwarz - SWOB S Polyskop 0.1 - 1300MHz | £2500 |
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MISCELLANEOUS

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| Danbridge JP30A - 30KV Insulation Tester | £1500 |
| Anritsu MG642A Pulse Pattern Generator | £1500 |
| Dranetz 626 - AC/DC - Multifunction Analyser | £850 |
| EIP 331 - Frequency counter 18GHz | £700 |
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| Farnell TSV 70 MkII Power Supply (70V-5A or 35V-10A) | £200 |
| Farnell DSG-1 - Synthesised Signal Generator | £125 |
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| Flure 5101B - Calibrator with Tape Deck | £4000 |
| Flure 5100B - Calibrator | £3500 |
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| Hewlett Packard 331A - Distortion Analyser | £300 |
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| Hewlett Packard 335A - Synthesised Signal Generator (10Hz-21MHz) | £1000 |
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| Hewlett Packard 3456A Digital voltmeter | £850 |
| Hewlett Packard 3438A Digital multimeter | £200 |
| Hewlett Packard 3711A/3712A/3791B/3793B Microwave Link Analyser | £2250 |
| Hewlett Packard 3776A - PCM Terminal Test Set | £POA |
| Hewlett Packard 3325A - 21MHz Synthesiser/Function Gen | £1500 |
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microphone its effect on your voice should be very obvious indeed. The data sheet for the HT-8950 does not give any precise details on how this effect is produced, but it apparently uses a "chopping" technique. Together with the vibrato this produces a sort of super "Dalek" effect! Remember that in any operating mode, pressing S1 toggles the vibrato effect on and off.

By operating S1 and S3 it should be possible to cycle the unit through all the available effects. Once again, the effects are very obvious, especially when using a large shift in pitch. In general it is best to move high pitched voices downwards and low pitched voices upwards. Moving a high pitched voice higher in pitch tends to take many of the voice frequencies outside the bandwidth of the modulator, and gives an output that can be difficult to understand. Similarly, shifting a low pitched voice even lower in pitch can give very poor intelligibility, and a very odd sound!

The input stage operates as a simple summing mode mixer, and the unit will work using microphone and line input signals simultaneously. However, using more than one input signal at a time might not give very good results, and the unit works best if it is only used with voice signals, and one signal at a time.

It is interesting to use the unit on the voices of the rich and famous. Try connecting the earphone output of a radio to the line input of the modulator, and then search the bands for victims. Results can sometimes be surprising, with the voice of someone famous being turned into the voice of someone else who is famous. Shifting the voice of John Major down a couple of notches produces a very good impersonation of Sir Edward Heath! No doubt many other interesting transformations are possible.

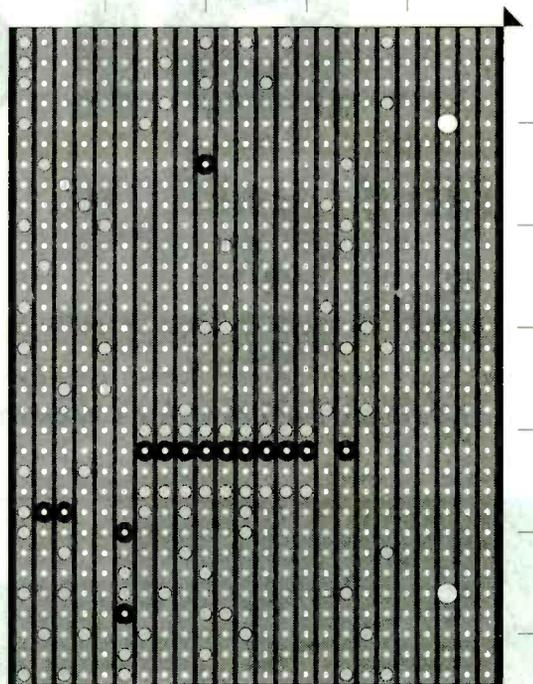


Figure 6: the stripboard reverse

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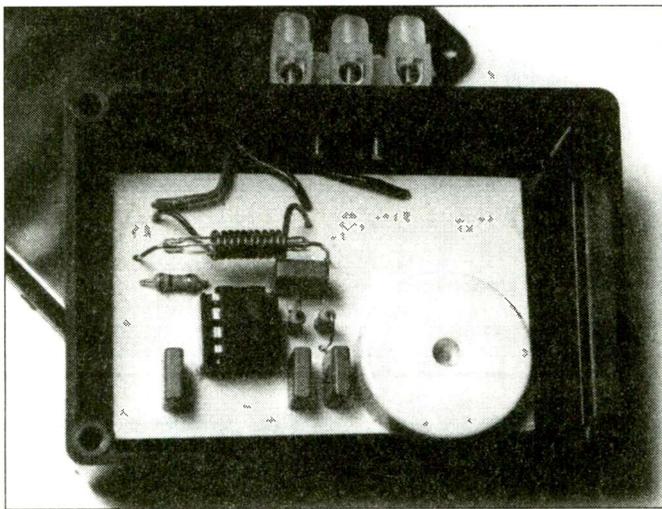
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Brake Light Checker

A self-test system for caravan and trailer brake lights by Terry Balbirnie



Self-check

There is no such checking requirement for the brake lights. However, these are also very important - especially when the lamps on the towing vehicle cannot be seen by the driver behind. The present circuit fulfils this need by checking that the stop lights are both working. Under normal conditions of use nothing happens. However, when there is a fault, a high-pitched bleeping will be given each time the brakes are applied. This will probably be unlike any other sound in the car and, being high-pitched, will be easily heard above engine and other noises. As well as failure of one or both bulbs, faults which will trigger the unit include poor connections at the towbar plug and socket, broken wires, corrosion in cables or at the lampholders and bad earthing. Note that the unit will not operate in the event of a fault which would cause the brake lights on the car itself to fail. An example of this would be the fuse feeding them having blown. Since this fuse carries an additional load of 100 percent, it is necessary to follow the manufacturer's recommendation regarding uprating it if necessary.

The law requires flashing indicators on towed vehicles to have some sort of built-in check to show the driver that they are working. This often takes the form of a small dashboard light which blinks in time with the car indicators if the corresponding one on the trailer is operating. Some systems use a buzzer instead.

How it works

The complete circuit for the Brake Light Checker circuit is shown on figure 1. The principle components are magnetic reed switch, S1, coil L1 and integrated circuit IC1. A complete description will be given presently.

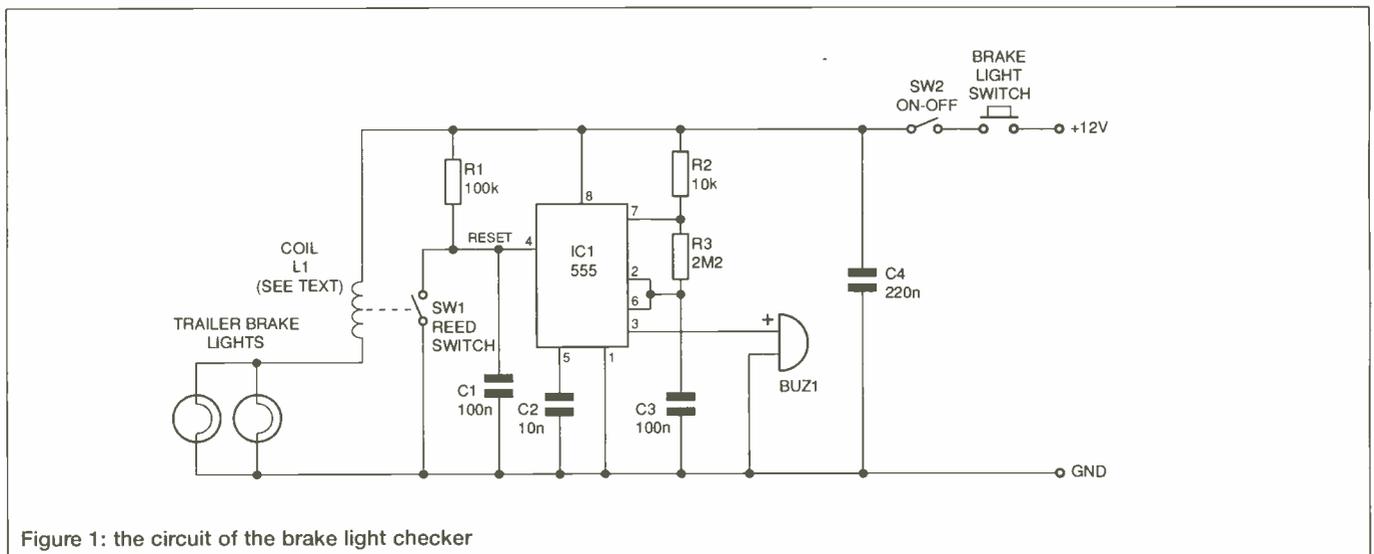


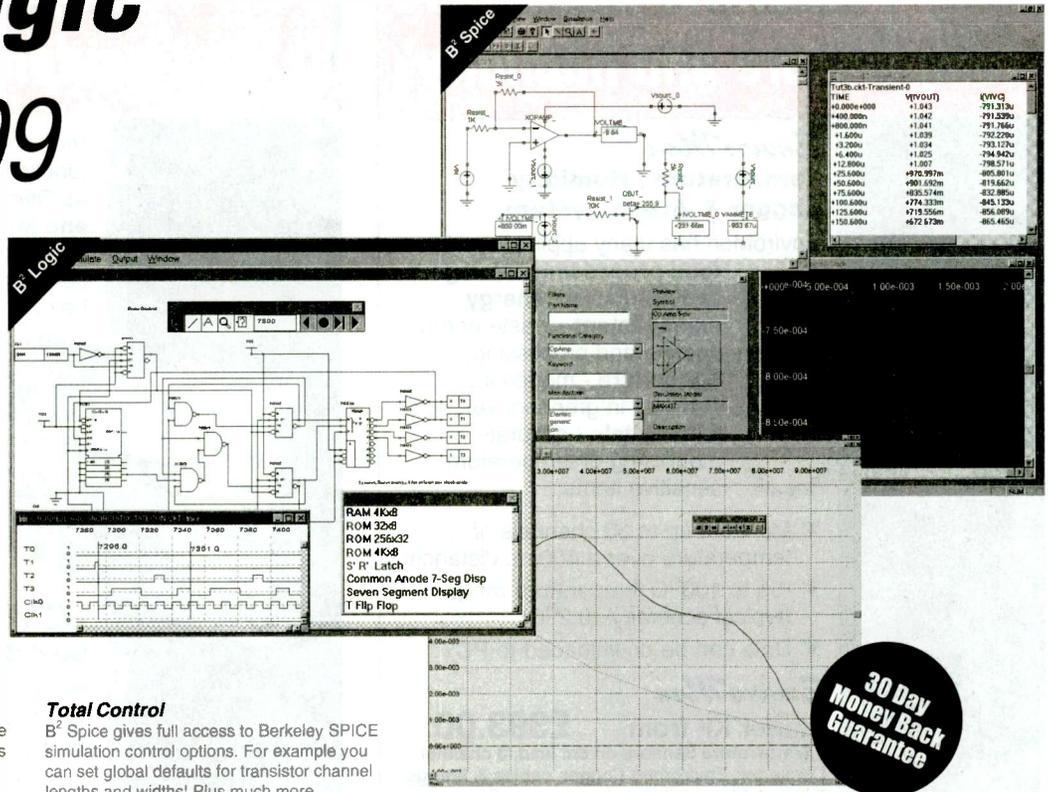
Figure 1: the circuit of the brake light checker

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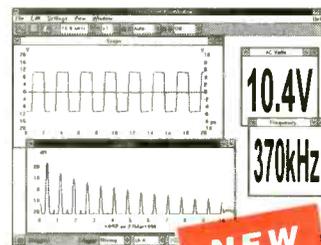
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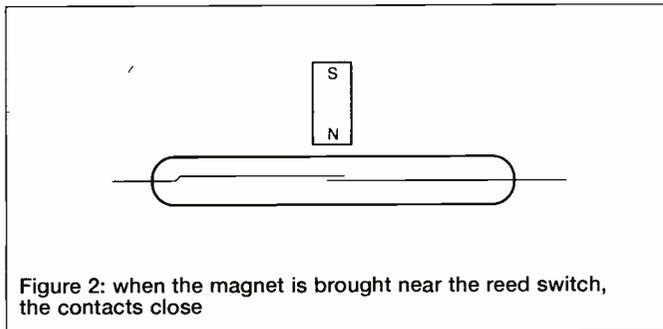
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A reed switch consists of a short glass tube containing two flat magnetic fingers which, under normal conditions, are held slightly apart by their own springiness (see figure 2). When a magnet is brought close to the device, the fingers, or "reeds", become magnetised with opposite polarity. They therefore attract and the switch contacts on them "make". They may be used to operate some external circuit although their current-carrying capacity is quite small. Reed switches have an extremely long mechanical life (in excess of 100 million operations). Providing they carry only a small current, they will therefore have an extremely long life. Their chief drawback is that they are easily broken.

The magnet which operates the reed switch need not be a permanent one. A coil carrying a current produces a magnetic field similar to that of a bar magnet. Such a coil may be wrapped around the reed switch body and, providing it carries sufficient current, will cause it to operate. This is the principle on which the Brake Light Check circuit works. The higher the current flowing through the coil and the greater the number of turns of wire, the stronger the magnetic effect will be. The specified reed switch will operate at between 20 and 50 amp-turns. To explain this, suppose a particular specimen of switch operates at 30 amp-turns. This means that a current of 1A flowing through 30 turns of wire would cause the contacts to close. Alternatively, a current of 2A flowing through 15 turns or 3A through 10 turns would produce the same effect.

Watt was that?

The number of turns on the coil will be chosen so that the current for one bulb is insufficient to operate the reed switch but the current for two will do so. The power rating of a standard brake light bulb is 21 watts. If this figure is divided by the nominal voltage of the car supply, ie 12V, it will give the operating current - that is, 1.75A. With both brake lights on, the current will be double this figure - 3.5A. If the reed switch operates with 30 amp-turns, the number of turns required so that the current for both bulbs will just cause the contacts to close will be 30 divided by 3.5, which gives a figure of about 9.

Since reed switches of the same type operate with different numbers of turns, it may be necessary to adjust the coil at the end of construction to make it work. With the specified switch, the correct number will lie between 6 and 15 turns. Trials suggest that these switches usually operate at the low end of the tolerance. It is suggested that 7 or 8 turns are used as a starting point. In the unlikely event of the switch operating at the high end of the tolerance, the coil will need to be re-wound with more turns. Using the specified thickness of wire (22 SWG) its resistance will be negligible and with 3.5A flowing, the voltage drop will only be about 20mV (0.02V). This is too small to have any noticeable dimming effect on the bulbs. Also, the coil will remain cool in use.

Pulse train

Referring once again to figure 1, the warning signal is given in the following way. IC1 is an integrated circuit timer configured as an astable. Assuming on-off switch SW2 is on, a supply will be provided from the 12V car system when the brake pedal is pressed. Providing reset input pin 4 is high, a train of pulses will be produced at the output, pin 3. The pulse repetition frequency depends on the values of fixed resistors, R2 and R3 in conjunction with capacitor, C3. With the values specified, there will be several pulses produced per second. No adjustment is provided since the exact rate is not thought to be important. These pulses operate buzzer, BUZ 1, which will switch quickly on and off to give a warbling tone. Capacitor C2 is needed to provide stability in the ic.

If both trailer brake lights are on, there will be sufficient current flowing in coil L1 to close the reed switch contacts and make pin 4 low. This disables the ic and no pulses will be produced. Capacitor C1 holds pin 4 low at the instant that the brake pedal is pressed and before the reed switch contacts take over. If insufficient current flows in L1 due to a faulty bulb or for any other reason, the contacts will fail to close. C1 will then charge through resistor R1 taking only a fraction of a second to do so. The voltage at pin 4 rises and the astable operates.

Dashboard switch SW2 prevents the circuit from working when a trailer is not being towed. Without this, the buzzer would sound each time the brakes were applied since the circuit would see the lack of trailer light bulbs as a fault..

Construction

Construction of the Brake Light Checker circuit is based on a single-sided printed circuit board (PCB) and the component overlay is shown in figure 3. Begin by soldering the ic socket in position and follow with all resistors and capacitors. Add the buzzer, observing the polarity - this is marked on the plastic body.

Prepare the reed switch by winding 7 or 8 turns of 22 SWG (0.71mm) enamelled copper wire around it. This must be done with extreme care to avoid breaking the glass. The turns should touch the body but must not be tight. The wire should be wound in one layer and occupy the central part of the reed switch as shown in the photograph. After winding the coil, grip each end lead of the reed switch close to the body using the tip of fine-nose pliers and bend the lead carefully through right-angles. Do not do this without supporting the wire at the body, since any bending pressure transmitted through the wire will crack the glass.

