# ETI ELECTRONICS TODAY INTERNATIONAL

## RF signal generator
## Audio output level indicator
## Add-on squarer circuit

# BACK TO FIREWOOD
## Biomass as a source of energy

# PLUS

- Diode and LED tester
- Windscreen washer check
- Restoring valve radios

AUGUST 1996 £2.25

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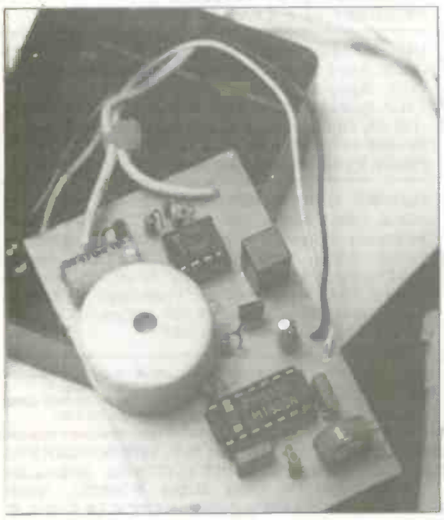
# Contents






## Volume 25 No.8


## Features & Projects



## Regulars

# POWER AMPLIFIER MODULES-TURNTABLES-DIMMERS-LOUDSPEAKERS-19 INCH STEREO RACK AMPLIFIERS

★ PRICES INCLUDE V.A.T. ★ PROMPT DELIVERIES ★ FRIENDLY SERVICE LARGE (A4) S.A.E., 60p STAMPED FOR CATALOGUE ★

## OMP MOS-FET POWER AMPLIFIERS HIGH POWER, TWO CHANNEL 19 INCH RACK

**THOUSANDS PURCHASED BY PROFESSIONAL USERS**

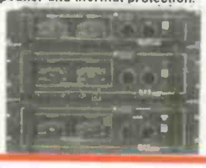
### THE RENOWNED MXF SERIES OF POWER AMPLIFIERS

FOUR MODELS:- **MXF200** (100W + 100W) **MXF400** (200W + 200W) **MXF600** (300W + 300W) **MXF900** (450W + 450W)

ALL POWER RATINGS R.M.S. INTO 4 OHMS, BOTH CHANNELS DRIVEN

**FEATURES:** ★ Independent power supplies with two toroidal transformers ★ Twin L.E.D. Vu meters ★ Level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low distortion ★ Aluminium cases ★ MXF600 & MXF900 fan cooled with D.C. loudspeaker and thermal protection.

USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.



SIZES:- MXF200 W19"xH3½" (2U)xD11"
MXF400 W19"xH5¼" (3U)xD12"
MXF600 W19"xH5¼" (3U)xD13"
MXF900 W19"xH5¼" (3U)xD14¾"

PRICES:- MXF200 £175.00 MXF400 £233.85
MXF600 £329.00 MXF900 £449.15
SPECIALIST CARRIER DEL. £12.50 EACH

## OMP XO3 STEREO 3-WAY ACTIVE CROSS-OVER

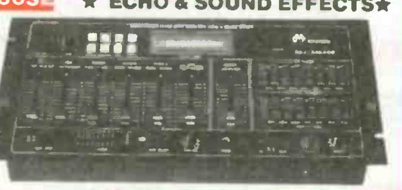
Advanced 3-Way Stereo Active Cross-Over, housed in a 19" x 1U case. Each channel has three level controls: bass, mid & top. The removable front fascia allows access to the programmable DIL switches to adjust the cross-over frequency: Bass-Mid 250/500/800Hz, Mid-Top 1.8/3/5KHz, all at 24dB per octave. Bass invert switches on each bass channel. Nominal 775mV input/output. Fully compatible with OMP rack amplifier and modules.

**Price £117.44 + £5.00 P&P**

## STEREO DISCO MIXER SDJ3400SE

**★ ECHO & SOUND EFFECTS★**

**STEREO DISCO MIXER** with 2 x 7 band L & R graphic equalisers with bar graph LED Vu meters. MANY OUTSTANDING FEATURES:- Including Echo with repeat & speed control, DJ Mic with talk-over switch, 6 Channels with individual faders plus cross fade, Cue Headphone Monitor. 8 Sound Effects. Useful combination of the following inputs:- 3 turntables (mag), 3 mics, 5 Line for CD, Tape, Video etc.

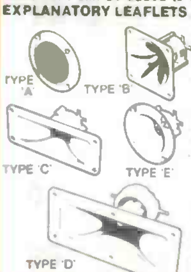


**Price £144.99 + £5.00 P&P**

SIZE: 482 x 240 x 120mm

## PIEZO ELECTRIC TWEETERS - MOTOROLA

Join the Piezo revolution! The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if two are put in series. FREE EXPLANATORY LEAFLETS ARE SUPPLIED WITH EACH TWEETER.




**TYPE 'A' (KSN1036A)** 3" round with protective wire mesh. Ideal for bookshelf and medium sized Hi-Fi apeakers. Price £4.90 + 50p P&P.

**TYPE 'B' (KSN1005A)** 3½" super horn for general purpose speakers, disco and P.A. systems etc. Price £5.99 + 50p P&P.

**TYPE 'C' (KSN1016A)** 2"x5" wide dispersion horn for quality Hi-Fi systems and quality discos etc. Price £6.99 + 50p P&P.

**TYPE 'D' (KSN1025A)** 2"x6" wide dispersion horn. Upper frequency response retained extending down to mid-range (2KHz). Suitable for high quality Hi-Fi systems and quality discos. Price £9.99 + 50p P&P.

**TYPE 'E' (KSN1038A)** 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-Fi monitor systems etc. Price £5.99 + 50p P&P.

**LEVEL CONTROL** Combines, on a recessed mounting plate, level control and cabinet input jack socket. 85x85mm. Price £4.10 + 50p P&P.

## ibl FLIGHT CASED LOUDSPEAKERS

A new range of quality loudspeakers, designed to take advantage of the latest speaker technology and enclosure designs. Both models utilize studio quality 12" cast aluminium loudspeakers with factory fitted grilles, wide dispersion constant directivity horns, extruded aluminium corner protection and steel ball corners, complimented with heavy duty black covering. The enclosures are fitted as standard with top hats for optional loudspeaker stands.

POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET
FREQUENCY RESPONSE FULL RANGE 45Hz - 20KHz

ibl FC 12-100WATTS (100dB) PRICE £159.00 PER PAIR
ibl FC 12-200WATTS (100dB) PRICE £175.00 PER PAIR
SPECIALIST CARRIER DEL. £12.50 PER PAIR

OPTIONAL STANDS PRICE PER PAIR £49.00
Delivery £6.00 per pair

## IN-CAR STEREO BOOSTER AMPS

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

**THREE SUPERB HIGH POWER CAR STEREO BOOSTER AMPLIFIERS**

150 WATTS (75 + 75) Stereo, 150W Bridged Mono
250 WATTS (125 + 125) Stereo, 250W Bridged Mono
400 WATTS (200 + 200) Stereo, 400W Bridged Mono
ALL POWERS INTO 4 OHMS

**Features:**
★ Stereo, bridgable mono ★ Choice of high & low level inputs ★ L & R level controls ★ Remote on-off ★ Speaker & thermal protection.

POSTAL CHARGES PER ORDER £1.00 MINIMUM. OFFICIAL ORDERS FROM SCHOOLS, COLLEGES, GOVT. BODIES, PLCs ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER. VISA AND ACCESS ACCEPTED BY POST, PHONE OR FAX.

## OMP MOS-FET POWER AMPLIFIER MODULES

**SUPPLIED READY BUILT AND TESTED.**

These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal power supply, integral heat sink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof.

### THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

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

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

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

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

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

## LOUDSPEAKERS

LARGE SELECTION OF SPECIALIST LOUDSPEAKERS AVAILABLE, INCLUDING CABINET FITTINGS, SPEAKER GRILLES, CROSS-OVERS AND HIGH POWER, HIGH FREQUENCY BULLETS AND HORNS, LARGE (A4) S.A.E. (60p STAMPED) FOR COMPLETE LIST.

McKenzie and Fane Loudspeakers are also available.

## EMINENCE:- INSTRUMENTS, P.A., DISCO, ETC

ALL EMINENCE UNITS 8 OHMS IMPEDANCE

8" 100 WATT R.M.S. ME8-100 GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID, DISCO.
RES. FREQ. 72Hz, FREQ. RESP. TO 4KHz, SENS 97dB. PRICE £32.71 + £2.00 P&P

10" 100 WATT R.M.S. ME10-100 GUITAR, VOCAL, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 71Hz, FREQ. RESP. TO 7KHz, SENS97dB. PRICE £33.74 + £2.50 P&P

10" 200 WATT R.M.S. ME10-200 GUITAR, KEYB'D, DISCO, VOCAL, EXCELLENT HIGH POWER MID.
RES. FREQ. 65Hz, FREQ. RESP. TO 3.5KHz, SENS 99dB. PRICE £43.47 + £2.50 P&P

12" 100 WATT R.M.S. ME12-100LE GEN. PURPOSE, LEAD GUITAR, DISCO, STAGE MONITOR.
RES.FREQ. 49Hz, FREQ. RESP. TO 6KHz, SENS 100dB. PRICE £35.64 + £3.50 P&P

12" 100 WATT R.M.S. ME12-100LT (TWIN CONE) WIDE RESPONSE, P.A., VOCAL, STAGE MONITOR. RES. FREQ 42Hz, FREQ. RESP. TO 10KHz, SENS 98dB. PRICE £36.67 + £3.50 P&P

12" 200 WATT R.M.S. ME12-200 GEN. PURPOSE, GUITAR, DISCO, VOCAL, EXCELLENT MID.
RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB. PRICE £46.71 + £3.50 P&P

12" 300 WATT R.M.S ME12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARD, DISCO ETC.
RES. FREQ. 47Hz, FREQ. RESP. TO 5KHz, SENS 103dB. PRICE £70.19 + £3.50 P&P

15" 200 WATT R.M.S. ME15-200 GEN. PURPOSE BASS, INCLUDING BASS GUITAR.
RES. FREQ. 46Hz, FREQ. RESP. TO 5KHz, SENS 99dB. PRICE £50.72 + £4.00 P&P

15" 300 WATT R.M.S. ME15-300 HIGH POWER BASS, INCLUDING BASS GUITAR.
RES. FREQ. 39Hz, FREQ. RESP. TO 3KHz, SENS 103dB. PRICE £73.34 + £4.00 P&P

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

ALL EARBENDER UNITS 8 OHMS (Except EB8-50 & EB10-50 which are dual impedance tapped @ 4 & 8 ohm)

BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND

8" 50watt EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 7KHz SENS 97dB. PRICE £8.90 + £2.00 P&P

10" 50WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS. 99dB. PRICE £13.65 + £2.50 P&P

10" 100WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz, FREQ. RESP. TO 3KHz, SENS 96dB. PRICE £30.39 + £3.50 P&P

12" 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz, SENS 93dB. PRICE £42.12 + £3.50 P&P

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

5¼" 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB. PRICE £9.99 + £1.50 P&P

6½" 60WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB. PRICE £10.99 + 1.50 P&P

8" 60WATT EB8-60TC (TWIN CONE) HI-FI, MILTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB. PRICE £12.99 + £1.50 P&P

10" 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC.
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB. PRICE £16.49 + £2.00 P&P

## TRANSMITTER HOBBY KITS

PROVEN TRANSMITTER DESIGNS INCLUDING GLASS FIBRE PRINTED CIRCUIT BOARD AND HIGH QUALITY COMPONENTS COMPLETE WITH CIRCUIT AND INSTRUCTIONS

3W TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 38 x 123mm, SUPPLY 12V @ 0.5AMP.
PRICE £14.85 + £1.00 P&P

FM MICRO TRANSMITTER 100-108MHz, VARICAP TUNED, COMPLETE WITH VERY SENS FET MIC, RANGE 100-300m, SIZE 56 x 46mm, SUPPLY 9V BATTERY.
PRICE £8.80 + £1.00 P&P

PHOTO: 3W FM TRANSMITTER


# B.K. ELECTRONICS

UNITS 1 & 5 COMET WAY, SOUTHEND-ON-SEA, ESSEX. SS2 6TR
Tel. 01702 - 527572 Fax: 01702-420243

**SURVEILLANCE TELESCOPE** Superb Russian zoom telescope adjustable from 15x to 60x! complete with metal tripod (imposible to use without this on the higher settings) 66mm lense, leather carrying case £149 ref BAR69

**RADIATION DETECTOR SYSTEM** Designed to be wall mounted and connected into a PC, ideal for remote monitoring, whole building coverage etc. Complete with detector, cable and software. £19.95 ref BAR75.

**WIRELESS VIDEO BUG KIT** Transmits video and audio signals from a minature CCTV camera (included) to any standard television! All the components including a PP3 battery will fit into a cigarette packet with the lens requiring a hole about 3mm diameter. Supplied with telescopic aerial but a piece of wire about 4" long will still give a range of up to 100 metres. A single PP3 will probably give less than 1 hours use. £99 REF EP79. (probably not licensable!)

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

**IR LAMP KIT** Suitable for the above camera enables the camera to be used in total darkness! £5.99 ref EF138.

**REMOTE CONTROLTANDATA TD1400 MODEM/ VIEWDATA** Complete system comprising 1200/75 modem, auto dialler, Infra red remote keyboard, (could be adapted for PC use?) psu, UHF and RGB output, phone lead, RS232 output, composite output. Absolute bargain for parts alone!£9.95 ref BAR33.

## 9 WATT CHIEFTAN TANK LASERS

Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignement 7 mile range, full circuit diagrams, new price £50,000? us? £349. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. five or more units £299 ea. £349 for one. Ref LOT4.

**TWO WAY MIRROR KIT** Includes special adhesive film to make two way mirror(s) up to 60"x20". (glass not included) Includes full instructions. £12 ref TW1.

**NEW HIGH POWER RF TRANSMITTERS AMPLIFIERS** Assembled PCB transmitters, 4 types available.
12.6vdc 90 watt 1.5-30mhz 75 ohm in/out FM/AM £75 ref RF1
12.6vdc 40 watt 50-200mhz 50 ohm in/out FM/AM £65 ref RF2
28vdc 125 watt 1.5-30mhz 75 ohm in/out FM/AM £85 ref RF3
28vdc 100 watt 50-200mhz 50 ohm in/out FM/AM £75 ref RF4
A heat sink will be required, ring for price and availability.
If you intend using these as audio transmitters you will need a also need a preamp. Complex module available at £40 ref RF5.

**COMPUTER/WORKSHOP/HI-FI RCB UNITS** Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends it by 750mm), fitted in less than 10 seconds, reset/test button, 10A rating. £9 each Ref MM5.

**RADIO CONTROLLED CARS FROM £6 EACH!!!!** All returns from famous manufacturer, 3 types available, single channel (left,right,forwards,backwards)£6 ref LOT1. Two channel with more features £12 ref LOT2. Two channel proportional (plug in crystals etc) £35 ref LOT3.

**THOUSANDS AVAILABLE RING/FAX FOR DETAILS!**

**MAGNETIC CARD READERS** (Swipes) £9.95 Cased with flyleads, designed to read standard credit cards! they have 3 wires coming out of the head so they may write as well? complete with control elctronics PCB. just £9.95 ref BAR31

**WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA?** We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC. Also included is the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74

**PANORAMIC CAMERA OFFER** Takes double width photographs using standard 35mm film. Use in horizontal or vertical mode. Complete with strap £7.99 ref BAR1

**COIN OPERATED TIMER KIT** Complete with coinslot mechanism, adjustable time delay, relay output, put a coinslot on anything you like! TV,s, videos, fridges, drinks cupboards, HIFI, takes 50p's and £1 coins. DC operated, price just£7.99 ref BAR27.

**ZENITH 900 X MAGNIFICATION MICROSCOPE** Zoom, metal construction, built in light, shrimp farm, group viewing screen, lots of accessories. £29 ref ANAYLT.

**AA NICAD PACK** Pack of 4 tagged AA nicads £2.99 ref BAR34

**PLASMA SCREENS** 222x310mm, no data hence £4.99 ref BAR67

**NIGHTSIGHTS** Model TZS4 with infra red illuminator, views up to 75 metres in full darkness in infrared mode, 150m range, 45mm lens, 13 deg angle of view, focussing range 1.5m to infinity. 2 AA batteries required. 950g weight. £199 ref BAR61. 1 years warranty

**LIQUID CRYSTAL DISPLAYS Bargain prices,**
16 character 2 line, 99x24mm £2.99 ref SM1623A
20 character 2 line, 83x19mm £3.99 ref SM2020A
16 character 4 line, 62x25mm £5.99 ref SMC1640A

**TAL-1 110MM NEWTONIAN REFLECTOR TELESCOPE** Russian. Superb astronomical 'scope, everything you need for some serious star gazing! up to 169x magnification. Send or fax for further details £249 ref TAL-1

**GOT AN EXPENSIVE BIKE?** You need one of our bottle alarms, they look like a standard water bottle, but open the top, insert a key to activate a motion sensor alarm built inside. Fits all standard botte carriers, supplied with two keys. SALE PRICE £7.99 REF SA32.

**GOT AN EXPENSIVE ANYTHING?** You need one of our cased vibration alarms, keyswitch operated, fully cased just fit it to

## WOLVERHAMPTON BRANCH NOW OPEN AT WORCESTER ST W'HAMPTON TEL 01902 22039

anything from videos to caravans, provides a years protection from 1 PP3 battery, UK made. SALE PRICE £4.99 REF SA33.

**DAMAGED ANSWER PHONES** These are probably beyond repair so just £4.99 each. BT response 200 machines. REF SA30.

**COMPUTER DISC CLEAROUT** We are left with a lot of software packs that need clearing so we are selling at disc value only! 50 discs for £4, thats just 8p each!!(our choice of discs) £4 ref EP66

**IBM PS2 MODEL 160Z CASE AND POWER SUPPLY** Complete with fan etc and 200 watt power supply. £9.95 ref EP67

**DELL PC POWER SUPPLIES** 145 watt, +5,-5,+12,-12, 150x150x85mm complete with switch, flyleads and IEC socket. SALE PRICE £9.99 ref EP55

**1.44 DISC DRIVES** Standard PC 3.5" drives but returns so they will need attention SALE PRICE £4.99 ref EP68

**1.2 DISC DRIVES** Standard 5.25" drives but returns so they will need attention SALE PRICE NOW ONLY £3.50 ref EP69

**PP3 NICADS** Unused but some storage marks. £4.99 ref EP52

**DELL PC POWER SUPPLIES** (Customer returns) Standard PC psu's complete with fly leads, case and fan. +12v,-12v,+5v,-5v SALE PRICE £1.99 EACH worth it for the bits alone! ref DL1. TRADE PACK OF 20 £29.95 Ref DL2.

**GAS HOBS AND OVENS** Brand new gas appliances, perfect for small flats etc. Basic 3 burner hob SALE PRICE £24.99 ref EP72. Basic small built in oven SALE PRICE £79 ref EP73

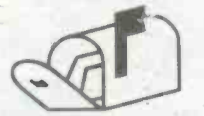
**RED EYE SECURITY PROTECTOR** 1,000 watt outdoor PIR switch SALE PRICE £6.99 ref EP57

**ENERGY BANK KIT** 100 6"x6" 6v 100mA panels, 100 diodes, connection details etc. £69.95 ref EF112.

**PASTEL ACCOUNTS SOFTWARE**, does everything for all sizes of businesses, includes wordprocessor, report writer, windowing, networkable up to 10 stations, multiple cash books etc. 200 page comprehensive manual. 90 days free technical support (0345-326009 try before you buy!) Current retail price is £129, SALE PRICE £9.95 ref SA12. SAVE £120!!!

**COMPLETE PC 200 WATT UPS SYSTEM** Top of the range UPS system providing protection for your computer system and valuable software against mains power fluctuations and cuts. New and boxed, UK made Provides up to 5 mins running time in the event of complete power failure to allow you to run your system down correctly. LAST FEW TO CLEAR AT £49 SAVE £30 ref LOT61

**BIG BROTHER PSU** Cased PSU, 6v 2A output, 2m o/p lead, 1.5m input lead, UK made,220v. SALE PRICE £4.99 REF EP7



**Check out our WEB SITE**

**http://www.pavilion.co.uk/bull-electrical**

**RACAL MODEM BONANZA!** 1 Racal MPS1223 1200/75 modem, telephone lead, mains lead, manual and comms software, the cheapest way onto the net! all this for just £13 ref DEC13.

**4.5mw LASER POINTER. BRAND NEW MODEL NOW IN STOCK!, supplied in fully built form (looks like a nice pen) complete with handy pocket clip (which also acts as the on/off switch.) About 50 metres range! Runs on 2 AAA batteries. Produces thin red beam ideal for levels, gun sights, experiments etc. just £39.95 ref DEC49 TRADE PRICE £28 MIN 10 PIECES**

**BULL TENS UNIT** Fully built and tested TENS (Transcutaneous Electrical Nerve Stimulation) unit, complete with electrodes and full instructions. TENS is used for the relief of pain etc in up to 70% of sufferers. Drug free pain relief, safe and easy to use, can be used in conjunction with analgesics etc. £49 Ref TEN/1

**RUSSIAN MONOCULARS** Amazing 20 times magnification, coated lenses, carrying case and shoulder strap £29.95 REF BAR73

**PC PAL VGA TO TV CONVERTER** Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware. Ideal for laptops or a cheap upgrade. Supplied in kit form for home assembly. SALE PRICE £25 REF SA34

**EMERGENCY LIGHTING UNIT** Complete unit with 2 double bulb floodlights, built in charger and auto switch. Fully cased. 6v 8AH lead acid req'd. (secondhand) £4 ref MAG4P11.

**YUASHA SEALED LEAD ACID BATTERIES** Two sizes currently available this month. 12v 15AH at £18 ref LOT8 and 6v 10AH (suitable for emergency lights above) at just £6 ref LOT7.

**ELECTRIC CAR WINDOW DE-ICERS** Complete with cable, plug etc SALE PRICE JUST £4.99 REF SA28

**AUTO SUNCHARGER** 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. £8.99 REF SA25.

**ECLATRON FLASH TUBE** As used in police car flashing lights etc, full spec supplied, 60-100 flashes a min. £6.99 REF SA15B.

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

# BULL ELECTRICAL

250 PORTLAND ROAD, HOVE, SUSSEX. BN3 5QT. (ESTABLISHED 50 YEARS).

MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £3 P&P PLUS VAT.

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**GYROSCOPES** Remember these? well we have found a company that still manufactures these popular scientific toys, perfect gift or for educational use etc. £6 ref EP70

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ETI ELECTRONICS TODAY INTERNATIONAL

# News...

## New coax matrix switching card for high speed

Keithley Instruments have introduced the model 7077, a new 8X 12 isolated coaxial matrix card for its models 707 and 708 matrix switching mainframes. The card's isolated coaxial connectors also allow high speed production testing of dc and ac signals up to 10MHz with insertion loss as low as 3db and crosstalk of -15db. These features facilitate a wide range of tests and simplify the integration of multiple instruments with differing connector types, which are often found in a production test environment.

The model 7077 provides 2-pole, form A (normally open) switching of each point in the card's 8-row x 12 column matrix. Each coax hi and lo conductor has its own set of relay contacts, a necessity for true differential measurements. Contact potential is less than 5µV and offset current is below 100pA. Contact settling is completed in less than 3 ms.

This performance ensures high accuracy, allows more complex set-ups with a larger number of simultaneous crosspoint connections and provides higher throughput in switching-intensive production tests.

The performance characteristics of the model 7077 make it well-suited for sensitive measurements of signals ranging from dc to 10MHz.

The model 7077 plugs into a card slot on Keithley's model 707 or 708 switching matrix mainframe. The mainframe provides a convenient means of interconnecting complex test system wiring and setting up the matrix switching program. Programming is accomplished with software over an IEEE-488 bus or by using an optional light pen and the mainframe's front panel matrix. The mainframe also allows switching to be triggered from an external source. Alphanumeric and individual LED displays provide readouts of operational status, program steps, relay states, and general status monitoring.

Keithley Instruments Inc. has been designing and manufacturing precision instrumentation since 1946. Today, Keithley is a world leader in providing hardware and software solutions for electronic test and measurement, data acquisition, and semiconductor characterisation. Keithley products and systems are found throughout the world in universities, industrial laboratories, engineering development departments, quality control areas, and on the production lines. They are second to none in providing highly accurate and reliable data related to the electrical, temperature and periodic phenomena they test and measure. More information: Keithley Instruments Ltd, The Minster, 58 Portman Road, Reading, Berkshire RG30 1EA. Tel: 01734 575666.

## Life in the old box

Can you remember when you were proud of your new BSB receiver and the entertainment that it could provide for you? And then it was made redundant. 3R Cardware can now offer conversion of your old unit into a working D2MAC decoder, enabling you to view up to 20 satellite channels including sport, movies and family viewing - and all without the monthly subscription fee. Alternatively, you can purchase your own conversion kit which comes complete with instruction sheet and component layout diagrams and is simple to fit. The decoder plugs straight into the back of your existing satellite receiver, giving superior picture and sound quality. The unit comes with its own upgradeable 'Smartcard' and scart leads from £139. Further information: 3R Cardware on 01246 455150.

## Partridge Electronics

In the July issue of ETI, we inadvertently published Partridge Electronics advertisement under the banner, Kits. This was an error as, under ABT rules, this equipment is illegal in kit form.

We apologise for any confusion.

## Leabank Shields

The application of coatings to provide RFI/EMI shielding for plastic enclosures has become a specialised service of Leabank Coatings Limited.

The metal coatings act to suppress emissions, help reduce interference and allow any electrostatic build-up to discharge safely to ensure compliance with the EMC regulations.

Although the major demand is for nickel loaded coatings, copper/silver and silver coatings are applied for specific requirements as these arise.

More information: Leabank Coating Ltd, Wycombe Road, Stokenchurch, High Wycombe, Bucks HP14 3RJ.

# Rugged miniature enclosures

Arcom Control Systems has launched two small enclosures offering a flexible basis for housing the compact, high-performance industrial computers used in today's machinery and automation. Dubbed ACE, the boot-shaped enclosure system is capable of being mounted on a wall or inside equipment cabinets, and offers room for a computer with up to six single Eurocard modules. This is adequate for a STEbus processor and a substantial quantity of signal-conditioned I/O channels if required; enough to implement a powerful stand-alone embedded controller, or a fieldbus node if the element is part of a distributed intelligent system - an increasingly popular design approach. Despite its potential capacity, the enclosures occupy half or less of the volume of a 19 inch sub-rack, the most commonly used form of industrial computer housing today.

Fabricated from die-cast metal components, ACE (Arcom Compact Enclosure) offers superb electromagnetic noise protection and has additionally been engineered to conform with Arcom's innovative Technical Construction File approach to EMC compliance. By using a range of preferred computer and I/O modules and cable assemblies, designers can use ACE to configure custom control systems and self-certify them as CE-compliant with confidence, providing a rapid and reliable path to market which can save months of effort and thousands of pounds in EMC testing costs.

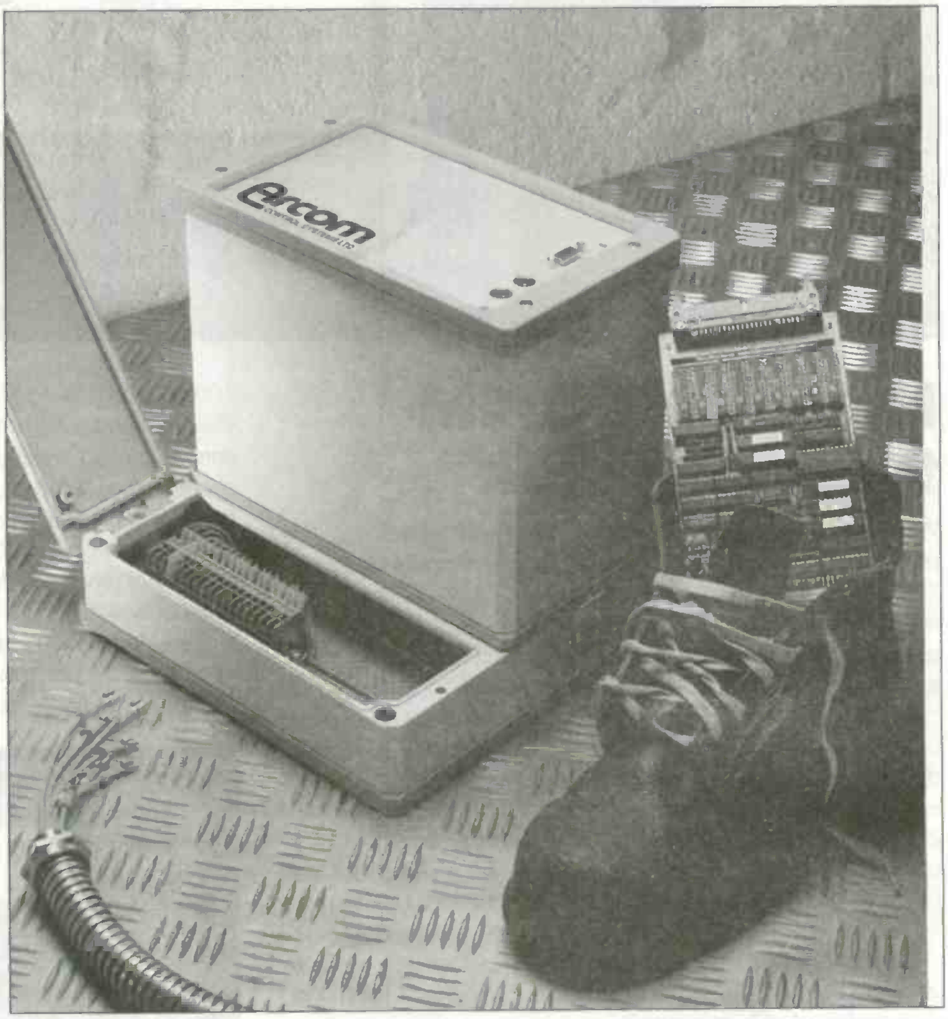
Arcom has created this product in response to the growing demand for smaller industrial computer systems with fewer function modules. Increasing levels of IC integration has meant that the vast majority of STEbus-based controllers being built today require just two to four boards. As most of Arcom's customers utilise 19-inch hardware to house such systems, 50% or more of a typical 3U sub-rack is empty - wasting space and money.

ACE resolves this problem by offering L-shaped enclosures with three separate areas for mounting the various components of a typical system to minimise dimensions. The single Eurocard computer modules are mounted vertically in the upper part of the boot shape minimising depth. The power supply sits underneath in the 'heel' area, while the 'toe' provides a convenient space-efficient area for cable entry and termination. Hinges provide three-way opening to allow easy access to any area for system building, installation, maintenance or reconfiguration purposes.

The enclosure is offered in a two main variants suitable for building STEbus-based industrial computer systems. ACE-28, is designed for 'target' systems, diskless PCs or remote I/O nodes, and offers 28E of board mounting width - enough for a backplane with three STEbus modules and two signal conditioning modules, plus a switching power supply and a 40-way cable termination block. ACE-42 is 50% wider with 42E space, and is suitable for larger systems including STEbus-based industrial PC compatibles with disk drives; it can accommodate typically four STEbus boards plus at least two signal conditioning modules, a 3.5-inch disk drive, power supply and cable termination.

Depending on the option chosen, the overall volume of the ACE enclosure is either around a third or half that of a typical 3U 19-inch card frame.

For more details, contact Ian Clarke at Arcom Control Systems Ltd, Clifton Rd, Cambridge CB1 4WH. Tel:01223 411200.




# Flash Microcontroller Programmer

In last month's ETI, we published a project on a serial flash microcontroller programmer. The author would like to add the following notes to readers interested in the project.

"If using the UCN5833A (thirty-three A), connect pin 21 of this chip to ground. A full working version of the software and operating/set-up notes may be obtained from Henry Myatt, 25 Annerley Road, Annan, Dumfriesshire DG 12 6HF. Cost is £2.50 (UK) or £15 (overseas) - this includes postage. If ordering from overseas, payment must be in pounds sterling and cheques drawn on a UK bank."