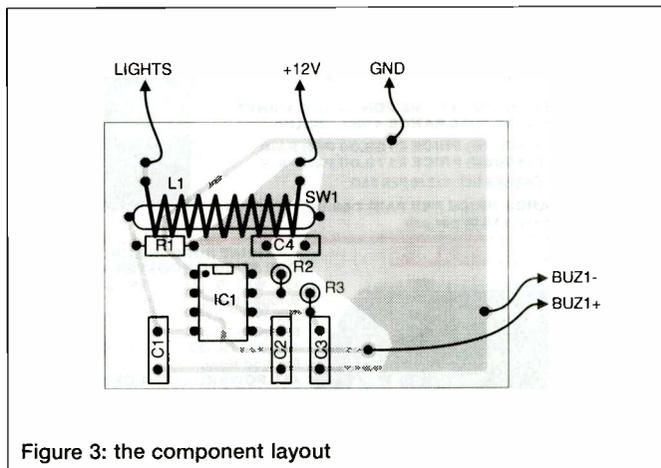


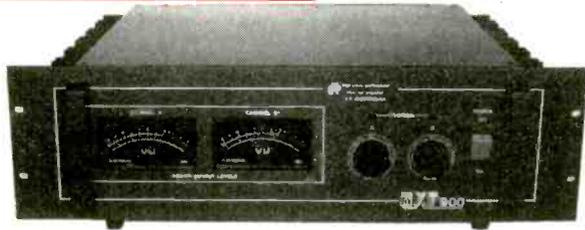
Figure 3: the component layout

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ALL POWERS INTO 4 OHMS

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PRICE £40.85 + £3.50 P&P



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



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



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



OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor > 300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE £259.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

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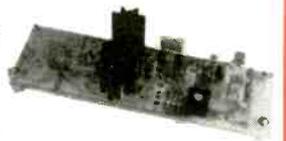


PHOTO: 3W FM TRANSMITTER

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Cut each end of the coil wire to a length of 20mm approximately. Gently scrape off the insulation from the ends using a blunt knife blade or sandpaper. Do not use a sharp blade because the wire may be nicked and will then break at that point sooner or later. Solder the reed switch and coil wires to the PCB in the positions indicated ("C" for the ends of the coil and "RS" for those of the reed switch). Note that the reed switch should be left standing about 5mm above the panel (see photograph).

Solder 5cm pieces of stranded connecting wire to the points labelled "lights", "+12V", and "gnd". Bend the "lights" and "+12V" wires over the short pieces of track leading to the coil connections. Solder them in position so that the wire provides a re-enforcement. This will ensure that the tracks can carry the current for both bulbs without problems. Complete construction of the circuit panel by inserting IC1 into its socket taking care over the orientation.

Adjustment and testing

The circuit panel may be housed in any small plastic box which can accommodate it. Drill a hole in the side for the wires from the PCB to pass through. Drill two small holes and mount the 3-section piece of screw terminal block on the side. Pass the wires leading from the PCB through the hole and, shortening them as necessary, connect them to the terminal block leaving some slack inside. Keep a check on which wire is which and label the terminal block accordingly.

Think about how the PCB will be secured in the box. However, do not attach it permanently yet since it may have to be removed to enable the number of turns on the coil to be adjusted. The PCB may possibly be attached using adhesive fixing pads. Alternatively, a small hole may be drilled in the large copper land area (above the buzzer position) to accept a nylon nut and bolt. If this method is to be used, a short stand-off insulator or plastic washer will be needed under the circuit panel. This will keep the soldered connections on the underside clear of the base of the box. If this is not done, the PCB could be placed under strain when fixing it down and it might crack.

Installing

Decide on a suitable place for the unit so that the buzzer will be heard without difficulty by the driver. A 9V battery may be used to make the circuit operate and this would be helpful in finding a good site. The positive and negative battery terminals should be connected to the "+12V" and "gnd" positions respectively on the terminal block. Note that the buzzer will be a little louder when operated from the 12V supply. Check that it can still be heard with the engine running. Now decide on a suitable position on the dashboard for on-off switch, SW2. This should be a proper auto-type switch with a rating of 5A minimum.

Attention may now be given to the external details. Locate the wire leading from the car wiring harness to the brake light terminal on the drawbar socket. The conventional colour for this wire is red. Cut it at a convenient point and extend the free ends to reach the chosen position for the unit. Use proper auto-type wire of adequate rating and make the joints using "snap lock" connectors which are available from any car accessory store. Where the wires need to pass through a hole in metal, a rubber grommet must be used. The end leading to the drawbar socket should be connected to the "lights" position on the terminal block. The other end,

PARTS LIST for the Brake Light Tester

Resistors

| | |
|----|------|
| R1 | 100k |
| R2 | 10k |
| R3 | 2M2 |

Capacitors

All metallised polyester with 5mm pin spacing

| | |
|--------|------|
| C1, C3 | 100n |
| C2 | 10n |
| C4 | 220n |

Semiconductors

| | |
|-----|--------|
| IC1 | NE555N |
|-----|--------|

Miscellaneous

| | |
|------|---|
| SW1 | Reed switch - 20mm body length x 3.2mm diameter approx. |
| SW2 | Auto-type on-off switch. 5A rating minimum |
| L1 | 22 swg (0.71mm) enamelled copper wire |
| BUZ1 | Miniature piezo buzzer |

2A screw terminal block - 3 sections required.
8-pin dill socket;
plastic box for project; small hardware.
Auto-type wire,
snap lock connectors.

All components for the Brake Light Checker are available from Maplin.

which will be live when the brake pedal is pressed, should be connected to one of the switch terminals. The other side of the switch should be connected to the "+12V" terminal on the unit. The "gnd" connection should be taken to a convenient nearby earth point.

Finishing off

Do not connect up the trailer yet. Switch on S2 and the ignition (if necessary). Press the brake pedal. The buzzer should sound. If it does not, there is a circuit fault and this must be investigated before proceeding.

If all is well, plug in the trailer. With both trailer lamps working the buzzer should remain silent. Remove one of the bulbs to simulate failure and operate the brakes again. The buzzer should now sound. If the buzzer fails to work with one bulb connected, it will be necessary to remove a turn or two from the coil. With care, this may be done without desoldering the reed switch. If the buzzer sounds with both bulbs working, it will be necessary to remove the reed switch from the PCB and wind a new coil with more turns on it. However, this is unlikely. Check operation with the engine running since then the current rises slightly.

Measure the position of the buzzer and drill a hole in the lid of the box to correspond. This should be a little larger than the hole in the top of the buzzer itself. Secure the PCB inside the box and check that it cannot move in service. Fit the lid. Mount the completed unit in position and check for correct operation.

Final note

Always remember to switch on the circuit before a period of towing. This should be made part of the routine such as immediately after the plug has been inserted in the drawbar socket.

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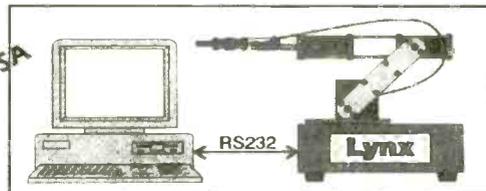
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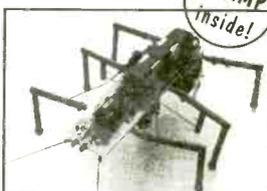
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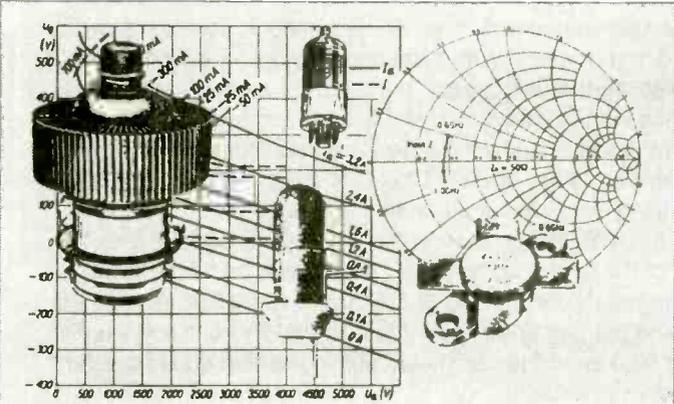
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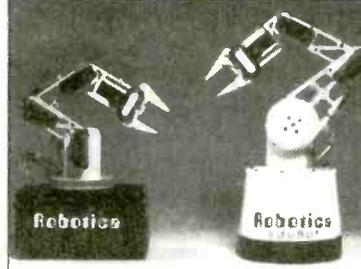


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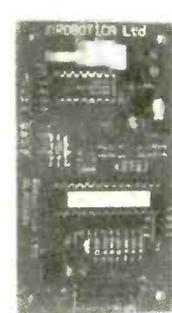
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Practically Speaking

BY TERRY BALBIRNIE

This month we go back for a refresher on Ohm's Law

This month we continue with some calculations used in electronics. We shall look at Ohm's Law and how it may be used during the testing and development of circuits. Ohm's Law is probably the most important calculation in this type of work. Even if your maths is very rusty, it is worth learning to use it because you cannot get very far without it.

Ohm is where a volt lives

Suppose you wish to know how much current is flowing through a resistor in some circuit. You may, for example, wish to know that the current is not too high and draining the battery too quickly. One method would be to disconnect one end of the resistor from the circuit panel and connect a multitester set to a current range between the free ends. This would give a direct result but it would be very inconvenient to do. A better approach would be to connect the multitester set to a voltage range across the resistor. From a knowledge of the value of the resistor (using the colour code) you could use Ohm's Law to calculate the current flowing through it.

This method does not require any de-soldering and re-soldering and so is much quicker to carry out.

Two out of three

Ohm's Law is a way of finding either the current, the voltage or the resistance by knowing the other two. It is expressed mathematically in the following three ways. The appropriate one is then used, depending on whether it is the current (I), the voltage (V) or the resistance (R) that you wish to know.

To find the current I (as in the above example) we use:

$$I = V/R$$

This means *current equals voltage divided by resistance.*

If we wish to find V we use:

$$V = I \times R$$

Which means *voltage equals current multiplied by resistance.*

If we wish to find R we use:

$$R = V/I$$

Which means *resistance equals voltage divided by current.*

You can then work out the result using a calculator or, if the numbers are easy, in your head.

You must remember that the current must be expressed in amps (not milliamps or microamps), voltage in volts (not millivolts or microvolts) and resistance in ohms (not kilohms or megohms). You will therefore need to convert any milliamps into amps, kilohms into ohms and so on (Practically Speaking deal with this last time).

Examples

A resistor having a value 2R is found to have a voltage of 12V across it. The current flowing through it will therefore be 12 divided by 2 or 6A.

A resistor of value 8R has a voltage of 2V across it. The current flowing through it will be 2 divided by 8 or 0.25A. Note that here it is vital to divide 2 by 8 and not 8 by 2.

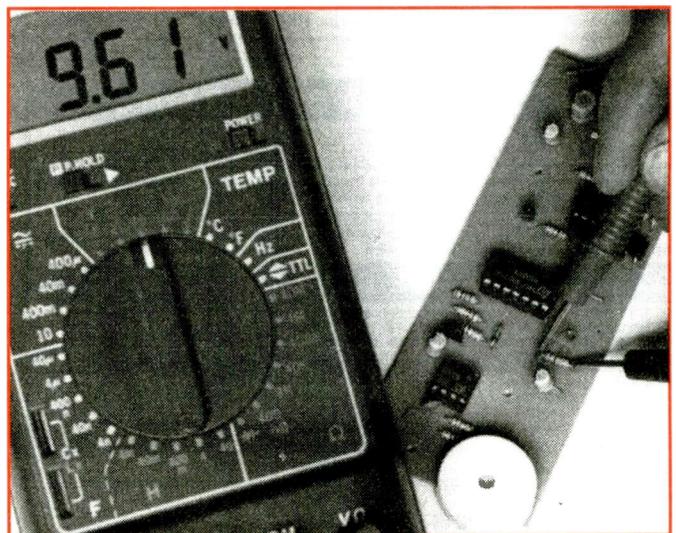
A resistor having a value of 4.7k has a current of 4mA flowing through it. The voltage across it will then be 0.004 multiplied by 4700 (having been converted into amps and ohms respectively) giving 18.8V

A resistor is found to have a voltage of 16.8V across it. The current flowing is 2.5mA. The value of the resistor is then 16.8 divided by 0.0025 or 6720 ohms.

Note: if the resistance is left in kilohms and the current in milliamps, the calculations work without conversion. It will also work where the resistance is in megohms and the current in microamps.

There is no problem measuring the voltage across a resistor when it is connected to the supply direct. However, most circuits are more complex and involve other resistors which appear in series with the one in question. In such situations, it is important for the meter itself to have a much higher resistance than that of the other resistors. This is because a negligible current must flow through the meter. If this were not so, it would seriously affect the result. A digital multitester generally has a resistance (usually called the impedance for reasons which will not be entered into here) of 10M or so and this will usually enable it to measure the voltage very accurately.

Measuring the voltage across a resistor



Higher Education in electronics

SPECIAL

If you are looking to go on to higher education in Electronics or Computer Science, this is the season to make up your mind what, where and how.

If you are one of ETI's younger, and maybe newer, readers you may be thinking about higher education, and whether to turn your main interest into a career.

You may not be studying electronics at school. The trend in recent years, especially in state schools in the UK, has been away from a few people doing electronics at GCSE level and towards everyone taking National Curriculum Design and Technology, and Science, both of which include some electronics.

The lack of a specialised electronics course at GCSE or 'A' level is not a barrier to higher study in electronics, engineering or computer science, especially if you are already an active hobbyist reading and building projects. There are numerous courses open to students with no specialist qualifications, and as many colleges also run introductory or foundation courses leading to degree study in electronics and engineering, you can go all the way if you are willing to dedicate the time and effort.

Not long before time of writing, a major semiconductor manufacturer opening new plant in the UK and expressing confidence in British design expertise nonetheless expressed concern about the lack of students studying Physics at school - an important requisite for high-level design work. But it is possible to make up study in these areas during Higher Education - something that engineering students may want to look into as they choose their courses.

To get a clearer idea about what qualifications you might need to work in a certain area of electronics, or, perhaps, what kind of employment your study could lead to, the first stop is your school careers officer. They should be able to give a broad view of what kind of employers are looking for electronics and engineering qualifications. Following this, it is worth finding out which colleges run the kind of courses you want to pursue - some reference works are listed at the end of this article - and writing or phoning for prospectuses as soon as possible. This will not only give you an overview of what the college teaches, and the kind of course modules you can take, but some prospectuses give information about which areas of industry your study can lead to.

Once you are forming your ideas, it can be thought-provoking to identify companies that employ technicians, engineers and designers and writing to (or phoning) their personnel departments with a general enquiry asking what kind of qualifications they are looking for. With large companies it may be more appropriate to write. With smaller companies, you are more likely to get a response if you (or someone in your family) makes a phone call. Make it clear that you are only looking for information and not fishing for a job. Take notes and try to keep calls short and to the point; all companies, especially small ones, avoid "time wasters". Of course, if you are lucky (or unlucky, depending on your view) you may get through to a boss who loves to tell people about the business. Possibly more than you ever knew there was to know!

Your school will introduce you to UCAS (Universities and Colleges Admissions Service), but if you are not at school, you can write after August 1 of the year you wish to enter college to UCAS, PO Box 28, Cheltenham, Gloucester GL50 3SA. You can also get assistance from your local Careers Office - look in your local phone book under, for instance, Careers Services. There are professional Careers Guidance companies, but look for local authority-run Careers Offices which will see you without charge.

Looking for a college

Higher education colleges offer a variety of courses distinct to each college, from foundation courses and GCSEs up to degree level and beyond. Which you are looking for depends on your qualifications and experience so far, the kind of work you hope to do and the amount of time you want to dedicate. Broadly, if you have 'A' levels and can study for three to four years further, you can aim for a degree course. One criticism aimed at degree courses in the past was that while the student studied all-important theory to a high level, practical experience and, particularly, experience of business and industry was often lacking. The Universities' answer was that students are expected to be bright and flexible enough to gain additional practical and business skills quickly when they go into employment. There is no substitute for practical experience on the job, but experience is not a substitute for an all-round education, either.



They need to complement each other. However, many Universities are now more conscious of the need for industrial awareness and take steps to include this. The other side of the argument is that for dedicated design engineers, an extensive grasp of mathematical engineering principles is much more important than business awareness, which they can gain in working life if they have any aptitude for it. There is much truth in this view; high-level engineering is demanding. We would say, though, that unless you are aiming for an esoteric career in academic electronics or physics, that choosing a higher education course that shows an appreciation of industry needs will give you a better grounding. There is nothing to beat having an understanding of what is actually needed by your company's customers.

Wherever you hope to enter the higher education system, find out from your likely colleges what their attitude to industry is and whether any out-placements or industrial awareness modules are included in your course. This may help you in your final choice.

Highbury College

Among the prospectuses that ETI looked at this year, Highbury College in Portsmouth offers a range of technology courses from foundation level up to pre-degree or a vocational degree equivalent. Highbury's Engineering (Electronics) BTEC

GNVQ Intermediate one-year course offers a broad-based introduction to Electronic Engineering, including relevant GCSEs if required, for students with no formal applications, leading straight to working life or on to A levels or the two-year Advanced BTEC GNVQ course - which itself leads the student into working life, or on to Degree or BTEC Higher National Diploma level. The BTEC HND is a two-year course offering a combination of academic and practical study in partnership with Portsmouth University, requiring five GCSEs (grade C or above) including Maths and a science, together with a relevant A or AS level pass, or the relevant BTEC Certificate or Diploma.

These are quite standard entry qualifications for Degree level, and the BTEC HNC is roughly equivalent to a Degree. A BTEC qualification is generally regarded as more vocational and less theoretically-based than a University; some employers may regard this as an advantage, but if you want to do design or research, or move into higher management you should consider entering for a degree course rather than an HNC as soon as you qualify.

Highbury also offers a two-year BTEC National Diploma at a slightly higher level than the Advanced GNVQ as a preparation for Degree study or working life. There is also a one-year introductory course in Electronic and Microcomputer Technology for unqualified applicants as a preparation for further study or trainee posts, including the Armed Forces. There is an equivalent set of Mechanical Engineering courses, as well as more general A level, GCSE and University Foundation courses on the same site. Another advantage of technically-based colleges like Highbury is that if you want to try your hand at video production (or journalism!), or get your hair curled by a fellow-student, you are very likely to be able to do so. There is also plenty of provision for student guidance, careers information, etc. and the college is happy for prospective students to call or visit the Student Advice Centre for advice before applying.

University of Hertfordshire

The University of Hertfordshire is based on several separate campuses in Hatfield, Hertford, St. Albans and Watford in Hertfordshire, about 50 miles north of London. The Faculty of



Engineering is based at the Hatfield Campus in Hatfield, and offers several BEng degrees involving electronics studies, plus two BSc degrees, and several Masters (MEng) degrees. The engineering courses aim to meet the needs of project management and creative application of technical knowledge for useful ends, and students will undertake case studies, project work and laboratory work, as well as opportunities to work in teams with students from other disciplines. Many of the courses include an opportunity to study a European language, and there are some opportunities for industrial placements and study in Europe and the USA. There are alternative routes into engineering for people without standard entry qualifications; several degrees are

also offered as extended degrees with a preliminary year. The preliminary year also addresses important general topics such as teamwork. There are Electronics and Manufacturing programmes available within combined modular degrees, again for students who are not following a traditional maths and physics based route.

The University's BEng courses include BEng Honours Electronic Engineering, BEng Honours Communications Systems, BEng Honours Digital Systems, BEng Honours Electrical and Electronic Engineering, BEng Electrical Engineering, BEng Honours Electronic Engineering with Medical Electronics, BEng Honours Power Electronics and Control and BEng Honours Computer Aided Engineering, all of which either fully accredited by the Institution of Electrical Engineers (IEE) and lead towards Chartered Engineer status, or are accredited qualifications by the IEE. There is also a BSc Honours in Medical Electronics or Medical Electronics with German, which can lead towards Chartered Engineer status upon graduation, and a BSc Honours in Engineering Management, in combination with the University's Business School to train managers capable of handling the resources of modern manufacturing and engineering industries.

All these courses can be undertaken as an Extended Degree, and most of them have a required or (usually) optional Sandwich Year, with a paid industrial placement. A Sandwich Year provides practical experience in a real industrial environment, working with engineers, managers and technicians already case-hardened to the job and therefore with a somewhat different slant on it. Indeed, some feel that one benefit of college study is that students can acquire knowledge and experience without the pressures of commercial life - the two must in time be combined into a grasp of practical engineering.

The University of Hertfordshire also offers several computing BSc Honours degrees, mainly four-year sandwich courses, including Computer Science in Europe, currently based around German. Students learn German, do a six-month industrial placement and a year of study in Germany, and gain the Diploma Informatiker (German BSc.) as well as the UK BSc. As second language capability is now a very valuable asset in



Electronics Engineering, Aston University

building a career, courses of this type (which tend to have a limited number of places) are much sought-after.

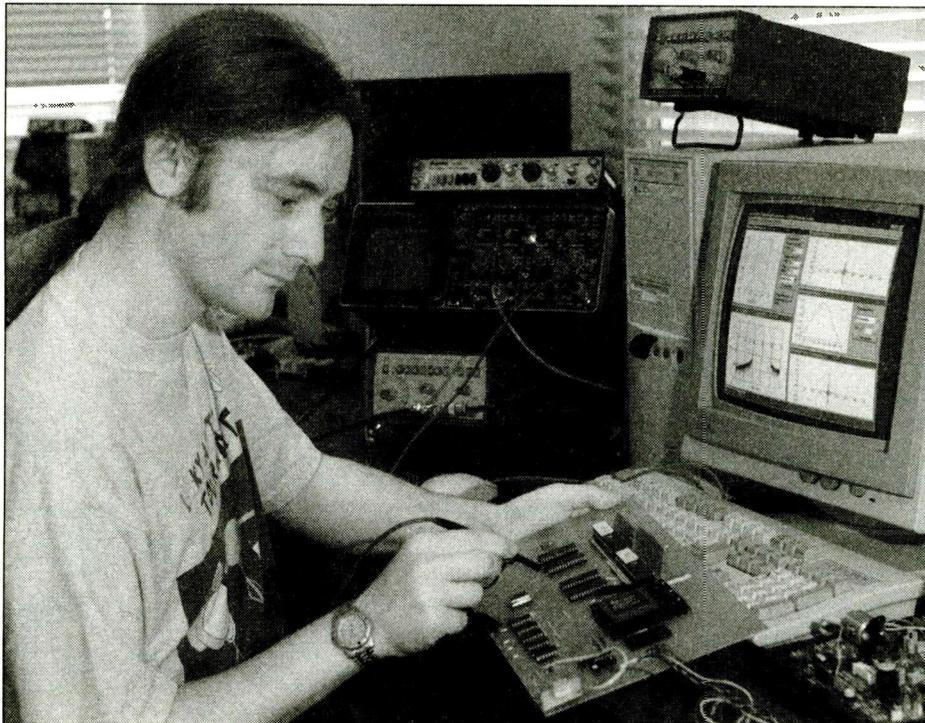
The faculty of Information Sciences also does a number of two-year (three years if Sandwich) HND courses in computing, which can lead to a final year degree course for students with good passes. A network of approved NVQ assessment centres at the University give students the opportunity to gain recognition in areas such as management, business administration, information technology, etc. as complementary to their degree courses.

The University encourages people who may not have traditional qualifications to enquire about routes. As with many colleges, a certain amount of advice about grants, application, how to build up qualifications for a career, and so on can be given to prospective students, especially those who are not coming from school and may not have access to this information.

Aston University

Aston University in Birmingham has a well-established reputation for mathematics and engineering, and prides itself in particular on two benefits: its heavy investment in high-quality computing facilities for all its students, with IT integrated into all degree programmes - indeed, it is proud to be able to claim that students "cannot avoid developing high-level skills in computing and information technology" - and a graduate employment "second to none", with a higher proportion of graduates finding permanent employment within six months of graduating than any other British university. There is also an emphasis on optional Sandwich programs for practical professional experience.

Aston offers BEng degree courses in Electrical and Electronic Engineering, Electronic Engineering with Management studies, ElectroMechanical Engineering, Electronic Engineering and Computer Science, Communications Engineering and Electronics combined with a Business, Language, Science or Social Science subject. These are available as three year courses, or four years with a Sandwich year. Electrical and Electronics, and ElectroMechanical also have a foundation year (STEPS) available. The first year of all the Electronics and



off on a campus deep in the country. If you are an outdoor type, you may feel equally cut off in the middle of a large city. Some people prefer to live away from the main campus (if one exists; in London, for instance, college accommodation is scattered throughout the city and suburbs); you may be expected to find your own living quarters for at least one year of your course, as there is still a shortage of college rooms. So it is a good idea to look for somewhere you will be happy to live - as long as the course takes priority.

Resources

Even small local libraries usually have reference books listing colleges and courses for the current or previous year. Some suggested sources are (usually to be found in the Reference section under Education - look under R378 and R370 for a start):

The Times Good University Guide
edited by John O'Leary (Times Books)

The Big Official UCAS Guide to University and College Entrance (Letts Study Guides with The Independent)

Which Degree 1997 - Volume 2: Engineering, Technology and Geography and Volume 3: Science, Medicine and Mathematics
CRAC Student Guide (Hobson's Publishing)

DOHE (Directory of Higher Education): How to Choose your Higher National Diploma Course
edited by Eric Whittington (Trotman & Co.)

Don't be daunted by the mass of information that some guides offer (the UCAS guide, in particular, is perhaps more suited to careers officers than new students), but use them to pick out the addresses and phone numbers of colleges offering courses that appeal to you, and then contact the colleges themselves for their Prospectuses, which will give you their up to date entrance requirements and other details in a format designed for students. The DOHE Guide is handy for pointing out which colleges offering HNDs also have "transfer" courses to degree level.

Next month

Next month we will be looking at some more colleges, including some Masters and other courses for postgraduates and people returning to college from working life.

To obtain prospectuses from the colleges above, contact Highbury College on 01705 283373 or write to Highbury College, Cosham, Portsmouth PO6 2SA; contact the University of Hertford on 10707 284000 or write to the University of Hertfordshire, Hatfield Campus, College Lane, Hatfield, Herts AL10 9AB; contact Aston University on 0121 359 3611 or write to Aston University, Aston Triangle, Birmingham B4 7ET (email prospectus@aston.ac.uk, Web Site <http://www.aston.ac.uk.home.html>)

Computer Science courses cover the fundamental principles of electronics engineering, physical science and computer science, so that whatever direction the student chooses to pursue in the second year and after, a grounding across all the related disciplines is firmly in place.

Arguably, as school courses become less specialised, firm grounding early in a degree course is increasingly necessary. As far back as the 1970s, when new math courses (some of them ill-fated) were being introduced into British schools, engineering students found that any gaps in their maths could not be filled by their University courses, and they had to make up lost ground as best they could. These days, good colleges are prepared to make certain that students are properly grounded during their course. A good study record at GCSE and A level, or any parallel qualifications offered, is still necessary for degree study at most Universities, but help can often be obtained in weaker subjects.

Aston's degree courses are accredited, as should be the case with good degree courses, by the IEE or the British Computer Society, or in the case of newer courses will be submitted for approval at the relevant body's next visit to the University. Aston has a further Open Day this year on Monday 29th September. University Open Days usually take place in late April/early May and September

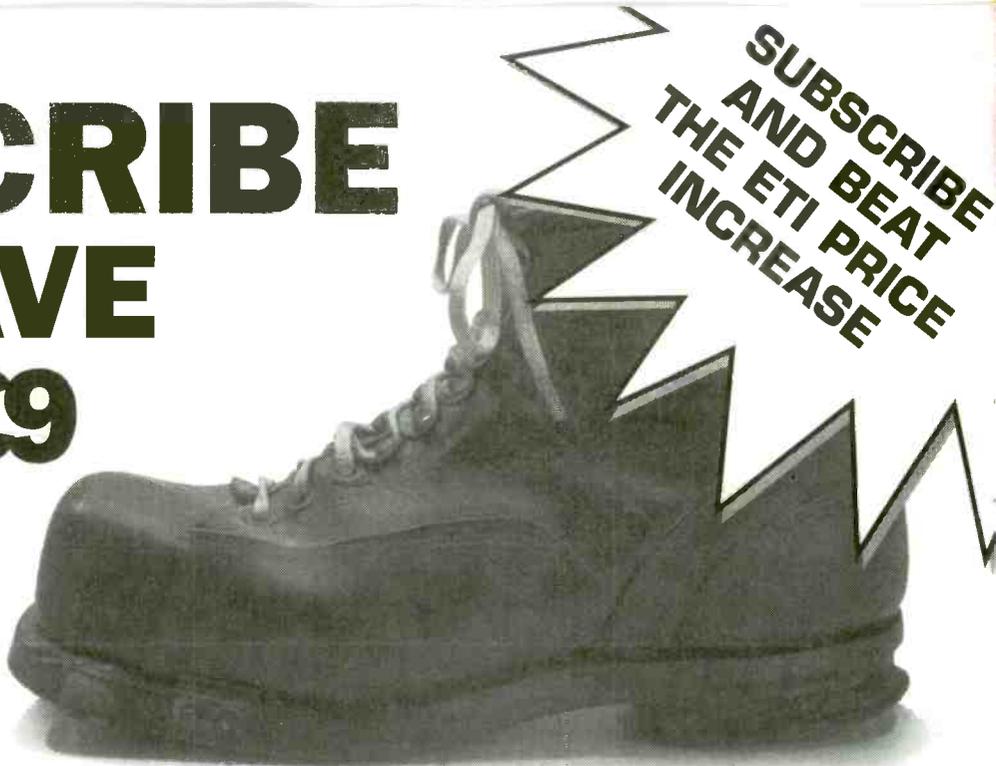
Other factors

When you depart on a Higher Education course, you will be spending between two and four years of your life in the neighbourhood of your college. If you are leaving your family home for this first time, this may also be your first major change of environment. College is rightly seen as a half-way house to independence, especially if you are not living on the College campus (the site where most of the teaching faculties and living accommodation are) throughout your course. Of course your choice of the right course and college and course is the most important consideration, but your choice of environment is not trivial. There are likely to be a number of good colleges offering courses that you want to follow, so look at them and consider where you would personally be happy to live. If you are not keen on outdoor pursuits, you may feel cut

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SPEED CONTROL in DC Motors

PART ONE

When David Ponting gained possession of a high-quality reel to reel recorder, all he had to do was create a constant-speed capstan drive suitable for both sides of the Atlantic. So began the experiments to find the best control circuit.

It was a most magnificent machine and I was being given it for nothing! It seemed that no-one else even wanted to give house room to this ancient but truly beautiful Rolls Royce of a reel-to-reel tape recorder. It was in excellent condition.... except that the all-important capstan motor had burnt out. The other two motors which provide the spooling and tension functions were fine, but the capstan motor which has to turn at a very precise and constant speed under a varying load no longer existed.

The original motor was a synchronous 115 volt AC type whose speed was locked to the American mains frequency of 60 Hz.. So even if I could replace it with a new one, the tape recorder would still not operate properly in England: any recording made on it would be non-standard and could only be replayed on the same machine.

So I started to look for circuits which are designed to drive small AC or DC motors at very constant speeds. I tried electronics magazines, past and present. I searched through collections of circuits in numerous books. I found nothing. There were many circuit designs that allowed a potentiometer to control and set the speed of a motor to the required value, but I found none that then kept that speed constant as the loading on the motor changed. I began to think that I would have to fit

an excessively large motor whose power would hardly notice a small varying load.

But surely there must be a better answer than that? I decided that if there were no tried and tested circuits available, I would have to start from scratch.

It quickly became clear that some sort of feedback loop (figure 1) was going to be required.

The feedback loop

The speed of the motor has to be measured in some way, and that measurement has to be compared with a speed standard. For example, suppose we want a motor to rotate at exactly 1000 revolutions per minute. We switch the motor on, count the number of revolutions the motor is actually making, and then compare this with the required 1000. If the measured figure is 999 or smaller, we can use the difference from 1000 to speed the motor up; but if the measurement is 1001 or larger, we can use the error to slow it down. If the revolution counter is measuring exactly 1000, we can turn the power to the motor off and not turn it on again until the speed drops to 999. We could arrange that the motor is braked if the speed exceeds 1000, but in practice loading and friction will automatically provide braking. So the power to the motor can be off both when the speed is exactly 1000 and when it is higher.

Having got that far in my thinking, I began to look around for what motors are available and soon discovered an advertisement which offered a DC motor with a fitted 'tach' (tachometer). In addition, the advertisement said that the motor operated from 6 to 21 volts, with a speed of 2900 rpm at 12 volts (300mA) and 5300 rpm at 21 volts (380mA). This told me that without any control circuit, the speed of this motor when unloaded depended directly on its supply voltage.

I responded to the advertisement and, when my motor arrived, I found that there were four connectors, two to power the motor and two which were the output of the 'tach'. Initially I was not sure what this output would be, and so I looked at it on an