# New from Hitachi

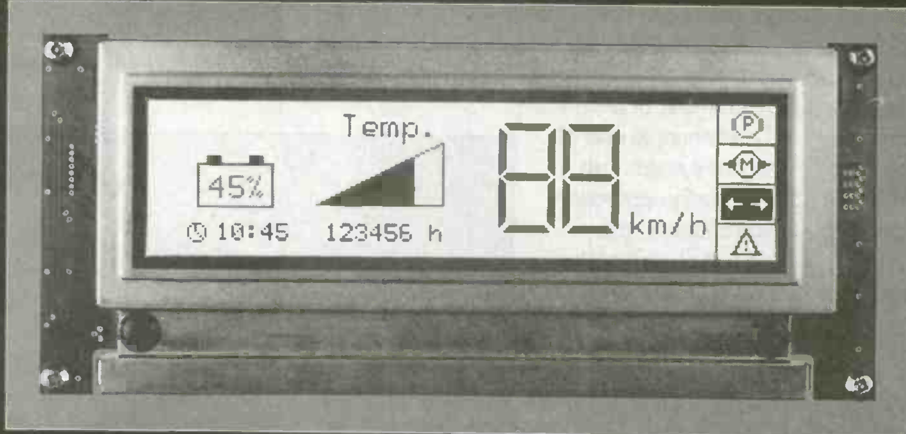
A new, low profile, compact design STN LCD display module is now available from Hitachi. The LMG738OQHFC film black and white transmissive graphics display module has a resolution of 256x64 dots and incorporates a single edge-lit CFL backlight. The combination of film retardation and CFL backlighting offers excellent contrast, very high brightness and wide viewing angles.

The module includes 8Kbytes of display and contains a T6963C graphics controller with built-in character generation. This configuration allows the module to display text and graphics simultaneously. The unit uses a fast response LC fluid making it ideal for animation without image ghosting or lag effects.

The low profile compact design (68mm x 160mm x l2mm), low power consumption (lW) and light weight (l5Og) make it attractive for use in portable applications.

A starter kit is also available, which consists of an INVC191 CFL backlight inverter and all the necessary interfacing cables.

Further information contact: Vince Pitt, Hitachi Europe Ltd, Whitebrook Park, Lower Cookham Road, Maidenhead, Berkshire SL6 8YA Tel: +44-1628 585163 Fax: +44-1628-585160.



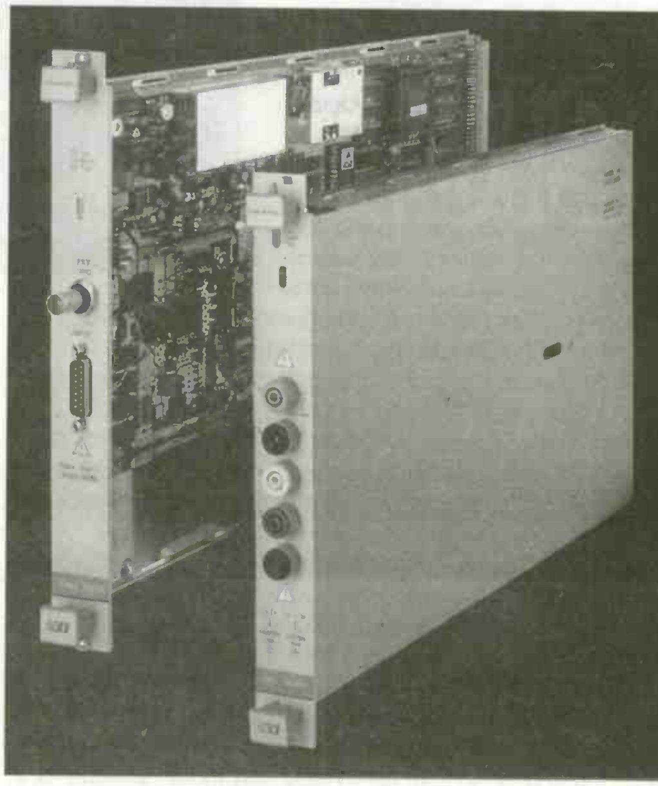

# New Card DMM from Wavetek

Wavetek is the first company to introduce a 6.5-digit multifunction VXI-bus card DMM that accepts inputs up to lOOOV DC or AC rms. Other VXlbus card DMMs on the market only measure to 300V. The new Model 1361 therefore gives VXI-bus system integrators the advantage of being able to measure the highest voltages likely to be encountered in typical ATE systems, without having to use external attenuators or signal conditioning circuitry. As well as DC and AC voltage, the Model 1361 measures resistance up to 20 Ω and, with the current option installed, measures DC and AC currents up to 2A. "Commercial systems integrators cannot always be aware of the future uses to which their systems will be put, particularly in military and aerospace projects", said Newell White, Wavetek's Marketing Manager for VXI-bus products. "The 1361 gives them the added confidence that their systems will meet the same broad performance envelopes of traditional rack-and-stack ATE systems."

In addition to measuring voltages up to 1000 V, the Model 1361 also has a unique level of isolation between its measurement circuits and the VXI-bus backplane. Its front-panel terminals, for example, can be floated as much as 650 V above or below ground potential. Together with extensive internal guarding, this results in a common-mode rejection ratio (CMRR) greater than 146 dB, making precision 6.5-digit measurements possible even when the voltage to be measured has a superimposed DC or AC potential. Switchable filters provide a normal-mode AC rejection (NMR) of more than 20dB, with matching of the Model 1361's measurement cycle to 50 Hz, 60 Hz or 400 Hz line supply periods providing an additional 54dB of noise rejection at line frequencies.

The Model 1361 is capable of making 6.5-digit DC voltage, DC current and resistance measurements at speeds up to five readings per second, and 4.5-digit readings at speeds up to 1000 readings per second. In situations where the available VXI-bus bandwidth limits the read rate, up to 8000 readings can be cached in onboard memory before being transferred over the bus. VXI-bus synchronous and asynchronous backplane triggers are supported, together with the SCPI command language. A diskette containing a plug & play instrument driver developed for the WIN-System framework will also be available.

The Model 1361 is a single-width C-size card that conforms fully to the VXI-bus Rev. 1.4 specification. Its front panel inputs accept 4-mm safety banana plugs.



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# SIGNAL GENERATOR

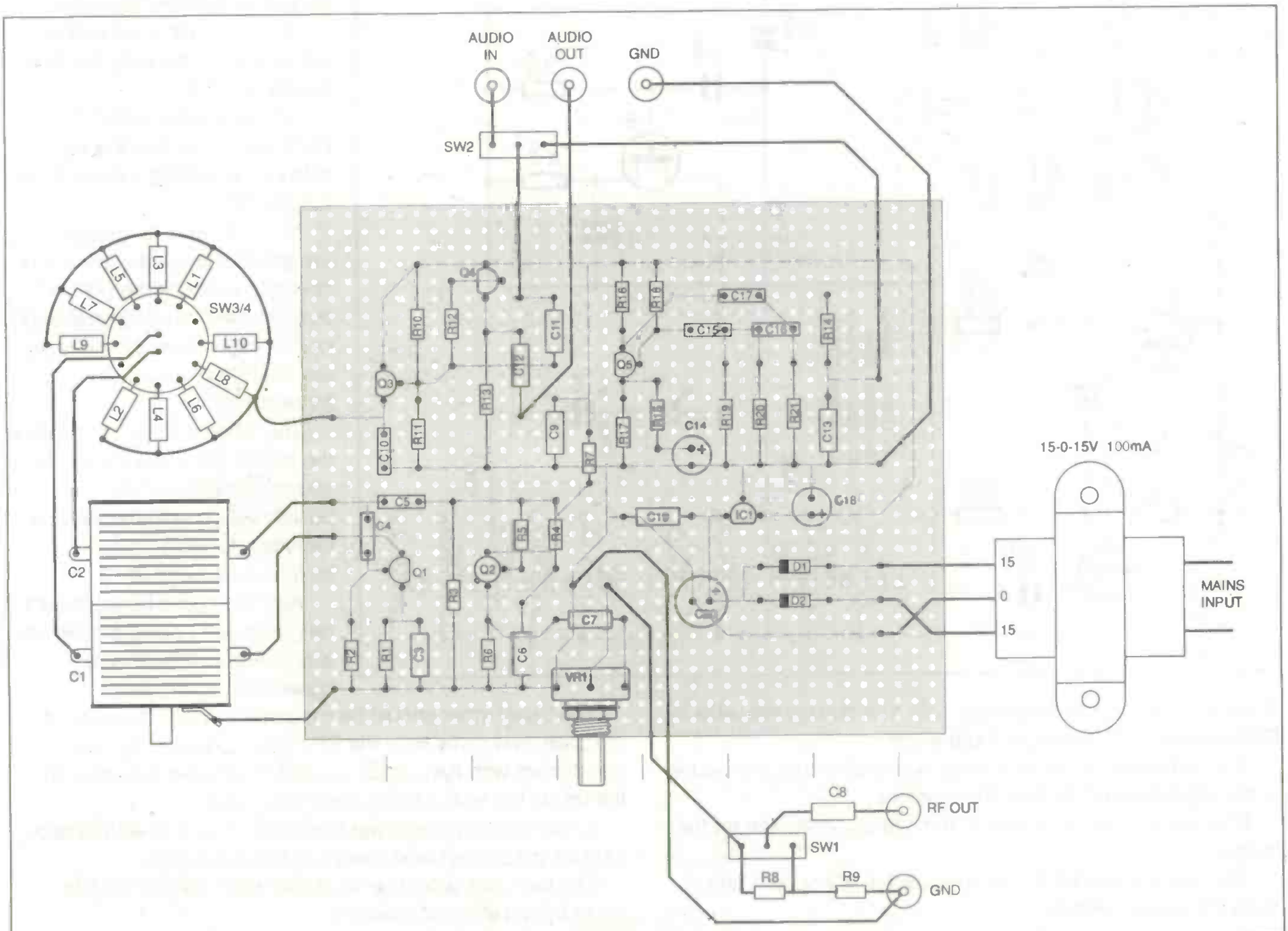
### *By Paul Stenning*

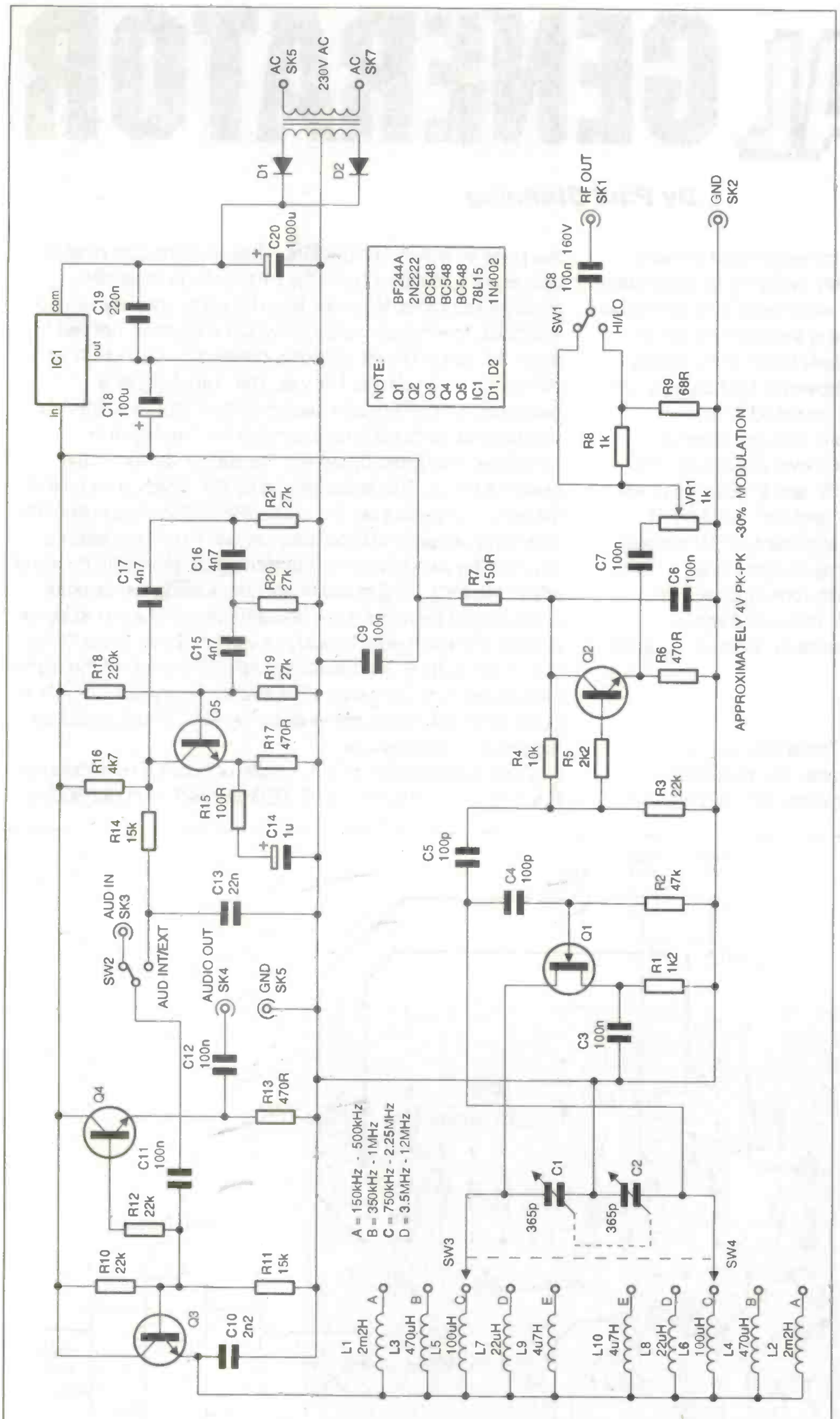
This project is intended for realignment of radio receivers. It was originally designed to accompany the Valve Radio Repair and Restoration series, but it can be used for aligning transistor equipment. The unit is cheap and fairly basic, but perfectly adequate for its intended purpose. However the output is not a pure sine wave, so the unit may not be suited for more exacting electronic development work. The unit covers a frequency range of 150KHz to 12MHz over five ranges. It is therefore suited to the alignment of RF and IF sections of AM (MW and LW) sets, as well as the IF sections of FM (VHF) circuits. It may also be used for RF alignment of SW circuits from 25 to 49 metres. The output may be amplitude modulated by an internal 800Hz audio tone (approx 30% modulation) or by an external signal. The output level is adjustable in two ranges up to a maximum of about 4V pk-pk. The unit is mains powered.

## Circuit description

Q1 is a high gain FET (Field Effect Transistor) and is configured as a Colpitts style oscillator. The oscillation frequency is set by the variable capacitor (C1+C2) and the five pairs of switched inductors. There is significant overlap between the ranges, due to the limited range of readily available inductors. However, even by using specially wound inductors, four frequency bands would have been needed to cover the range.The RF output is buffered by Q2, which is configured as an emitter follower. The output signal is developed across R6, and passes to the output sockets via variable and switched attenuator circuits. The signal is amplitude modulated by varying the supply voltage to the oscillator circuit. This is carried out by Q3, which is an emitter follower. C10 decouples the feed at RF. SW2 selects either the internal or an external modulation signal. If no modulation is required the switch is set to the external position with no signal applied to SK3. To give reasonable modulation the external signal should be about 1.5V RMS (4V pk-pk). If a music signal is used, the bandwidth should not extend above about 8KHz due to the limits of AM broadcasting. C10 will roll-off the higher frequencies to some extent. The selected modulation signal is buffered by Q4 and made available on SK4. This is useful for triggering an oscilloscope.

Q5 is configured in an R-C oscillator circuit. The frequency is set by C15, C16, C17, R19, R20 and R21 to about 800Hz.






IC1 is a standard three-pin 100mA regulator, fed by the full-wave rectified supply from a small mains transformer.

## Construction

The prototype was constructed on a piece of plain matrix board. Stripboard is not suitable because of the capacitance between adjacent tracks. A PCB could be designed, but this should follow the same general layout as the matrix board.

In the diagram the components and wires on the top face of the board are shown in black, while the underside connections are grey.

Much of the circuit board wiring can be carried out using the component leadout wires, with pieces of tinned copper wire added where these are not long enough.

The unit should be built into a suitable metal cabinet to give adequate screening. This should be earthed via the earth wire of three core mains flex.

C1+C2 is a Jackson Type-O air spaced variable capacitor.

This is the most expensive component in the unit, costing around £15.

However valve radio enthusiasts may be able to salvage something suitable from a scrap set.

You may wish to arrange a suitable pointer and scale if you intend to calibrate the unit. A suitable ball reduction drive and pointer (also made by Jackson) are available from Maplin and other suppliers.

The inductors are mounted on the rear of the rotary switch as shown. This should be positioned close to the variable capacitor to keep the wire lengths to a minimum.

Also the circuit board should be positioned to give a minimum wire length to the variable capacitor and switch.

If you wish to alter the frequency, note that altering the value of R19 will affect the biasing of the transistor.

Any variations should be carried out by changing the values of the capacitors rather than the resistors.

R14 and C13 act as a filter to remove any distortion on the output.

The circuit is powered from a regulated 15V supply, and consumes about 30mA.

The transformer should be mounted towards the back of the case, well away from the RF tuning components. If a transformer with flying leads is used, these may be joined to the mains flex with a choc-block connector.

It may be worth including the Audio Output Level Indicator (due for publication next month) in the same case.

The two units would generally be used together so this could be a useful combination.

### Accurate calibration

For accurate calibration a frequency calibrator or accurate oscilloscope is required.

The unit may be set for various frequencies and these should be marked on the scale.

Mark the scale every 5KHz between 400 and 500KHz if possible, so that the AM IF frequency (typically 455KHz, 465KHz or 470KHz) may be accurately set. Also make every 0.1MHz between 10.4MHz and 11MHz, to allow the FM IF of 10.7MHz to be accurately set.

Alternatively a good quality Short Wave receiver with digital readout may be used.

With the internal modulation switched on, connect the unit to the receiver aerial connection.

Set the receiver to the required frequency and adjust the signal generator frequency until the tone is heard.

### Alternative calibration

If none of these items are available, you should be able to adjust part of the range with a domestic radio receiver, as described above.

If you have a good quality Hi-Fi receiver with a digital readout this would be better, otherwise use a set where the calibration is known to be good.

If the receiver does not have an external aerial connection, connect a coil of a few turns of wire about 150mm in diameter to the signal generator output, and position this close to the receiver.

You should be able to pick up the third harmonic of the frequencies between the MW and LW bands, at the appropriate position on the MW band.

Thus you should be able to tune in the third harmonic of 400KHz at 1200KHz.

Between 450KHz and 480KHz you could hit the IF frequency of the radio.

This is generally fairly obvious as the radio's tuning control will have little effect.

It is also possible for the unit to beat with the radio's local oscillator, so do not be too concerned if the results do not seem to make sense.

If it does not seem to work properly, try using a different radio. You will not be able to calibrate frequencies above the top of the MW band (about 1600KHz) by this method. However, for most radio alignment work this will not be a problem.

For alignment of VHF sets you will need to know the position of the IF (10.7MHz).

Connect the unit to the aerial of an FM radio, turn the modulation off and set the output level to maximum. Tune the set to a weaker station on FM, then adjust the signal generator frequency around the top band.

When the IF of the set (invariably 10.7MHz) is found the reception should become much weaker or disappear altogether.

This works better with some radios than others - and is generally more effective on cheaper sets.

## PARTS LIST

### Resistors (all 5% 0.25W or better)

| | |
|---|---|
| R1 | 1K2 |
| R2 | 47K |
| R3,10,12 | 22K |
| R4 | 10K |
| R5 | 2K2 |
| R6,13,17 | 470R |
| R7 | 150R |
| R8 | 1K0 |
| R9 | 68R |
| R11,14 | 15K |
| R15 | 100R |
| R16 | 4K7 |
| R18 | 220K |
| R19,20,21 | 27K |
| VR1 | 1K0 Lin Pot |

### Capacitors

| | |
|---|---|
| C1+C2 | 365pF + 365pF Variable |
| C3,6,7,9,11,12 | 100nF |
| C4,5 | 100pF |
| C8 | 100nF 160V |
| C10 | 2.2nF |
| C13 | 22nF |
| C14 | 1uF |
| C15,16,17 | 4.7nF |
| C18 | 100uF |
| C19 | 220nF |
| C20 | 1000uF |

### Inductors (RF Chokes)

| | |
|---|---|
| L1,2 | 2.2mH |
| L3,4 | 470uH |
| L5,6 | 100uH |
| L7,8 | 22uH |
| L9,10 | 4.7uH |

### Semiconductors

| | |
|---|---|
| D1,2 | 1N4002 |
| Q1 | BF244A |
| Q2 | 2N2222A |
| Q3,4,5 | BC548C |
| IC1 | 78L05 |

### Miscellaneous

SW1,2 SPDT Toggle or Slide Switch
SW3+SW4 2 Pole 6 Way Rotary Switch (1 off)
X1 15-0-15V 100mA Transformer
SK1,2,3 4,5 4mm Socket or Binding Post
Metal case
Plain matrix board
Tinned copper wire
Knobs
Materials for pointer
Mains flex
13A plug with 3A fuse
Choc-block connector.

**Acknowledgement**

Some aspects of this circuit are broadly based on a design by Steve Knight in the May 1995 edition of Everyday with Practical Electronics.

The Steve Knight unit covers a range of 1.5MHz to 30MHz, and is a much higher quality piece of equipment.

# The TERRESTRIAL FLIGHT TELEPHONE System: an overview

***by***
***Brian P. McArdle***

The Terrestrial Flight Telephone System(TFTS) is a recent development in the general area of mobile communications and provides passengers with the capability to make telephone calls from within an aircraft. The service is primarily voice and facsimile (Group 3). However, this range may be extended in due course.

This article considers the general technical characteristics in ETSI Specification ETS 300-326 which covers the equipment parameters with the exception of aviation requirements. Any comments expressed in the paper are purely personal and are not intended as a formal interpretation of the standard. Problems of implementation by operators of TFTS are not examined.

## Call Procedure

Figure 1 shows the general arrangement in TFTS. An important point to note is that TFTS uses 164 dual frequency channels which are part of the specification. The frequencies cannot be changed but there is provision for offsets to overcome certain problems. This is discussed further in Section 4. An aircraft communicates with a ground station which is connected to the public telephone network. It is the ground and not the aircraft station that acts as the controller. Each ground station can be considered as a cell which controls and communicates with every aircraft within its own operational area. It may operate with one or more radio frequency channels in accordance with international frequency assignments. The system distinguishes between three different cells: en-route for coverage of large areas at high altitude; intermediate for coverage in the general vicinity of airports; and airport cells for use near or on the ground. Cell sizes can be difficult to estimate. A typical radius would be 250 km at 12,000 metres - a considerable distance in comparison to ground systems. Since an aircraft is usually travelling at high speeds, it is very likely to pass through a number of different coverage areas. In order to avoid disruption of calls, there is a handover procedure between ground stations. This happens automatically and callers would not be aware of any alteration in the routing of traffic.
The procedures required to implement the arrangement of Figure 1 are very complex.

In this type of article it is not appropriate to examine the various layers in the management and control protocols. They follow the 0SI Model. It suffices to state that TFTS uses a number of logical channels to implement the various control, synchronisation and data transfer functions. These are not radio frequency channels which are discussed in Section 4. The term 'logical' refers to the function and all logical channels are applied in a definite order on each radio frequency channel. The various applications are listed in Appendix 1. Each channel is transmitted using a slot or block of 208 bits with a specific composition. Their formation and interpretation are examined in the next section.

During operation, an aircraft station monitors the up-link frequencies to identify a ground station that could prove a satisfactory link. Each ground station transmits a conrol signal on the BCCH that provides an aircraft station with the appropriate information (channel and time-slot for access purposes). The aircraft station transmits a request on the RACH and waits for an acknowledgement. If the particular ground station responds on the IRCH, then normal communications can proceed on the TCH. Otherwise, the aircraft station repeats the procedure three times.

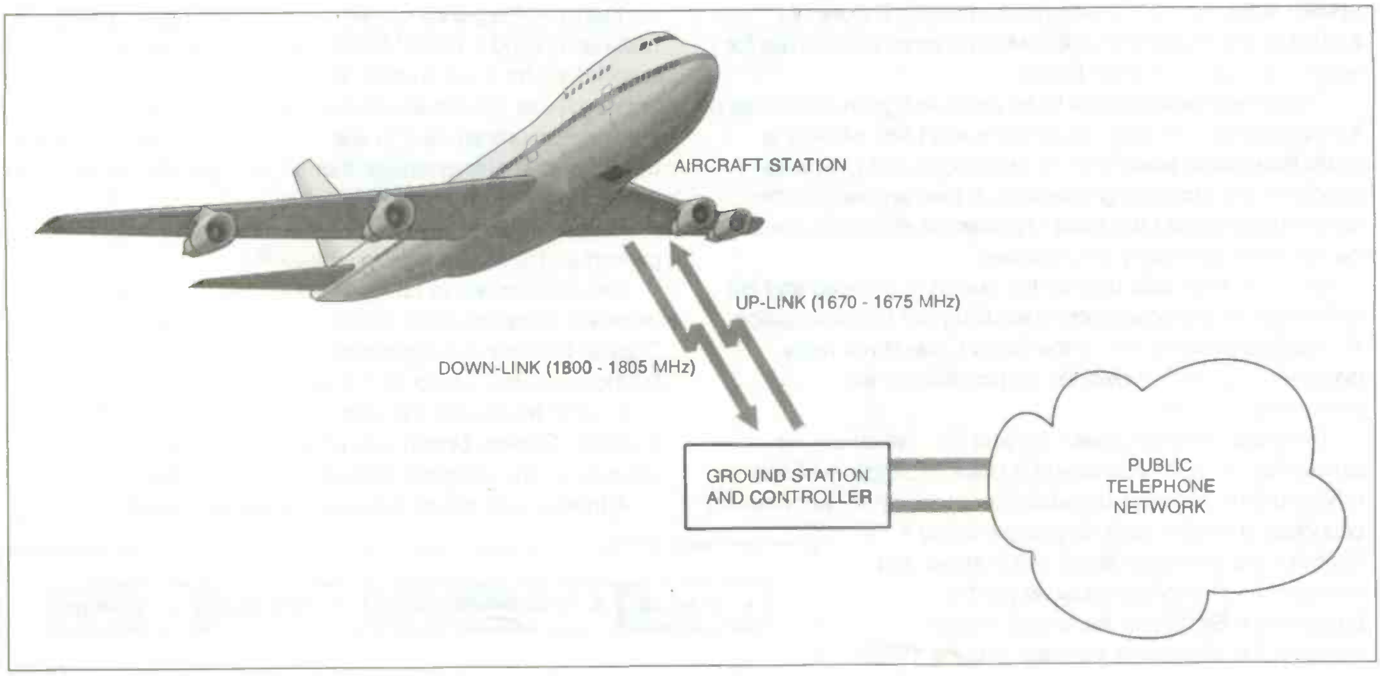
## Transmission slots

TFTS uses two different slots for transmission of all categories of data - G for general and S for synchronisation. Both consist of 208 bits with a duration of 4.706 milliseconds. The system is fully digital. Voice is digitised using an INMARSAT codec which is not analysed in this article.

Figure 2 illustrates the composition of a G slot. Fields A and B are fixed but C contains the data, either control or message information, which undergoes the full range of coding operations. The sequence is as follows:

| | Stage 1 | Stage 2 | Stage 3 |
|---|---|---|---|
| Input Block | Golay Code | Bit Interleaving | Scrambling |
| Output Block | 12 | 24 -(over 8 blocks) | 208 |

A block of 12 bits is turned into 23 using the Golay Code (Appendix 2). The 11 check bits are capable of correcting up to threee errors per block.



| A GUARD (5) | B SYNCHRONISATION (11) | C DATA (192) |
|---|---|---|

A further parity bit is added to produce a new block of 24. The additional bit means that an odd number of errors can always be detected but only a maximum of three can be corrected. The standard does not specify any particular decoding algorithm. However, the code is widely used for paging equipment and a decoding procedure should not present any problem for manufacturers.

A total of eight blocks are grouped together to create a further block of 192 bits.

The positions of individual bits are re-ordered to produce a new block of 192 bits. It is not necessary to list the actual table of substitutions. The process is the equivalent of wire-crossing in electronic engineering and is known as a permutation in mathematical analysis. Its purpose is to scatter the bits around within the block to ensure that errors in adjacent positions do not have a catastrophic effect.

Decoding is simply the inverse table. It must be emphasised that the interleaving operation has no error correction or detection capability. However, the combination of both the block code and interleaving results in a coding procedure with a considerable improvement over the Golay Code on its own.

The final stage is a scrambling operation. It is similar to stream encryption in cryptography but has no secrecy value. A pseudo-random binary sequence is applied in a modulo 2 addition to the incoming block.

The sequence is the same for all units - irrespective of manufacturer or user. Consequently, the operation does not provide any level of secrecy. Its purpose is to generate an output block which will have approximately equal numbers of logic level '1' and '0'. It is desirable that a long sequence of the same logic level should not be input to the modulator (Appendix 3).

Decoding requires the exact same process except that the output sequence from the encoder becomes the input sequence for the decoder.

The three stages together form a forward error correction system suited to dealing with random errors. It does not include a convolutional code[2] which is more appropriate for errors that oaccur in short bursts.

The general procedure is to be expected given the nature of the application. The only exception is a G1 slot where the traffic information skips the first two stages and proceeds directly to the scrambling operation. It may appear that the data is passing over the most important stage where the check bits for error correction are produced.

However, the traffic bits are the output of a codec and are well mixed by the scrambling operation prior to transmission. The additional protection of the Golay Code is not really necessary. Figure 3 shows the composition of the synchronisation slot.

There are two categories - S1 and S2 - which are very similar. Field C in S1 consists of a block of 26 bits which is repeated four times but no additional operation for error control is applied. It is particularly important in that it indicates the access channel, slot number and frame number to initiate a call as per the procedure in Section 2. An aircraft station monitors this slot as the first step in using TFTS.

However, the composition is straightforward in comparison to the G slots.

After the encoding operations a full block of 208 bits is formed and input to the modulator for transmission between stations. The exact procedure is explained in Section 4. The type of block and logical application have no bearing on the method. Each block is processed in exactly the same manner and transmitted on an assigned radio frequency channel using Time Division Multiple Access(TDMA). A total of four callers can be multiplexed together. Their slots are grouped into frames in accordance with a specific pattern with a basic frame as follows:

| 1 2 3 4 | 5 6 7 8 | 9 10 11 12 | 13 14 15 16 | 17 |
|---|---|---|---|---|
| T1 T2 T3 T4 | T1 T2 T3 T4 | T1 T2 T3 T4 | T1 T2 T3T4 | Control Slot |

← TrafficSlots →

The frame structure is the same for both directions. The 17th slot is for control purposes and is never allocated to traffic. In the up-link direction it would contain the BCCH, IRCCH and RCCH as required (Appendix 1). Traffic slots may be assigned for control where the full range of four callers are not operating on a channel. Different slots are identified by their compositions as per the figures.

TFTS is a very complicated system. The above explanation is purely introductory in order to provide an overview.

## Modulation and RF channels

A complete block of 208 bits is input 2 bits at a time to the modulator as illustrated in Figure 4 and a phase-shift is produced as per the table in Appendix 3. This stage of the process marks the end of the parts of the system based on digital signal processing.

From this point onwards the signals may be considered as analog in nature and are applied as the modulation of a radio frequency carrier.

The method Is Differential Quaternary Phase Shift Keying(DQPSK). Each phase-shift generates In-Phase and Quadrature terms which are used to modulate the radio frequency carrier.

The radio frequency carrier is one of 164 values: (1670 + n/33) and (1800 + n/33) MHz for up and down links respectively for n = 1 to 164. The carrier spacing is approximately 30 kHz which is a break with tradition as European countries tend to use 25 kHz. A channel consists of a specific pair of frequencies that are represented by the same value of n in the previous formulas.

Frequency accuracy must be 4x1-8 and 2x1-7 for the ground and aircraft stations respectively.

This is adequate to cover any drift from the nominal value. However, since an aircaft is travelling at high speeds, the Doppler Shift can be significant. For example, at 1,000 km/hour the shift would be 1.6 kHz.

In order to counter the total drift there is provision for frequency offsets. During operation, a unit transmits and receives on the assigned frequencies using TDMA.