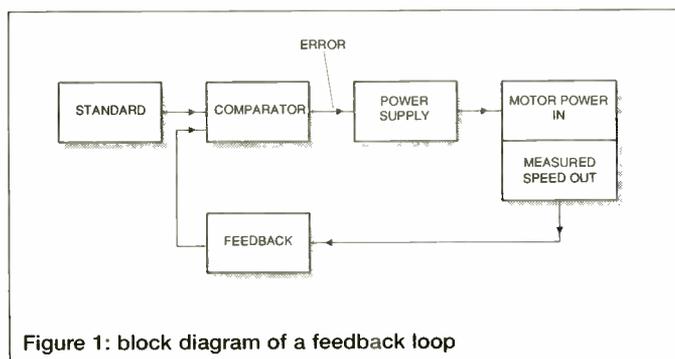


Figure 1: block diagram of a feedback loop

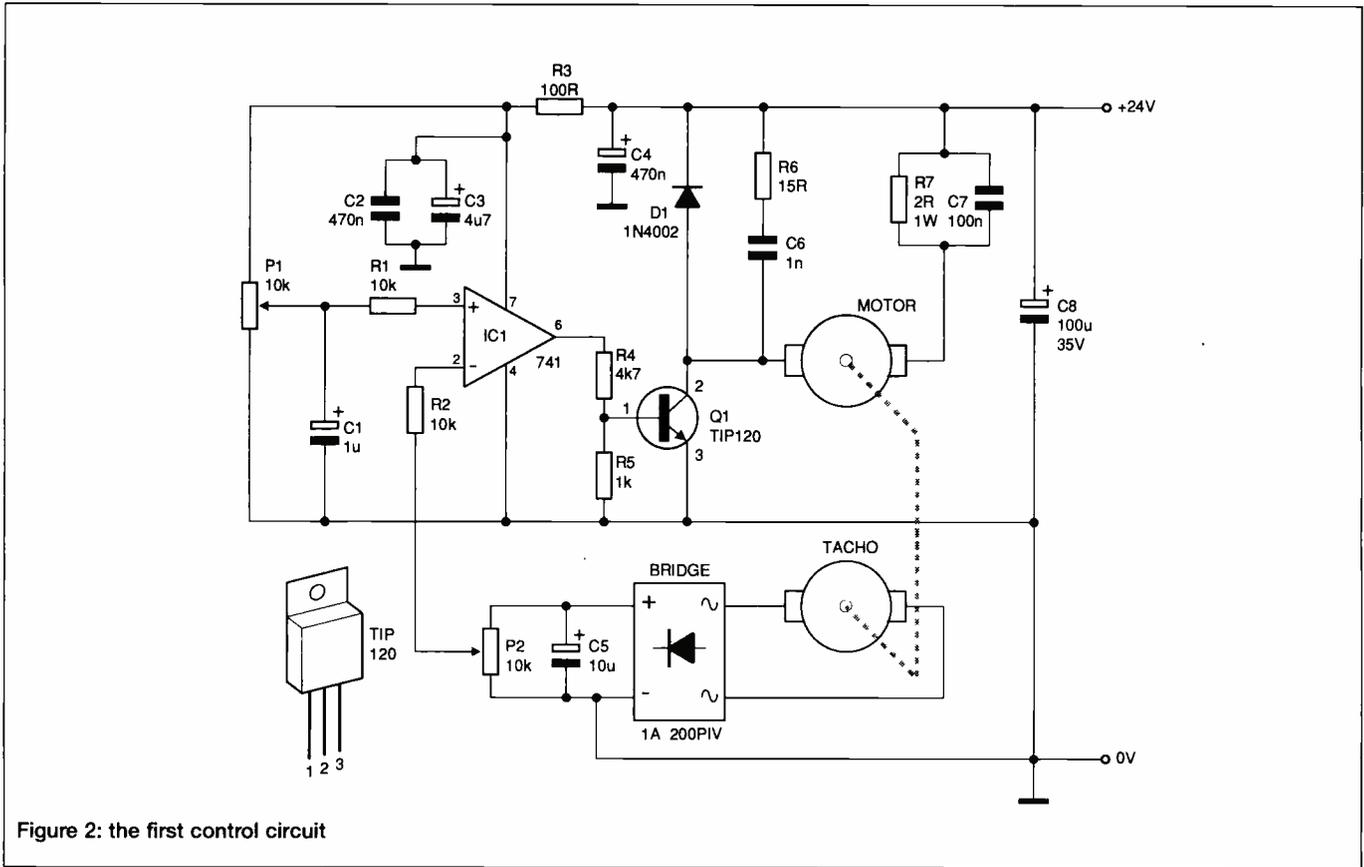


Figure 2: the first control circuit

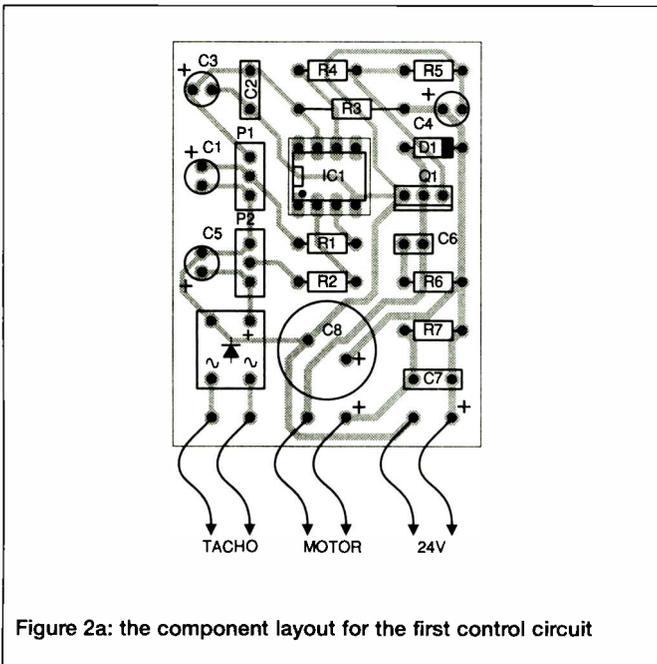


Figure 2a: the component layout for the first control circuit

oscilloscope. As I had suspected, it was a very regular sine wave whose peak-to-peak voltage was completely independent and floating with respect to the power supplying the motor. Clearly this tach was just a small AC generator driven directly by the shaft of the motor. The original advertisement had included the additional information that "the tach produced approximately 3.15 volts per 1000 rpm". I was able to confirm this experimentally when I found that at 1000 rpm the output of the tach was 3.2 volts rms.

Much more important than the value of this voltage is the fact that as the speed of the motor increased, the peak-to-peak AC tach voltage increased as well. Clearly the size of this voltage is a measure of the speed of the motor.

So, if the tach voltage can somehow be compared to a fixed voltage which represents the required speed, our aim of a motor which rotates at constant velocity under varying loads is achieved. This led me to my first useable control circuit (figure 2 is the circuit and figure 2a is the component layout for this board).

How it Works

As connected, the output of IC1, an ordinary LM 741 op-amp, is high (within a couple of volts of 24) as soon as the power to the circuit is applied. Consequently Q1 is switched on via R4 and the motor starts to turn, drawing its power via R7.

Driven by the motor, the tach starts to generate an increasing AC voltage. This is rectified by the bridge, smoothed by C5 and reaches pin 2 of IC1 via P2 and R2. At pin 3 of IC1 is a fixed voltage set by P1.

Eventually, if the 24 volt supply is great enough, the motor will spin so fast that the rectified and smoothed DC from the tach into pin 2 of IC1 will exceed the set voltage into pin 3. When that happens, the output at pin 6 will go low (within a couple of volts of zero), Q1 will switch off, and the motor will start to slow down until the voltage at pin 2 drops below that at pin 3 when the whole process repeats itself.

In effect, the motor is supplied by pulses of power resulting in its rotating at constant speed even when the loading on the motor changes. When that happens, the pulses just get longer, supplying the motor with greater power. The final speed of the motor can be controlled either by adjusting P1 or P2, or both.

R3, C2, C3 and C4 de-couple the supply to the motor from that to the control circuit. R7 is a 1-watt current limiting resistor, and should be of a higher wattage if the current to the motor exceeds 1 amp. R6, C6 and C7 limit the electronic noise produced by all switching circuits similar to this. D1 is an important component as, with a highly inductive load like a motor, every time the power to the motor is switched off, a

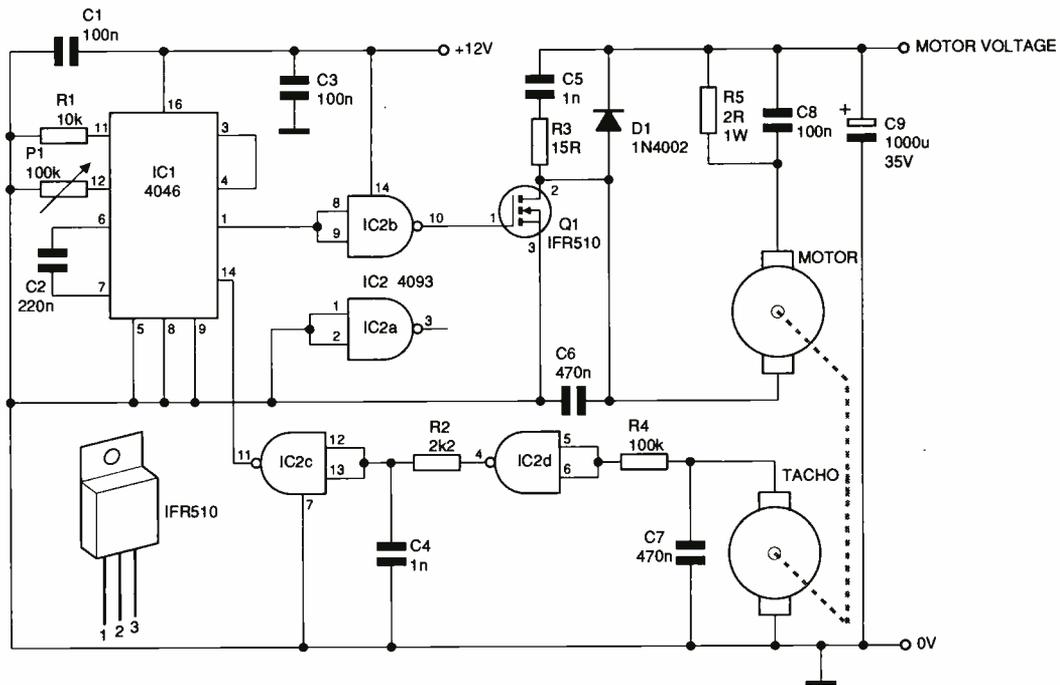


Figure 3: the 4046 circuit

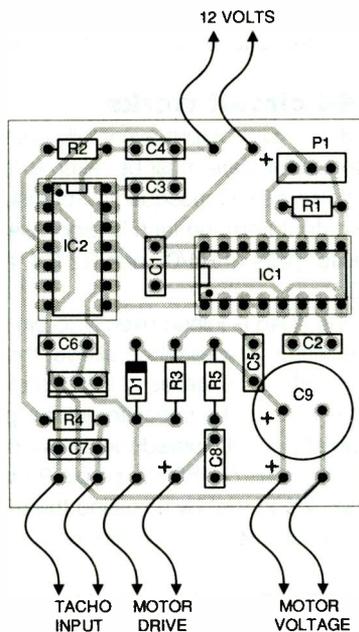


Figure 3a: the component layout for the 4046 circuit

reverse voltage is generated in the motor's windings, which would destroy the transistor if the diode were not there to clamp this voltage to the 24 volt rail.

Success and the first problem

Using this rather straightforward circuit, a very stable and relatively constant rotational speed can be achieved. For the tape recorder I was trying to restore, transporting the tape at the standard speed of 7.5 inches per second required the motor to rotate at 1800 rpm. Using this circuit, I could set the motor to 1800 rpm when it was unloaded (200 mA), and the

rotational speed was only reduced by 8 rpm when the motor was heavily loaded and close to stalling (greater than 1 amp). Further, driving the motor by this pulse method (which is called pulse-width modulation, or PWM), ensures that the motor starts readily, has a high torque as it starts to rotate, and continues to provide that high torque when it reaches its constant speed.

So this motor, driven by the above circuit, seemed to meet all my requirements for constant speed. But I quickly discovered that there was one major problem: if the motor was run for an extended period of time, its speed increased away from that set by the standard. In practice, starting from cold at a set 1800 rpm, the speed had increased to 1910 rpm after running for about an hour or so.

The reason for this is annoying but interesting. The current passing through the main windings causes the motor to warm up. This results in the windings of the tach coils also becoming warmer. When copper is heated, its resistance increases and the result is that the output voltage of the tach decreases. Consequently, the motor speeds up to produce a voltage to match the "standard". If the motor could be cooled so that it never became warmer, this circuit would provide the necessary accuracy to run a tape recorder. As it is, someone with perfect pitch would be only too well aware that the key of music played on the machine would increase in pitch by about a semi-tone after running for half an hour. However, if your need for (relatively) constant velocity is met by a motor whose speed variation is no more than about +6 percent after running for an hour and then remains more or less constant, the above circuit is for you. Unfortunately it was not sufficiently accurate for me. So it was back to the drawing board.

AC frequency

It had occurred to me when first checking the tach on my motor that not only did the rms voltage increase as the motor's speed increased, but so did the frequency of the AC signal. To

Figure 2

| | |
|------------|-------------------|
| 'P1', 'P2' | 10k |
| R1,2 | 10k |
| R3 | 100R |
| R4 | 4k7 |
| R5 | 1k |
| R6 | 15R |
| R7 | 2R 1 watt |
| C1 | 1uF electro |
| C2 | 470n |
| C3 | 4u7 electro |
| C4 | 470n electro |
| C5 | 10u electro |
| C6 | 1n |
| C7 | 100n |
| C8 | 1000u 35V electro |
| D1 | 1N4002 |
| Q1 | TIP120 |
| 1C1 | 741 |
| Bridge | 1A 200PIV |

Figure 3

| | |
|--------|-----------|
| R1 | 10k |
| R2,4 | 2k2 |
| R3 | 15R |
| R5 | 2R 1 watt |
| P1 | 100k |
| C1,3,8 | 100n |
| C2 | 220n |
| C4 | 100k |
| C5 | 1n |
| C6,7 | 470n |
| C9 | 1000u 35V |
| D1 | 1N4002 |
| Q1 | IFR510 |
| IC1 | 4046 |
| IC2 | 4093 |

Figure 5

| | |
|------|-------------------|
| R1 | 2k2 |
| R2 | 1M |
| R3 | 1k |
| R4 | 15R |
| R5 | 2R 1 watt |
| R6 | 220R |
| R7 | 1k3 |
| R8 | 2k |
| C1 | 100p |
| C2 | 5 - 25p |
| C3 | 1u tantalum |
| C4 | 100n |
| C5,9 | 100n |
| C6,7 | 1n |
| C8 | 470n |
| C10 | 1000u 16V electro |
| D1 | 1N4002 |
| Q1 | IFR510 |
| IC1 | 4060 |
| IC2 | 4017 |
| IC3 | 4077 |
| IC4 | 7812 |
| IC5 | LM317 |
| XTAL | 1.8432 MHz |

date I had concentrated on the voltage increase because the comparison of two voltages is so much easier than the comparison of two frequencies. But the latter clearly became the route I was going to have to take since, unlike voltage at a given speed, the frequency of the tach output was independent of the temperature of the motor's windings.

By experiment I found that at a speed of 1800 rpm, the frequency of the AC output from the tach was (coincidentally) 180 Hz.. Now I had to consider what I should use as a comparator and how I should obtain an adjustable frequency which would become my standard.

It was at that point that I remembered that I had recently done some work on a little used but useful 4000 series CMOS chip, the 4046. This IC is generally employed as the basis for a phase-locked loop, a not-so-dissimilar function to what I wanted.

The 4046 effectively includes two independent exclusive-or gates, both having pins 3 and 14 as common inputs and pins 1, 2 and 13 as outputs. Now both exclusive-or and exclusive-nor gates can be thought of as frequency comparators. Consider the two-input, exclusive-nor gate: when both inputs are the same, the output is high, ie when the frequency and phase of each signal into the inputs are identical, the output is high; as soon as there is any difference between the two inputs, the output is low more often than it is high. It seemed like a promising start.

In addition, the 4046 has an on-board voltage-controlled oscillator, a VCO. With a couple of resistors and a single capacitor, a varying voltage into pin 9 will reappear at pin 4 as a corresponding variable frequency. I found that you get a similar effect if you fix the input voltage and vary one of the resistors.

How the 4046 circuit works

Looking at figure 3, the tach output eventually enters the 4046 at pin 14. Using this input, care must be taken to ensure that the signal here is noise-free. Consequently, to ensure a clean square wave, the output from the tach is processed through the two resistor/capacitor pairs of R4/C7 and R2/C4, and the two gates, N4 and N3.

Input pin 3 on the 4046 is joined directly to pin 4, the output of the on-board oscillator. As described above, the frequency of this VCO is determined by the values of the two resistors into pins 11 and 12, the value of the capacitor joining pins 6 and 7, and the DC voltage at pin 9. I wanted the output of the VCO to have the relatively low value of 180 Hz, so pin 9 was held at zero volts and I then found that by adjusting the resistance of P1 at pin 12, I could achieve an output frequency of 180 Hz at pin 4.

The final output from the 4046 I took from pin 1. This is essentially low when the frequency into pin 14 is less than that into pin 3, is high when the two inputs receive equal frequencies, and is mainly high when the frequency into pin 14 exceeds that into pin 3. This represents the reverse of what I wanted, hence the use of gate N2 of 1C2, used here as an inverter. Gate N1 is unused and so its inputs are tied low to prevent random switching.

The motor's power supply is switched by a mosfet transistor, type IFR 510, and the rest of the circuit around the motor helps to limit switching noise.

The positive supply to the motor's circuit is critical this should be set high enough so that the motor will speed the revolutions per minute required and there lock with the signal, but it should not be so high that the motor speeds through the locking point before it can be stabilised by the clock.

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TELESCOPIC AERIAL, chrome plated, extendible and folds over for improved F.M. reception, Ref: 1051.

MES LAMP HOLDERS, slide on to 1/4" tag, pack of 10, Ref: 1054.

PAXOLIN TUBING, 3/16" internal diameter, pack of two, 12" lengths, Ref: 1056

ULTRA THIN DRILLS, 0.4mm, pack of 10, Ref: 1042.

20A TOGGLE SWITCHES, centre off, part spring controlled, will stay on when pushed up but will spring back when pushed down, pack of two, Ref: 1043.

HALL EFFECT DEVICES, mounted on small heatsink, pack of two, Ref: 1022.

12V POLARISED RELAY, two changeover contacts, Ref: 1032.

PAXOLIN PANEL, 12" x 12" 1/16" thick, Ref: 1033.

MINI POTTED TRANSFORMER, only 1.5VA 15V-0V-15V or 30V, Ref: 964.

ELECTROLYTIC CAP, 32µF at 350V and 50µF section at 25V, in aluminium can for upright mounting, pack of two, Ref: 995.

PRE-SET POTS, one megohm, pack of five, Ref: 998.

WHITE PROJECT BOX with rocker switch in top left-hand side, size 78mm x 115mm x 35mm, unprinted, Ref: 1006.

6V SOLENOID, good strong pull but quite small, pack of two, Ref: 1012.

FIGURE-8 MAINS FLEX, also makes good speaker lead, 15m, Ref: 1014.

HIGH CURRENT RELAY, 24V A.C. OR 12V D.C., three changeover contacts, Ref: 1016.

LOUDSPEAKER, 8 Ohm 5W, 3.7" round, Ref: 962.

NEON PILOT LIGHTS, oblong for front panel mounting, with internal resistor for normal mains operation, pack of four, Ref: 970.

3.5MM JACK PLUGS, pack of 10, Ref: 975.

PSU, mains operated, two outputs, one 9.5V at 550mA and the other 15V at 150mA, Ref: 988.

ANOTHER PSU, mains operated, output 15V A.C. at 329mA, Ref: 989.

PHOTOCELLS, silicon chip type, pack of four, Ref: 939.

LOUDSPEAKER, 5" 4 Ohm 5W rating, Ref: 946.

LOUDSPEAKER, 7" x 5" 4 Ohm 5W, Ref: 949.

LOUDSPEAKER, 4" circular 6 Ohm 3W, pack of 2, Ref: 951.

FERRITE POT CORES, 30mm x 15mm x 25mm, matching pair, Ref: 901.

PAXOLIN PANEL, 8 1/2" x 3 1/2" with electrolytics 250µF and 100µF, Ref: 905.

CAR SOCKET PLUG with P.C.B. COMPARTMENT, Ref: 917.

FOUR-CORE FLEX suitable for telephone extensions, 10m, Ref: 918.

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SOLENOIDS, 12V to 24V, will push or pull pack of two, Ref: 877.

2M MAINS LEAD, 3-core with instrument plug moulded on, Ref: 879.

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pack of two, Ref: 884.

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FIGURE-8 FLEX, mains voltage, 50m, £2, Order Ref: 2P345.

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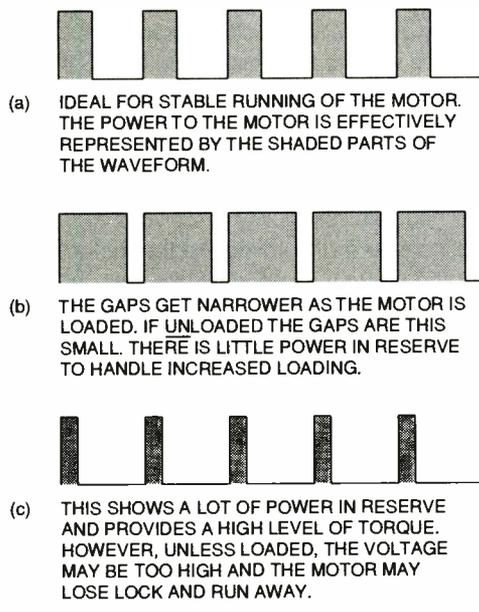


Figure 4: waveforms into pin1 of the mosfet transistor IFR510

Referring to Figure four, section (a) shows the ideal waveform into pin 1 of the mosfet when the motor speed is firmly locked to the clock frequency. The shaded part of the waveform is a representation of the power driving the motor. If you provide mechanical loading of the motor, you will see (section (b) that the shaded areas will increase in size horizontally, showing that the motor is working harder to hold its speed constant.

The same effect will occur if you just reduce the voltage to the speed-locked motor. Now the waveform will again look like Section (b) but there will be a smaller amount of potential power to cope with any increased loading. Indeed, as loading increases, the gaps may narrow until they disappear altogether and the motor may stall.

If the voltage applied to the motor is too high, Section (c), there is a greatly increased reserve of power, but if the shaded areas become too narrow, the motor may again become unstable, lose lock and speed up out of control.

The circuit in figure 3 meets many of the requirements I had for a replacement motor for my tape recorder. Unfortunately, the clock frequency in this circuit is very dependent on the stability of the 12 volt supply to the control circuit, and a 7812 voltage regulator chip was not quite stable and constant enough for my very high quality tape recorder. A more accurate clock seemed to imply some sort of crystal drive.

How the crystal drive circuit works

The clock is built around the 4060, a chip which not only permits the design of a crystal-driven oscillator, but also has a number of pins which allow the repeated division-by-two of the crystal's fundamental frequency, down to a level more useful for this application. When connected as shown in the diagram, the

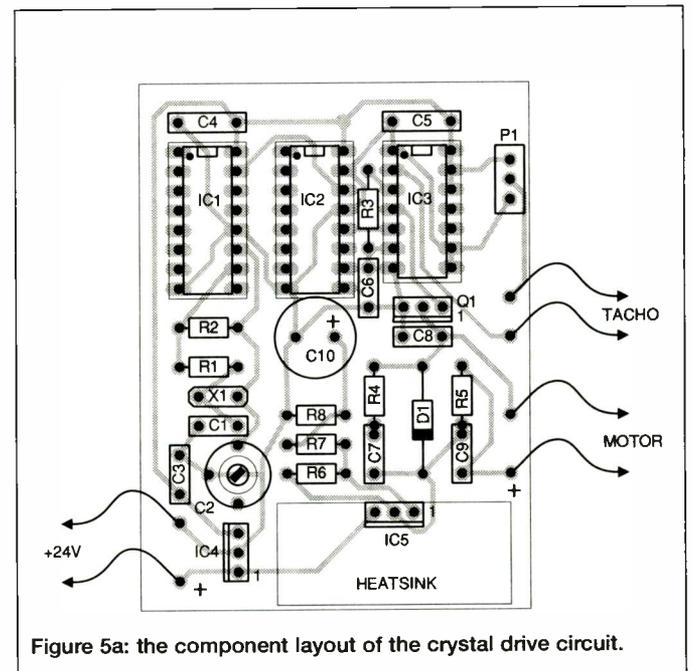


Figure 5a: the component layout of the crystal drive circuit.

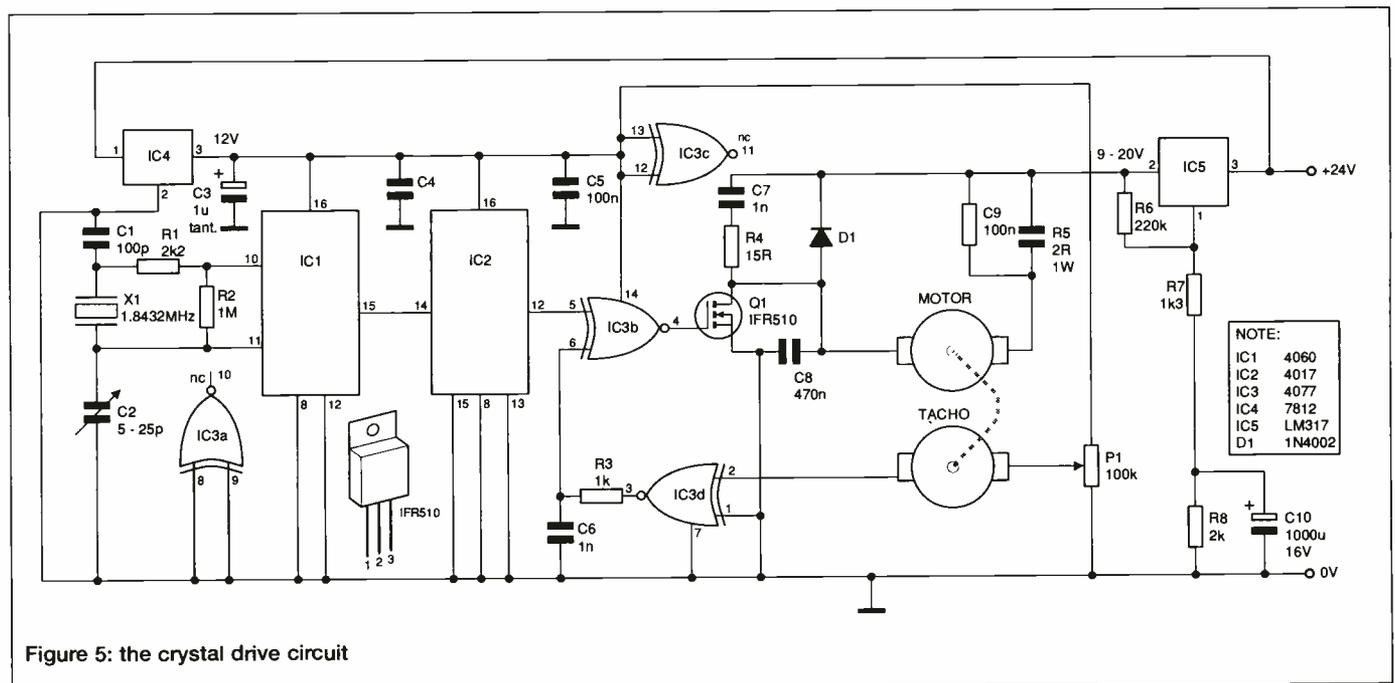


Figure 5: the crystal drive circuit

NOTE:

| | |
|-----|--------|
| IC1 | 4060 |
| IC2 | 4017 |
| IC3 | 4077 |
| IC4 | 7812 |
| IC5 | LM317 |
| D1 | 1N4002 |

4060 produces a 1800 Hz signal at pin 15. This is derived from the fundamental of the 1.8432 megahertz crystal by dividing it by 2 to the power of b.

The next IC in the chain is the 4017, used here as a decade divider. Consequently, the 1800 Hz. signal applied to the clock input at pin 14 is divided by 10 and emerges from pin 12 as a frequency of 180 Hz..

Clearly I did not chose this particular crystal at random. Knowing that I wanted a final frequency of 180 Hz and that divisions by 2 and 10 are easy, I worked backwards to try and find a suitable one. Only a small amount of trial and error was required to arrive at a fundamental of 1.8432 MHz. for which crystals are easily available.

Using this circuit does produce a very accurate and stable clock, but it also means that changes in the clock frequency, and hence variation of the "standard", are only possible by division.

An understanding of the workings of the rest of this circuit largely follows previous explanations. However there are perhaps one or two points which should be made.

The clock function of the previously used 4046 chip is no longer required, and so this IC is replaced by a 4077 which has four exclusive-nor gates on board. One of these, N2, is used as the comparator. These gates are more tolerant of noise at inputs than those of the 4046, but they do require a very exact 50 percent duty cycle (that is, equal high and low states in the waveform). Consequently, one side of the tach is joined to P1 which allows exact adjustment to 50 percent of the final waveform into pin 6 of N2. Gate N4 and the low pass filter R3/C6 square off the tach's sine wave and eliminate any spikes which might be present.

The rest of the circuit is similar to the previous one except that figure five does show how the two voltages are produced: 12 volts for the control circuit and eventually 20 volts to drive the motor. I say *eventually* 20 volts, because that is what the output voltage is when a total resistance of 3k3 (R7 + R8) is connected between pin 1 of the variable voltage regulator, LM 317, and earth. But the inclusion of C9, a 1000 microfarad capacitor, means that on the first application of 24 volts to the input of LM 317, the initial output from pin 2 will be about 9 volts and will rise relatively slowly to 20 volts as C9 charges. This gradual increase in the voltage to the motor's drive circuit ensures that the motor will speed up gradually, allowing it to lock at the required speed and not race through that point. Incidentally, there is never any doubt when the shaft speed is locked: the motor will maintain constant rotation against powerful attempts to load the motor.

Care must be exercised in the construction and setting up of this circuit since mains hum can be a problem. Motor jitter can also be present as a result of comparing two similar frequencies which may "beat" together. However, the final circuit shown as figure five meets all the requirements for a constant speed motor to run my tape recorder.

But wouldn't it be nice if as well as a tape speed of 7.5 inches per second, I could also record and play tapes at other standard speeds?

In a following article I want to look at a motor with a different kind of tach, develop a circuit which uses as the standard clock the frequency of the mains (either 50 or 60 Hz. at the flick of a switch) and which allows the tape recorder to run at 3.75 and 15 inches per second as well as at 7.5 ips.

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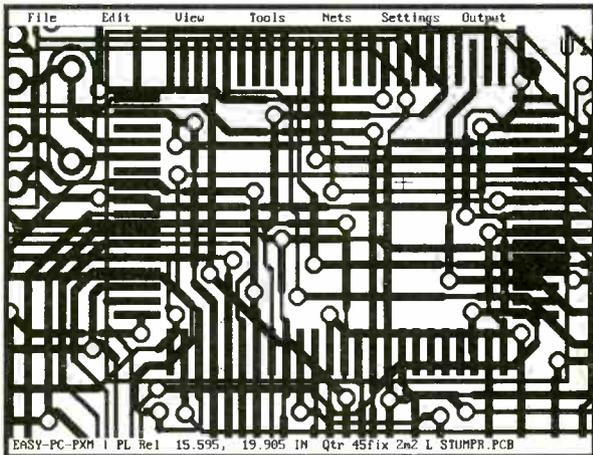


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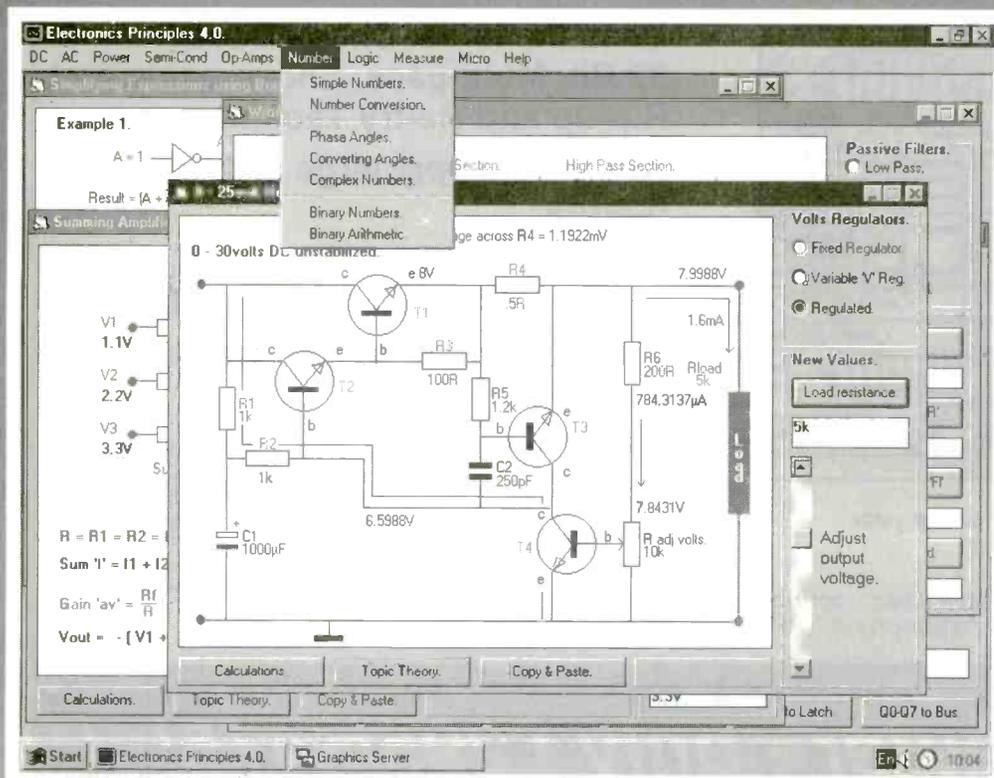
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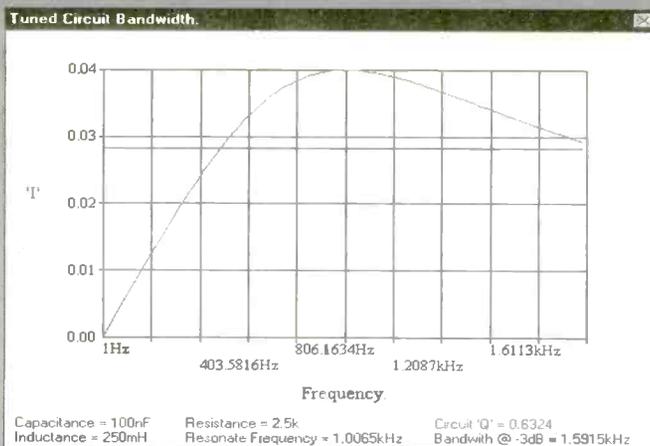
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$$I_C = \frac{50}{31.83099} = 1.570796 = 1.5708\text{A}$$

$$I_L = \frac{50}{157.0796} = .3183099 = 318.3099\text{mA}$$

$$I = \sqrt{.5^2 + (.3183099 - 1.570796)^2} = 1.3486 = 1.3486\text{A}$$

$$\theta = \tan^{-1} \frac{1.570796 - .3183099}{.5} = 68.2378^\circ$$

$$Z = \frac{100 \times 157.0796 \times 31.83099}{\sqrt{157.0796^2 \times 31.83099^2 + 100^2 \times (157.0796 - 31.83099)^2}} = 37.0755\Omega$$

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VALVE CHARACTERISTIC

Tester

PART 1

Peter Kenyon's valve tester assists in checking the essential characteristics of most types of electronic valve, and making up matched pairs.

The increasing popularity of valves in new designs for audio amplifiers, pre-amplifiers and filters is creating the need for appropriate test equipment. This article describes a small portable unit (figure 1) which, with the aid of information from data sheets and other sources, enables the essential characteristics of most types of electronic valve to be obtained. Where two or more valves of the same type have to be matched, this unit provides a fast and convenient method.

Valves which use the most popular bases, B7G, B9A and 10 (International Octal) are catered for. The less common

base types can be accommodated by constructing an adapter to be plugged into the 10 socket.