A total of four callers may use the same channel

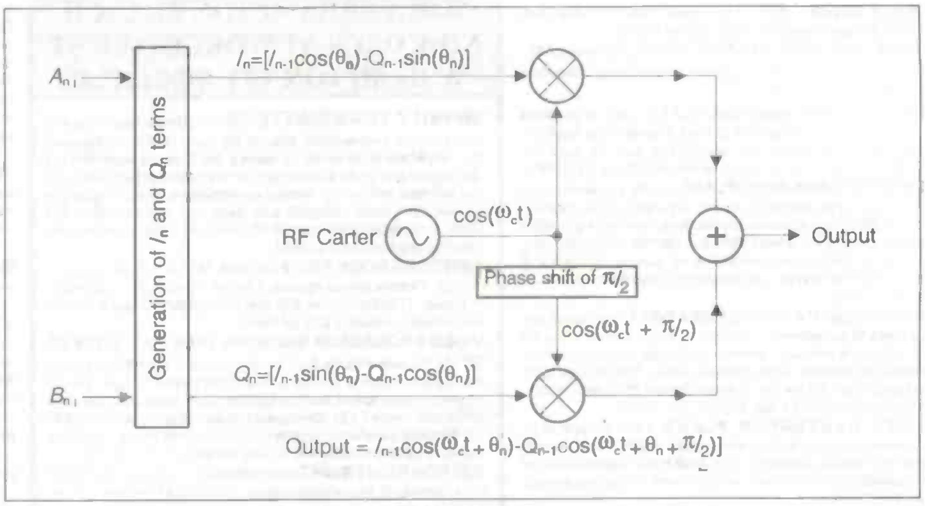
| A GUARD (5) | B SYNCHRONISATION (71) | C DATA (26 x 5) | D SHARE (2) |
|---|---|---|---|

simultaneously. In addition to the channel a timeslot is allocated. The term 'physical channel' refers to the radio frequency channel and the time-slot.

The handover procedure described in Section 2 can involve a change in time slot or in the radio frequency channel for communications with the same ground station.

Full handover means that the ground station and controller are changed. Further analysis is outside the scope of this paper (see opening paragraphs).

The specification has very extensive requirements on the radio frequency side including antenna characteristics and adaptive control of the aircraft station's EIRP by the ground station




This is the case for TFTS. The generator polynomial affects the encoding process and a choice is not possible.

## Remarks

TFTS is a major development in communications for mobile applications. It has the advantage of being a harmonised specification which does not require modifications in different countries. An important point to note is that it is not a confidential system.

There is no encryption operation as part of the equipment specification as in GSM cellular telephone or TETRA in mobile radio. However, the coding operations and call procedures are unique to TFTS which means that evesdropping on messages would be difficult.

A hacker would require special equipment and an expert knowledge of the system.

## References


[1] ETSI Specification ETS 300-326

[2] Brewster, R. L. : "Communication Systems And Computer Networks". John Wiley & Sons (1989).

[3] Sweeney, P. : "Error Control Coding". Prentice-Hall (1991).


## Appendix 1: Logical channels

Broadcast Control(BCCH): unidirectional Ground - Air(S1 slot)
Random Access(RACH): unidirectional Air - Ground(S2 slot)
Initial Response Control(IRCCH): unidirectional Ground - Air (G3 slot) Radio Control(RCCH): unidirectional Ground - Air(G2 slot)
Dedicated Control(DCCH): bidirectional(G2 slot)
Traffic(TCH): bidirectional(G1 slot)

G2 and G3 undergo the full range of coding operations. G1 skips the first two stages of the Golay Code and Bit Interleaving. S1 and S2 skip all three stages.

## Appendix 2: Golay (23,12) Code

This is a cyclic code of length 23. The modulus is (x23 + 1) and has 3 irreducible factors as follows:

(x+1), (x11+x10+x6+x5+x4+x2+1) and (x11+x9+x7+x6+x5+x+1).

Either of the factors of degree 11 would satisfy the mathematical requirements for use as the generator polynomial in the code. However, in TFTS the first is specified and must be applied. A manufacturer is not free to make his own particular choice.

As decoding operations are not unique, it has become practice to permit manufacturers to choose their own methods.

## Appendix 3: DQPSK modulation

A modulation symbol may be written in complex form as: Sn = In + jQn. The In-Phase and Quadrature terms are deduced from previous values as follows:

In=In-1cos(Øn)-Qn-1sin(Øn) and Qn=In-1sin(Øn)+Qn-1cos(Øn).

Hence the term 'differential' in the title. Both equations may be combined as follows:

Sn=Sn-1exp(jØn) with the Phase-Shift being deduced from the table

| | | | | |
|---|---|---|---|---|
| Even Numbered Positions (0 to 206): | 1 | 0 | 0 | 1 |
| Odd Numbered Positions(1 to 207): | 1 | 1 | 0 | 0 |
| Øn(Phase-shift): | π/4 | 3π/4 | -3π/4 | -π/4 |

•The table has the form of a Grey Code where successive symbols differ in just one bit.

From an operational viewpoint the symbols are chained together, such that, there is a total of 8 possible symbols(+/-π/8, +/-3π8, +/-5π/8 and +/-7π/8). Therefore, it is not necessary to repeat the calculations for every 2 bits that are input to the modulator. The process, if properly executed, must generate 1 of the 8 values. Figure 4 shows the individual steps. In electronic terms In and Qn are impulses which are input to a modulation filter with a raised cosine roll-off and applied as phase modulation to 2 orthogonal radio frequency carriers - cos(wct) and cos(wct+π2) respectively. Both outputs are combined to give the transmitted signal. The various mathematical expansions required in the process are:

cos(wct+π/2) = cos(wct)cos(π/2)-sin(wct)sin(π/2) = -sin(wct)

cos(wct+Øn) = cos(wct)cos(Øn)-sin(wct)sin(Øn)

sin(wct+Øn) = sin(wct)cos(Øn)+cos(wct)sin(Øn)

cos(wct+Øn+π2) = cos(wct+Øn)cos(π/2)-sin(wct+Øn)sin(π/2)

= -sin(wct+Øn).

This is a simplified explanation to provide an overview of TFTS and a reader should refer to the specification for a detailed analysis.

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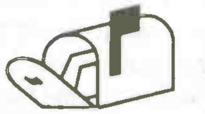

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# AutoDimmer

***Andrew Bloomfield offers a rather different form of baby soother***

This auto dimmer has been purposely designed for a baby's bedroom. When the baby wakes up and cries, the light (over a short period) will increase to its full brightness. The longer the baby cries the brighter the light will be. If the baby stops crying the lamp will dim again and eventually turn off. If the light is not enough to comfort the baby back to sleep then a melody generator could also be introduced, connected to IC1a pin 1.

With the components I have selected the dimming period from full brightness to off is approximately 9 minutes. This period can be adjusted by changing R3 or C2.

This circuit will NOT dim a fluorescent tube!

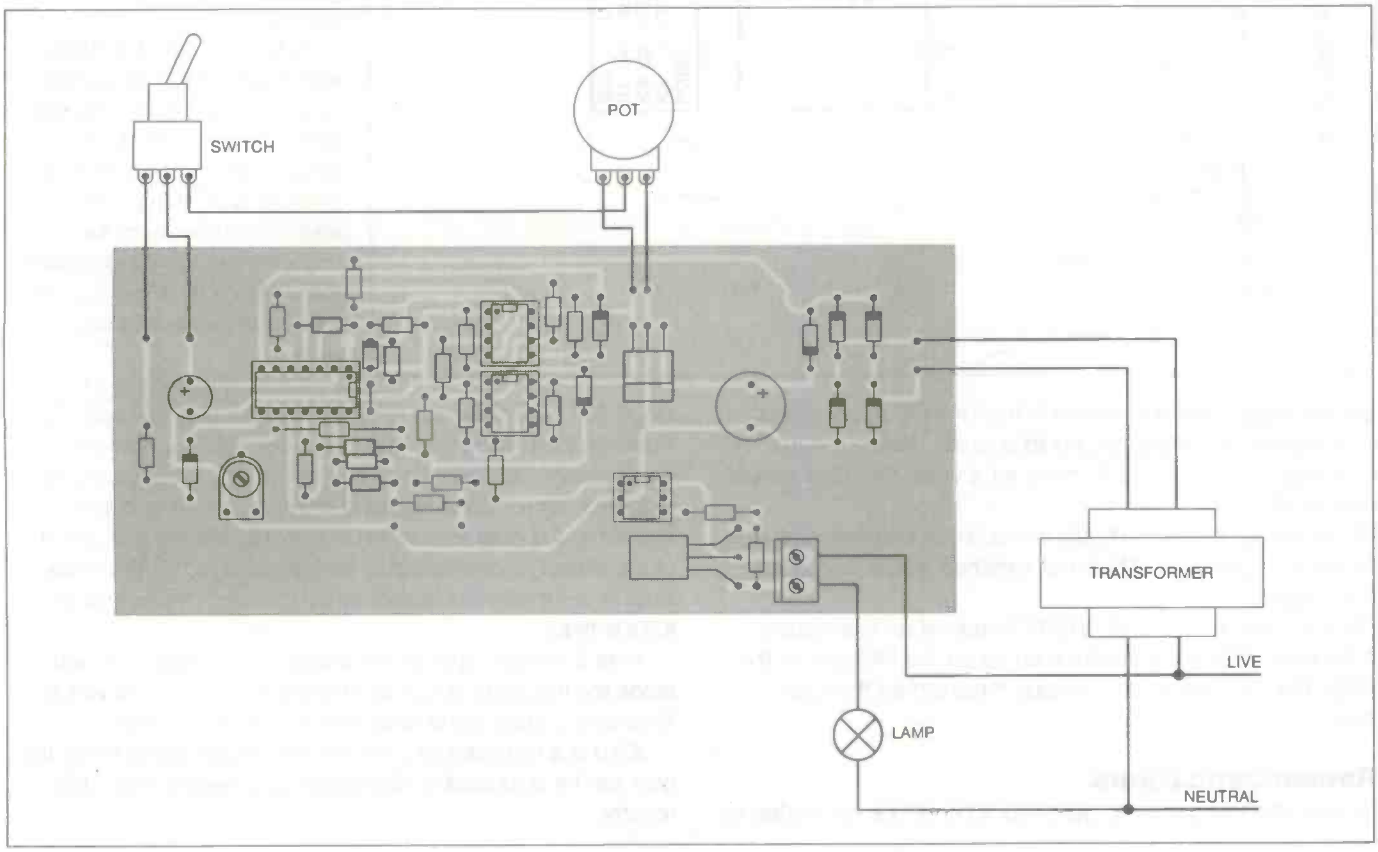
## Construction

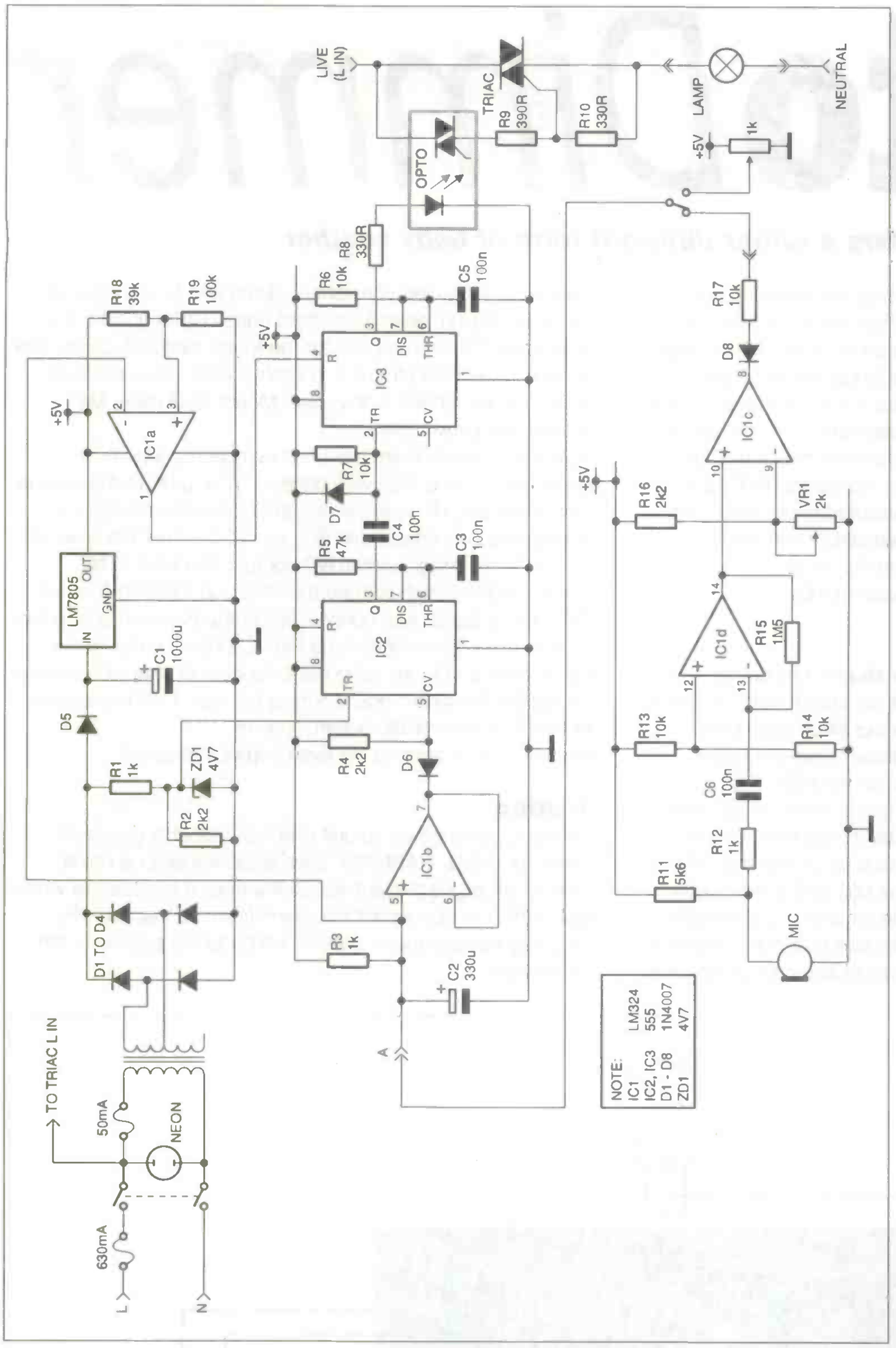
First, a suitable size box should be saught, I recommend a sloped Front Panel box. Drill about six small holes (1mm) in the area where the Microphone will be mounted. Mount the transformer away from the Microphone to prevent mains interference, leaving enough space for the PCB. The Microphone could either be glued to the inside of the case using hot melt glue or suspended by 22swg tined copper wire from the PCB. Drill holes for the mains input and lamp output and insert grommets (9.5mm). If the box is of a reasonable size, then plugs & sockets could be mounted for the mains input and lamp output. Although the lamp may only require live and neutral, the input to the box should also contain an earth. Connect earth to the transformer clamp and to any external metal, ie 1K POT, Switch and front panel. Drill a hole for the front panel Pot (9.5mm) and for the toggle switch (6.5mm). Drill 4 holes in the PCB (4mm), 1 in each corner. Using the PCB, mark and drill 4 holes in the case. Mount PCB using M4 screws and plastic pillars.

Now the main hardware has been completed, wiring can commence. Using 7/02 wire connect 5V and 0V to the outside pins of the pot. (Turning the pot anti-clockwise the wiper s voltage should increase and vice versa.) Connect the wiper of the pot to the toggle switch NO contact. Connect to NC contact of the switch to B on the PCB and the C to A on the PCB. Using 32/02 wire connect live to the transformer and the PCB terminal block (right-hand Pin). Connect neutral to the transformer and to the lamp output socket or lamp output wire via another terminal block. Connect live from the lamp output to the PCB terminal Block (Pin close to edge). Connect earth to the lamp output if required.

## Testing

Before applying power to unit check and double check all mains for safety. WARNING Even when the lamp is not lit there is still mains present across the triac. It is advisable when fault finding to disconnect the mains from the triac circuitry. That way the only mains present will be to the primary of the transformer.






the output of IC1. As this circuit is sound operated the melody must not be too loud or the lamp will never dim. IC1's output will supply just over 4 Volts at 20mA.

## Circuit Description

The low voltage AC from the transformer is rectified through D1-D4, bridge network. This inverts the negative cycle of the sine wave to provide a zero voltage trigger for IC2. R1 limits the current to ZD1 and R2 acts as a pull down resistor for IC2. D5 blocks the DC voltage to the resistor Zener network. The DC voltage is then smoothed and regulated via C1 and the 7805 Regulator.

IC2 is zero voltage triggered. The time constant at which the output stays high is determined by R5, C3 and the input voltage on pin 5. Varying the voltage on pin 5 determines the point at which the mains is triggered, which in turn determines the lamp's brightness (Phase Control). The 2k2 Resistor (R4) on pin 5 has been selected for the required range at which the lamp will operate. D6 also has been introduced to provide a 0.6 Volt drop for this application.

IC1b is a current amplifier with a gain of 1. It has a high input impedance so does not affect the charging of C2, 330uF Capacitor. R3 and C2 provides a dimming time of about 9 minutes from full brightness to off. By increasing these values the dimming time will also increase and vice versa.

IC3 is triggered from IC2 via C4, 0.1uF capactitor and R7, 10K Resistor time constant. D7 Prevents the voltage from the Capacitor, Resistor network from going above 5.6 Volts, which can cause IC3 to be incorrectly triggered. When IC3 is triggered a time constant of 1mS is applied to the opto triac which in turn triggers the triac. Pin 4 of IC3 (Reset) is connected to the output on IC1a. When the lamp is at full brightness and during dimming, the output of IC1a is high.

After 9 minutes approx, the output of IC1a goes low and stops the triggering of IC3 and the triacs. The point at which IC1a output goes low is determined by R18 and R19.

IC1d is a high gain amplifier for the electret Microphone. Its gain can be increased or decreased by changing R15, 1M5 resistor.

Set the toggle switch to switch in the 1K POT. Apply power and vary the pot, the lamp should operate. Switch out the 1K POT and leave on in a quiet room for a while, the lamp should now be dimming.

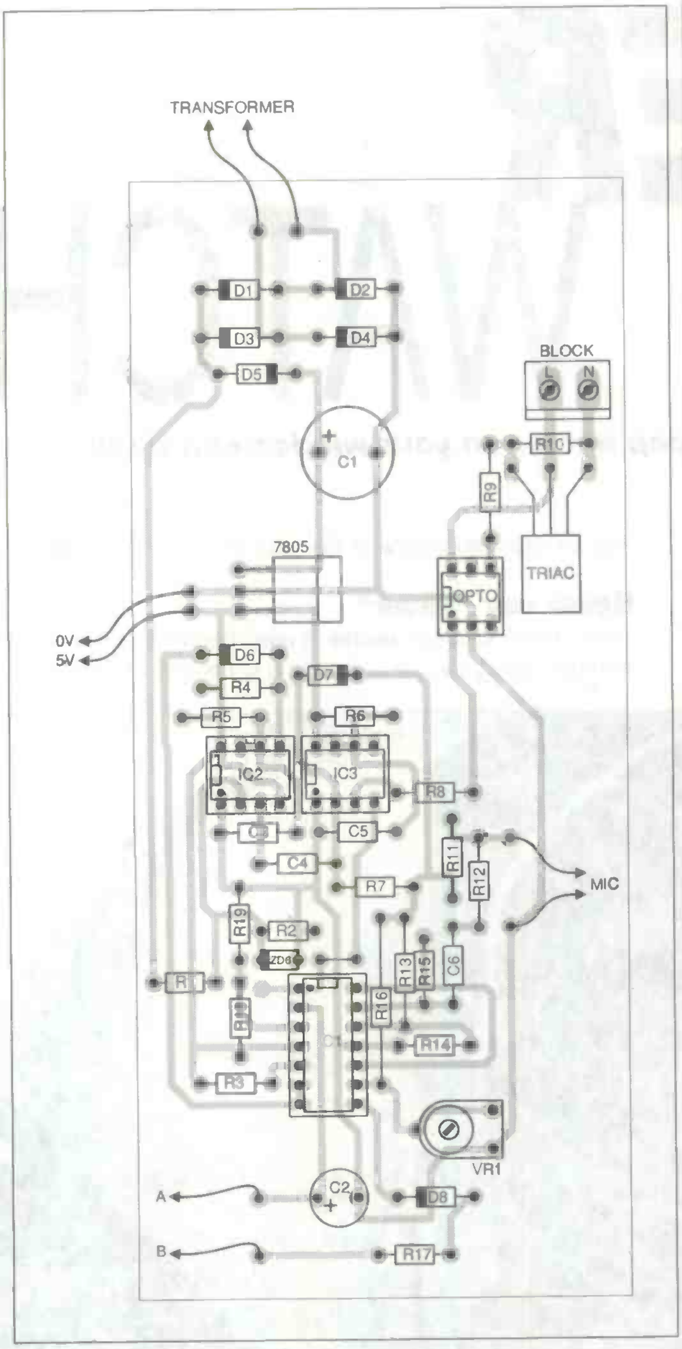
On power up, the lamp should come on full brightness as long as the front panel pot (1K) is not switched in. (C2 will be fully discharged.)

Refer to the CIRCUIT DESCRIPTION text when fault finding.

If the lamp does not auto dim then adjust the 2K2 pot on the PCB. This POT adjusts the voltage threshold for the sound input.

## Recommendations.

I mentioned that a melody generator IC could be connected to




IC1c is used as a voltage comparitor. Its output is high when there is silence and pulses low when noise is present. VR1 should be set to one end (2K0).

If the circuit will not dim due to voltage ripple on pin 10 IC1d, then decrease the pot's value.

The Mic circuit will not operate if the pot's resistance is too low, so adjust in very small steps.

D8 only lets through negative going pulses to discharge C2 and not charge. The discharging of C2 is limited by the R17, 10K resistor.

For normal operation, point A is connected to point B. During silence, the lamp decreases in brightness and when noise is present the lamp increases in brightness.

By disconnecting point A from point B and connecting the wiper of a 1K pot to point A (5V & 0V to the outer terminals), the lamp's brightness can be set/adjusted by the pot.

The output of IC1a can be connected to a melody generator IC via the spare point on the PCB.

This output could also drive a relay via a transistor to switch on other appliances.

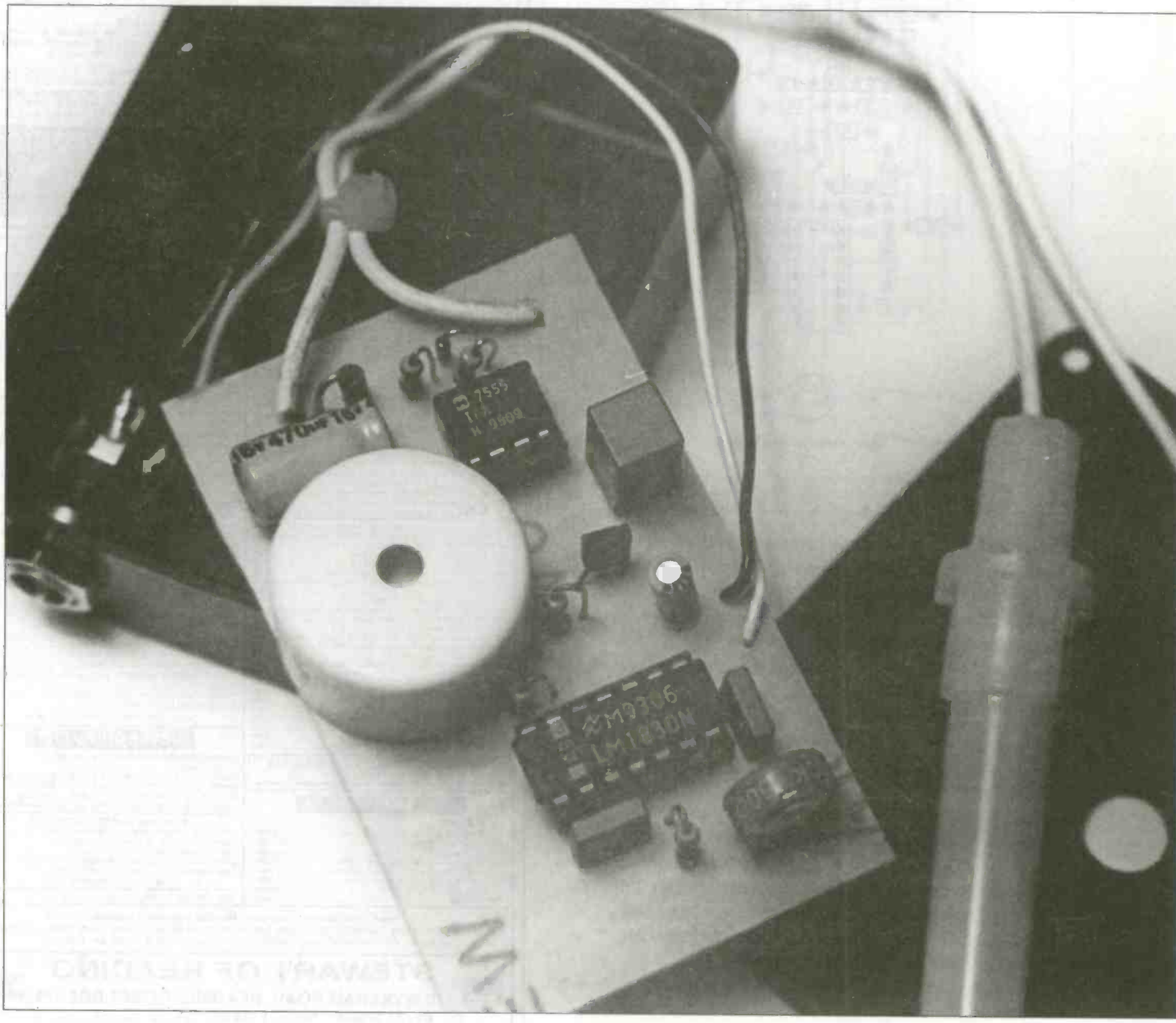
# WASHER WATCH

***Terry Balbirnie explains how to keep an ear on your windscreen fluid!***

It is a legal requirement to keep the car windscreen washer system in good working order. This includes making sure that there is sufficient water in the reservoir at all times. But let's be honest. Most of us have run out of water at some time and have driven home with a dangerously smeared windscreen. It may be regarded as one of the hazards of winter driving.

## Never say "never"

When the windscreen washer is used frequently, as when mud is thrown up by the car in front, the water can be used



surprisingly quickly. Compact cars often have a reservoir which is too small to hold a reasonable amount of water. This means that topping-up will be required in the course of a journey. Some cars have a huge bottle and this breeds complacency - it is never checked because if "never" runs out! Some up-market cars have a low fluid warning device fitted as standard equipment. This circuit is designed for the majority of vehicles which don't.

In use, the Washer Watch will provide a discreet bleep every 15 seconds when the water level has dropped below some level decided by the user. There will then be sufficient warning to fill the reservoir at the next opportunity. An audible signal is better than a warning light which is easily missed. It also avoids possibly spoiling the appearance of the instrument panel by drilling holes in it. The unit is simply hidden out of sight behind the dashboard - the internal buzzer is high-pitched and the sound will be heard above engine and other noises.

The principle of the circuit is simple and relies on the fact that tap water conducts electricity to some extent. Pure water hardly conducts at all and would not work. However, the conductivity is greatly increased by certain dissolved solids which exist in tap water. The windscreen washer reservoir is filled either with plain tap water or water mixed with an additive such as an anti-freeze agent or detergent. Such additives will not affect operation of this circuit.

## Bridge that gap

For the reason above, two wires immersed in windscreen washer fluid will be found to have a relatively low resistance between them. When removed, the resistance will become near-infinite and it is this change which is detected. In this circuit, the wires are arranged side by side in a plastic probe with their tips held at a certain height in the reservoir. While fluid bridges them, the circuit is held off. When it falls below them the circuit is activated.

There is a problem in the design of a system such as this. It comes about because, in responding to the resistance between the probe wires, a current must flow between them. This would normally result in chemical action (electrolysis) occurring and could result in the wires corroding and eventually preventing operation. The problem is solved here by using alternating current (a.c.) instead of the more usual d.c. (direct current) signals used in electronic equipment. Any chemical effects which occur when the current flows in one direction will be reversed when it flows the other way. The wires therefore remain in better condition. Any remaining problems are eliminated by using materials which resist chemical attack.

## How it works

The complete circuit for the Washer Watch project is shown in Figure 1. The supply is derived from the nominal 12V car electrical system via diode, D2. It operates only while the ignition is switched on so there is no drain on the battery. In any case, the current requirement is only 5mA approximately. The diode prevents damage if the circuit were to be connected with the wrong polarity since no current would flow. Capacitor C5 improves the rather noisy output from the car alternator and provides a smooth supply for the rest of the circuit.

IC1 is a special fluid detector integrated circuit. Capacitor C1, connected between pins 1 and 7, determines the frequency of its internal oscillator (a.c. generator). With the value specified, this will be about 6kHz but is not critical. Capacitor, C2, couples the signal from the oscillator output (pin 5) to one of the probes (pin 10) via network R1/VR1. These latter components provide a reference resistance. If the resistance between the probes is less than this (as when they are immersed in water), there will be no further effect. If the resistance is greater (probes removed) this is detected by pin 10 (detector input) and the a.c. signal is coupled to the base of an on-chip transistor. RV1 provides an adjustment to the reference resistance and this will be useful in areas of particularly low water conductivity.

The output, pin 12, connects to the open-collector of the on-chip transistor referred to above.

However, the signal appearing here is a.c. and would be unsuitable for controlling the rest of the circuit.

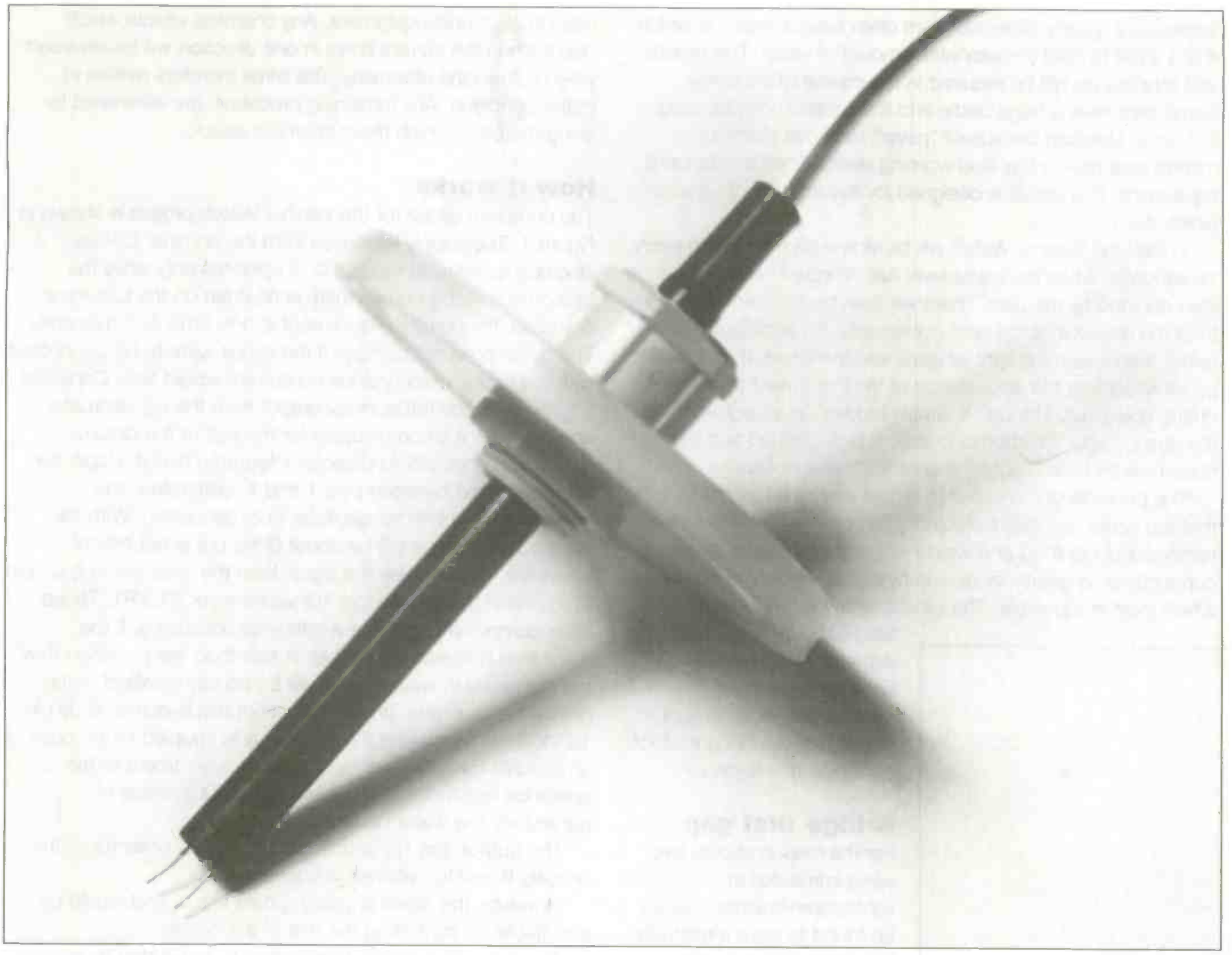
The signal is therefore filtered (that is, converted to smooth d.c.) at an earlier point in the circuit using capacitor, C3, connected between pin 9 and supply negative.

## Rapid pulse

When pin 12 is open circuit (probes immersed), resistor R2 allows base current to flow to external transistor Q1 so switching it on. The collector will therefore go low and this state is applied to IC2 reset input (pin 4). IC2 is a timer integrated circuit configured as an astable (pulse generator) but with pin 4 low, it is disabled and there is no further effect. When pin 12 is low (probes removed from the liquid), Q1 is turned off and the collector is made high via the load resistor, R3. This state, when applied to IC2 pin 4, enables the device to oscillate and to provide pulses at the output, pin 3.

The frequency and mark/space ratio of the pulses is dependent on the values of resistors R4 and R5, capacitor C4 and the presence of diode, D1. The diode allows the very small mark/space ratio which would not be possible otherwise. The mark/space ratio is the length of the "on" time compared with the "off" one. With the values specified, there will be one very short pulse (about 0.2 second) every 15 seconds or so. When this signal is applied to buzzer, BUZ1, it will bleep accordingly. No adjustment to the frequency or mark/space ratio is provided since they are not thought to be particularly critical. If more rapid pulses are needed, R5 could be reduced in value.

The frequency of the sound produced depends on the buzzer. Using the component specified, this will be about 2.7kHz and being higher in pitch than other sounds in the car, will be easily heard...



## Construction

The PCB component overlay for the Washer Watch circuit is shown in Figure 2. Solder the i.c. sockets and the short piece of wire labelled "link" into position. Note that the link may be difficult to locate later. Follow with the resistors, including preset RV1, and capacitors taking care with the polarity of C3 and C5. Note that C5 leads are bent through right angles so that this component lies flat on the panel (see photograph). Solder the two diodes observing their orientation (the striped end is the lower one in each case).

Add the buzzer - the polarity is marked on the plastic body and if this is not followed it will not work. Solder 15 cm pieces of stranded connecting wire to the "+ 12V" and "car gnd" pads and 10 cm pieces to the two "probe" ones. Adjust RV1 to approximately mid-track position. Place the PCB temporarily on the bottom of the case. Measure the position of the hole in the top of the buzzer and drill a slightly larger one in the lid of the box to correspond. Drill a hole in the side for the sensor socket and mount it - this could be a 3.5mm mono jack socket or a power-type connector. Connect it to the "probe" wires on the PCB - the outer (sleeve) connection should be the negative one (the one connected to the large land area on the PCB leading to the "car gnd" input).

Drill a hole for the "+ 12V" and "car gnd" wires to pass through. Place a small cable tie around them to provide strain relief on the inside and pass them through the hole. Make sure that pulling will not detach them from the PCB. Fit a car type in-line fuseholder to the "+ 12V" wire and an eyelet to the "car gnd" one. Note that this circuit must be fused. With the specified plastic box, all that is needed is a thin piece of foam on the base to secure the circuit panel with the buzzer pressed firmly against the lid and with the holes aligned. Make any adjustments as necessary and attach the lid. Decide on a suitable position for the unit behind the dashboard. It could be attached to a fixed part using PVC tape.

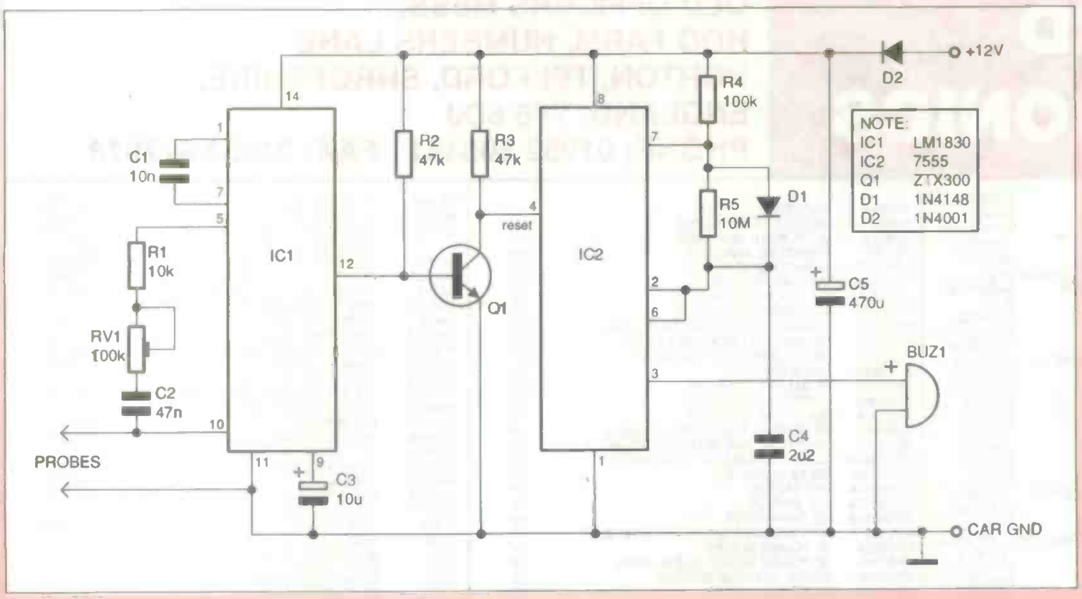
## Probing the secret

The probe used in the prototype was made to the design shown in Figure 3. There is ample room for experiment with this and it is likely that other materials and arrangements would work just as well.

The piece of plastic tube was obtained from a round-section ball point pen with the inner part removed and the ends cut off. Choose a pen with a diameter between 6 and 8 mm if using the specified cable gland. The wires themselves were made from short pieces of gold plated phosphor bronze wire of the type used for musical instrument keyboard contacts. This material should be resistant to chemical attack which might occur with some washer additives. The wires were soldered to a piece of thin 2-core wire sufficiently long to reach the main unit.

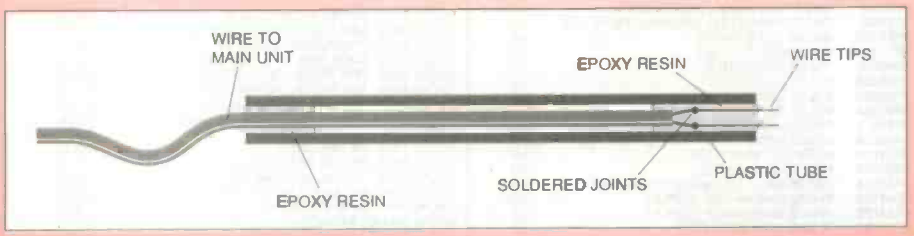
Quick-setting epoxy resin adhesive was used to seal both ends of the plastic tube and to hold everything firmly in place. The adhesive also encapsulates the soldered joints, protects them and prevents them from touching each other.

Make a hole in the windscreen washer bottle lid and attach the waterproof cable gland. Alternatively, find a household item with a top which fits so that the original one is not damaged.




## Testing and adjustment

It is likely that the circuit will work correctly with no further adjustment. In areas of low water conductivity, it may be necessary to increase the threshold resistance using RV1. In use the buzzer will probably sound intermittently, and possibly in a "chirpy" way, before the critical level is reached. This is because the fluid moves around in the course of braking and cornering. Exactly how this happens will depend on the shape of the reservoir and how the car is driven.




## Buy Lines

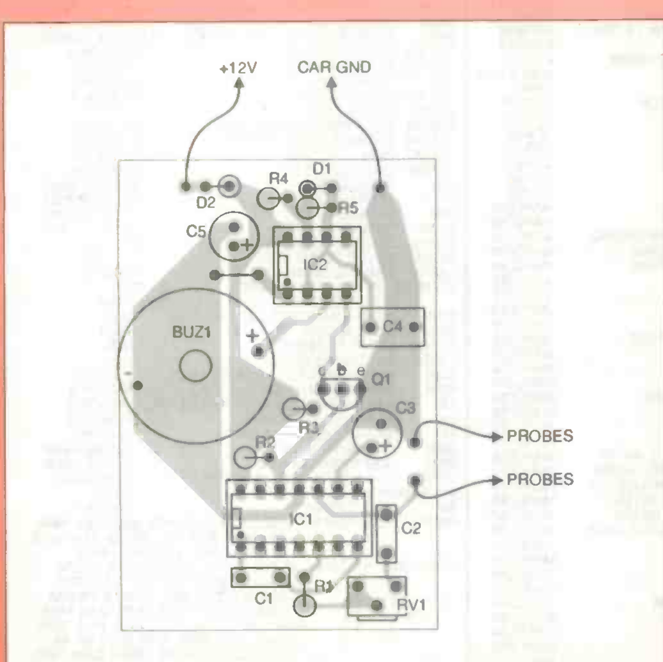
Most of the components are freely available. Those which could cause problems are available from Maplin and their order codes are given below.

| | |
|---|---|
| Buzzer | KU56L |
| Gold plated wire | XB00A. |
| LM1830 Fluid Detector i.c. | YY99H. |
| Waterproof cable gland | JR76H. |
| Plastic box | KC91Y |

Push the probe through the gland and adjust it to the required height (see photograph). The seal is then tightened firmly. Run the probe connecting wires back to the main unit position. If they need to pass through a hole in metal, fit a rubber grommet to prevent the sharp edge from cutting them. Solder the plug to the end - polarity unimportant.

Secure the "car gnd" wire on the unit to an earth point and connect the fuseholder to a wire which is live only when the ignition is switched on.

Use a snap-on connector (Scotchlok) for this purpose. Alternatively, wire it to a suitable outlet at the fuse-box. Fit a 250mA fuse in the fuseholder. Timid readers could simply connect it to the cigar lighter socket and omit the in-line fuse providing a fused plug was used.




## PARTS LIST

### Resistors

| | |
|---|---|
| R1 | 10k |
| R2, R3 | 47k |
| R4 | 100k |
| R5 | 10M |
| RV1 | 100k min. vert. preset |

### Capacitors

| | |
|---|---|
| C1 | 10n metallised polyester - 5mm pin spacing |
| C2 | 47n metallised polyester - 5mm pin spacing |
| C3 | 10m 16V radial electrolytic |
| C4 | 2.2m metallised polyester - 5mm pin spacing |
| C5 | 470m 16V radial electrolytic |

### Semiconductors

| | |
|---|---|
| IC1 | LM1830 |
| IC2 | ICM7555 |
| D1 | 1N4148 |
| D2 | 1N4001 |
| Q1 | ZTX300 |

### Miscellaneous

| | |
|---|---|
| BUZ1 | DC operated piezo buzzer. 12V operation |
| F1 | 250mA fuse in car type in-line fuseholder. |

Waterproof gland for 5 to 8 mm cable

Materials for probe - see text.

# SIMPLE DIODE & LED TESTER

***The polarity markings on LEDs (Light Emitting Diodes) seem to be a common cause of confusion, as Paul Stenning explains***

The polarity may be indicated by a flat section on one side of the body or by one lead being shorter than the other, but different manufacturers are not consistent as to which lead they are marking!

Rectangular and other shaped LEDs often rely on lead lengths as the only indication, which is not very helpful if the component has been used previously and the leads shortened. Sometimes you can peer at the innards through the casing and establish the polarity from this, but you still have to remember which bit is which electrode - and some LEDs do not have see-through bodies. The connections of LED displays can be particularly difficult to establish - especially those with several digits.

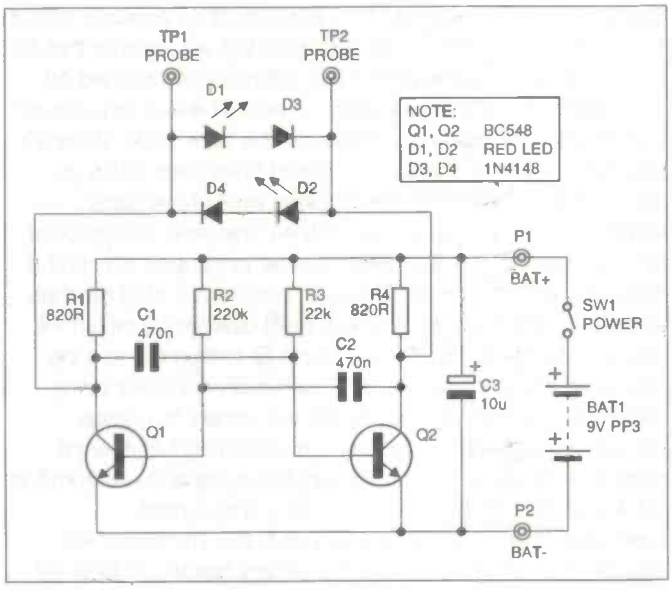
You could connect the LED to a battery via a suitable resistor, but this can be fiddly and is not much help with infra-red devices. Also the maximum rated reverse voltage for an LED is about 4V, so you could damage it if you are using a 9V battery for testing.

The simple Diode and LED Tester presented here costs under £5 to build (including all components, the battery and a cheap case) and will indicate the polarity of almost all types of LED and other diodes with no risk of damage. The average test current is about 5mA (10mA pulses), which is sufficient to illuminate the LED being tested.

The unit has two test probes and two indicator LEDs. The diode or LED to be tested is simply connected either way round between the test probes, and the cathode connection is indicated by the LED closest to that connection illuminating. My original prototype has been used regularly for several years, and has saved me a lot of time and irritation.

The unit can be used to test all conventional LEDs including the multi-colour types and IR devices. The only types of LED that cannot be tested are those containing additional circuitry, such as the flashing and constant-current types.

It can also be used to check most silicon and germanium diodes and rectifiers providing they can withstand a test current of 10mA. Zener diodes can be tested for forward drop but not for Zener effect, although this is sufficient to prove if they are alive or dead. The unit can also be used for basic diode tests on bipolar transistors, although the test current may be too high for the base connection of some devices.

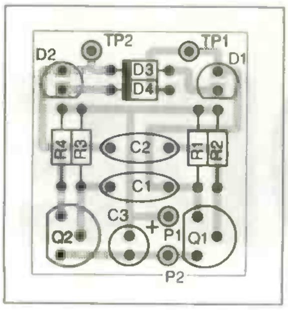



## Circuit operation

The circuit was designed to be simple and low cost. A simple transistor circuit was used because the components (or suitable alternatives) are more likely to be in the constructor's "junk box". A brief discussion of the IC based alternatives that could have been used is given later.

The circuit consists of a standard two transistor astable multivibrator arrangement, the operation of which will be described shortly. The outputs on the collectors of the two transistors are a square wave signal of about 200Hz. The two outputs are out of phase with each other - when one output is high the other is low and vice-versa.

Between these two outputs are connected two LEDs (Dl and D2), back-to-back, with series diodes (D3 and D4) to increase the forward voltage drop. When Ql is on and Q2 is off, current flows through D2, causing it to illuminate - the current being limited to about 10mA by R4. When Ql is off and Q2 is on, Dl illuminates. Although the LEDs are flashing, the 200Hz rate is sufficiently fast that they both appear to be continuously illuminated. Since the test current is 10mA for 50% of the time, the average is 5mA.




When the diode to be tested is connected between TPl and TP2 it will bypass either Dl or D2 depending on the polarity. The test current will therefore flow through the diode being tested instead of through the bypassed LED on the unit. The series diodes (D3 and D4) ensure that the voltage drop of Dl and D2 are greater than the forward drop of any diode being tested. When the diode being tested is reverse biased, the remaining LED on the unit will illuminate. The diode being tested receives a reverse voltage of about 2.5V (1.9V from the LED plus 0.6V from the series diode) which is insufficient to cause damage. If the diode being tested was short-circuited neither LED on the unit would light. The astable multivibrator would also stop oscillating in this case, but this is not a problem. If the diode being tested were open-circuit both LEDs on the unit would remain lit.

## Astable multivibrator

The trouble with describing the operation of an oscillator circuit is defining a suitable starting condition! We will assume that Ql has just switched on and therefore Q2 has just switched off. Just prior to the change of state, Cl would have charged such that its left plate is positive relative to the other plate. When Ql switched on the left plate of C1 would have been taken to about 0V and therefore the right plate would have gone negative, switching Q2 off. Cl will then charge in the opposite direction via R3. The time taken for this to happen affects the frequency of the oscillator. When the right plate of Cl reaches about 0.6V there will be sufficient base bias for Q2 which will turn on. The charge on C2 will cause Ql to turn off, and the sequence of events will continue with each transistor being switched on in turn. C3 decouples the supply, to ensure correct operation as the battery runs down and its internal resistance increases. The total supply current is about 20mA at 9V. A standard PP3 battery can supply this current intermittently and still give a reasonable life. The circuit will operate down to about 4V so the battery has to run fairly flat before it needs replacing.

## Alternative oscillator circuits

This two transistor astable multivibrator circuit was used extensively some years ago, but has largely fallen into disuse due to a couple of shortcomings. The frequency of oscillation varies with changes in the supply voltage and output loading, and the output waveform is not quite a true square wave. None of these problems are relevant in this application. A more modern approach might have been to use an IC based oscillator. The requirement for two anti-phase outputs rules out timer ICs such as the 555 unless they are used with an additional inverter circuit. A suitable circuit could be constructed using CMOS logic, but the output drive current is not sufficient unless buffer stages of some sort are used. The net result would be more expensive than the current circuit. TTL logic would be able to drive the LEDs directly, but this has the drawback of needing a 5V supply. A regulator IC could be used but again this adds to the cost. On balance it was decided that a simple circuit, using two transistors costing 10p each offers a cheap and elegant solution.

## Construction

The prototype was built on a small PCB as shown. However, the circuit could easily be constructed on stripboard or some other prototyping system as the layout is not critical. Two new LEDs should be used for Dl and D2 - so you can be sure the polarity is correct! The PCB overlay assumes the flat on the body is the cathode. The diodes, transistors and capacitor C3 must be inserted with the correct polarity. None of the component values are critical so they can be varied to some extent to use what you have available. Pairs of components that are the same value (i.e. Rl/R4, R2/R3, Cl/C2 and Ql/Q2) should remain equal to keep the mark-space ratio at about 50%. The two LEDs can be the same colour, or they can be coloured to match the relevant test leads. The unit may be fitted into a small plastic case if required. Ensure there is sufficient room to house the PCB, battery and switch. The PCB will be held sufficiently secure by two mounting clips on the LEDs. The battery should be held in place with some foam rubber, to prevent it rattling around and touching the rear of the PCB, causing short circuits. The power switch may be a small slide switch or a momentary normally open push button. Note that small slide switches are not normally supplied with the fixing screws. The switch and battery should be connected to the PCB as shown on the circuit diagram. For the test leads, two short lengths of flex fitted with small insulated crocodile clips are ideal. These should pass through small holes in the case, close to the relevant LED, and knotted on the inside to prevent stress on the PCB if they are pulled.

## Testing and using

When the unit is initially switched on, both LEDs should light. If the two test leads are touched together, both LEDs should extinguish. Connect a diode between the two leads, and one of the LEDs should go out. The LED that remains lit should be the one closest to the lead that is connected to the cathode of the test diode. The cathode end of the diode is normally marked with a band. Reverse the polarity of the diode and check that the other LED remains on. Now try the same thing with an LED. The same results should be obtained, and the test LED should light both times. If these tests are successful the unit is working correctly. To conserve battery life the unit should be switched off when not in use. If one or both LEDs fail to light when the test leads are not connected the battery should be replaced.

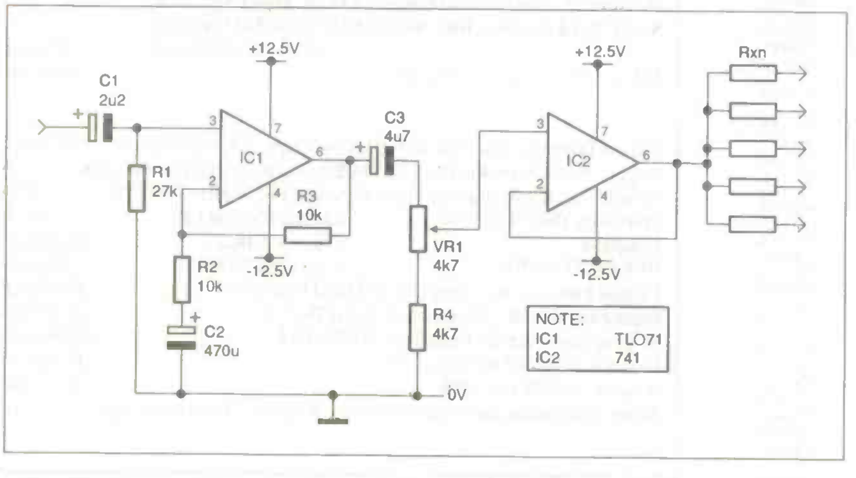
## PARTS LIST

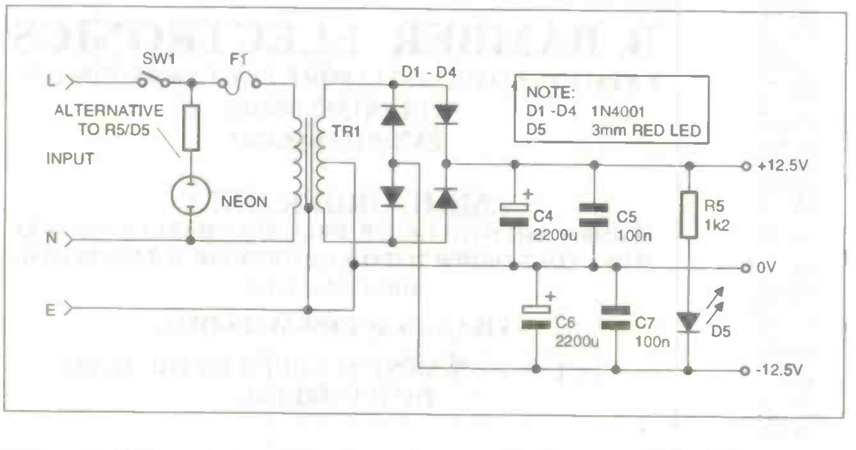
| | | |
|---|---|---|
| **Resistors** | | |
| 2 | R1,R4 | 820R 0.25W Resistor |
| 2 | R2,R3 | 22K 0.25W Resistor |
| **Capacitors** | | |
| 2 | C1,C2 | 470nF Capacitor, 7.5mm (0.3") pitch |
| 1 | C3 | lOuT 25V Radial Eectrolytic Capacitors |
| 2 | Q1,Q2 | BCS4S Transistor |
| 2 | D1,D2 | Red 5mm LED |
| 2 | D3,D4 | 1N4148 Diode |
| 1 | SWl | Min Slide Switch |
| 1 | BATTl | PP3 Battery |
| 2 | PP3 | Battery Clip |
| 2 | Miniature Insulated Crocodile Clip | |
| 1 | PCB | |
| 1 | Case | |
| 2 | 5mm LED Clip | |
| As Req'd | Flex (for test leads) | |

# A SIMPLE DISTRIBUTION AMPLIFIER

***Tony Sercombe offers a simple, low-cost project***

Some time ago a colleague had a requirement to run ten cassette recorders from one DAT master, in order to bulk copy in real time. He invited me to suggest a way of connecting all the machines to the one stereo replay output so as to avoid overloading it, and so preserve the integrity of the signal. Although of good quality, none of the machines had floating inputs, but were all situated in reasonable proximity with each other. Since time was limited, I made up a couple of 741's wired as buffers, with 10 output resistors in each case.



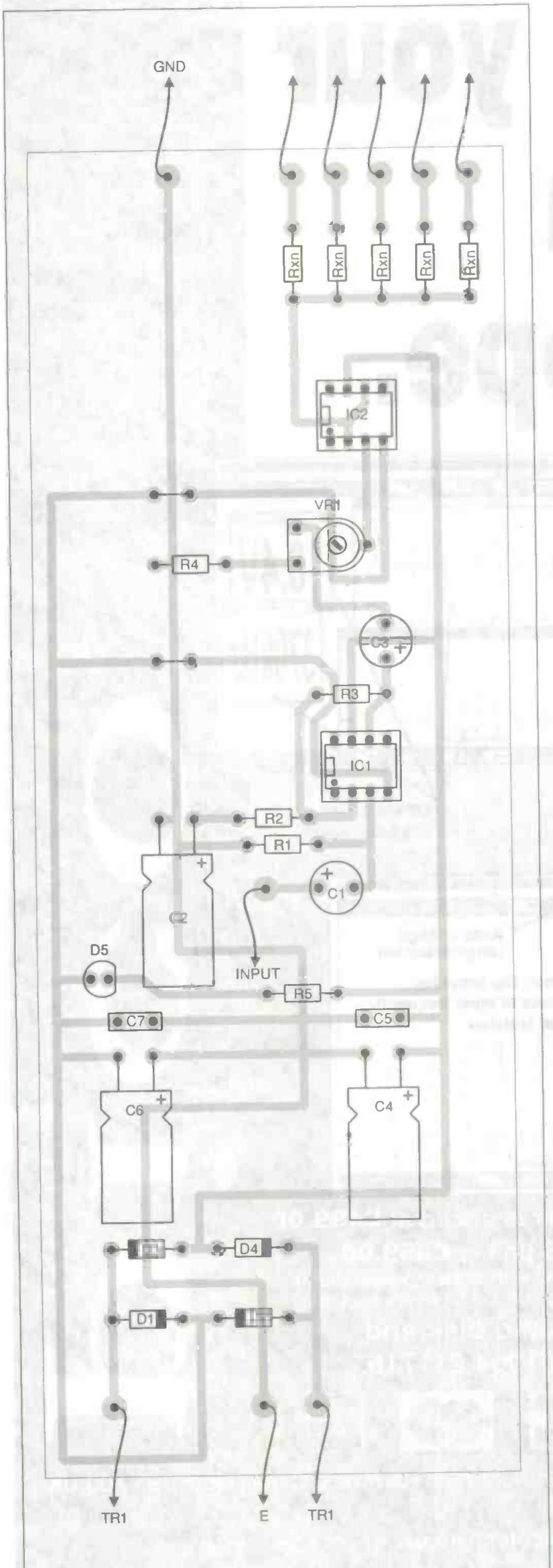




This arrangement worked well, overcoming an immediate problem. However, I decided to make another example which was a little more refined, and with its own power supply, unlike the original. The result is shown here.

As will be seen, it can be made into a very compact, stand-alone unit, and built at quite modest cost. It uses two easy-to-come-by operational amplifiers, and has one adjustable level preset control on the PCB, although this may be brought to a front panel control if required. But since it is not likely to get much use it could still be left as a preset.

It is important that a system such as this does not alter the phase relationship of the signal from input to output, and certainly not invert it, otherwise problems may occur later on in the chain, and so a non-inverting amplifier is used for the first stage. This is a TLO7l, which is a low noise device.

Distribution amplifiers do not provide a deal of gain in the main, often none at all. However, the first stage here gives a fixed gain of 2X (6db). This is because it is not possible to get a gain of unity from such a stage, due to the configuration of the resistor feedback network. It does have the advantage, though, of providing a high input impedance. The output feeds the preset in series with another resistor, and with this arrangement the gain can be




adjusted from unity to +6dB. It may seem odd at first glance to amplify the signal and then to attenuate it again. However, these amounts are so limited that no noticeable loss of quality occurs, and it does have the advantage of leaving a little gain in hand, should it be required to make up any minor losses that may happen. The second stage is simply a buffer amplifier. The input impedance is thus very high indeed, and so the input resistor to ground in parallel with this can be regarded as the practical impedance.

The output is equally very low, in fact about 0.1 Ohm. This is thus modified by the output resistors feeding the destination equipment. The 741 device specified here will supply about 30 Ma , and in a unity gain stage, such as this, will not suffer any bandwidth limitation.

The power supply is quite conventional, utilising a transformer with a centre tapped secondary to ground, and the usual bridge arrangement to supply the two rail voltages. Two ceramic capacitors are fitted in parallel with the main smoothing capacitors to remove any HT noise. A LED with series resistor completes this part of the circuit. Testing amounts to little more than switching on, other than checking the circuit board is correct, and that no solder bridges, dry joints etc exist. It is always worth using IC sockets, as once soldered in IC's are notoriously difficult to remove without quite severe damage occurring.

When setting up initially with the unit out of its case, take great care with the mains supply at the switch and transformer connections. These voltages are at least dangerous, and can be lethal. If possible connect a signal generator to the input, and check that there is a signal at each output point. If an oscilloscope is available, set the gain to unity or other value up to +6db by adjusting the preset control.

Otherwise use a multi-range meter set to a low AC volt range, and a frequency of no more than 1Khz. Repeat this procedure for the other channel and this completes the line up. The final setting is best left at unity initially, and only reset if required later on. It should now be possible to put a direct short circuit on all but one of the outputs, leaving the one working with no disturbance, so exhibiting isolation between the outputs.

## PARTS LIST

### Resistors

| | |
|---|---|
| R1 | 27K |
| R2 | 10K |
| R3 | 10K |
| R4 | 4K7 |
| R5 | 3K2 |
| VRI | 4K7 |
| Rn | 1K(As reqd) |

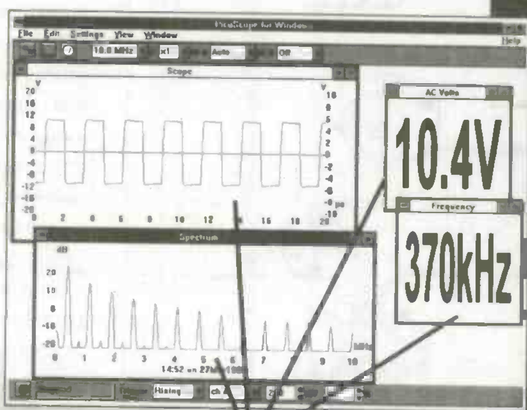
### Capacitors

| | |
|---|---|
| C1 | 2u2 |
| C2 | 470uF |
| C3 | 4u7 |
| C4 & C6 | 2200uF |
| C5 & C7 | 100n ceramic |
| DI to D4 | 1N4001 |
| D5 | 3mm 20mA red LED |

**Transformer: mains pri: 9-0-9 V Sec**
**1C1 TLO7l, 162 741, 8 pin Dil sockets**
**100 mA Fuse & holder, mains switch, and case to suit. Neon indicator only required if R5/D5 not used.**

# Transform your PC into an Oscilloscope.

Never before has it been so easy to capture information about a signal. The **ADC 200** simply plugs into the parallel port of your portable or desktop PC, no complicated setting up - just run the software and start measuring. With the advanced PicoScope Software, your computer can be used as a high speed - 50 MSPS Dual channel Digital Storage Oscilloscope (DSO), 25MHz Spectrum Analyser, Frequency Meter or Voltmeter.