The specification of the Valve Characteristic Tester is as follows:

Anode voltage (V_a): 75 to 300 volts at up to 100mA

Screen grid voltage (V_{g2}): Equal to V_a and up to 200 volts less than V_a at up to 25mA

Control grid (V_{g1}): 0 to -6I volts

Heater voltage (V_h): 1.4 volts fixed and 4.0 to 20 volts continuously adjustable at up to 2.5A

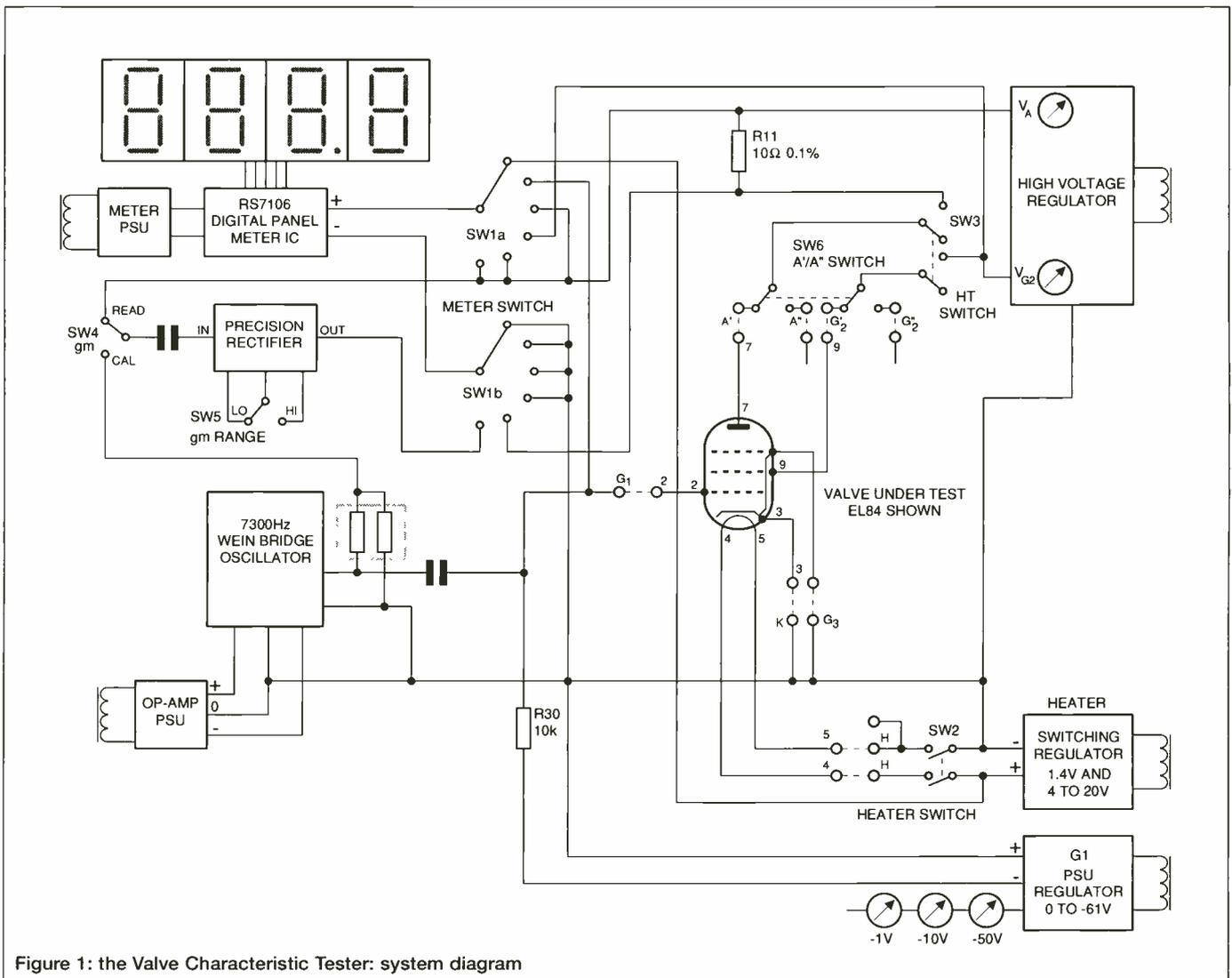


Figure 1: the Valve Characteristic Tester: system diagram

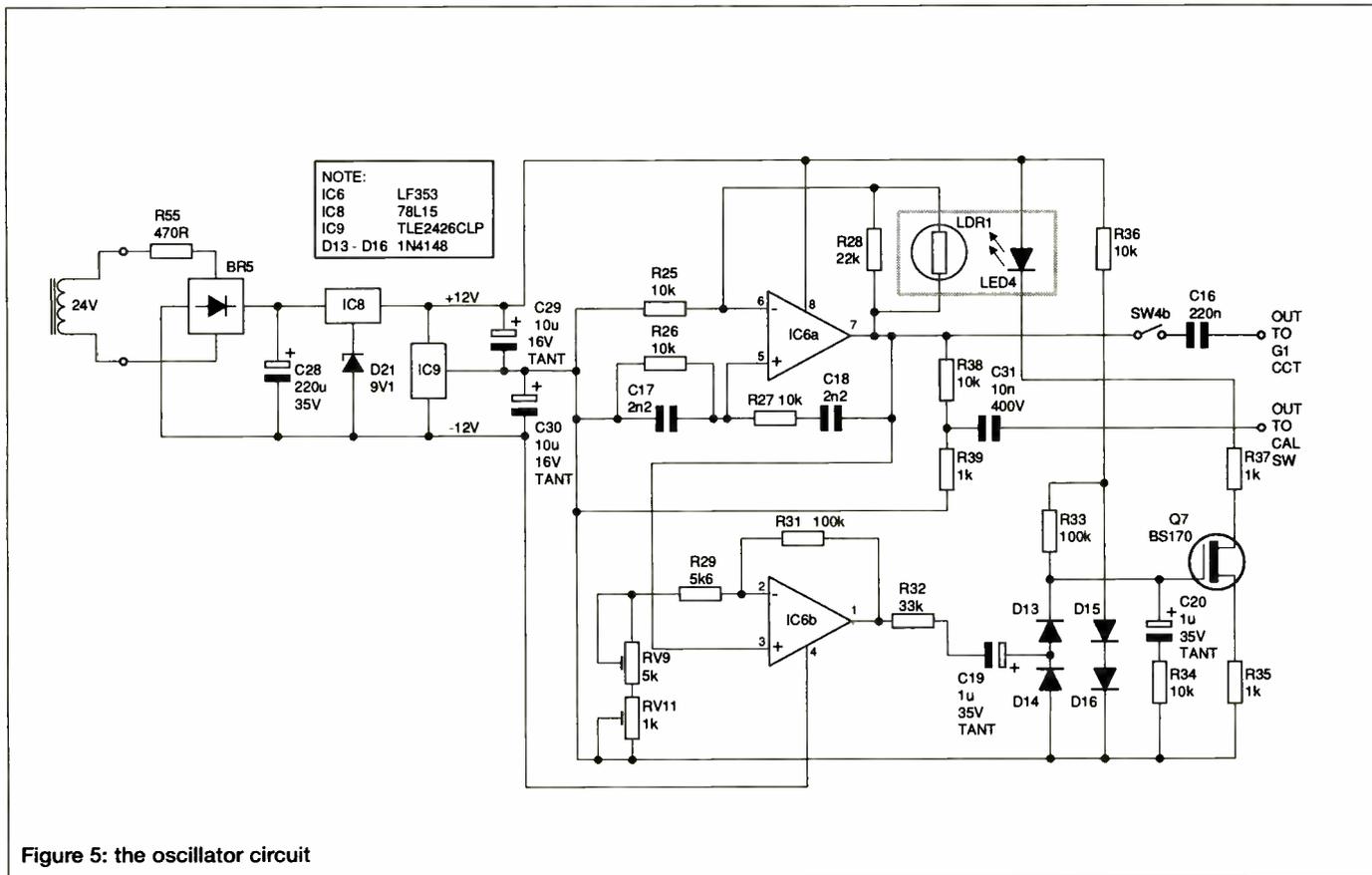


Figure 5: the oscillator circuit

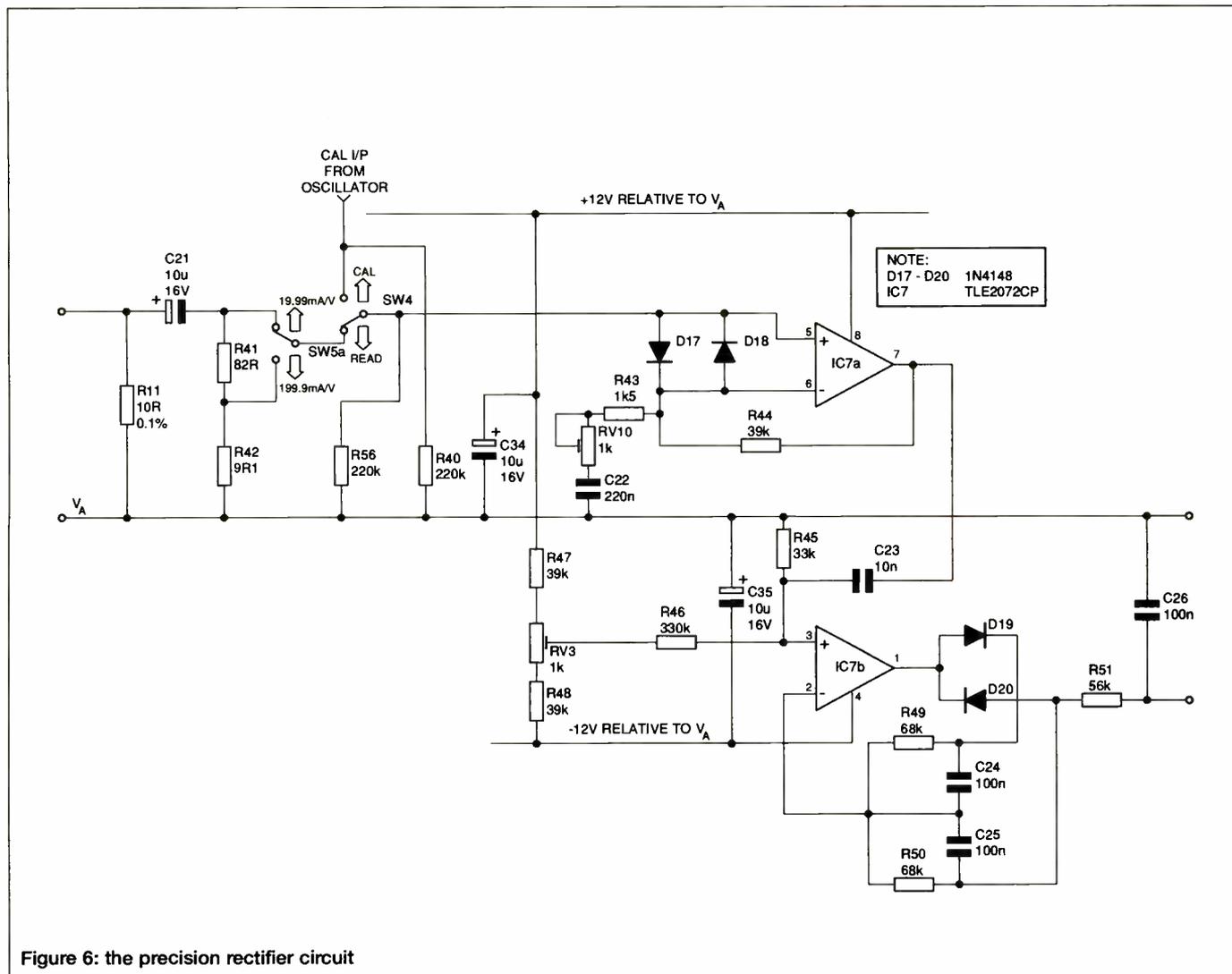


Figure 6: the precision rectifier circuit

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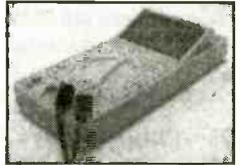
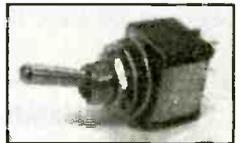
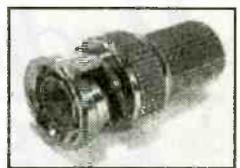
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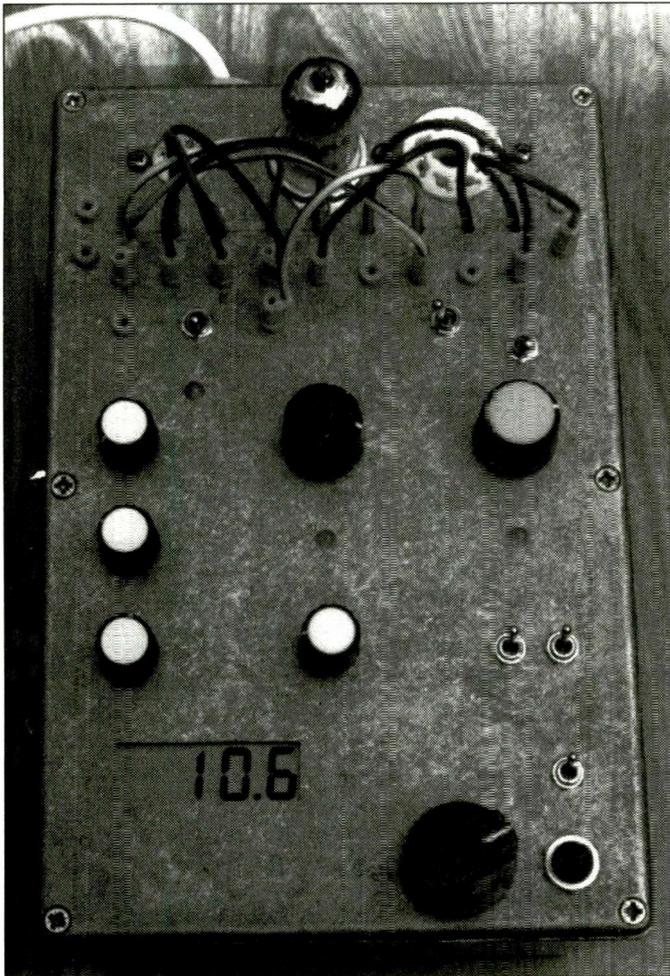
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The top panel with a valve in test

the same voltage difference between its input and output. V_{g2} will therefore track V_a regardless of the voltage set for V_a , with the proviso that at least 1mA flows through $VR2$. $Q4$ limits the current through $Q3$ to about 25mA by robbing base current from $Q3$, lighting $LED2$ to show overload. Add a small flat heatsink 25mm by 15mm to $Q3$ to help heat dispersion.

Control grid negative bias supply

In the $g1$ negative bias supply (figure 3), 48vac is rectified by $BR2$ and smoothed by $C10$. The programmable zener $TL431C$ ($IC7$) adjusts the current into its cathode to maintain 2.5V at its control pin. From $I = E/R$, a current of 1.064mA flows in $R15$ and $R52$. $Q5$ is in common gate mode, and this same current therefore flows in $VR4$, $VR5$ and $VR6$. Since this is a constant current, the voltage at the wiper of $VR4$ (47k) will change with the settings of both $VR5$ and $VR6$. Thus, up to 1 volt can be added by $VR6$ (1k) and up to 10 volts can be added by $VR5$ (10k). $D11$ protects against flashover or other leakage in the valve under test.

Heater regulator

To minimise power dissipation, $IC4$, an $LT1074CT$ switching regulator is used (figure 4). However, when 1.4 volts is required for battery valves, $IC4$ is a pre-regulator and $IC5$ ($LM317T$) brings the output down to 1.4 volts, preset with $VR8$. $VR7$ is a 22k pot with integral DPST switch. In the "off" position, $Q6$ is biased on via $R22$ into saturation giving 1.4 volts at the output. When $VR7$ is rotated to the "on" position, contact 'a' bypasses $IC5$ and contact 'b' removes bias from $Q6$, thus isolating $IC5$ from the 0V rail and