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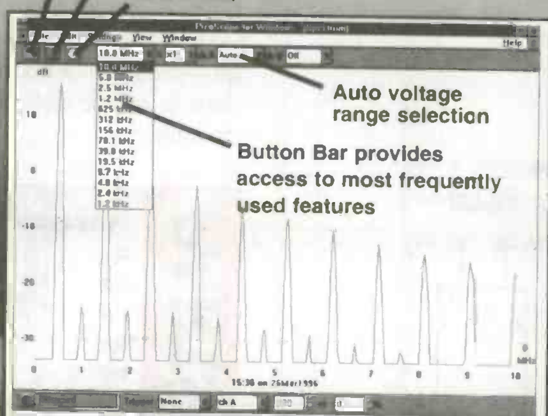



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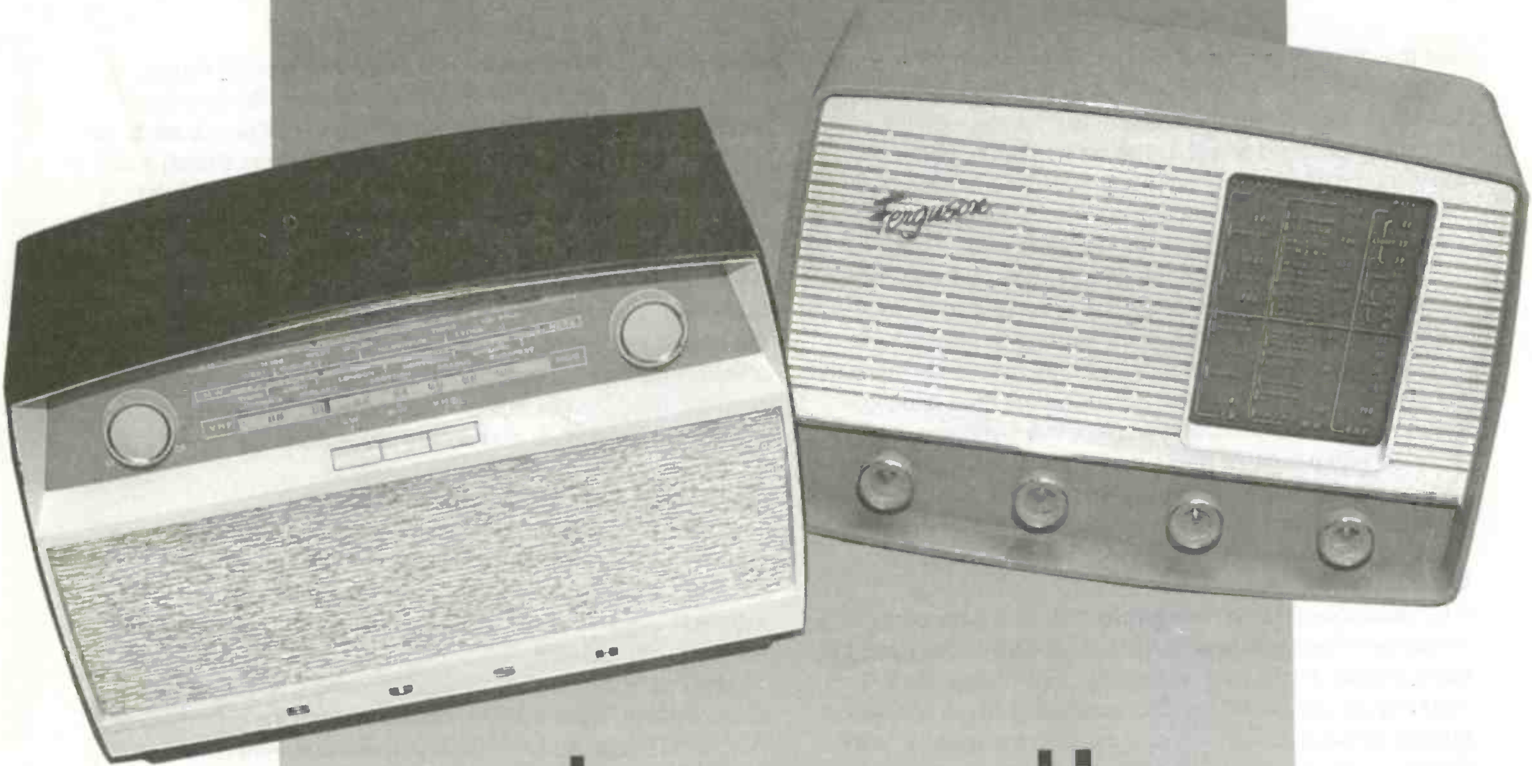


# valve radio SERVICING AND RESTORATION

## PART 5

***Paul Stenning continues his exploration of 'antique electronics'***

### Dismantling the Cabinet

Before attempting to clean and restore the cabinet it should be dismantled as far as possible. Normally the speaker baffle board is a separate assembly and is held in place with screws or clips. Items of trim and manufacturers logos are often held in place with nuts, clips or bent-over pins on the inside, or possibly glued in place. The tuning scale glass is normally held with a few metal fixing plates, fitted with rubber pieces to protect the glass.

These items can usually be readily removed, and then cleaned and restored individually. Also remove the speaker from the baffle board. Do not try to separate glued items unless it is absolutely necessary.

On many bakelite sets the baffle board and other components are held in place with spring clips pressed over pillars. Sometimes there is a flat side on the pillar, in which case the clip can be removed by turning it so that one of the gripping sections is next to the flat. Otherwise you will need to lift one of the grips slightly with a small screwdriver while lifting it off. Alternatively grip the sides of the clip with long nosed pliers and rotate it back and forth as you pull it off.

### Knobs and cabinet trim

Plastic, bakelite and metallic parts can initially be cleaned with warm water and washing-up liquid. A strong washing-up liquid such as Fairy Excel is recommended. The water should not be so hot that you cannot put your hand in it, as very hot water can cause plastic parts to soften and distort, and clear plastic items to cloud. Leave the parts to soak for a few minutes, to soften the dirt. An old tooth brush is ideal for cleaning the parts and removing the grime from the finger-grips of the knobs. Once the parts are clean, rinse them in clean water to remove the detergent, and leave them to dry. Brass items can them be polished using Brasso or a similar product. You will often find that they have been coated with a lacquer which has become chipped and stained. Once you have a good polished brass surface, it should be protected with lacquer to prevent it becoming tarnished and dull. The car aerosol lacquer mentioned earlier is ideal for this. Brass trim on knobs is difficult to spray without coating the rest of the knob, you could either mask it carefully or leave it without lacquer.

Chrome plated items can be carefully polished with Brasso, taking care not to remove the plating. If the plating is already badly chipped and damaged you may have to paint over it.

Plastic and bakelite knobs can be wax polished in the same manner as for bakelite cabinets. If the knobs have printing which is lightly recessed, and some of this is missing, it can be replaced with a suitable colour model paint. Any paint on the surface can be removed with Brasso once the paint is completely dry (24 hours).

## Speaker fabric

It is impossible to clean dirty speaker fabric. If it becomes damp the adhesive fixing it to the baffle board softens and the fabric shrinks. I have tried several methods of cleaning it, including car upholstery cleaning products, with no success. If anyone knows a good method of cleaning the speaker fabric, please let me know and I will share it with other readers.

Normally all you can do is brush it carefully with a soft paintbrush to remove the worst of the dust. Sometimes the shape of the speaker can be seen in the fabric as a dirty shadow, which cannot be removed.

You are very unlikely to be able to obtain an exact replacement fabric since it is no longer manufactured. Anode Electronics and S.W.Chaplin carry stocks of more modern fabrics that will act as reasonable replacements.

The new fabric can be fixed in place with a spray carpet adhesive such as Gripperrods Spray Adhesive. Spray a thin layer on the baffle board only and stretch the fabric across it. Without specialist equipment you will be unable to stretch it as tight as the original. Place a piece of wood over the top and hold the lot together for a couple of hours, with clamps, bricks or heavy transformers.

If the cone of the loudspeaker itself is damaged or coming away from the frame, it can be repaired with a contact adhesive such as Thixofix or Evostick. These adhesives dry to a flexible rubbery consistency. If it is badly damaged you will probably need a replacement. Both products are messy and give off fumes, so take appropriate precautions.

## Cleaning bakelite cabinets

The bakelite or plastic cabinet can be washed with warm water and washing-up liquid. A washing-up brush and a tooth brush are useful for getting the muck out of the corners and recesses. When the cabinet is clean, rinse it in clean water and leave it to dry naturally.

The best finish can be obtained by using a specialist bakelite polish. Bake-o-Bryte is available from the publishers of Radiophile magazine for £2 plus 50p postage. Alternatively a good quality wax polish such as Colron Finishing Wax (available from DIY stores) can be used. If the surface is dull and cloudy it can be improved with the gentle application of a slightly abrasive polish such as Brasso.

## Repairing bakelite cabinets

Clean cracks and breaks can be successfully repaired with a little Super-glue. Do not apply the glue directly from the bottle as you will get far too much. Place a few drops on a piece of


scrap card, and use a pin or piece of wire to apply it to the crack or break. In the case of a crack, apply the glue to the inside of the cabinet and let it work its way into the crack by capillary action. Once the glue is thoroughly dry (allow several hours), any excess can be gently removed with a razor blade or modeling knife.

Super-glue is only suitable for repairing clean breaks, and is unable to fill even small gaps. If the broken parts do not fit cleanly together you will need to use an adhesive that fills the void. An epoxy resin such as Araldite (the standard type, not the fast drying) is suitable. Any excess can be removed with a modeling knife once the glue has dried completely (at least 24 hours).

More major rebuilding work can be carried out with a two part car body repair filler such as Davids Isopon P38. Cardboard coated with Sellotape can be fixed to the inside of the cabinet to act as a mould to hold the filler in place while it dries. The filler should be built up over three or four layers, allowing an hour or so for each layer to set before applying the next. When the filled section has sufficient strength to be self supporting the cardboard can be removed.

Continue to apply filler until the outside is slightly over-size. Additional filler can be applied on the inside if necessary to give extra strength. Leave the cabinet for 24 hours for the filler to set fully, then sand it carefully to shape. When you are close to the right shape, use finer sandpaper, and finish off with fine wire wool. Any voids can be filled with additional filler or cellulose putty. The only problem with these repair techniques is that the Araldite or filler is not the same colour as the cabinet. With care and practice you may be able to mix an appropriate coloured powder paint with the filler to disguise the repair. This will only work if the cabinet is a single colour, and even then it will be very difficult to get an exact match.

## Painting cabinets

The easier solution is to paint the whole cabinet with a suitable colour car spray paint. If you want a deep brown bakelite colour, Vauxhall Brazil Brown is a good match. Car aerosol paint is also ideal for repainting the painted sections of cabinets. For off-white sections, Ford Sierra Beige or Lada Cream is often suitable. For small repairs you may prefer to paint just the repaired section using car touch-up paint which is supplied in a small container with a brush.

If you are trying to find a close colour match you should take the cabinet to the car accessory shop with you. It is difficult to match the colour accurately under the pink or yellow glow of the shop lighting, so ask an assistant if you can take three or four likely colours outside and look at them in daylight.

While you are there get a "Can-Gun". This is a pistol shaped device that clips to the top of the can and has a trigger to operate the button. It makes the job easier, prevents strain on your finger and is well worth the £1.20. Also get a face mask to filter some of the fumes and dust.

Anything that should not be painted must be protected with newspaper and masking tape. Tape over any gaps in the newspaper as the paint will get into the smallest gaps.

Spraying should be done outdoors on a dry still day. If you are working in a covered area such as a garage, leave the door fully open to let the fumes out. Do not try spraying indoors because the fine spray will settle as dust on everything in the room. The fumes will build up, even if you open the windows.

Shake the can thoroughly before use. Spray painting needs practice to obtain good results. Each coat should be just thick enough that it has an even wet look. If it looks powdery you need to spray it a little thicker, and if you are getting runs it is too thick. With practice you can sometimes do the job in one coat. If you need additional coats they should be applied at about half-hour intervals. Do not let the can run empty, as it will spit and splatter the last bit of paint.

Remove the masking tape and newspaper about half-an-hour after the final coat, then leave the cabinet to dry thoroughly for at least 24 hours. The paint finish will probably be fine as it is, but it can be polished with Colron Finishing Wax if necessary. Do not use car polish as it gives an artificially glossy finish.

## Restoring wooden cabinets

In this section I will discuss some of the more straight-forward methods of repairing and restoring wooden cabinets. If you are feeling more ambitious it would be worth finding a good book or magazine about furniture restoration.

## Woodworm

If the cabinet shows any signs of woodworm, this must be treated before continuing. Remove the chassis and any other removable parts if you have not already done so. Cuprinol Woodworm Killer is available is available in an aerosol can with a pointed nozzle for squirting into the woodworm holes. Treat the cabinet in accordance with the instructions and safety warnings on the can. A hyperdermic syringe and fine needle will ensure 100% penetration, avoiding air pockets that may remain at the bottom of the holes using the aerosol alone.

After treatment, leave the cabinet in a warm place for a few days. If there is any further sign of woodworm activity, such as new holes or wood dust, treat it again. Wait at least a week for the Woodworm Killer to thoroughly dry out before carrying out any repair or restoration work on the cabinet.

## Cabinet repairs

Wooden cabinets sometimes come apart at the joints, which are normally held together with glue alone. Apply a little Cascamite Woodworking Glue (or Evostick Woodworking Adhesive) to the gap, and use a scrap of cardboard to spread the glue well in.

Hold the joint tightly closed with clamps or heavy items while the glue dries. Use scraps of wood to protect the cabinet finish from the clamps. Any glue that oozes out should be wiped off with a damp tissue.

If you need to repair several joints, check the cabinet is square after the clamps have been applied. This can be done by measuring the two diagonals from the back - they will be equal if the cabinet is square.

If the layers of the plywood come apart they can be repaired in a similar manner. The plywood should be clamped firmly between two solid boards while the glue is drying to ensure the result remains flat.

## Cleaning the cabinet

The build-up of dirt, household polish and nicotine on the surface of the cabinet can often be removed with White Spirit. If this does not work, try Foam Cleaner. Warm water and washing-up liquid is also effective, but you should not submerge the cabinet and do not allow it to become too wet. The aim is to remove the grime without disturbing the original finish.

## Stripping the original finish

If the original polish or varnish is in a poor state you may have no option but to strip it and start again. Do not rush into this, as it can be difficult to get a finish similar to the original. Refer to the section detailing levels of restoration in Part 4, and consider the options very carefully.

If the cabinet has a wax polish finish you may be able to remove it with metholated spirits. Normally, however, you will need to use a varnish stripping product such as NitroMors Varnish Remover.

Use this with medium grade wire wool in accordance with the instructions on the tin. The product burns if it gets on your skin, so wear rubber gloves and an old cotton shirt with sleeves. Once the varnish is removed, the cabinet should be thoroughly cleaned with metholated spirits or white spirit. The surface should then be rubbed over with fine wire wool to give a smooth finish.

## Preparing the surface

If the wood colour is too light it can be darkened at this stage with Colron Wood Dye. The colour obtained is often slightly lighter than the shop display would suggest, so choose a fairly dark colour such as walnut.

Any woodworm holes and other blemishes can be filled with plastic wood. This also dries lighter than expected. If the repair is darker than the surrounding wood it will look less conspicuous than a light coloured repair.

The exposed wood should then be protected and sealed with Colron Wood Reviver. This is rubbed into the surface with a soft cloth and allowed to dry.

If the cabinet had a shiny lacquered finish it may be sprayed with two or three coats of car lacquer. Do not use polyurethane varnish or any other brush-on product as it is very difficult to get a smooth finish.

## Polishing and finishing

Most older sets had a more subtle polished finish. If the colour of the wood is correct, a couple of coats of Colron Finishing Wax can be applied. If you require a darker finish, Colron Liquid Wax is available in three shades. These products requires a considerable amount of buffing to obtain a good finish but it is worth the effort. Do not use Colron Liquid Wax and Colron Finishing Wax on the same cabinet, as they do not mix.

These products can also be used if you have not stripped the original finish. Try a small amount in a corner first to make sure it does not affect the original finish. Colron Finishing Wax

lacquer does not affect the original finish.

## Replacement backs

If the original back is missing you should arrange an alternative. This is particularly important if the set is to be used, to prevent little fingers finding their way onto live terminals. If you have a supply of scrap sets you may have a suitable back that can be modified to suit.

A suitable replacement back can be made from hardboard or thin plywood. Once it has been cut to size, drill a large number of 10mm (3/8") holes for ventilation. In particular there should be holes near the output and rectifier valves, and any high power resistors. Drilling hardboard gives a rather tatty finish, which can be tidied somewhat with medium grade sandpaper. The back can then be sprayed with black aerosol paint if desired. If you want the innards to be visible, use clear perspex drilled accordingly.

is generally the better choice. The Colron range of products are specifically designed for furniture restoration, and are therefore ideal for valve radio cabinets. They are available from DIY stores, with the woodcare products. A detailed leaflet covering the complete range is available in the store or direct from the manufacturers.

## Touching up minor blemishes

If a polished finish is scratched or chipped, the blemishes can be masked to some extent with Colron Liquid Scratch Remover. This is supplied in a bottle with a small brush, and is applied to the scratch and allowed to dry before buffing.

Scratches in lacquered cabinets can be repaired with car lacquer. This should be sprayed into a suitable container (such as the aerosol lid) and applied to the damaged area with a small paint brush. Several layers may be needed to build up the depth. Test in a hidden corner first, to ensure that the

## On-going cabinet care

Normally the cabinet will require only occasional dusting. Do not use household polish such as Pledge or Mr Sheen on polished cabinets. If the finish becomes dull it should be re-polished with the product that you used originally.

If possible do not display the set in a kitchen or a room where people smoke regularly otherwise the finish will require regular cleaning and polishing. The set must not be displayed in a kitchen, bathroom or anywhere that steam or water is present, for safety reasons.

## Regular Use

The finished set should be used and enjoyed. Periodic use will keep the set in good order, and dry out any damp. The electrolytic capacitors also benefit from regular use, as it avoids the need for further reforming.

I would suggest that the set should be used for at least one hour every three or four weeks. One hour or more allows the set to warm up properly, which is better for the valves than brief periods of operation.

## And finally...

I hope this series has encouraged you to obtain a couple of valve radios, and enjoy repairing and restoring them. It can become a fascinating hobby! At the very least, I hope it has provided an interesting diversion from the world of microprocessors.

Special thanks are due to Nigel Rogerson of Anode Electronics for his many helpful suggestions, and for proof-reading and checking this series.

## POSTSCRIPT

The author is grateful to Mr J Barrington-Gray for his recent letter which contained the following valuable comments and information:-

"Some old sets have been modified so that they are putting the public at risk; a few have been KILLED by touching metal speaker grills or underside case nuts or screws in contact with the mains or HT supply. The radio sets in this series may involve people in the interest, but many could be at risk if they just plug an unknown set in to test it. Some sets could be quite old, or could have been repaired unprofessionally in the past. Please take care. I feel that a 'Megger' is a useful instrument for this work, if used with due care. It is useful for confirming that all externally accessible metalwork is indeed adequately insulated form the dangerous voltages within.

The grub screws (Page 67, April 1996) which hold the control knobs onto AC/DC sets were sometimes covered in pitch or beeswax. This MUST be replaced, or the next person working on the set is at risk of a SHOCK as the chassis is connected to the mains. If one can obtain a flexible drill with a small head, it is quite an easy job to drill out grub screws, starting with a small sharp pilot drill. You should not need to damage a knob or radio case" Mr Barrington-Gray has been repairing and restoring vintage sets for 40 years. He can also supply valves, spares, books and technical information. Write to 132 Lincoln Way, Corby, Northants, NN18 9HW.

### Oops!

The gremlins have been at work again. In Part Three of this series (June 1996) the valve in Figure 1 (page 58) is shown the wrong way round! The AC input should be connected to the anode of the valve, while the cathode should be the half-wave rectified DC output. The author would like to apologise for any confusion caused by this error. He would also like to thank Mr T Windsor at Windsor Electrical, Carrickfergus, County Antrim, Northern Ireland, for pointing out this error.

### Sunrise Press

We have had a number of enquiries about the Sound and Vision Yearbook which was mentioned in the first part of this series (ETI April 1996). Unfortunately, we have not been able to contact the publishers, Sunrise Press, and can only assume they have gone out of business. However, the author of the aforementioned book also publishes a 405-line magazine from Northampton and we suggest any further enquiries should be directed to: 71 Falcutt Way, Norhampton NN2 8PH.

Transportation can be a significant cost in systems for utilisation of biomass products. (Courtesy ETSU)

# BIOMASS AS A SOURCE OF ENERGY or 'Back to Firewood'

***By Douglas Clarkson***

Collection of forest waste can yield significant amounts of biomass material for energy production. (Courtesy ETSU)

If asked about the 'Energy Crisis' the general response would be 'What Crisis?'. After all not only are the utility power companies reducing their prices - the price of petrol has fallen recently due to competition triggered by supermarket outlets. The real issue is surely not even about availability or price but rather about global warming. Like tinkering with a complex mechanism whose workings are not fully understood, the rapid release of carbon dioxide into the atmosphere over the period of a few centuries is like squeezing butter into a watch as recommended by the Mad Hatter in Alice in Wonderland.

In the 1990's, however, is beginning to be seen a change in awareness. There has already been coverage in ETI of energy from the sun via photovoltaics and energy from wind turbines. Such initiatives are expanding rapidly - but from a relatively low base. It would indeed be a paradox if the first form of energy that humankind released from the sun - that of firewood - came again in the form of biomass energy to represent an important source of energy for the future and one that would have a neutral effect on CO2 emissions. In the UK the Ministry of Agriculture Forestry and Fishing (MAFF) is certainly taking the concept seriously.

## Expanding the alternatives

While solar and wind energy can provide pollution free power some of the time, there is always the requirement to provide power at any time of the day or night independent of availability of solar or wind energy. This core or base line demand is at present met from coal, oil or gas fossil fuel sources, hydro-electric power or the nuclear sector. The concept of Biomass

Fuel pellets derived from watse paper. (Courtesy ETSU)

Energy is that is can be used to replace some of the use made of fossil fuel sources. It can be used as a fuel in specifically designed generating plant for Biomass systems or it can be mixed with conventional fuels such as coal to reduce dependence on fossil fuels.

Considerable research is at present on going to determine optimised methods of growing Biomass crops. The interfacing of agriculture to the energy supply infrastructure adds considerable complexity to such an initiative and to this extent the hurdles tend to be administrative, procedural, economic and political. The developing world as such uses biomass to provide some 12% of its energy requirements - compared with 3% in the developed world. Some contributions can be quite significant. In the USA for example, the use of biofuel-fired generating, mostly provided by wastes from saw mills provides around 9000 MW of capacity.

Table 1 indicates the biomass contribution to the UK Energy Statistics for 1993.

It is anticipated that each of these sectors will experience significant growth in the future.

| Source | Tonnes oil equivalent | % of total |
|---|---|---|
| Landfill Gas | 150,000 | 18 |
| Sewage Digestion | 150,000 | 18 |
| Wood combustion | 175,000 | 21 |
| Straw Combustion | 75,000 | 9 |
| Municipal waste | 175,000 | 21 |
| Other | 100,000 | 13 |
| Total | 825,000 | |

Table 1: Biomass contributions to UK Energy Statistics: 1993

## The response to Rio

In the complex eco system in which we live, it is unrealistic to consider environmental problems and solutions as things which affect only limited parts of the eco system. The truth is more complex. According to the UK's strategy following the 1994 UN Conference on Environment and Development at Rio De Janeiro the way forward is ' to provide an adequate supply of good quality food and other products in an efficient manner; to minimise consumption of non-renewable and other resources, including by recycling; to safeguard the quality of soil, water and air and to preserve and, where feasible, to enhance biodiversity and the appearance of the landscape, including the UK's archaeological heritage'.

This directive has in particular focused attention on UK initiatives to add additional dimensions to forms of agriculture at present undertaken. While attention has been focused on the ability of the industrialised sectors to manufacture and export products, attention has been more recently focused on the resources within agriculture to contribute to the economy. This involves, for example, using land taken out of food production, - the 'set aside' land - for the growing of non-food crops. At the same time there has also been identified the desirability of achieving this without cost to the environment and indeed with the emphasis on adopting techniques that will contribute to its benefit. These would include, for example, reduction of use of artificial fertilisers and change of work patterns to bring new opportunities for wildlife populations. This represents the beginning of a shift away from policies in open conflict with the environment.

Considerable work has already been undertaken in assessing the potential for steering agriculture towards Biomass farming in as much as at pilot scale level many projects have been demonstrated successfully and await expanding to more meaningful sized ventures.

## Biomass fuels

Table 2 indicates the energy content of a range of biomass fuels and conventional fossil fuels for comparison.

| Fuel | Net Calorific | Value Unit |
|---|---|---|
| Hydrogen | 10.2 | Mj/m3 |
| Methane | 33.9 | Mj/m3 |
| Natural gas | 34.8 | Mj/m3 |
| Sewage gas | 20 to 26 | Mj/m3 |
| Wood Gas | 4.5 to 7 | Mj/m3 |
| Methanol | 19.9 | Mj/Kg |
| Ethanol | 27.2 | Mj/Kg |
| Diesel | 42.9 | Mj/Kg |
| Refuse | 7 to 10 | Gj/odt |
| Straw | 14.8 | Gj/odt |
| Wood | 13.7 | Gj/odt |
| Coal | 24 to 30 | Gj/odt |

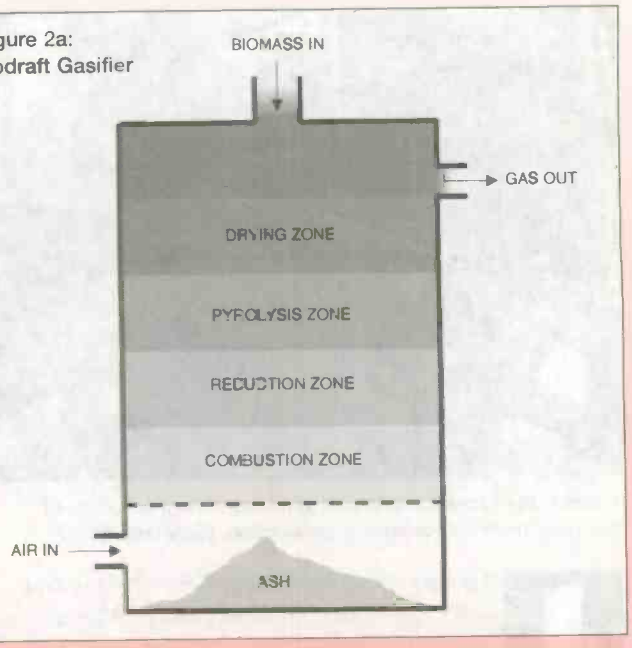
**Table 2: Table of energy contents of various fuels in appropriate units. (odt = oven dried tonne)**

## Short rotation coppice

The ancient coppice system of woodland management is being used in what is called Short Rotation Coppice where selected high yielding clones of willow and poplar are planted at a density of around 10,000 per hectacre. After one year the young trees are cut back to ground level and then subsequent growth harvested after between two and four years later. Existing UK plantations have yielded on average between 10 to 12 oven dry tonnes per hectacre. Yields as high as 15 tonnes have also been reported. There are indications, however, that yields as high as 20 tonnes may be possible with new species and improved land management. It is estimated that an SRC plantation would remain in production for at least 30 years on suitably fertile soils. Figure 1 shows short rotation coppice in England.

A range or markets of SRC is being studied. In rural communities, transport costs can add to the cost of conventional fuels so that locally produced SRC can be an attractive alternative. Standards

**Figure 2a: Updraft Gasifier**

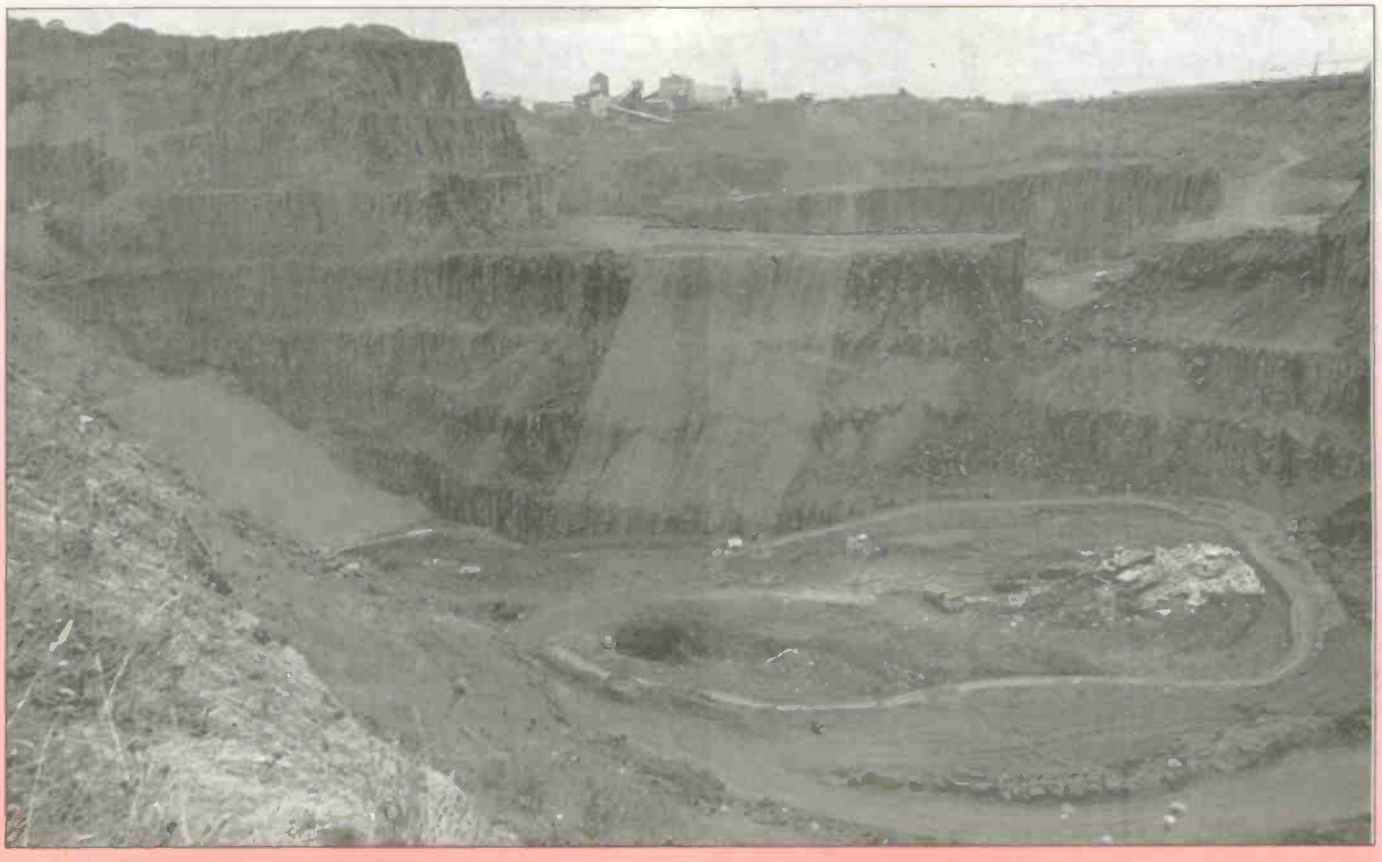



applications include burning in conventional heating systems for domestic and limited scale industrial use. For power generation, generating plant in excess of 5 MW would provide higher efficiencies.

Studies are also being undertaken into gasification or pyrolysis where wood feedstock is converted to an intermediate gaseous or liquid fuel. In gasification the fuel is made to react with air to produce a mixture of carbon monoxide, carbon dioxide methane and hydrogen. The resulting gas has a relatively low calorific value - approximately one seventh of that of natural gas. In pyrolysis the fuel is heated in the absence of air to produce gas, oil and char. The relative proportions of product depend on the temperature of operation. At the highest processing temperatures - termed flash pyrolysis - the proportion of liquid fuel produced is greatest with as much as 85% of biomass converted to liquid form.

The development of thermal gasification tends to be more advanced than that of pyrolysis. Gasification systems are becoming available for generating capacity between 100 kW to 30 MW. Pyrolysis processes present more technical problems

**Energy conservation systems require complex engineering and control systems to optimise performance. (Courtesy ETSU)**



Rowley Regis Landfill site in the West Midlands – a very large hole in the ground. (Courtesy ETSU)

but also hold out a range of advantages in expected performance. The production of a liquid product is certainly an advantage for storage and distribution compared with a gaseous product.

In gasification, up-draft or down-draft gasifiers can be used. The down-draft gasifier introduces the gas at a lower level which encourages hydrocarbon deposits to be removed during the gasification process. The various forms of gasifiers are shown in figures 2a and 2b.

It is estimated that SRC can provide an annual production equivalent to 6 tonnes of oil per hectacre per year. In this form the fuel can deliver far higher conversion efficiencies. In a more distant future - will cars run on trees? In terms of present economics, the cost of production of SRC material is estimated at L14 - L24 per oven dried tonne.

## Miscanthus

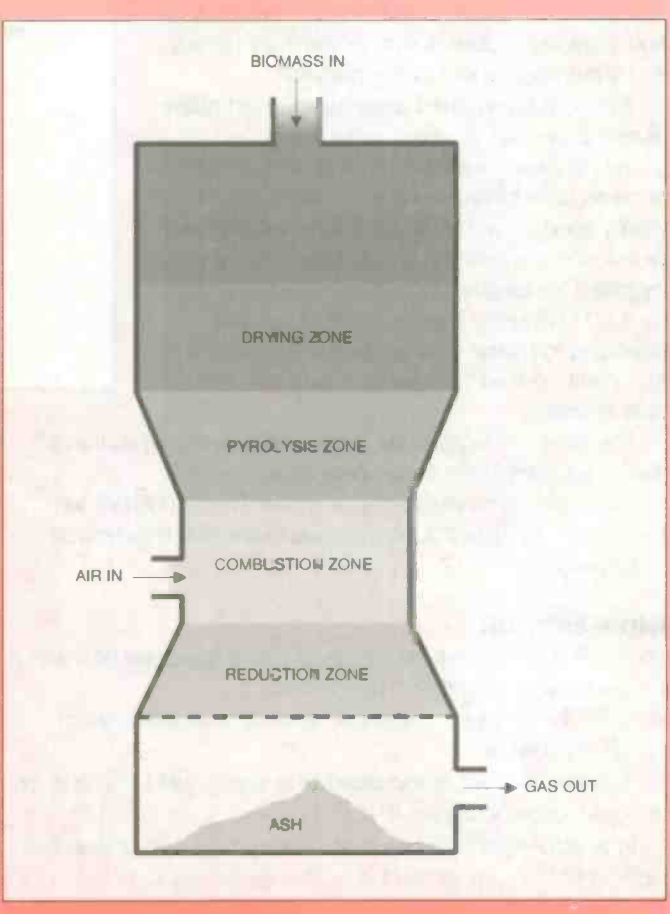
Miscanthus is a 'woody' perennial - a type of elephant grass that is currently being investigated in the UK as a biomass product. It can grow to around 4 metres high in one year and is more readily grown in the warmer parts of the country.