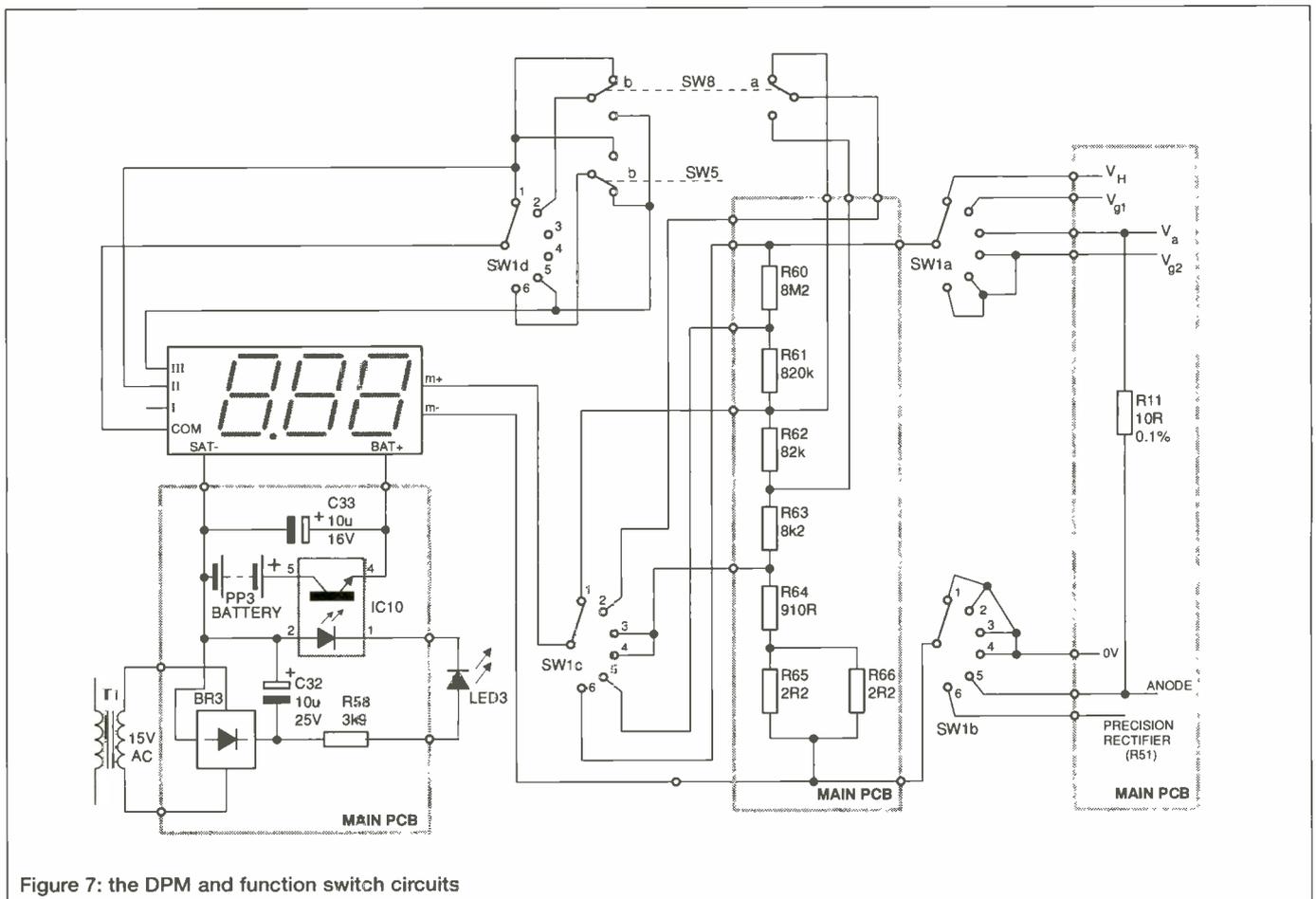


Figure 7: the DPM and function switch circuits

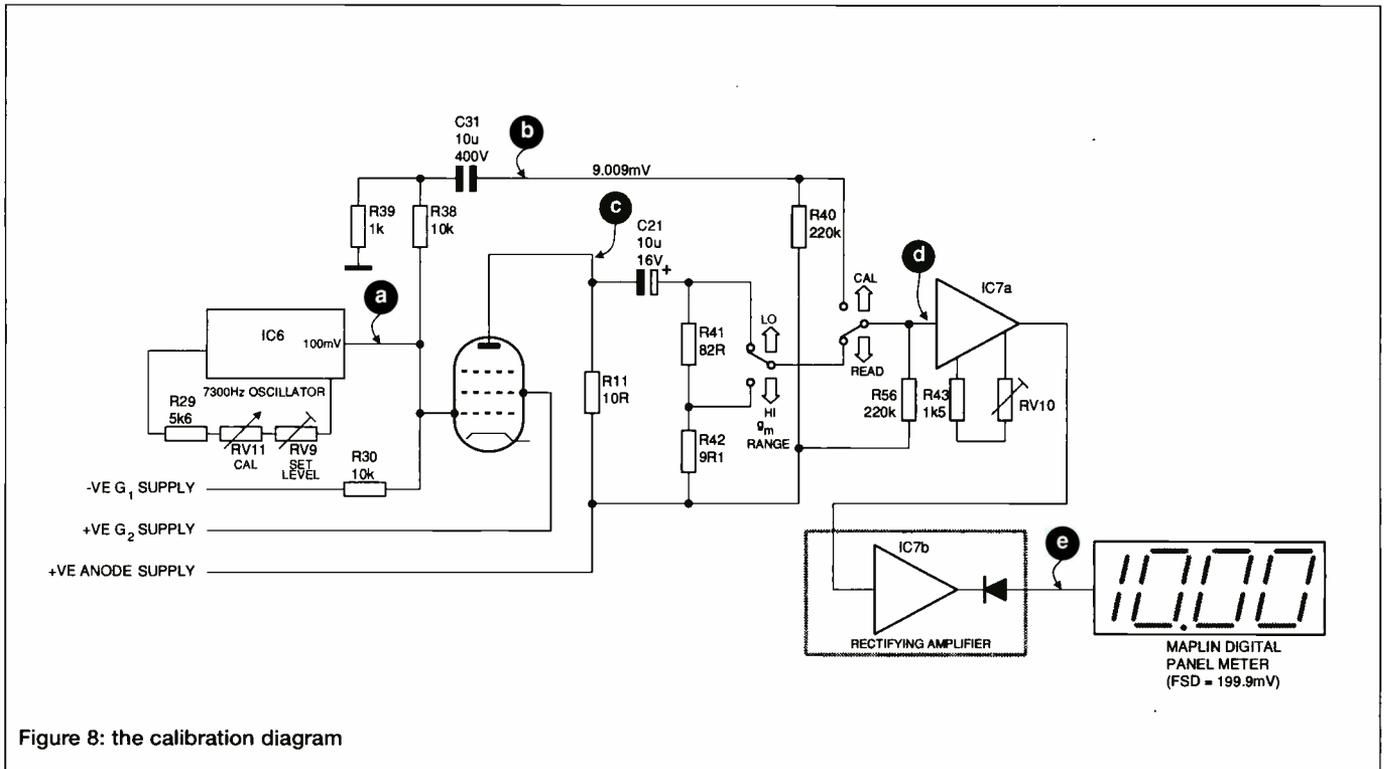


Figure 8: the calibration diagram

preventing damaging currents from flowing into its output. The heater voltage is now continuously adjustable from 4.0 volts up to 20 volts.

The oscillator

The oscillator (figure 5) is a Wien bridge type, amplitude stabilisation being provided by a light dependent resistor illuminated by an LED. The output signal at IC6a is amplified by IC6b and rectified by D13 and D14 to provide a dc control voltage at Q7 gate. The resulting current through LED4 illuminates LDR1 to control the negative feedback loop of IC6a. D15 and D16 provide forward bias for Q7 and simultaneously give temperature compensation. The change in output voltage is less than 2 percent for a temperature change of 15 degreesC. The preset VR9 sets the output level, while VR11 is the front panel CALIBRATE control.

Range switching

To measure ac volts a precision rectifier (figure 6), IC7, converts the ac signal across Rh to dc for measurement by the DPM. Since IC7 is only used in the anode circuit of the valve under test, it is powered by the same supply as IC1 and is, therefore, at Va above 0 volts. VR10 presets the gain of the precision rectifier.

A Maplin module (Catalogue reference GW01B) is used as the basis of the measurement system. This uses the ICL7106 dual ramp digital panel meter ic. SW1a and SW1b switch between the various measurement points in the valve tester. SW1c switches ranges while SW1d selects the appropriate decimal point. See figure 7.

A high pass filter comprising C21 and R41/R42 couples the signal voltage to IC7a. SW5 selects "gm HI" or "gm LO" for two ranges of mutual conductance. The "LO" range is likely to be the most commonly used range. SW4 is the "CAL/READ" switch. VR3 is an offset adjustment for the op-amp so that the DPM will read zero when no signal is present. To simplify the wiring, the negative output from the precision rectifier is measured by the DPM.

Power for the DPM is obtained from a PP3 9V battery. A 15vac winding on T1 provides current for the opto-isolator IC12 and LED3 in series, IC10 acting as the on/off switch for the DPM. Since the DPM module current consumption is less than 1mA, an alkaline battery life of at least 500 hours can be expected.

Calibration

Referring to the calibration diagram, figure 8, consider the hypothetical valve under test (VUT) to have a mutual conductance, gm, of 10mA per volt. A signal at the control grid, g1, of 100mV will develop an ac voltage of:

$$E = (0.1 \times 10\text{mA/V}) \times R_a$$

where Ra is the combined value of R11 and R41 + R42 in parallel, 9.011ohms. Therefore, E equals 9.011mV. (Remember that measurement of dc current is developed across R11 alone, while measurement of ac current is developed across R11 and R41 + R42 in parallel.)

This voltage of 9.011mV is raised in level by IC7a and peak rectified by IC7b to read 100mV on the DPM. The decimal point is positioned to show 10.00.

Theoretically we could use our hypothetical valve to calibrate the Valve Tester, but since such a device does not exist, we use a combination of resistors to do the job. Thus, R38, R39 with R40 and R56 in parallel simulate the hypothetical valve.

To calibrate the Valve Tester, SW4 is moved to the "CAL" position and the front panel control VR11 is adjusted for a reading of 10.00 on the DPM. Switch SW4 back to "READ" and a real life valve can be measured.

Next month

In the second and final part of this project in the next issue, we will print the construction details, wiring, Parts List and pcb layouts for the Valve Characteristic Tester.

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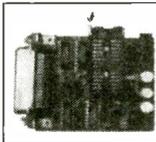
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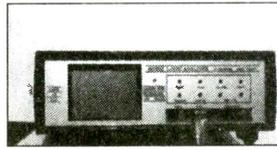
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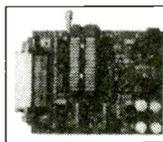
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Fast Fivers

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

On many instances, the Old Technology has advantages that we did not appreciate at the time. We took them for granted. And often these advantages have not been carried forward into the New Technology. Take the hour-glass, for example. It may have been cumbersome and not all that precise, but it had one big advantage. At a glance you could tell (near enough) how much of the hour had elapsed (lower bulb) and how much time there was still to run (upper bulb). Doing the same thing with a digital watch involves a load of mental arithmetic, which is prone to error if you are timing a telephone call and need to concentrate on the conversation.

This project is the New Technology equivalent of the hour-glass, with the added advantage of being able to time up to three consecutive stages of a process. It can time a multistage process lasting for half-an-hour or so and, provided that you are willing to go beyond the £5 limit, you can increase the number of stages to seven, or even more. The design is flexible, allowing stages to be set to different lengths, and there is scope for variety in the LED display.

How it works

The circuit consists of two parts, a ramp generator or integrator (top left in figure 1) and an array of comparators driving LEDs (right in figure 1). The circuit employs a single ic, a TL064CN,

which contains four operational amplifiers. One of the op amps is used for the ramp generator and the other three are used as comparators. The ramp generator is based on the principle of the building up of charge on a capacitor. As current flows into a capacitor, the charge increases and so does the voltage - it ramps upward. When a capacitor is charged from a fixed voltage source, the amount of current (and hence the charge) flowing into the capacitor depends on the voltage difference between the fixed source and the voltage across the capacitor. This difference becomes less and less as the capacitor charges, so current gradually falls and the rate of ramping decreases. A varying ramp rate is not usually suitable for timing purposes, but there are ways to produce a constant ramp. This circuit relies on the fact that when the op amp is connected as in figure 1 its inverting (-) input acts as a virtual ground. This is because an op amp acts to keep both its inputs at the same potential, and the non-inverting (+) input here is connected directly to the 0V (ground) line. Thus, whatever charge there may be on the capacitor C1, point A in figure 1 stays at 0V. Current reaches A from the network to the left. This consists of a Zener diode ZD1 wired so as to produce a constant voltage (3.9V) across R2 and VR1. We tap off a very low voltage (say 30mV) by adjusting VR1. This too is constant. If one end of R3 is at 30mV, and the other at 0V, a constant current flows through R3 and this current is equal to $0.030/10000000 = 3nA$.

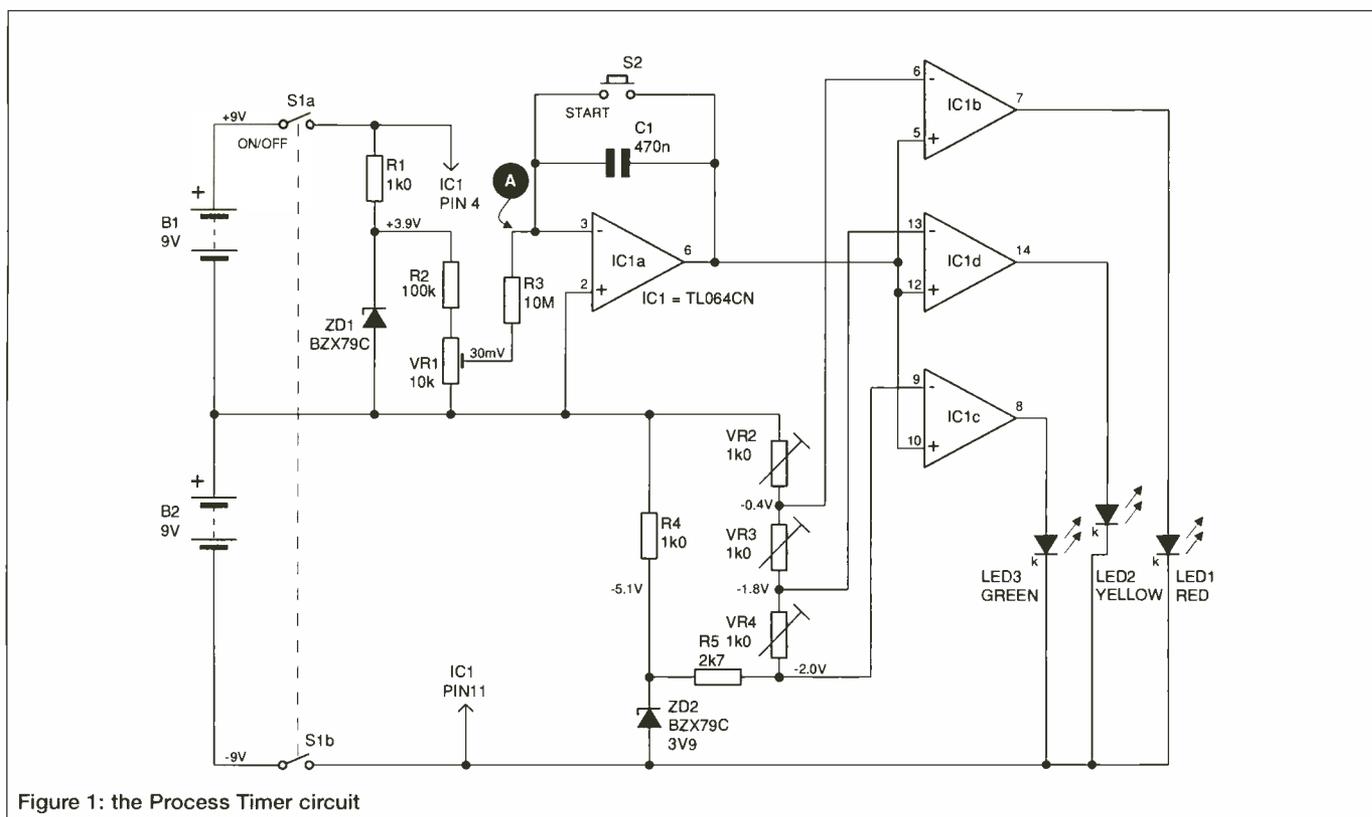


Figure 1: the Process Timer circuit

The current flowing arriving at A must go somewhere. Not much of it can enter the opamp because the opamp has FET inputs with an input resistance of about 10(the the power of 12) ohms, that is, a million megohms. So the current flows into the capacitor and begins to charge it. But opint A must stay at 0V. To make it possible for C1 to accept the charge, the potential at its other terminal must go down. As current enters the capacitor and a potential difference develops between its terminals, the output of the opamp goes negative by just the right amount to hold A at 0V. A constant current of 3nA carries charge into C1 at the rate of 3nC per second. For a capacitor, capacitance C, charge q, the voltage across its is $V=q/C$. Thus the voltage across Cq increases by 3 nanocoulombs/470 nanofarads = 6.38mV per second, or approximately 0.4V per minute. Putting it the other way round, the voltage output of IC1 falls by 0.4V per minute. This is the basis of the timing. A beneficial feature of this circuit is that quite long times are obtainable when using a capacitor of relatively small value. This is an advantage over circuits that require large-value electrolytic capacitors, which not only vary widely from their nominal values but also change in value with use and as they age.

The output of IC1 is fed to the (+) inputs of three op amps wired as comparators. A resistor chain consisting of VR5 and three preset resistors provides a series of voltages with which to compare the ramping-down output from IC1. The voltage across the chain is fixed at -5.1V by another 3.9V Zener diode, ZD2. The values used for R5 and VR2 to VR4 depend on the total process time and the times of the individual stages. It is as well to calculate these before you build the project as you may need different values for any or all of these. We will illustrate the calculations by taking an example

PARTS LIST for the Process Timer

Resistors
(0.25W, 5% tolerance or better; variable resistors are all miniature horizontal presets)

| | |
|------------|----------------------------------|
| R1, R4 | 1k |
| R2 | 100k |
| R3 | 10M |
| R5 | 2.7k (for 5-min period) |
| VR1 | 10k |
| VR2 to VR4 | 1k (or other values as required) |

Capacitor

| | |
|----|-----------------------------------|
| C1 | 470nF, metallised polyester, 100V |
|----|-----------------------------------|

Semiconductors

| | |
|--------------|-------------------------------|
| ZD1, ZD2 | Zener diode, BZX79C, 3.9V |
| LED1 to LED3 | Light-emitting diodes |
| IC1 | TL054CN fet input quad op amp |

Miscellaneous

| | |
|---|----------------------------|
| S1 | 2-pole single throw switch |
| S2 | Push-to-make push-button |
| Stripboard (98mm x 40mm, 15 strips x 38 holes), 1mm terminal pins (5 off), PP3 battery clips (2 off), 14-pin dil ic socket. | |

of a telephone call timer. Suppose we want a total period of 5 minutes, subdivided into three periods, of lengths 1, 3.5 and 0.5 min. The first period is for indicating a reasonable limit for trunk calls. The middle period allows extra time for local calls. The final 0.5 min is the period for closing down the conversation prior to hanging up. It is a warning that time is nearly up. Maximum call time is 5 min.