While more difficulty is being encountered in establishing this crop, it can potentially provide yields as high as 20 tonnes of dry matter per hectacre per year. Also, in its harvested state it requires less drying - thus reducing post harvest costs. As a relatively recent newcomer to biomass development, its chief advantage is a more rapid cropping cycle compared to short rotation coppice. It may also be that alternative plants with even greater levels of productivity may be utilised in the future.

## Straw

Each year the UK produces around 7 million tonnes of straw - corresponding to an energy content of 3.6 M tce (tonnes coal equivalent). The use of this byproduct as a fuel is relatively limited - with around 200,000 tonnes or some 3% of total being used as a farm based fuel.

With legislation now banning burning of straw in fields, it is anticipated that utilisation could increase four-fold by the year 2000. Efforts are being directed to developing technology in order to reduce the bulk of straw and render its transport more economical.



A fresh delivery of biomass. (Courtesy ETSU)

There is also considerable interest in the use of straw as a partial substitution for coal in industrial coal fired boilers.

Suitably processed material can in fact be used up to levels of 50% substitution.

As a green bonus, the acid emissions at this level of substitution are reduced substantially. This in turn would be a factor minimising production of acid rain. There appears less interest in converting straw by gasification or pyrolysis since the combustion of straw is relatively well established and there are problems with its low bulk density and small particle size of the material.

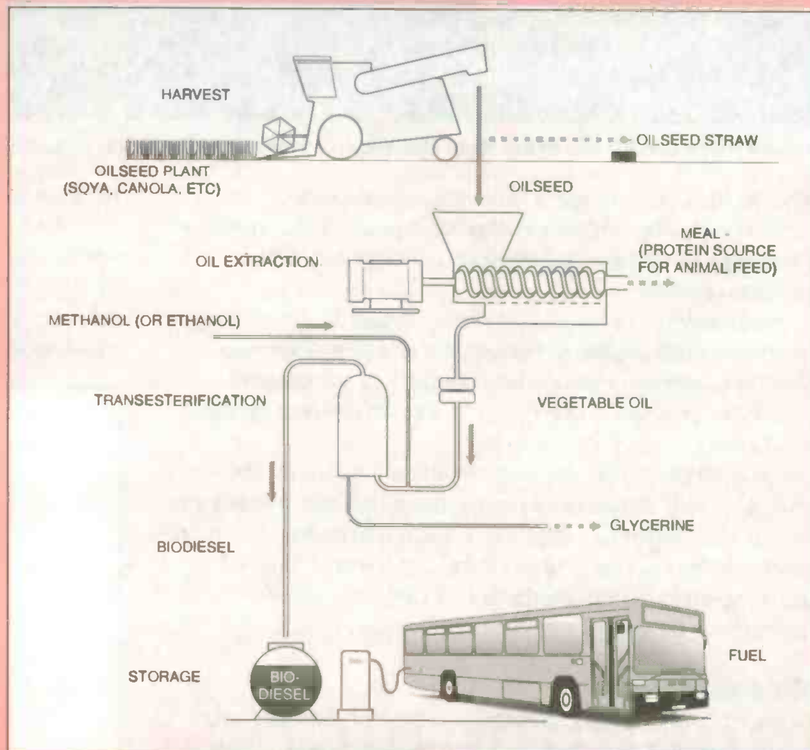
By comparison, the Danes make much more use of straw than the UK.

This is largely explained by the widespread use of community based heating schemes which initially used conventional fuels such as coal and oil but with the taxation of fossil fuels, have migrated to using straw instead.

A 30 MW straw burning plant has been operating for some time at Haslev. Another 70 MW plant co-fired by straw and coal has been built at Grena.

The UK's first large scale straw fired generating station is due to be completed in Cambridgeshire in 1997.

On single farm installations, a typical Farm 2000 burner system will provide 200 kW and consume 300 large round bales per year.




## Biodiesel oil

The largest single crop for industrial use is rapeseed oil - with a set aside value of 100,000 ha in 1994.

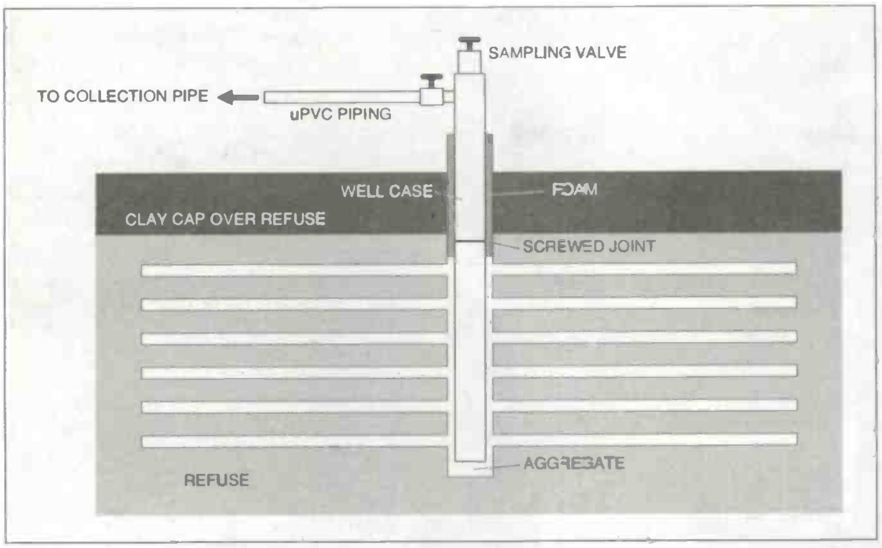
Table 3 indicates comparable rates of production within Europe for 1993.

A limited amount of rapeseed oil is processed in Europe for the production of biodiesel.

In Austria, encouragement of development of biodiesel has led to a 5% uptake of this fuel in the 'diesel' market.

| Country | Area of non-food oilseeds on set-aside 1993/94 marketing year |
|---|---|
| Belgium | 2820 |
| Denmark | 18060 |
| Germany | 60870 |
| Greece | 0 |
| France | 49950 |
| Ireland | 0 |
| Italy | 28150 |
| Luxembourg | 0 |
| Netherlands | 540 |
| United Kingdom | 40610 |
| Spain | 4000 |
| Portugal | 0 |

Table 3: Production of non-food oilseeds (principally rapeseed) in Europe: 1993




Rape seed oil can be processed to produce biodiesel. The process of its production can be described as: Rapeseed + methanol = diester (RME) + glycerol oil where RME = Rapeseed Oil Methyl Ester Studies are at present evaluating whether ethanol from Biomass production, can be used to replace the methanol in the conventional process. It is estimated that even if the entire set aside land area of the UK (1/6 th of arable land or 600,000 hectacres) was used to produce rapeseed for biodiesel, this would only produce some 6 % of the UK's current diesel consumption. While Biodiesel is unlikely to supplant conventional diesel, there are however, certain uses notably on inland waterways where the use of Biodiesel would be beneficial to the environment. Specific geographical areas include the Norfolk Broads and the National Parks where in particular there is considerable pollution due to spillage of marine diesel. Figure 3 summarises the process of production of biodiesel. Preliminary studies conducted by the Centre for Aquatic Plant Management, Sonning on Thames, have indicated that biodiesel produces less severe effect on the environment than marine diesel. Studies involved the effects on plankton, macrophytes and a range of aquatic animals.

The Transport Research Laboratory has carried out a trial of biodiesel in Reading where various factors were investigated with the fuel used in buses. Table 4 indicates some of the initial findings. While the biodiesel tended to produce less smoke, it at the same time appeared to produce more particulate material. A - sign indicates improved performance of biodiesel compared with fossil diesel.

| Pollutant | Difference % | Confidence level |
|---|---|---|
| Carbon Monoxide | + 10 | Medium |
| Hydrocarbons | - 10 | Low-medium |
| Oxides of nitrogen | - 10 | Medium |
| Carbon Dioxide | + 5 | Low |
| Smoke | - 45 | High |
| Particulate | + 80 | High |

**Table 4 (*Below Left*): Comparison of fossil diesel with biodiesel in tests undertaken by Transport Research Laboratory**

Conventional literature on biodiesel normally highlights the much lower levels of Sulphur Dioxide in biodiesel yet this study apparently does not make any reference to this pollutant. Other Biodiesel studies, however, have indicated reductions in particulate emissions. It would appear that more research requires to be undertaken to better investigate the environmental impact of biodiesel.

At a time where there is particular concern over the link between particulate contamination and the rising incidence of asthma, a more thorough review is perhaps necessary. Studies are also being undertaken of the use of vegetable oils for offshore drilling.

Conventional oil drilling technology makes extensive use of mineral oils in water suspension to lubricate the drill bit. Surplus fluid invariably contaminates the marine environment.

There is a specific interest in use of rapeseed oil in formulation of drilling fluids to reduce toxicity to benthal communities, eliminate taint in fish and enhance recovery of sea bed following periods of exploration.

## Bioethanol

The USA and Brazil have established bioethanol industries where ethanol is produced from agricultural feedstocks by fermentation. The cost of bioethanol is approximately three times that of chemical methods.

Ethanol can be used as a single fuel or it can be added to petrol as a fuel oxygenate to improve its calorific value. In addition, ethanol can be processed to form ethyl tertiary butyl ether (ETBE) which is a preferred oxygenate agent for petrol.

In Brazil, all non-diesel vehicles run on either gasohol which is 22% ethanol and 78 % petrol or neat hydrated ethanol which consists of 95% ethanol and 5 % water.

In the USA, ethanol is produced from corn or maize which is initially broken down by enzymes to produce sugars from starch which can in turn be fermented.

There is considerable interest, however, in developing processes which would allow low grade sources containing cellulose such as crop residues to be processed to produce ethanol. While methanol can also be used as a fuel, its prime sources tend to be from fossil fuel sources such as methane.

There is considerable interest, however, in developing gasification systems which use high concentration of oxygen for the production of methanol.

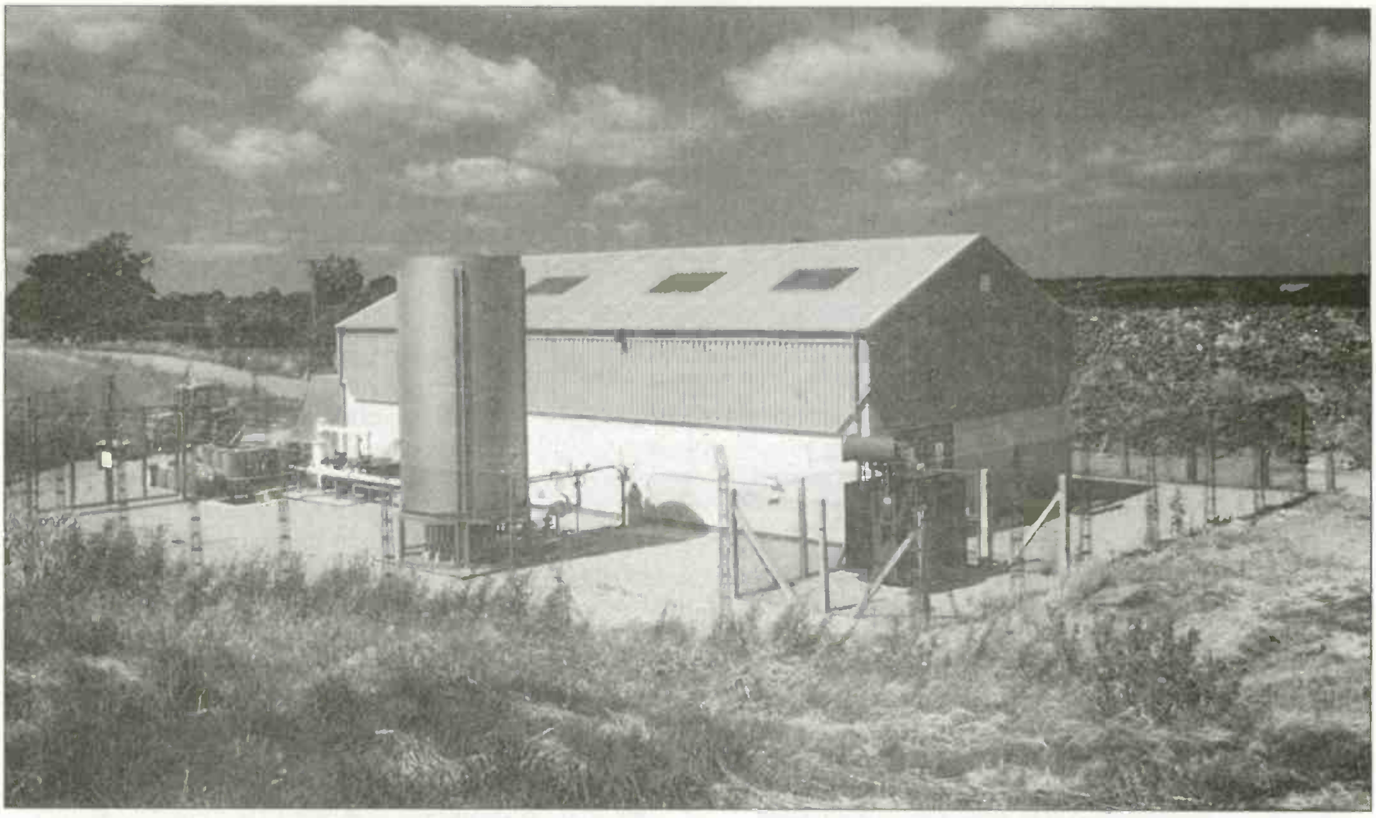
## Vegetable Oils

Biodiesel can be burnt in existing diesel engines. While vegetable oils such as rapeseed can be burnt directly as a fuel, this requires modification of existing engines.

A limited number of agricultural vehicles have been converted in Germany to run on raw vegetable oil for a trial period. While this has been demonstrated as a success in terms of reduced emissions, and the fuel is considerably cheaper to 'produce' than biodiesel, it is none the less more expensive than fossil diesel as available on farms with duty free fuel.

## Pyrolysis Oils

Although at an early stage in development, the pyrolysis process where dry biomass such as wood or miscanthus is processed by heat with limiting oxygen may offer the most effective means of producing the biofuels of the future. In addition to providing fuels, this process could also provide useful chemical industry feedstocks.



**Landscaped landfill: the gas collection and generating plants at Ryton conceals the large source of biomass material. (Courtesy ETSU)**

## Algae

One of the more futuristic biomass candidates is algae. Algae tend to make the news by reports of its infestation into nutrient rich waterways. If algae could be reared and fed on, for example, sewage effluent, the processed dried biomass would produce a high yield of oil based substances.

## Taxation on Biofuels

As ever, the financial framework within biomass production has a critical effect on its development. The levels of taxation of Member States in the EC on biofuels will have a significant effect on the speed of developments.

While the environmental arguments against the spiralling use of road transport are self evident, there would appear to more than a little sense in lessening the impact of such an expansion on the environment by taking steps to encourage the use of biofuels in the future.

## Growing raw materials

The recent changes in environmental perception and the addition of new crops indicate that in some ways aspects of agriculture are being re-integrated into industrialised society. Progress is being made in identifying products used as raw materials that can be provided as renewable commodities rather than ones processed, for example, using non-renewable products.

There is considerable interest in development of plant oils as a substitute for some ranges of products derived from mineral oils. The UK each year uses around 750,000 tonnes of lubricating oils and greases so this is a large potential market to investigate. Generally short molecular length chains tend to be used in production of soaps and detergents with longer molecular chains being used for lubricants and more specialist applications.

Figure 4 indicates the summary of plant derived oils, sources and uses.

Developments in plant breeding and also developments from genetic engineering may on the one hand improve existing crop efficiencies and also introduce wholly new creations targeted to produce specific agro products.

The increase in land production in set aside is in turn a reflection of the significantly increased efficiencies of food production within the European Community.

## Wastes

While there is a certain focus of attention on the role of agriculture to grow energy crops, there is all the time a vast supply of wastes from a modern industrialised society with a high level of 'development' within agriculture. Among so-called 'dry' wastes can be considered domestic refuse, industrial and agricultural wastes including straw and forest residues. The so-called wet wastes can be included sewage, animal wastes and industrial effluents.

The production of wastes continues relentlessly and in such a way that the activity is in place almost uniformly across the country. At a time when there is increasing anxiety from environmental considerations about the disposal of wide ranges of wastes, including slurry from agricultural sources, the processing of such wastes for use as fuel may offer two main advantages - provision of energy and reduction of pollution.

It is estimated, moreover, that an energy content of 21 million tonnes of coal equivalent (M tce) are discarded in the UK each year through disposal of wastes.

Some key problems, however, in the processing of such wastes lies in the relatively low energy density of the product and the production of wastes at some distance from the energy market.

## Landfill gas

Anaerobic digestion is a process in which natural bacterial decomposition takes place in the absence of oxygen. Such a process can be used, for example, to break down sewage, animal wastes and plant residues in large tanks called disgestors.

The gaseous products of such a process is a methane rich biogas. Such a gas is also released in landfill sites that have been filled with domestic waste. In the UK, several installations have been constructed to tap into this gas byproduct to either provide combustible gas for industrial processes such as kilns, boilers or furnaces or also for generating of electricity.

The gas produced - landfill gas - typically contains equal proportions of methane and carbon dioxide. While this can be compressed to produce a liquid byproduct or cleaned for supply to the gas utility network, these operations are both complex and expensive.

From initial observations of London Brick's Stewartby Site, it was realised that commercial quantities of landfill gas can be produced from landfill sites. An array of simple wells is drilled into the landfill volume and the gas collected by a pumping system as indicated on figure 5. The collection of the gas has also a positive environmental effect of minimising odour and also reducing migration of gas from the landfill sites.

The present annual production of gas from such landfill sites is of the order of 300,000 tce.

There are many such landfill sites in the UK - as many as 5000. Figure 6a shows the Rowley Regis Landfill site in the West Midlands where municipal waste is still actively being deposited as shown in figure 6b.

Some landfill schemes have been established on completed landfill schemes where landscaping conceals the vast amount of municipal waste that has been infilled.

Figure 7 shows the Ryton landfill site where the plant installation for collection of gas and power generation occupies a relatively small area. The production of landfill gas from such systems has largely been achieved in an empirical way. It is estimated, however, that only around a third of the available gas is in fact extracted. Various options are being investigated for management of land fill sites in order to increase gas collection efficiency. It is estimated that the UK potential for such landfill gas schemes could with improved management range between 1 to 3 M tce per year. The methane released by landfill sites is a potent green house gas. Thus its collection and burning does represent a positive effect for reduction of global warming. The UK now has around 50 landfill schemes currently active and generating around 80 MW of power. A further 177 projects with a potential capacity of 358 MW are being considered for the forthcoming NFFO-4.

## Municipal waste

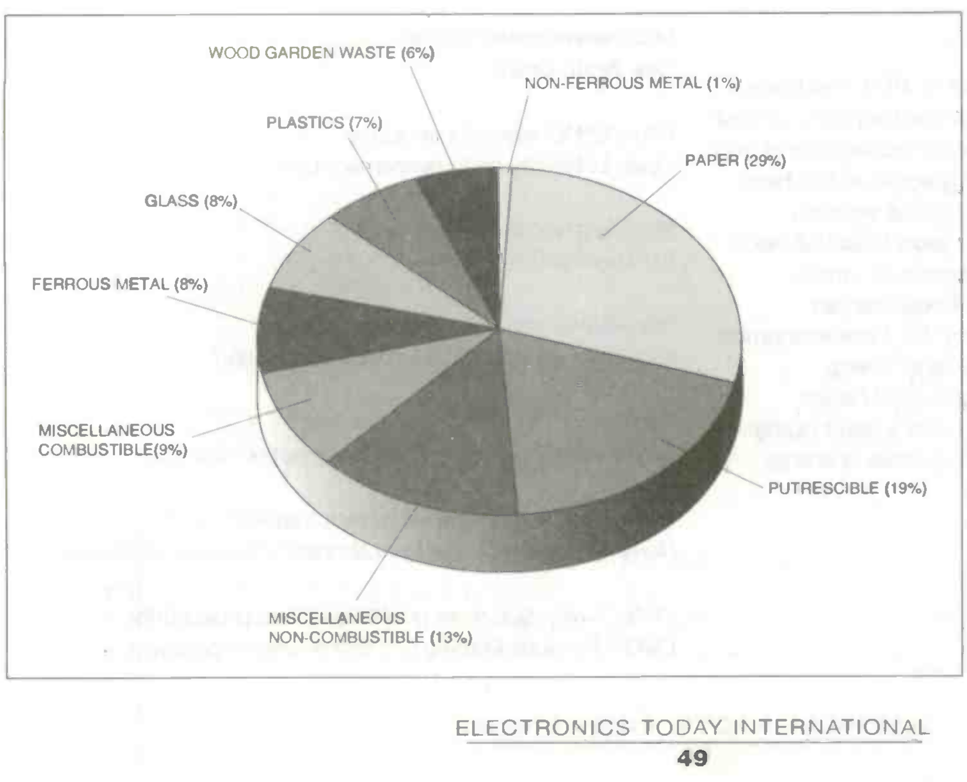
The composition of municipal waste is indicated in figure 8. This poses a challenge to recycling schemes to sort relevant useful material or for processes to concentrate fuel fraction. Processing systems have already been developed to supply what is termed Refuse Derived Fuel (RDF). In the UK, the landfill of refuse is a preferred option - primarily due to its lower cost. Elsewhere in Europe, the direct incineration of domestic waste is widely adopted. The UK has developed demonstration systems for the processing of domestic waste to produce a fuel acceptable to many applications. So called coarse RDF, where a modest degree of processing is undertaken, can find use in a limited range of applications - such as cement kiln heating and chain grate water tube boilers. With further processing of the pellets, however, in which the fuel fraction of the rubbish is mechanically separated and concentrated in the processed product, it is possible to produce an RDF pellet with around 60% of the calorific value of typical British coal. A number of RDF production installations are already in production although the technical problems in using such RDF fuel have been greater than anticipated.

While domestic waste is much the same between Lands End and John O' Groats, industrial waste can be considerably more diverse, with each byproduct requiring its own potential controls on processing and compaction.

Developments in this sector tend to focus on optimising the function of combustion systems such as the cyclone combustion unit with integral ash remover being developed at University College, Cardiff. There are reservations, however, on the widespread use of incineration plants in relation to the production of dioxins. These highly toxic chemicals tend to be released when products containing chlorine are incinerated. High temperatures, around 1000 C are required to be sustained to reduce emission levels to 'safe' levels.

## Pig slurry

One of the largest anaerobic digestors in the UK is at Piddlehinton in Dorset. A 750 cubic metre digester is capable of handling 22,000 gallons of slurry a day. The slurry is processed for between 7 to 10 days at a temperature of 37 to 40 C to maintain stable conditions for bacterial growth. The rate of production of biogas can power generators at around 90 kW. While the system does operate at a commercial profit under a NFFO (Non Fossil Fuel Obligation) scheme agreed in 1990, of more significant benefit is the reduction in odour and biological oxygen demand (BOD) arising from the process of anaerobic digestion. This term has fallen by around 60% with indications that further reductions can be achieved. This in turn reduces the impact of the intensive agriculture on the local environment. Perhaps the Berrybank Farm in



Victoria, Australia was the inspiration for the gas production system graphically displayed in Mad Max II. Raising 24,000 pigs a year and producing 200,000 litres of slurry per year, slurry is digested in a two stage process. Methane produced as a byproduct is used to generate 160 kW of electricity with a small amount being exported to the local electricity grid.

The main environmental benefit of the system, however, is the safer processing of the large amount of organic material thus produced. What will always remain a mystery in Mad Max II is what the pigs were fed on.

## Chicken litter

In a curious twist to the tale of biomass energy, the mere fact that chicken litter is proving to be a major biomass fuel is an indication of the chicken loving habits of the UK.

The Eye Power station in Suffolk, operational since June 1992, burns 130,000 tonnes of chicken litter per year - enough to generate 12.7 MW of capacity to the grid.

A further 82 MW of capacity which plan to use chicken litter have been subsequently awarded via NFFO (Non-Fossil Fuel Obligation) -3 and the Scottish Renewable Obligation for chicken litter schemes. As such, this must still represent a relatively small component of the available resource from this specific biomass fuel.

## Combined Heat and Power (CHP)

Combined heat and power can provide much better utilisation of energy from biomass and other sources. A state of the art combined heat and power system at Mabjervaerket in Denmark. The first stage uses biomass fuel to produce steam which in turn is superheated using natural gas prior to entry to the turbine system.

Around 28 MW of electrical power is exported and 67 MW of heat provided to the local district heating system. As fuel, the system is designed to burn 135,000 tonnes of municipal waste, 50,000 tonnes of straw and 17,000 tonnes of wood chips. This sensible extraction of energy can be contrasted with the large quantities of heat blown off into the UK sunset by giant concrete cooling towers at its numerous power stations. Such vast quantities of heat could never be used by the local 'neighbourhood'. Are any Power Utility companies diversifying into such schemes?

## Summary

The initial reflection after the energy crisis of 1974 was based on the risk to world economies from restricted supplies of fossil fuels. With upward revisions on the levels of recoverable oil and gas in the world, the anxiety in the energy equation has been replaced by uncertainty in the context of global warming.

As the developing world struggles for rapid industrialisation and in so doing risks further massive releases of carbon dioxide, the developed world has if not a duty then an obligation to provide a future 'soft landing' for these economies in terms of developing responsible systems of energy production. In many ways the largely agricultural based economies of the developing world represent a good platform from which to establish biomass derived sources of energy.

## Points of Contact

TSU, Harwell, Oxfordshire, OX11 0RA.
Tel 01235 432450
Fax 01235 433066

MAFF Alternative Crops Room,
Room 401,
10 Whitehall Place,
London, SW1A 2HH.
Tel 0171 270 8323
Fax 0171 270 8607

The Centre for Alternative Energy, Machynlleth,
Powys, SY20 9AZ,
Tel 01654 702400
Fax 01654 702782

National Network for Alternative Technology and Technology Assessment, c/o Faculty of Technology,
The Open University, Walton Hall,
Milton Keynes, Bucks.
Tel 01908 653272
Fax 01908 653744

## Further Information

Power Plants: Biofuels made simple, Brian Horne, CAT Publications, New Futures number 16

Renewable Energy General Literature List: Agriculfure, ETSU.

Crops for Industry and Energy: Information Pack, MAFF Alternative Crops Unit

## Internet Sites

http://solstice.crest.org
The Center for Renewable Energy and Sustainable Technology (Major Source)

The Bioenergy Mailing List at Solstice is:
<http://www.teleport.com/-tmiles/biolist.htm>

http://greenpeace,org
Greenpeace

http://www.oneworld.org/
One World Online

http://EERU-www@open.ac.uk
Open University and Environment Unit

http://erg.ucd.ie.opethermie.html
EU Thermie Programme

http://www.demon.co.uk/ici
ICI's Environmental Performance information

http://www.iisd.c/linkages/consume/
Sustainable Production and Consumption dialogue

<http://asd.nrel.gov/projects/rredc/data/biomass>
National Renewable Energy Laboratory Biomass Resource

<http://web.ngdc.noaa.gov/dmps/ols-app-bio.html>
DMSP Biomass Burning (US Government Agency)

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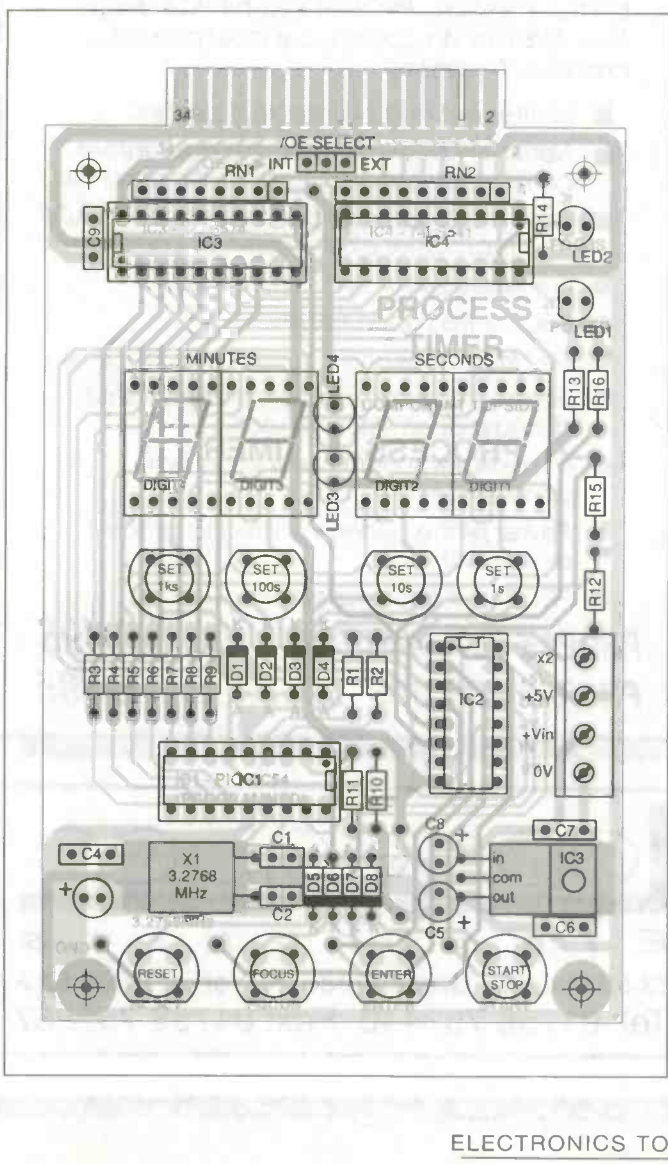
# PROCESS TIMER *and* CONTROLLER

## WITH EXTERNAL I/O INTERFACE

***Project Design by Tim Parker***




The title 'Process Timer/Controller' is perhaps a bit of an understatement, since you will discover later that the potential applications for this project are limited only by your own imagination and PIC programming capabilities. In this initial application it functions as a countdown darkroom timer with its own dedicated power supply, which also provides a single channel input, and a single channel output interface. The input channel will accept an ORP 12 or equivalent Light Dependent Resistor (LDR) to detect the light, and the output channel provides a SPCO mains relay for connection to the exposure lamp itself. To complement this project a range of PCBs will be available for software development and further expansion of the main controller. This process timer provides a very good example of how to multiplex numerous devices onto the 12 I/O port lines available on the low-end PIC16C54 Microcontroller, and demonstrates just how powerful this device can be made to appear simply by adding a few extra components and some good controlling software.

For example, the Process Timer has its own on-board regulator, four 7-segment LED displays, eight on-board pushbutton controls., a piezo transducer (not a buzzer) which allows an infinite range of audible tone outputs, an expansion interface bus with seven independent buffered TTL inputs, and seven independent latched and buffered TTL level outputs, all of which can be tri-stated and accessed via direct connection to a separate computer's data bus.

Output channel 1 of the expansion interface bus has its own on-board LED status indicator. And all of this is connected to a PIC16C54, and built on a PCB which will fit into a pocket-sized enclosure, no bigger than your average digital multimeter.

Given all these features, this provides for an extremely versatile unit. It follows then, that the board does not have to be dedicated to one task. By 'plugging' in a different program and adding an external interface board, it can become the basis for a whole range of other applications in domestic, commercial and industrial environments.

## Main timer/controller

If all of the inputs and outputs that are built into this project were to be controlled individually, you would need a processor with at least 52 I/O lines available. Although this is possible, it is by no means practical, for two main reasons.

The first is that the processor would be very expensive, and the second is that if static driving of the LED displays was used, that is, each one permanently lit - such is the case when using ICs similar to the MM5450/51, the current consumption would increase enormously. To overcome these, we use what is known as multiplexing. This is where numerous devices are connected to the same port, but only one at a time is accessed, scanned or updated.