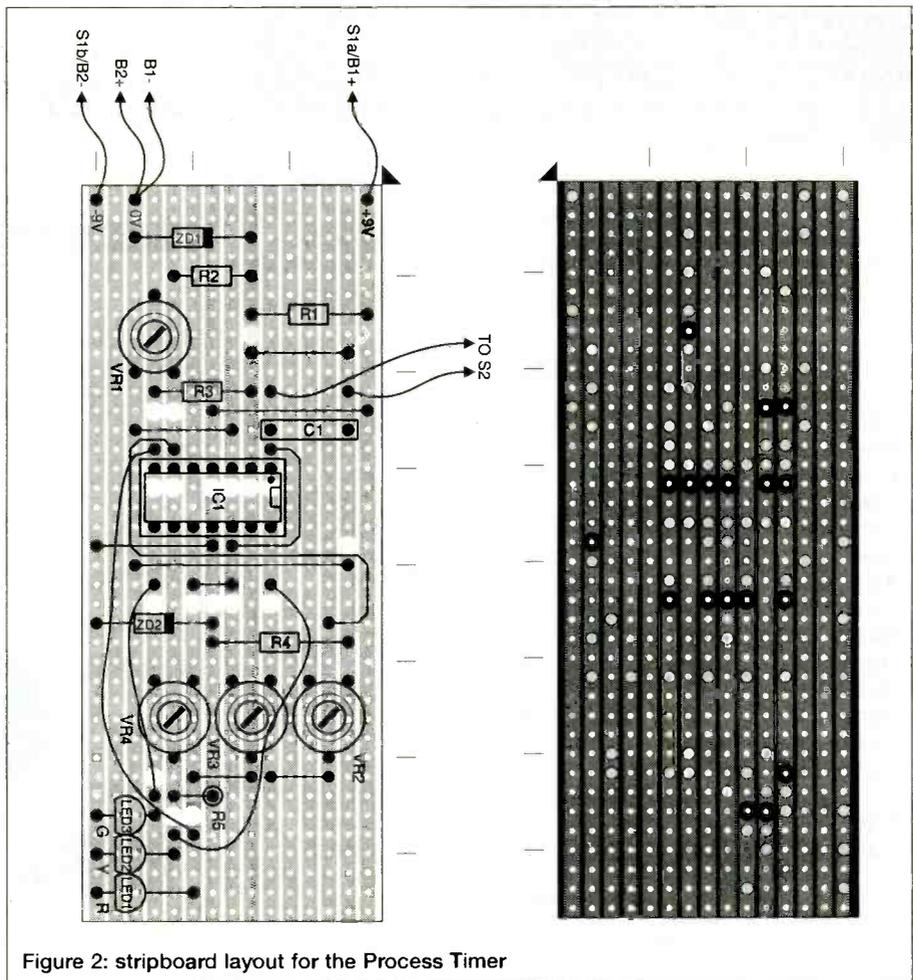
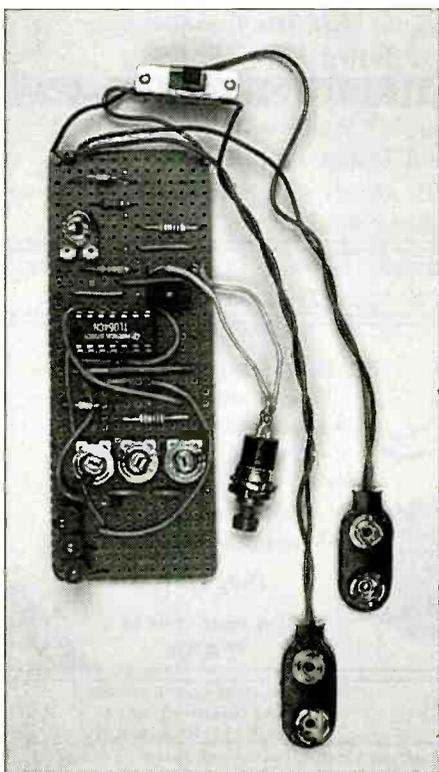
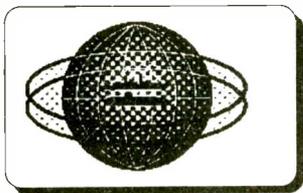


Figure 2: stripboard layout for the Process Timer



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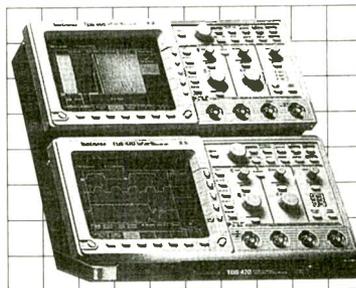
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Calculations

We will assume that you have adjusted VR1 to produce a voltage of 30mV at its wiper, so obtaining a ramp down of 0.4V per minute (approximately, to make calculations easier). Pressing S2 sends the output of IC1 to 0V at 0 min. At 1 min it will have fallen to -0.4V, at 4.5 min (that is 3.5 min later) it will have reached -1.8V, and at 5 mins it is -2.0V.

Assume that the current through the chain is to be 1mA. The voltage across R5 is to be $5.1 - 2 = 3.1$. So the value of R5 is $3.1 / 0.001 = 3100$ ohms. For convenience use 2.7 kilohms, and let the current be $3.1 / 2700 = 1.15$ mA. If t is the required length of a period, the resistance needed is $R = (t \times 0.4) / 0.00115$. For periods of 1, 3.5 and 0.5 min the required resistances are 348, 1217, and 173 ohms. If you are not too worried about exact timing, you could use fixed resistors in place of the presets. Values of 330 ohms, 1.2 kilohms and 180 ohms would do. If you use presets, you need 1 kilohm or 470 ohm presets for VR2 and VR4, and a 2.2 kilohm or 4.7 kilohm preset for VR3. These are adjusted to the exact value as calculated.

For longer periods you can decrease the value of R5, or set VR1 to produce a voltage lower than 30mV and hence a slower ramp.

Displays

With the circuit as shown in figure 1, all three LEDs come on when S2 is pressed. LED1 goes out at the end of the first period (in the example, after 1 min). LED2 goes out at the end of the second period (after 4.5min) and LED3 goes out at the end of the third and final period (after 5 min). We used ordinary 5mm red LEDs in our prototype but you can vary this by using

LEDs of different colours (red, yellow, green) or shapes. You can also use flashing LEDs. For example, if LED3 is a flashing type it effectively signals the imminent end of the process. It is also possible to wire the circuit for the reverse operation, with all LEDs off to begin with and all on at the end. Just reverse the input connections to the op amps.

Construction

Figure 2 shows the stripboard layout and connections to the main switch S1. The circuit is powered by two 9V PP3 batteries, using two battery clips. First assemble the ramp generator circuit, which includes everything on the board to the left of column 20. The ramp generator is best tested at this stage, using a meter with high-impedance input, for example a digital multimeter. A moving-coil meter will probably require too much current and give misleading low voltage values at the wiper of VR1. Check the voltage at the cathode of ZD1; it should be close to 3.9V. Measure the voltage at the wiper of VR1 and adjust VR1 to bring this to 30mV or any other value you have decided upon. Finally monitor the voltage at pin 1 of IC1. This should be 0V when S2 is pressed and released, then fall steadily at a rate close to 0.4V per minute. If you have decided upon the timing of the periods, have a seconds clock handy, press and release S2 and note the voltages (negative) as each of the period ends. These figures form the basis for calculating the resistances required in the resistor chain (see previous section).

Having decided on timings, the values of resistances and the types of LED, assemble the rest of the circuit. If you are using presets, switch off the power, connect a multimeter across each in turn and adjust each to its calculated value.

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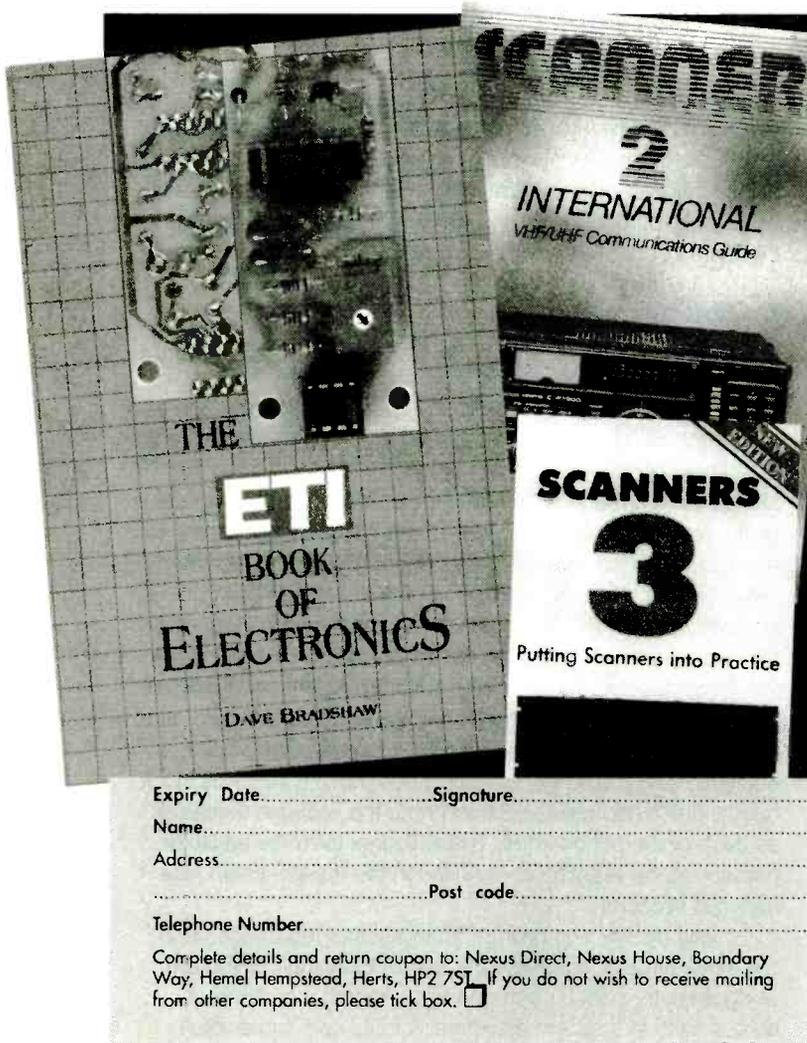
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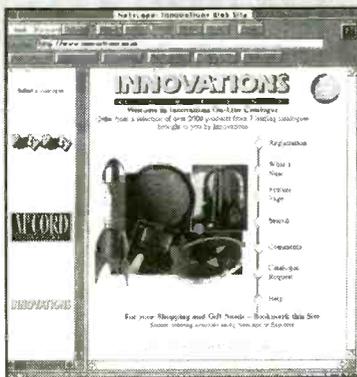
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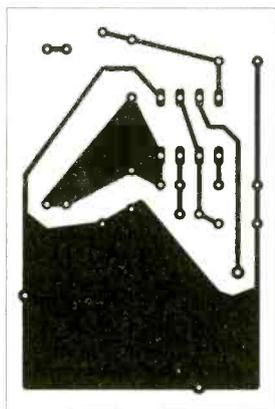
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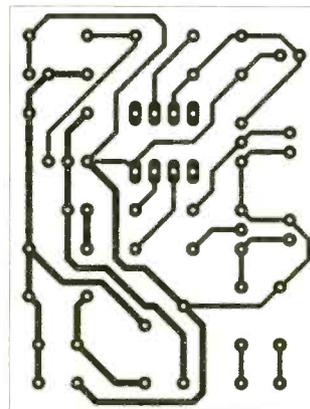
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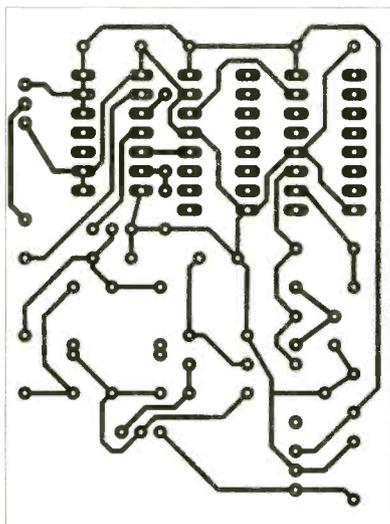
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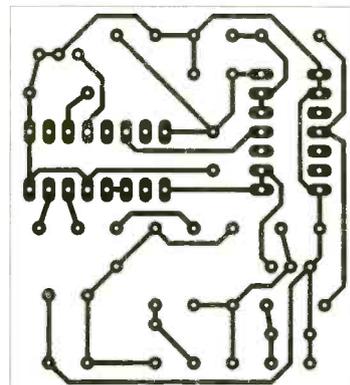
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Around the Corner

Every so often, a manufacturer can make the boast that their kit is currently the ruggedest on the streets (see News: The World's first 5 GB laptop disk drive). This leads us to wonder - how many computers are at risk? We knew someone who hit a printer once (yes: it broke. One of those £2.95 parts that costs £10 to replace.), and someone who used to thump his monitor (it made it work - right up to the day it blew up. He wasn't injured, but a colleague lost two hours' work when the circuit breaker tripped) and a technician who swears that hitting keyboards makes them work better (like the monitor, perhaps). But we have yet to meet anyone who hits computers. Even other people's computers. On trains? Maybe ...

But seriously, although for some electronics purists anything with a moving part is distinctly suspect, it is likely that rotating storage media will be with us for some time. The technological advances in hard discs should not be underestimated. Many people remember mainframe hard discs, with stacked disc packs used in a clean room environment, and storing a few hundred kilobytes if you were lucky.

The 'head crash' (now a science fiction title) used to be an ever present risk. A tiny particle, perhaps cigarette smoke, would get between the head and the disk, and trigger a destructive operation in which the head scraped the magnetic coating off the disc. This is still physically possible with modern hard discs, it doesn't happen often.

When 20 megabytes constituted a large hard disc, it was necessary to run a program to park the heads before moving the computer, to stop the heads clattering against the platter and chipping the magnetic coating off. Nowadays that is

taken care of in the mechanism, and when the power is switched off the heads are moved to a safe position. More effort is made to give each new generation of disc drives improved aerodynamics for the heads and ever smoother coatings for the platter to permit closer spacing between disc and head, so that we can read and write ever smaller magnetic domains.

What does this mean for portable computers? The most obvious problem is that the heads must not chip the platter even when shock is applied while data is being written. Ideally, there should be no disruption to the data storage accuracy.

There is another less obvious problem: the platter is spinning very fast, and even a small tilt applied to it will generate strong precession forces (which can be illustrated with an ordinary gyroscope). This precession is a result of the conservation of angular momentum, so the faster the spin, the more change in angular momentum from a given tilt, and the more force. This force tries to flex the platter, and puts strain on the bearings. The whole assembly must be rigid enough so that the platter does not contact the head and use it like a lathe tool to machine pieces off.

When you consider all these factors, the production of a 5 Gigabyte hard disc (see News) for use in a portable computer is another modern marvel.

Last Month's Competition Winners

Congratulations to our RIAT competition winners from issue 6. 15 pairs of complimentary tickets to the Royal International Air Tattoo at RAF Fairford, Gloucester, in July are winging their way to the winning entries.

Next Month...

Volume 26 no. 9 of **Electronics Today International** will be in your newsagent on 15th August 1997 ... **H. Paul Shuch** will be scanning the heavens for signs of life as yet unknown ... **Terry Balbirnie's** mock alarm flasher offers a very low cost safety feature for cars ... We take a look at some more **Electronics** courses, including some postgraduate and research departments ... all the regulars, and more.

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



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|---------------------------|-------|-------|-------|---------|-------|---------|---------|
| Flash Code ROM (bytes) | 4K | 8K | 20K | 8K | 12K | 1K | 2K |
| RAM (bytes) | 128 | 256 | 256 | 256 | 256 | 64 | 128 |
| EEPROM | - | - | - | 2K | - | - | - |
| In-system re-programmable | - | - | - | YES | YES | - | - |
| I/O Pins | 32 | 32 | 32 | 32 | 32 | 15 | 15 |
| 16-bit Timer/Counters | 2 | 3 | 3 | 3 | 3 | 1 | 2 |
| Watchdog timer | - | - | - | YES | YES | - | - |
| Interrupt sources | 6 | 8 | 8 | 9 | 9 | 3 | 6 |
| Serial UART (full duplex) | YES | YES | YES | YES | YES | - | YES |
| SPI Interface | - | - | - | YES | YES | - | - |
| Analogue comparator | - | - | - | - | - | YES | YES |
| Data pointers | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| Package Pins (DIL) | 40 | 40 | 40 | 40 | 40 | 20 | 20 |

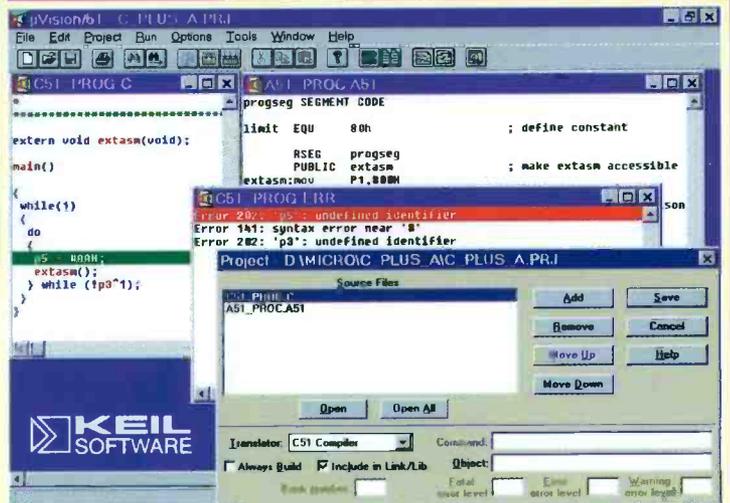
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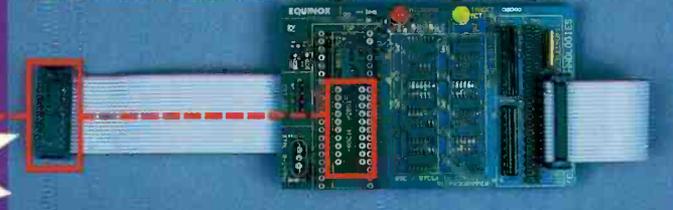
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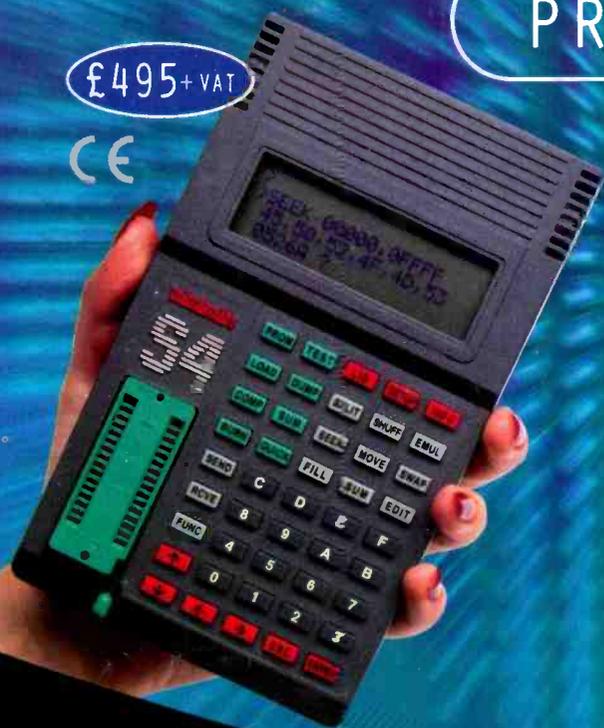


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