Once all of the devices have been attended to, the whole process starts again, and must keep repeating indefinitely. Because this happens at a very high speed, it gives the appearance that many things are happening at a the same time - almost simultaneously. The displays, for instance, will all appear to be continuously lit, whereas in reality, at any given time only one of them contains any information at all, and even then, for the majority of the time the display is actually blank, but the persistence of vision of the human eye means that we don't see all the blank periods in between. Multiplexing the displays is probably the largest single contribution to reducing the current consumption of the board.

## The circuit

As with nearly all microcontroller designs, the circuit diagram is fairly simple, so there isn't an awful lot to explain about it, because all of the donkey work is done by the program stored inside the PIC. However, the circuit does demonstrate the use of multiplexing techniques, and incorporates a good example of interfacing and expanding the available port lines available on the PIC16C54. In order to obtain sufficient strobe lines for all of the devices, three output bits - RA0 to RA2 of IC1 are decoded by IC2 into one-of-eight active low (negative going) signals. IC2 is actually a 4-to-10 line decoder, but address line 'D' is forced to logic '0' by tying it to ground since it is not required. Just as a matter of caution, if this line is left floating then all manner of unpredictably weird and wonderful things might happen with the scan lines when running software on the board. I know, I've done it!.

It might be worth mentioning here that IC2 as listed (7445) has open collector outputs. This is ideal for the purpose of display strobing because it can easily handle the current consumption of the displays, particularly when all seven segments on all four of the displays are lit at the same time - "88:88". Unfortunately, however, there are a couple of minor drawbacks with the 7445 device.

One is that it requires pull-up resistors on its outputs to function as TTL level strobe lines. The other is that - presumably because of a decreasing 'supply & demand' - it is now being stocked by fewer suppliers, so is becoming difficult to obtain. If you can get hold of it, use it, because it is the best device for the job, although you may find the price is a little expensive. All is not lost, however, if you can't get it, there is an alternative device - the 7442 or 74LS42 - which provides standard TTL outputs and is a pin-for-pin compatible direct replacement for the 7445. By applying a positive logic code between 00h and 07h to address lines A, B and C of IC2, the corresponding output line will go low. Output 7 is left unconnected, since code 07h is used by the software as an 'all off' code, where outputs 0 to 6 can all be turned off. Outputs 0 to 4 are connected to display digits 1 to 4 respectively. These four outputs have been used purposely for the displays because it makes software writing much easier, and also allows small routines to be more powerful, since a program loop can be implemented to scan each display in sequence, rather than having a routine for each digit.

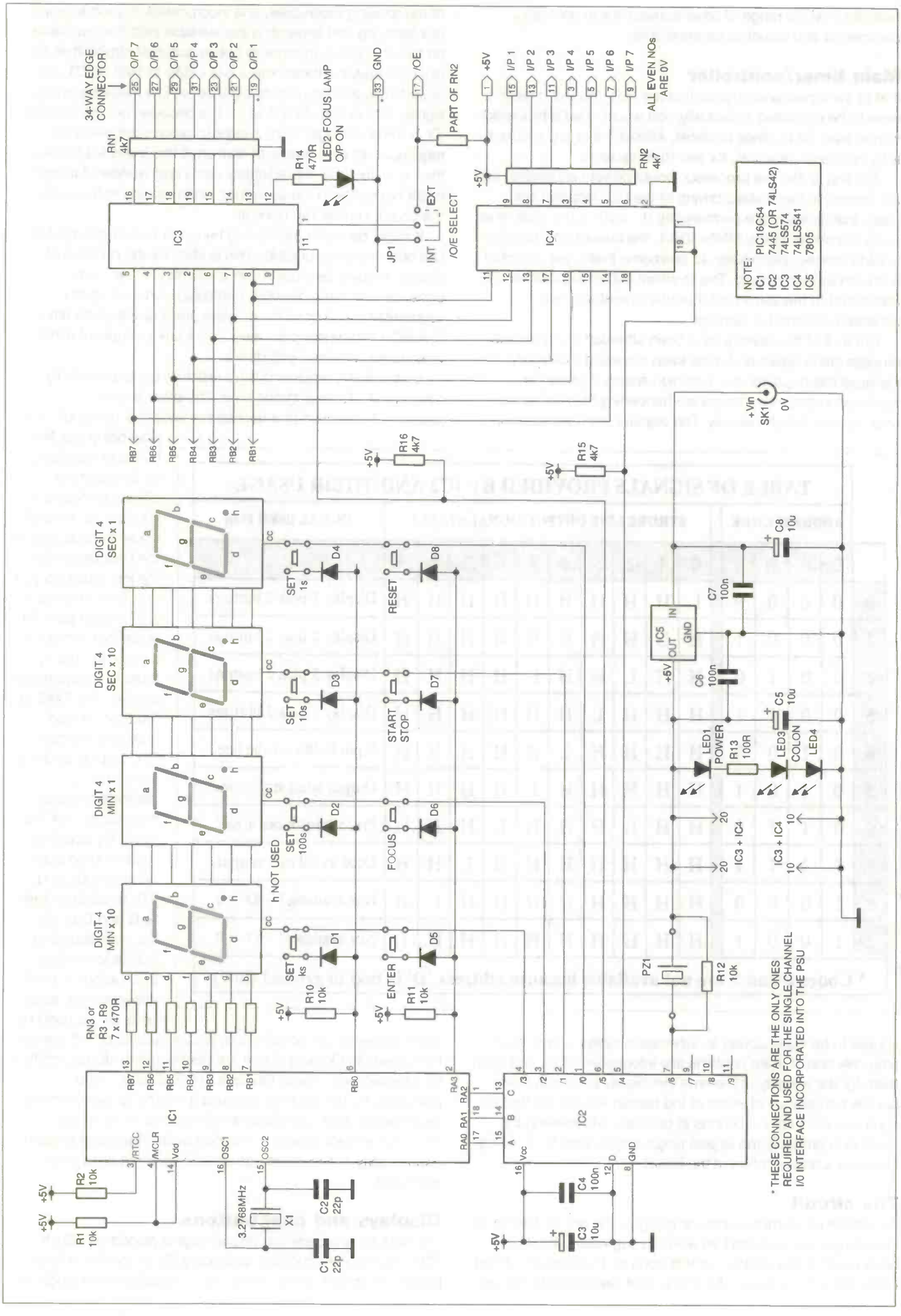
**TABLE OF SIGNALS PROVIDED BY IC2 AND THEIR USAGE**

| | ADDRESS CODE | | | | STROBE LINE OUTPUT SIGNAL STATES | | | | | | | | | | SIGNAL USED FOR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | D | C | B | A | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| 0 | 0 | 0 | 0 | 0 | L | H | H | H | H | H | H | H | H | H | Display 1 plus 2 buttons |
| 1 | 0 | 0 | 0 | 1 | H | L | H | H | H | H | H | H | H | H | Display 2 plus 2 buttons |
| 2 | 0 | 0 | 1 | 0 | H | H | L | H | H | H | H | H | H | H | Display 3 plus 2 buttons |
| 3 | 0 | 0 | 1 | 1 | H | H | H | L | H | H | H | H | H | H | Display 4 plus 2 buttons |
| 4 | 0 | 1 | 0 | 0 | H | H | H | H | L | H | H | H | H | H | Input buffer strobe line |
| 5 | 0 | 1 | 0 | 1 | H | H | H | H | H | L | H | H | H | H | Output latch strobe line |
| 6 | 0 | 1 | 1 | 0 | H | H | H | H | H | H | L | H | H | H | Piezo transducer driver |
| 7 | 0 | 1 | 1 | 1 | H | H | H | H | H | H | H | L | H | H | Used as 'all off' output |
| 8 | 1 | 0 | 0 | 0 | H | H | H | H | H | H | H | H | L | H | Not available* - 'D' = 0 |
| 9 | 1 | 0 | 0 | 1 | H | H | H | H | H | H | H | H | H | L | Not available* - 'D' = 0 |

*** Codes 8 and 9 are not available because address 'D' is tied to ground (low)**

## Displays and pushbuttons

The data for any particular display digit is placed on RB1 to RB7. The relevant common cathode (CC) strobe line is then pulled low to light up the display for a predetermined length of


34-WAY EDGE CONNECTOR
O/P 7
O/P 6
O/P 5
O/P 4
O/P 3
O/P 2
O/P 1
GND
/OE
PART OF RN2
+5V
I/P 1
I/P 2
I/P 3
I/P 4
I/P 5
I/P 6
I/P 7
ALL EVEN NOs ARE 0V
RN1 4K7
R14 470R
LED2 FOCUS LAMP O/P ON
IC3
JP1
INT
EXT
/O/E SELECT
IC4
RN2 4K7
NOTE
IC1 PIC16C54
IC2 7445 (OR 74LS42)
IC3 74LS574
IC4 74LLS541
IC5 7805
+Vin
SK1
0V
R16 4K7
R15 4K7
DIGIT 4 SEC x 1
DIGIT 4 SEC x 10
DIGIT 4 MIN x 1
DIGIT 4 MIN x 10
h NOT USED
SET 1s
SET 10s
SET 100s
SET ks
RESET
START STOP
FOCUS
ENTER
C8 10u
C7 100n
C6 100n
C5 10u
LED1 POWER
R13 100R
LED3 COLON
LED4
IC3 + IC4
PZ1
R12 10k
R10 10k
R11 10k
RN3 or R3 - R9 7 x 470R
IC1
IC2
R2 10k
R1 10k
3.2768MHz
X1
C1 22p
C2 22p
C4 100n
C3 10u
* THESE CONNECTIONS ARE THE ONLY ONES REQUIRED AND USED FOR THE SINGLE CHANNEL I/O INTERFACE INCORPORATED INTO THE PSU

time - known as the light-up period. The strobe line is then turned off again (high) and the next digit is processed in the same way. Connected to each of the four display strobe lines are two pushbuttons (by the way, the buttons are given names simply to correspond to the software listing used for this project). At some stage during the light- up period (whilst the strobe line is low), these buttons are scanned in pairs using RB0 and RA3, and a file register (RAM) byte is built up two bits at a time with the status of the buttons until all eight of them have been read, in other words all displays have been refreshed. This byte then represents the status - pressed or released - of all eight buttons. Being able to scan for any combination of pushbuttons in this way enables the program to detect various sequences and adjust certain parameters accordingly.

As an example, if certain buttons were held down on power-up, the program could be made to sense this and carry out timing in hours and minutes, rather than minutes and seconds as used here.

The diodes D1 to D8 prevent any back-feed that could occur between the pushbuttons, which would cause 'bleeding' of display data from one digit to another, and erroneous button status information if more than one pushbutton on any opposing axis is held down simultaneously. This probably sounds as clear as mud, so I'll explain.

Let's assume that the diodes were not fitted and that the pushbuttons were connected directly between the strobe lines and the button sensing input lines RB0 and RA3. We will also assume that display digit 1 is being refreshed (updated). Strobe line 0 will be low (digit 1 light-up period).

If both the reset and enter buttons are now held down at the same time, this low strobe line will be transferred via the buttons along the RA3 line to digit 4, which will now produce the same reading as digit 1 because it too will be enabled by the same strobe line.

This will also happen in reverse when digit 4 is being refreshed, where digit 1 produces the same reading. What makes matters worse is that because the displays are refreshed so rapidly, this 'illegal' code will appear to be superimposed on top of the valid information for that digit. I hope you're following all this, because it now gets even worse! Furthermore, if (say) the set1s button is added to the two already being pressed, not only will the displays remain corrupted, but false readings will now be generated when building up the status byte for the 'button pressed' information, because although the software will register the reset, enter and set1s buttons correctly as being pressed, when digit 4 is strobed it will also register the set1Ks button as being pressed when it isn't.

This is because the low strobe line for digit 4 will be transferred via the enter button, along the RA3 line, through the reset and set1s buttons back onto the RB0 line, and when the software samples the RB0 line, it will get a low signal and therefore register the set1Ks button as being pressed, simply because this is the only one which should be connected across the digit 4 strobe line and RB0. Phew!. Confusing, or what!.

## Piezo transducer

Output strobe line 6 from IC2 is used to drive a piezo transducer - PZ1. You cannot connect these devices alone between a supply and open collector output, because they don't do anything that way, so resistor R12 is fitted across it so as to produce a DC voltage with enough current for it to make a sound. Note that this is not one of the buzzer types with a built-in oscillator, it is the transducer alone.

These are available in 'cased' and 'uncased' versions. It doesn't matter which is used, although the cased ones are perhaps easier to use, since they require little effort for installation.

The prototype project was fitted with the uncased version, which was super-glued to the inside of the finished enclosure, which in turn acted as the resonant surface for the sound output. The nice thing about using a piezo transducer instead of a buzzer is that you can connect them directly to TTL outputs, and generate a whole variety of bleeps, clicks and tonal sounds - quite sufficient for the purposes of this project - without having to resort to expensive sounders.

The only pitfall is that you can't make a noise with it simply by turning it on, you will have to generate every single sound yourself through software, but at least it's only a matter of turning it on and off at a reasonable speed. The programmed PIC16C54 available for this project uses various pitched sounds to indicate certain actions during the use of the timer. For instance, the 'time up' sound is an ascending ramp tone.

## The expansion bus

To make this project more powerful and versatile it is fitted with a 14-bit I/O expansion bus. This facilitates the connection of external devices to the Process Timer, and provides a means for this application to interface to the dedicated power supply which accompanies this project.

The power supply incorporates a single channel I/O interface and makes specific use of I/P 1 and O/P 1 of the expansion bus. Because this application for the Process Timer is a darkroom timer, O/P 1 is used to drive a SPCO relay to which the exposure lamp can be connected, and I/P 1 is used to detect when the lamp is actually on. This will be explained in depth at a later date.

## Expansion bus input port

Port lines RB1 to RB7 of the PIC are also connected to the outputs of IC4. This is an 8-bit buffer with tri-state outputs. Information present on its inputs - pins 2 to 9 - is allowed through to the outputs when pins 1 and 19 are low. Only seven of the eight buffers are used by the controller board, and the inputs to these are pulled up to +5V via resistor network RN2.

This allows them to be driven by open collector outputs from remote devices, which means that with no inputs present on IC4, all seven bits will read as 1s.

The unused eighth input is tied to 0V to prevent instability of IC4. Resistor R15 ensures that the enable lines to IC4 are pulled up to +5V when the strobe signal is removed. The main function of port lines RB1 to RB7 is as an output port to supply digit data for the displays. However, to read the information present at the inputs to IC4, port B must be programmed for input, in fact, this is the only occasion when RB1 to RB7 need to be inputs.

Next, strobe line 4 must be pulled low (i.e. code 04h on port A), followed by a read operation from port B to obtain the value. The strobe line must then be taken high again, and port B re-programmed for output. Remember that all eight bits of port B will be read, but since only bits 1 to 7 are connected to the expansion port, bit 0 will be un-defined, except for the fact that it will read the internal value held in its own output latch.

## Expansion bus output port

Port lines RB1 to RB7 are also connected to the inputs of IC3. This is an octal (8-bit) edge triggered flip-flop with tri-state outputs. Information data for this is placed on port B of IC1 and is 'clocked' into the latches by pulling strobe line 5 low then high again. The code on the inputs is 'latched' onto the outputs of IC3 on the rising edge of the strobe signal, and will remain there irrespective of any activity on port B, until another strobe signal is applied. Resistor R16 ensures the 'clk' control input to IC3 is pulled high, and not just left floating, when the strobe line is released.

Remember that IC2 has open collector outputs, and without R16 strange things will happen on the outputs of IC3, and therefore on the expansion bus too.

As can be seen from the circuit diagram, RB1 is connected to two inputs of IC3. This is to allow LED 2 to act as a status indicator for O/P1 without loading the output which is used for the expansion bus itself. In this particular application as a darkroom timer, this LED provides an indication of the lamp driver output bit.

## Computer compatibility

Associated with the output latch is the 'output enable' jumper link JP1. If this is set to the internal (INT) position, then pin 1 (OE) of IC3 is held permanently low and it's outputs will always be at a TTL level '0' or '1'. With JP1 set to the external (EXT) position, then pin 1 of IC3 is pulled up to supply via part of the resistor network RN2, and also linked to the expansion bus connector via JP1. The outputs of IC3 will now be in tri-state mode or 'floating'. This allows the outputs to be connected directly to the data bus of a computer without presenting any load to the data lines.

The computer can then, via suitable decoding, read the value of the outputs of IC3 by strobing the OE line and sampling its own data bus.

Note that the link MUST be fitted in one or other position; if it is left out then pin 1 of IC3 will be left floating, which results in very erratic operation of it's outputs.

Having JP1 fitted in the EXT position therefore allows control of the board from a remote computer. If, for instance, the PIC controller board was programmed to perform various specific tasks, these could be invoked from the computer by supplying particular codes to the expansion bus input port, and the PIC could be programmed to report its status back to the computer via the expansion bus output port.

This form of external control does not in any way change the method used to latch information into IC3 by the PIC controller, but it does remove the ability to see the outputs of IC3 switching on and off if, say, the software development board is connected (to be described at a later date).

## Power supply

The Process Timer has been designed for use either as a stand-alone unit, or for connection to the power supply outlined previously.

To this end it has its own on-board regulator, so it can be powered from a suitably smoothed DC source capable of providing about 200mA continuously at 7 - 15V. Above this voltage it is wise to fit a heatsink to IC5 otherwise it's going to get a little too hot.

LED1 indicates there is power to the board, and LEDs 3 and 4 act as a 'colon' in between the left and right hand pairs of display digits. With all three connected in series the voltage drop across them is sufficient to enable them to be wired directly across +5V and 0V, but the inclusion of R13 allows compensation for various types of LEDs, and the overall brightness to be reduced if necessary. This is useful for dimming the 'colon' so that it doesn't cause a distraction from the data present in the LED displays, or at worst obliterate it.

## Construction

The Process Timer is built onto a conventional double-sided (non PTH) PCB. These require a little more attention than single-sided ones, but basically it's a case of where there's a pad on the top (component) side of the board, solder to it. IC sockets can only be used for the PIC16C54 and the displays (if required), because the remaining ICs all require various pins to be soldered on both sides of the board.

There is a particular order in which to solder the components in place, so that you don't end up with any inaccessible joints on the topside soldering points. You are wise to adhere to the following order and, as you go, solder to both sides of the board where the components require you to do so. Start with the seven pin-through points marked ' '.

These just require a short length of wire inserting and soldering top and bottom.

Next, solder in ICs 2, 3, 4 & 5, followed by the crystal, diodes and resistors - including the SIL networks - in that order. Ensure the SIL networks are soldered in the right orientation; pin 1 of these is identified by a dot at one end, which should line up with the corresponding dot on the topside of the PCB (right facing). Bolt down the tab of IC5 to the ground plane.

There is a hole available in the copper ground plane to the left of where the crystal lies to accept a short length of wire for soldering to the top edge of the crystal case for screening purposes, and to secure the crystal in place.

The 'colon' LEDs 3 & 4 should be soldered next. These should be set at a height corresponding to that of the 7-segment displays, which will differ depending on whether sockets are used for them or not. The remainder of the components - displays, socket for IC1, capacitors, switches, JP1, LEDs 1 & 2 and the 4-way terminal block (if used) can now be added at will.

The electrolytic capacitors may have to be the lower profile sub-miniature versions to prevent them protruding above the pushbuttons. This won't become a problem until you try to fit the board into an enclosure.

## Don't miss this bit...

If the Process Timer is to be used as a stand-alone board without the aforementioned power supply (like now, so that you can test it), then it's not going to work 100% correctly, because when the start button is pressed the timer won't start counting down until it detects the presence of a low signal on I/P 1 of the expansion bus. In other words, it's going to assume that the lamp hasn't come on, and won't start timing until it does.

This is NOT a fault, it is a feature of the program to ensure that accurate timing is achieved by only timing the period that the lamp is actually alight.

This will not be a problem if the associated power supply is used - even if the feature is not required - because it can be disabled very easily. Full details will be given next month in the power supply article.

To overcome this minor obstacle for now, simply apply a small 'blob' of solder between pins 9 & 10 of IC4 on the underside of the board, so as to bridge them together.

This will tie I/P 1 of the expansion bus to 0V and allow the timer to function normally.

Don't forget though, to remove the solder bridge when the power supply is connected (you will be reminded of this in the relevant article). When construction is complete, make a very close inspection of the board for solder bridges (particularly between the soldered IC pads on the topside of the board), missed or dry joints etc.

Plug in the programmed PIC16C54, solder the piezo transducer between the +5V OUT and PZ1 points, and fit a jumper link to the INT position of JP1, DON'T just leave the link off the board. Solder a couple of lengths of wire to the +V IN and 0V points and apply a smoothed DC voltage between 7 - 15V.

## How to use the timer

As mentioned, the task of the program is to operate as a darkroom timer, so the following information will be specific to that task. The operation of the darkroom timer can be split into two basic 'Modes', which are; 'Command' mode and 'Run' mode. When the board is first powered up, a couple of bleeps will be heard and 00:00 will appear in the display. This is now in 'Command' mode.

Each display digit can be incremented individually with its associated pushbutton, up to a maximum 99:59 (1 hour 40 minutes - all but 1 second). Whilst in Command mode, the focus button can be pressed to turn on the lamp, which allows you to work on the focus and composition of the image in the exposure unit. Pressing the focus button once more will turn off the lamp. Further button depressions will toggle the lamp on and off etc..

The focus button is not operative in Run mode because the lamp is then under control of the program, which, incidentally makes no restrictions on the state of the lamp before the timing sequence can begin, so the lamp can be turned on with the focus button and then the start button pressed to begin timing. Once the required time period has been set up in the displays you have one of two options:

1 Press the enter button. This will store the displayed value in memory to allow it to be recalled and used again at a later stage.

2 Press the start/stop button. This will enter the Run mode, turn on the lamp output and begin the timing sequence without storing the displayed value.

For obvious reasons the program will not allow timing to begin with 00:00 in the display. Pressing the reset button whilst in Command mode will recall the stored value set up using the enter button - assuming a value has been previously entered of course.

If not, then pressing the reset button will reset the display to 00:00. Whenever the start/stop button is pressed from Command mode the timer will always use the time shown in the display, irrespective of any value stored with the enter button. From this it will be apparent that a time period can be set up and stored in memory, yet still make temporary use of a different time period.

During the timing period the start/stop button can be pressed to halt the timing sequence.

This will exit the Run mode and put the timer back into Command mode. At this point the start/stop button can be pressed once more to continue timing with the remaining value in the display, or, the display can be adjusted and the timer started again from that value, or, the reset button can be pressed to recall the value previously set up with the enter button (or 00:00 if no value is stored), and the timer started from there. At the end of the timing period, the lamp output is turned off, all four of the displays will flash rapidly and the program produces an audible ramped tone output on the transducer until the reset button is pressed to return the timer to the Command mode.

## Software

A fully documented source code listing for this project is available on disk from the author, but because this listing is so large, space does not permit the entire software listing to be reproduced here.

However, it is helpful to have some of the basic routines used in the program explained briefly, so here goes. By the way, any constants and variables used in the following listings are assumed to have been pre-defined earlier in the program, all of which are given a full explanation in the complete source code listing.

## Command mode

The following listing is the initial 'program entry point' as used on the Process Timer. This sets up the port lines, DDRs, RTCC prescaler, and default display reading etc.

```
PIC16C54 PROCESS TIMER/CONTROLLER V1.00
; FOR USE ON THE DTE PROCESS TIMER/CONTROLLER
BOARD.
; (c) 1996 TIM PARKER / DTE MICRO SYSTEMS.
; BEGINNING OF THE MAIN PROGRAM (PROGRAM ENTRY
POINT)
START
CLRF   PORTB              ; PRESET THE PORT LINES
MOVLW OFF                 ; BEFORE SETTING THE DDRs
MOVWF PORTA               ; PUT 'OFF' CODE ON PORT
A
MOVLW B'00001000'         ; SET RA3 FOR I/P
TRIS   PORTA              ; DO IT
MOVLW B'00000001'         ; SET RB0 FOR I/P
TRIS   PORTB              ; DO IT
MOVLW 06
OPTION                        ; PRESCALER = 1:128
(40mS)
CLRF   DIG4BK             ; CLEAR 1000s DIGIT
BACKUP
CLRF   DIG3BK             ; CLEAR 100s DIGIT BACKUP
CLRF   DIG2BK             ; CLEAR 10s DIGIT BACKUP
CLRF   DIG1BK             ; CLEAR 1s DIGIT BACKUP
CLRF   FLAG               ; CLEAR PROGRAM STATUS
BYTE
CLRF   OPBUFF             ; CLEAR OUTPUT BUFFER
BYTE

; RESTORE DIGIT DATA FROM BACKUP STORAGE
DEFAULT
MOVF   DIG1BK,W           ; GET 1s DIGIT BACKUP
MOVWF DIGIT1              ; PUT IT IN DISPLAY
BUFFER
MOVF   DIG2BK,W           ; GET 10s DIGIT BACKUP
MOVWF DIGIT2              ; PUT IT IN DISPLAY
BUFFER
MOVF   DIG3BK,W           ; GET 100s DIGIT BACKUP
MOVWF DIGIT3              ; PUT IT IN DISPLAY
BUFFER
MOVF   DIG4BK,W           ; GET 1000s DIGIT BACKUP
```

```
MOVWF DIGIT4              ; PUT IT IN DISPLAY
BUFFER
COMMAND
CALL  BLEEP               ; MAKE A NOISE
CALL  DISPLAY             ; SCAN PUSHBUTTONS
CALL  BLEEP               ; MAKE ANOTHER NOISE
LOOP
INCF  BUTTON,W            ; ALL BUTTONS RELEASED ?
BTFSS STATUS,ZERO         ; YES - DON'T BLEEP
CALL  BLEEP               ; MAKE A NOISE
MOVF  BUTTON,W            ; UPDATE "LASKEY" WITH
MOVWF LASKEY              ; CURRENT INFORMATION
LOOP2
CALL  DISPLAY             ; REFRESH THE DISPLAY
MOVF  BUTTON,W            ; GET BUTTON DATA IN 'W'
XORWF LASKEY,W            ; ANY BUTTON ACTIVITY ?
BTFSC STATUS,ZERO         ; YES - FIND OUT WHICH
GOTO  LOOP2               ; NO - GO ROUND AGAIN
; A BUTTON HAS BEEN PRESSED OR RELEASED, BUT WHICH
ONE IS IT,
; AND WHAT DO WE DO ABOUT IT ANYWAY ?

BTFSS BUTTON,SET1         ; SKIP IF NOT 'SET1'
GOTO  BUT1                ; ELSE ADD 1 TO DIGIT1
BTFSS BUTTON,SET10        ; SKIP IF NOT 'SET10s'
GOTO  BUT2                ; ELSE ADD 1 TO DIGIT2
BTFSS BUTTON,SET100       ; SKIP IF NOT 'SET100s'
GOTO  BUT3                ; ELSE ADD 1 TO DIGIT3
BTFSS BUTTON,SET1K        ; SKIP IF NOT 'SET1Ks'
GOTO  BUT4                ; ELSE ADD 1 TO DIGIT4
BTFSS BUTTON,RESET        ; SKIP IF NOT 'RESET'
GOTO  DEFAULT             ; ELSE RECALL BACKUP
DISPLAY
BTFSS BUTTON,ENTER        ; SKIP IF NOT 'ENTER'
GOTO  BUT5                ; ELSE ENTER DISPLAYED
VALUE
BTFSS BUTTON,STRT         ; SKIP IF NOT
'START/STOP'
GOTO  TIMER               ; ELSE START TIMING
SEQUENCE
BTFSS BUTTON,FOCUS        ; SKIP IF NOT 'FOCUS'
GOTO  LMP                 ; ELSE TOGGLE LAMP OUTPUT
GOTO  LOOP                ; NONE LEFT - GO ROUND
AGAIN

;****************************************************
****************************

; MANUAL DISPLAY ADJUSTMENT CONTROL SECTION

BUT1
CALL  ADD1                ; INCREMENT DIGIT 1
GOTO  LOOP
BUT2
CALL  ADD10               ; INCREMENT DIGIT 2
GOTO  LOOP
BUT3
CALL  ADD100              ; INCREMENT DIGIT 3
GOTO  LOOP
BUT4
CALL  ADD1K               ; INCREMENT DIGIT 4
GOTO  LOOP
****************************************************
**************************
```

```
; ACCEPT THE CURRENTLY DISPLAYED READING BY
COPYING IT INTO THE
; BACK-UP STORAGE AREA
BUT5
MOVF  DIGIT1,W            ; GET DIGIT 1 DATA
MOVWF DIG1BK              ; STORE IT IN BACKUP
MOVF  DIGIT2,W            ; GET DIGIT 2 DATA
MOVWF DIG2BK              ; STORE IT IN BACKUP
MOVF  DIGIT3,W            ; GET DIGIT 3 DATA
MOVWF DIG3BK              ; STORE IT IN BACKUP
MOVF  DIGIT4,W            ; GET DIGIT 4 DATA
MOVWF DIG4BK              ; STORE IT IN BACKUP
GOTO  DEFAULT             ; NOW UPDATE THE WHOLE
LOT
;****************************************************
****************************
```

## Displays, buttons and expansion bus control

Whenever LED displays are multiplexed onto an MPU, a software routine must exist to refresh them.

No matter what else is going on in the system, this routine must be called often enough to prevent erratic (and very annoying) display flickering. It makes sense then, to use this routine to carry out various other repetitive tasks which are essential to the operation of the system.

The following routine is used to refresh the displays, scan and record the state of the eight pushbuttons, update the output latch with current data, record the current data on the input buffer, and finally, check & 'flag' the display for a zero reading - 00:00 - although not necessarily in that order A point to bear in mind when refreshing the displays, is to always make sure that current digit is turned off again after the light-up period, before moving on to the next digit.

This is essential to prevent 'ghosting', where the data from the next display appears very briefly in the current one. In fact, it appears for no more than a few microseconds, and is actually caused due to the length of time it takes between setting up the data on RB1 to RB7 for the next digit whilst the first one is enabled, and then turning on the next display. This form of 'ghosting' might not be apparent in bright ambient light, but becomes very visible when the ambient light level falls, and more particularly with high efficiency LED displays.

```
@pr:; DISPLAY ROUTINE AS USED ON THE PIC16C54
PROCESS TIMER/CONTROLLER
; FOR USE ON THE DTE PROCESS TIMER/CONTROLLER
BOARD.
; (c) 1996 TIM PARKER / DTE MICRO SYSTEMS.

; THIS ROUTINE PERFORMS THE FOLLOWING TASKS:-

; 1 - PUTS THE VALUE HELD IN "OPBUFF" INTO IC3 AND
SO ONTO THE OUTPUT PORT OF THE EXPANSION BUS

; 2 - READS THE VALUE OF THE EXPANSION BUS INPUT
BUFFER AND STORES THE RESULT IN "IPBUFF".

; 3 - PUTS THE VALUES HELD IN "DIGITs" INTO THE
DISPLAYS.

; 4 - UPDATES THE "BUTTON" BYTE WITH KEYPRESSED
INFORMATION.

; 5 - CHECKS THE DISPLAY READING FOR '0000' (ZERO)
```

```
AND SETS THE APPROPRIATE 'DZERO' BIT IN THE "FLAG"
REGISTER.
; FIRST OF ALL UPDATE THE EXPANSION BUS OUTPUT
PORT
DISPLAY
MOVF   OPBUFF,W                ; GET "OPBUFF" DATA
MOVWF PORTB                    ; PUT IT ON PORT B
MOVLW OPB                      ; GET IC3 STROBE LINE
MOVWF PORTA                    ; AND PULL IT LOW
MOVLW OFF                      ; GET 'ALL OFF' CODE
MOVWF PORTA                    ; AND APPLY IT TO PORTA
; NOW READ THE VALUE ON THE EXPANSION BUS INPUT
PORT

MOVLW B'11111111'
TRIS   PORTB                   ; SET PORT B AS ALL
INPUTS
MOVLW IPB                      ; GET IC4 STROBE LINE
MOVWF PORTA                    ; AND PULL IT LOW
MOVF   PORTB,W                 ; GET DATA ON PORT B
MOVWF IPBUFF                   ; AND STORE IT IN
"IPBUFF"
MOVLW OFF                      ; GET 'ALL OFF' CODE
MOVWF PORTA                    ; SET ALL STROBE LINES
HIGH
MOVLW B'00000001'
TRIS   PORTB                   ; AND RESTORE RB0 FOR
INPUT

; NOW SORT OUT THE DISPLAYS AND READ THE STATUS OF
THE PUSHBUTTONS

MOVLW 03                       ; START WITH LEFT DIGIT
MOVWF STROBE                   ; SET "STROBE" TO 3
DISP2
CALL   CONVERT                 ; GET DIGIT CHARACTER
MOVWF PORTB                    ; PUT IT ON O/P PORT
;CALL LIGHTUP                  ; LIGHT UP THE DIGIT
DECF   STROBE                  ; PREPARE FOR NEXT
DISPLAY
MOVLW 255                      ; Don't use 'OFF' code
here
MOVWF PORTA                    ; TURN OFF ALL DISPLAYS
XORWF STROBE,W                 ; DONE ALL 4 LINES ?
BTFSS STATUS,ZERO              ; YES - SKIP NEXT BIT
GOTO   DISP2                   ; NO - GO ROUND AGAIN

; NOW CHECK IF THE DISPLAY IS SHOWING A ZERO
READING - '0000'

BCF    FLAG,DZERO              ; CLEAR 'DISPLAY ZERO'
BIT
MOVF   DIGIT1,W                ; DIGIT 1 = 0 ?
BTFSS STATUS,ZERO              ; YES - NOW TEST DIGIT 2
RETLW 0                        ; NO - LEAVE "FLAG" ALONE
MOVF   DIGIT2,W                ; DIGIT 2 = 0 ?
BTFSS STATUS,ZERO              ; YES - NOW TEST DIGIT 3
RETLW 0                        ; NO - LEAVE "FLAG" ALONE
MOVF   DIGIT3,W                ; DIGIT 3 = 0 ?
BTFSS STATUS,ZERO              ; YES - FINALLY TEST
DIGIT 4
RETLW 0                        ; NO - LEAVE "FLAG" ALONE
MOVF   DIGIT4,W                ; DIGIT 4 = 0 ?
BTFSC STATUS,ZERO              ; NO - LEAVE "FLAG" ALONE
BSF    FLAG,DZERO              ; YES - SET 'DISPLAY
ZERO' BIT
RETLW 0                        ; EXIT DISPLAY ROUTINE
; LIGHT UP THE SELECTED DISPLAY DIGIT, AND AT THE
SAME TIME, BUILD
; UP THE "BUTTON" BYTE BY SCANNING THE PUSHBUTTONS
WHILST THE
; STROBE LINES ARE LOW. SINCE THIS 'LIGHTUP'
ROUTINE IS CALLED
; FOUR TIMES BY THE 'DISPLAY' ROUTINE, THE
"BUTTON" BYTE IS BUILT
; UP 2 BITS AT A TIME CORRESPONDING TO THE STATES
OF RB0 AND RA3
; AT THE TIME OF EACH LOW STROBE SIGNAL

LIGHTUP
MOVF   STROBE,W                ; GET CURRENT STROBE
VALUE
MOVWF PORTA                    ; LIGHT UP THE DIGIT
BCF    STATUS,CARRY            ; INITIALLY CLEAR CARRY
BIT
BTFSC PORTB,RB0                ; LEAVE IT CLEARED IF
RB0=0
BSF    STATUS,CARRY            ; OTHERWISE SET CARRY BIT
RRF    BUTTON                  ; TRANSFER TO D7 IN
"BUTTON"
BCF    STATUS,CARRY            ; CLEAR THE CARRY BIT
BTFSC PORTA,RA3                ; LEAVE IT CLEARED IF
RA3=0
BSF    STATUS,CARRY            ; OTHERWISE SET CARRY BIT
RRF    BUTTON                  ; TRANSFER TO D7 IN
"BUTTON"
; NOW TIME OUT THE LIGHT-UP PERIOD FOR THE
SELECTED DIGIT
MOVLW 128
MOVWF COUNT1
MOVLW 1                        ; SET COUNTER FOR 128
LOOPS
MOVWF COUNT2                   ; AND FALL THROUGH TO
'DELAY'

; GENERAL PURPOSE DELAY ROUTINE. THE VALUES OF
"COUNT1" & "COUNT2"
; MUST HAVE BEEN SET UP BEFORE CALLING THIS
ROUTINE.

; WARNING: THE 'LIGHTUP' ROUTINE FALLS THROUGH
'DELAY'.
; DO NOT MOVE THIS ROUTINE RELATIVE TO THE
'LIGHTUP' ROUTINE

DELAY
DECFSZ                         COUNT1
GOTO   DELAY                   ; WAIT ...
DECFSZ                         COUNT2
GOTO   DELAY                   ; AND WAIT ...
RETLW 0                        ; OK FINISHED - RETURN

; GET THE REQUIRED DISPLAY CHARACTER DEPENDING ON
THE
; CURRENT VALUE HELD IN "STROBE" BYTE

CONVERT
MOVF   STROBE,W                ; PUT "STROBE" VALUE IN
```

```
'W'
ADDWF PC,F                ; USE AS OFFSET FOR 'PC'
GOTO  CONV0               ; IF 'W'=0 USE 1s DIGIT
GOTO  CONV1               ; IF 'W'=1 USE 10s DIGIT
GOTO  CONV2               ; IF 'W'=2 USE 100s DIGIT
MOVF  DIGIT4,W            ; ELSE GET 1000s DATA
GOTO  CONV3               ; AND CONVERT IT
CONV0
MOVF  DIGIT1,W            ; GET 1s DIGIT DATA
GOTO  CONV3               ; AND CONVERT IT
CONV1
MOVF  DIGIT2,W            ; GET 10s DIGIT DATA
GOTO  CONV3               ; AND CONVERT IT
CONV2
MOVF  DIGIT3,W            ; GET 100s DIGIT DATA
CONV3
ADDWF PC,F                ; USE 'W' AS OFFSET
RETLW DC0                 ; RETURN WITH "0" CODE
RETLW DC1                 ; RETURN WITH "1" CODE
RETLW DC2                 ; RETURN WITH "2" CODE
RETLW DC3                 ; RETURN WITH "3" CODE
RETLW DC4                 ; RETURN WITH "4" CODE
RETLW DC5                 ; RETURN WITH "5" CODE
RETLW DC6                 ; RETURN WITH "6" CODE
RETLW DC7                 ; RETURN WITH "7" CODE
RETLW DC8                 ; RETURN WITH "8" CODE
RETLW DC9                 ; RETURN WITH "9" CODE
RETLW DCA                 ; RETURN WITH "A" CODE
RETLW DCB                 ; RETURN WITH "b" CODE
RETLW DCC                 ; RETURN WITH "C" CODE
RETLW DCD                 ; RETURN WITH "d" CODE
RETLW DCE                 ; RETURN WITH "E" CODE
RETLW DCF                 ; RETURN WITH "F" CODE
```

## RTCC and Timing

Because the PIC16C54 does not have an interrupt available from the RTCC, in applications such as this, where the PIC has to keep control of multiple input and output devices AND perform accurate timing periods at the same time, some clever software is called for in order to keep things running smoothly.

Take, for instance, the timing process itself. Not only does the program have to take care of the displays (this alone takes up a lot of processing time due to the light-up periods required), pushbuttons and expansion port continuously, but it also has to keep an accurate track of the elapsed time. OK, so we can set the prescaler to slow down the output of the RTCC to a more manageable speed, but it's no good just checking for RTCC rollover to zero, because there's a very high possibility that by the time we manage to read it, it's rolled over by quite a few counts, so catching it at exactly zero is very hit and miss, and of no use at all.

This is overcome in the Timer/Controller software by using a very simple mathematical function. When the Run mode is first entered, a copy of the RTCC is stored in a file register, and, after sorting out all of the devices, instead of checking the RTCC for zero, the contents of this file register are subtracted from the current RTCC value.

If the result is positive then the RTCC must contain a value greater than the file register, so the register is updated with the new RTCC value and the timing continues. If the result is negative then the RTCC must have rolled over to a value less than that of the file register. It makes no difference by how much it has rolled over, just so long as we know that it has, which means that a very large time margin is available to us for system control functions. From this result, we can adjust the necessary file registers and displays etc.

The file register is still updated afterwards with the current RTCC value, and the timing process continues. Because the RTCC is left free running and never interfered with during the timing process, this is all we ever need to do to keep accurate time. Incidentally, a 3.276800MHz crystal is used because the speed is divisible in binary format and produces accurate time divisions from the RTCC prescaler.

This reduces the amount of program space required to achieve accurate time periods. Anyone who has tried to produce accurate time periods without considering the crystal frequency will be aware of the extra software involved, by having to continuously compensate the RTCC value.

The clock speed to the PIC is internally divided by 4, resulting in an internal clocking speed of 819,200Hz or 819.2KHz, producing a time period fractionally more than 1.22µS. Actually 1.220703125µS to be precise. With the prescaler set to +/-128 the time period to the RTCC is 156.25µS. The RTCC itself is left free running at 256 counts, which means that a roll over to zero occurs every 40mS. In simple calculation terms this is;

$1 / (3276800 / 4) \times 128 \times 256 = 0.04$ (seconds).

By using a file register to count 25 of these, the final period is 1 second ($25 \times 0.04 = 1$).

```
; TIMING ROUTINE AS USED ON THE PIC16C54 PROCESS
TIMER/CONTROLLER
; FOR USE ON THE DTE PROCESS TIMER/CONTROLLER
BOARD.
; (c) 1996 TIM PARKER / DTE MICRO SYSTEMS.

; THE 'START' BUTTON HAS BEEN PRESSED, SO BEGIN
TIMING
; AND TURN ON THE OUTPUT BIT FOR THE LAMP (BIT
RB1).
; THE TIME PERIOD IS THAT WHICH IS BEING DISPLAYED
; WHEN THE 'START/STOP' BUTTON WAS PRESSED, WHICH
; MAY NOT BE THE VALUE HELD IN THE BACKUP STORAGE.
; THE BACKUP WILL REMAIN INTACT FOR FUTURE USE AND
; CAN BE RECALLED BY PRESSING THE 'RESET' BUTTON.

; BECAUSE THERE IS NO INTERRUPT ON THE PIC16C54 WE
NEED
; TO KNOW EACH TIME THE RTCC ROLLS OVER TO ZERO.
; LOCATION "TIMER1" IS USED AS A REFERENCE VALUE
; TO THE RTCC, AND MOST OF THE TIME CONTAINS THE
; SAME VALUE AS THE RTCC. A VERY SIMPLE METHOD OF
; DETECTING RTCC ROLLOVER IS USED, BY SUBTRACTING
; "TIMER1" CONTENTS FROM THE CURRENT RTCC VALUE
AND
; CHECKING FOR A NEGATIVE RESULT. WHEN RTCC ROLLS
; OVER TO ZERO (OR EVEN IF IT OVER-RUNS BY A FEW
; COUNTS) AN ATTEMPT WILL BE MADE TO SUBTRACT A
LARGE
; VALUE FROM THE LOW RTCC VALUE, THE RESULT IS
NEGATIVE.
; WHEN RTCC=00h AND "TIMER1"=FFh THEN A TIME
PERIOD
```

```
; OF 40mS HAS ELAPSED, SO THE "MSEC40" REGISTER
; (WHICH STARTS WITH A VALUE OF 25 TO MAKE 1000mS)
; IS DECREMENTED BY ONE AND THE TIMER CONTINUES.
; WHEN "MSEC40"=0 THEN A TIME PERIOD VERY CLOSE TO
; ONE SECOND HAS ELAPSED, SO THE DISPLAY IS
REDUCED
; BY ONE COUNT AND CHECKED FOR ZERO IN ALL DIGITS.
TIMER
BTFSC FLAG,DZERO          ; ONLY START IF VALID
TIME
GOTO  TIME8               ; OTHERWISE FORGET IT !
CALL  BLEEP               ; QUICK NOISE FIRST
MOVF  BUTTON,W            ; UPDATE "LASKEY" WITH
MOVWF LASKEY              ; CURRENT "BUTTON" INFO

BSF   OPBUFF,LAMP         ; SET LAMP O/P BIT TO 1

CLRF  RTCC                ; RESET RTCC & PRESCALER
CLRF  TIMER2              ; RESET "TIMER2"
TIME0
MOVLW 25
MOVWF MSEC40              ; SET "MSEC40" TO 1000mS
TIME1
MOVF  TIMER2,W
MOVWF TIMER1              ; COPY "TIMER2" TO
"TIMER1"
; CHECK TO SEE IF THE INPUT BIT IS LOW BEFORE
CONTINUING
; WITH THE TIMER ROUTINE. THIS ALLOWS BETTER
TIMING OF
; THE LAMP BY ONLY TIMING THE PERIOD THAT IT IS
ACTUALLY ON.
; IF THE TIMER DOESN'T CONTINUE BECAUSE THE INPUT
BIT NEVER
; GOES LOW, THEN ALLOW THE 'RESET' BUTTON TO ABORT
TIMING.

CHKIP
BTFSS IPBUFF,LAMP         ; SKIP IF I/P IS HIGH
GOTO  CHKIP2              ; ELSE CONTINUE TIMING
CALL  DISPLAY             ; REFRESH DISPLAY ETC...
BTFSS BUTTON,RESET        ; NO - IS 'RESET' PRESSED
?
GOTO  TIME8               ; YES - QUIT
GOTO  CHKIP               ; NO - KEEP TRYING
CHKIP2

; NOW TO CHECK THE 'START/STOP' BUTTON AND THE
RTCC ETC...
; THE 'START/STOP' BUTTON MAY STILL BE PRESSED
FROM THE
; INITIAL COMMAND ROUTINE OR AFTER BEING PUT ON
'STOP', SO
; WE NEED TO MAKE SURE THAT IT HAS BEEN RELEASED
FIRST,
; BEFORE TAKING THE DECISION TO STOP THE TIMER
ONCE MORE.
BTFSC BUTTON,STRT         ; SKIP IF 'START/STOP'
PRESSED
GOTO  TIME2               ; ELSE CONTINUE TIMING
BTFSC LASKEY,STRT         ; SKIP IF PRESSED FROM
BEFORE
GOTO  TIME8               ; EXIT WITH DISPLAY
INTACT
TIME2
MOVF  BUTTON,W            ; UPDATE "LASKEY" WITH
MOVWF LASKEY              ; CURRENT "BUTTON" INFO
CALL  DISPLAY             ; REFRESH DISPLAY
BTFSC FLAG,DZERO          ; SKIP IF DISPLAY NOT
ZERO
GOTO  TIME3               ; TIME UP. DISPLAY =
'0000'

MOVF  RTCC,W              ; GET CURRENT RTCC VALUE
MOVWF TIMER2              ; COPY IT TO "TIMER2"
MOVF  TIMER1,W            ; GET OLD RTCC VALUE
SUBWF TIMER2,W            ; HAS RTCC ROLLED OVER ?
BTFSC STATUS,CARRY        ; YES - ADJUST "MSEC40"
GOTO  TIME1               ; NO - GO ROUND AGAIN
DECFSZMSEC40              ; "MSEC40" = "MSEC40" - 1
GOTO  TIME1               ; "MSEC40" NOT ZERO - GO
BACK
CALL  SUB1                ; DECRIMENT THE 1s DIGIT
BTFSC STATUS,CARRY        ; DOES 10s NEED ADJUSTING
?
GOTO  TIME0               ; NO - START ALL OVER
AGAIN
CALL  SUB10               ; YES - DECRIMENT 10s
DIGIT
BTFSC STATUS,CARRY        ; DOES 100s NEED
ADJUSTING ?
GOTO  TIME0               ; NO - START ALL OVER
AGAIN
CALL  SUB100              ; YES - DECRIMENT 100s
DIGIT
BTFSS STATUS,CARRY        ; DOES 1000s NEED
ADJUSTING ?
CALL  SUB1K               ; YES - DECRIMENT 1000s
DIGIT
GOTO  TIME0               ; NO - START ALL OVER
AGAIN
; TIMER HAS COMPLETED. SOUND THE BUZZER UNTIL
'RESET' IS PRESSED.
; THE TONE GENERATED IS A DESTINCTIVE STEPPED
ASCENDING PITCH-RAMP.
TIME3
BCF   OPBUFF,LAMP         ; TURN OFF THE LAMP BIT
MOVLW 80
MOVWF TEMP                ; INITIAL NOTE PITCH
TIME4
MOVLW 110
MOVWF TEMP2               ; NUMBER OF PULSES PER
NOTE
TIME5
MOVLW BUZ
MOVWF PORTA               ; TURN PIEZO ON
```

```
CALL  TIME6                ; LEAVE FOR A WHILE
MOVLW OFF
MOVWF PORTA                ; TURN PIEZO OFF
CALL  TIME6                ; LEAVE FOR A WHILE
DECFS ZTEMP2               ; DONE ALL PULSES ?
GOTO  TIME5                ; NO - DO ANOTHER
CALL  DISPLAY              ; SCAN BUTTONS
CALL  DISPLAY              ; SCAN BUTTONS (AGAIN)
BTFSS BUTTON,RESET         ; NO - IS 'RESET' PRESSED
?
GOTO  COMMAND              ; YES - QUIT
MOVLW 5                    ; NO...
SUBWF TEMP                 ; INCREASE PITCH OF NOTE
MOVLW 50                   ; CHECK IF HIGHEST NOTE
REACHED
XORWF TEMP,W               ; "TEMP" = 50 ?
BTFSC STATUS,ZERO          ; NO - SELECT NEXT NOTE
GOTO  TIME3                ; YES - START AGAIN
GOTO  TIME4                ; DO THE NEXT NOTE
TIME6
MOVF  TEMP,W
MOVWF COUNT2
TIME7
DECFSZ                     COUNT2
GOTO  TIME7
RETLW 0
; INVALID START TIME (DISPLAY ='0000') OR 'STOP'
SELECTED SO QUIT.
TIME8
BCF   OPBUFF,LAMP          ; TURN OFF THE LAMP BIT
CALL  DISPLAY              ; AND DO IT NOW !
CALL  BURP                 ; MAKE LOW PITCH NOISE
CALL  BURP                 ; AND AGAIN...
CALL  BURP                 ; AND AGAIN
GOTO  LOOP                 ; RETURN TO COMMAND MODE
```

## Sound

The following two routines are used by the Process Timer to generate audible tones through the piezo transducer PZ1. By adjusting the on and off times of the pulses sent to the transducer, it is possible to generate various sounds, but these are just two examples.

```
BASIC TONE GENERATION FOR THE PIC16C54 PROCESS
TIMER/CONTROLLER.

; IN ORDER TO KEEP BOTH THE LOW AND HIGH TONES TO
ABOUT THE
; SAME DURATION, A LOWER NUMBER OF PULSES IS
REQUIRED FOR
; THE LOW TONE, OTHERWISE THE SOUND WOULD LAST FAR
TOO LONG.
; A COMMON ROUTINE IS USED TO GENERATE THE SOUND
ITSELF, BUT
; THE 'PITCH' BIT IN THE "FLAG" BYTE IS USED TO
INDICATE WHETHER
; A LOW TONE OR HIGH TONE IS CALLED FOR
; GENERATE A SHORT, LOW PITCHED TONE THROUGH
TRANSDUCER
BURP
BCF   FLAG,PITCH           ; SET LOW PITCH
MOVLW 130
MOVWF COUNT1               ; NUMBER OF PULSES=130
GOTO  BLEEP2               ; MAKE THE SOUND
; GENERATE A SHORT, HIGH PITCHED TONE THROUGH
TRANSDUCER
BLEEP
BSF   FLAG,PITCH           ; SET HIGH PITCH
CLRF  COUNT1               ; NUMBER OF PULSES=256
; NOW GENERATE THE SOUND REQUIRED BASED ON THE
SETTING OF
```

## PARTS LIST

### Resistors

| | |
|---|---|
| R1,2,10,11,12 | 10K (5 off) |
| R3-R9, R14 | 470R (8 off) |
| R13 | 100R |
| R15,16 | 4K7 (2 off) |
| RN1 | 4K7 x 7 SIL Network |
| RN2 | 4K7 x 8 SIL Network |
| RN3 (if used) | 470R x 7 DIL Network |

### Capacitors

| | |
|---|---|
| C1,2 | 22pF Ceramic plate (2 off) |
| C3,5, | 10uF/35V Electrolytic (3 off) |
| C4,6,7,9 | 100nF Ceramic or Polyester (4 off) |

### Semiconductors

| | |
|---|---|
| D1 - D8 1N4148 | (8 off) |
| LED1,3,4 | 3mm Red LED (3 off) |
| LED2 | 3mm Yellow LED |
| DIGIT1-DIGIT4 | 7-Segment CC LED Display (4off) |
| IC1 | Programmed PIC16C54XT/P (available separately if required) |
| IC2 | 7445 or 7442 (see text) |
| IC3 | 74LS574 Octal Latch |
| IC4 | 74LS541 Octal Buffer |
| IC5 | 7805 +5V Voltage Regulator |

### Miscellaneous

| | |
|---|---|
| X1 | 3.276800MHz Crystal |
| PZ1 | Piezo Transducer |
| JP1 | 3-Way PCB Pin Header + Jumper Link |
| Pushbuttons | D6 Series Tactile Pushbuttons (8 off) |
| IC Socket | 18-Pin IC Socket for IC1 |
| SK1 | 2.1mm DC Power Socket * |
| Terminals | 4-Way PCB Terminal Block * |
| Case | Enclosure to suit * |
| Hardware | General Fixing Hardware * |
| PCB | DTE Process Timer/Controller |
| PCB | (available separately if required) |

* optional - not supplied with the kit

```
; THE 'PITCH' BIT IN THE "FLAG" BYTE
BLEEP2
MOVLW  BUZ                    ; GET STROBE LINE FOR PZ1
MOVWF  PORTA                  ; TURN THE PIEZO ON
CALL   WAIT                   ; LEAVE FOR A WHILE
MOVLW  OFF                    ; GET 'ALL STROBES OFF'
CODE
MOVWF  PORTA                  ; TURN THE PIEZO OFF
CALL   WAIT                   ; WAIT A WHILE
DECFSZ COUNT1                 ; DONE ALL PULSES ?
GOTO   BLEEP2                 ; NO - DO ANOTHER
WAIT
MOVLW  70                     ; SELECT HIGH PITCH DELAY
BTFSS  FLAG,PITCH             ; SKIP IF HIGH PITCH SET
MOVLW  110                    ; ELSE SWAP FOR LOW PITCH
MOVWF  COUNT2                 ; STORE PULSE DELAY TIME
WAIT2
DECFSZ COUNT2                 ; TIME THE 'QUIET' PERIODS
GOTO   WAIT2                  ; IN BETWEEN EACH CLICK
RETLW  0                      ; AND RETURN (OR EXIT)
```

These listings give some idea of how the board is controlled, but is by no means complete.

## KITS and BITS available

Apart from a kit of components - which includes the PCB, displays, pushbuttons, transducer and a programmed PIC16C54 (in fact, virtually everything) - various other items are also available separately from the author by mail order only at the following address:

DTE MICRO SYSTEMS 112 SHOBNALL ROAD
BURTON ON TRENT, STAFFORDSHIRE. DE14 2BB

| | |
|---|---|
| The price for the kit of necessary components is; (Kit includes PCB and programmed PIC16C54) | £29.50 |
| The Double-Sided PCB is available separately at: | £9.00 |
| A programmed PIC16C54 is available separately at: | £8.50 |
| Fully documented Source Code text on 3.5 inch disk: (The complete Source Code + various other files) | £8.50 |
| Fully documented Source Code listing - printed copy: (The complete Source Code printed out on paper) | £8.50 |
| A suitable smart (undrilled) sloping front enclosure: (The PCB was designed specifically to fit this case) | £8.00 |
| 1 Metre pre-assembled 34-way expansion bus cable: (fitted with three 34-way expansion bus connectors) | £4.00 |

All prices are inclusive, but please add £1.50 to the total order value to cover carriage and handling charges. If ordering from overseas, payment must be in Pounds Sterling (£) and Cheques/Bank Drafts/Money Orders etc. must be drawn on a British Bank. Goods will normally be dispatched within five working days from receipt of order, but please allow up to 28 days for delivery.

## TRANSISTORS

| PART | PRICE | PART | PRICE | PART | PRICE | PART | PRICE |
|---|---|---|---|---|---|---|---|
| BU105 | 80P | BU408D | 75P | BUT18AF | 80P | MJ15024 | 400P |
| BU108 | 100P | BU409 | 85P | BUT30V | 1700P | MJ15025 | 700P |
| BU109 | 80P | BU426A | 70P | BUT56A | 100P | MJE13004 | 100P |
| BU110 | 90P | BU506DF | 120P | IRF450 | 650P | MJE13005 | 60P |
| BU111 | 100P | BU508APH | 80P | IRF520 | 150P | MJE13007 | 100P |
| BU124 | 60P | BU508AF | 95P | IRF530 | 300P | MJE13009 | 100P |
| BU125 | 100P | BU508APH | 80P | IRF540 | 300P | MJE15028 | 200P |
| BU126 | 65P | BU508D | 90P | IRF610 | 150P | MJE15029 | 200P |
| BU133 | 125P | BU508DF | 115P | IRF630 | 150P | MJE15030 | 250P |
| BU137 | 150P | BU508DR | 130P | IRF640 | 400P | MJE15031 | 400P |
| BU180 | 100P | BU508V | 110P | IRF730 | 175P | MJE18004 | 125P |
| BU184 | 100P | BU508VF | 100P | IRF740 | 400P | OC28 | 350P |
| BU204 | 65P | BU801 | 70P | IRF820 | 150P | OC29 | 250P |
| BU205 | 70P | BU806 | 70P | IRF830 | 225P | OC35 | 350P |
| BU206 | 100P | BU807 | 60P | IRF840 | 200P | OC36 | 250P |
| BU207 | 150P | BU2508A | 130P | IRF9530 | 400P | S2000A3 | 175P |
| BU208 | 70P | BU2508AAF | 130P | IRF9540 | 300P | S2000AF | 175P |
| BU208A | 75P | BU2508D | 130P | IRF9610 | 200P | S2055A | 175P |
| BU208AT | 200P | BU2508DF | 150P | IRF9620 | 225P | S2055AF | 200P |
| BU208D | 130P | BU2520AF | 225P | IRF9630 | 325P | 2N3053 | 18P |
| BU209 | 90P | BU2520DF | 225P | IRF9640 | 375P | 2N3054 | 40P |
| BU225 | 120P | BU2525AF | 325P | IRFBC30 | 200P | 2N3055 | 38P |
| BU226 | 120P | BUH315 | 200P | IRFC40 | 400P | 2N3055H | 50P |
| BU312 | 90P | BUH515 | 200P | MJ2501 | 100P | 2N3440 | 45P |
| BU325 | 55P | BUH517 | 275P | MJ2955 | 55P | 2N3441 | 175P |
| BU326A | 75P | BUH715 | 425P | MJ15003 | 250P | 2N3442 | 85P |
| BU406 | 60P | BUT11AF | 55P | MJ15004 | 300P | 2N3771 | 85P |
| BU406D | 85P | BUT12 | 80P | MJ15015 | 250P | 2N3772 | 90P |
| BU407 | 55P | BUT13 | 310P | MJ15016 | 350P | 2N3773 | 100P |
| BU407D | 75P | BUT18 | 80P | MJ15022 | 250P | | |
| BU408 | 60P | | | MJ15023 | 400P | | |

## SATELLITE PSU REPAIR KITS

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| PACE SS900, 9200, 9010,9210, 9020, 9220 | SATPSU2 | 650P |
| AMSTRAD SRD510, SRD520 | SATPSU3 | 650P |
| AMSTRAD SRD500 | SATPSU4 | 650P |
| AMSTRAD SRX340, SRX345, SRX350 | SATPSU5 | 650P |
| PACE D100/150 | SATPSU6 | 650P |
| CHURCHILL D2MAC | SATPSU7 | 650P |
| PACE MSS100 | SATPSU8 | 730P |
| PACE MSS200/300 APPOLLO | SATSPU9 | 650P |
| PACE MSS500/1000 | SATPSU10 | 1230P |
| FERGUSON SRD4 | SATPSU11 | 835P |
| ECHOSTAR SR5500 | SATPSU12 | 1735P |
| ECHOSTAR 6500/7700/8700 | SARPSU13 | 3125P |
| AMSTRAD SRD600 | SATPSU14 | 3125P |
| MIMTEC (Surensen) | SATPSU15 | 775P |
| AMSTRAD SRD700/SR950/SRX100/302 SRX501/502/1002/2001/SRD2000 SAT250 | SATPSU16 | 730P |

**PACE 9000 SWITCH MODE TRANSFORMER**
**ORDER CODE; PACE9000 PRICE 800p**

## SERVICE AIDS

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

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| 160mA | FUSE01 | 75P | FUSE17 | 60P |
| 250mA | FUSE02 | 75P | FUSE18 | 60P |
| 315mA | FUSE 03 | 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 |

### 32mm CERAMIC SLOW BLOW

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

### 38mm CERAMIC TIME LAG

| CURRENT RATING | ORDER CODE | PRICE |
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| 10A | FUSE48 | 825P |

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| 25 WATT SPARE ELEMENT | S103 | 450p |
| 15 WATT SPARE ELEMENT | S104 | 450p |

SOLDERING STAND & SPONGES

| DESCRIPTION | CODE | PRICE |
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| SOLDERING STAND (MADE BY ANTEX) | S108 | 350p |
| SPARE SPONGE | S109 | 55p |

SOLDER

| DESCRIPTION | CODE | PRICE |
|---|---|---|
| 18 SWG 500 GRAMMES | SI10 | 500P |
| 20 SWG 500 GRAMMES | SI11 | 650P |
| 22 SWG 500 GRAMMES | SI12 | 700P |

DESOLDERING AIDS

| DESCRIPTION | CODE | PRICE |
|---|---|---|
| SOLDER MOP STANDAR GUAGE 1.2mm x 1.5 METRE | SI07 | 80P |
| SOLDER MOP 1.2mm x 10 METRE | SI13 | 400P |
| DESOLDERING PUMP | SI05 | 320P |
| SPARE NOZZLE | SI06 | 60P |

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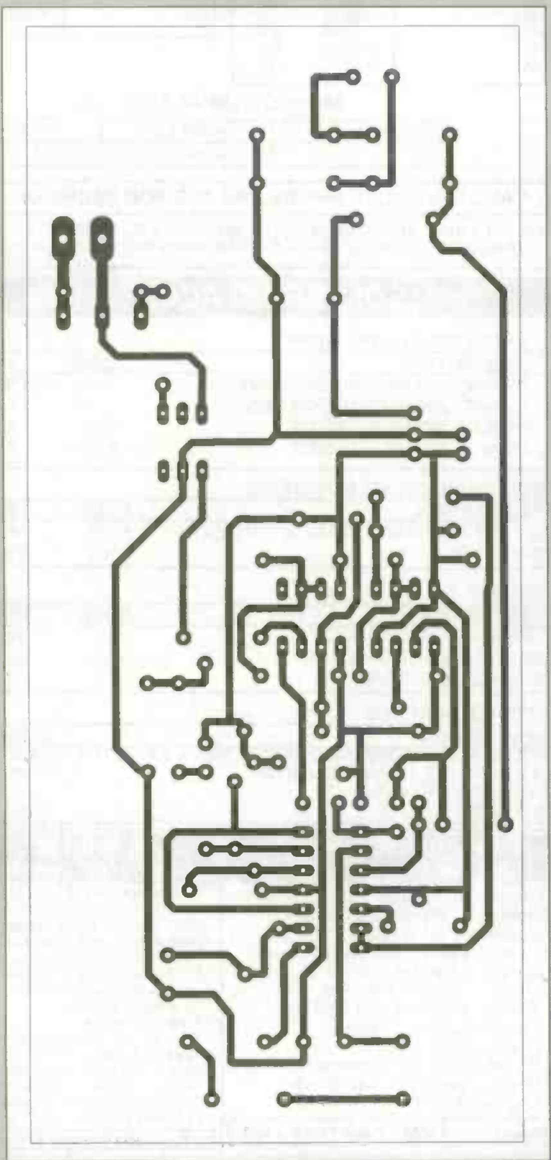

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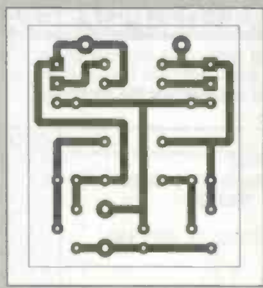

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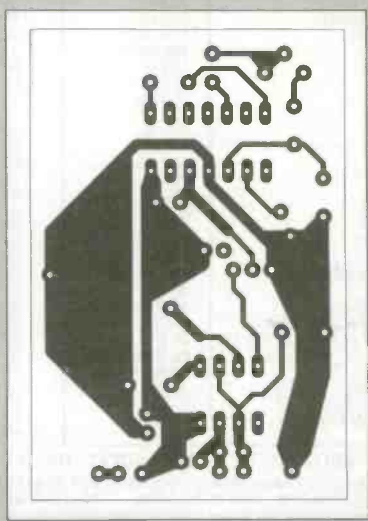

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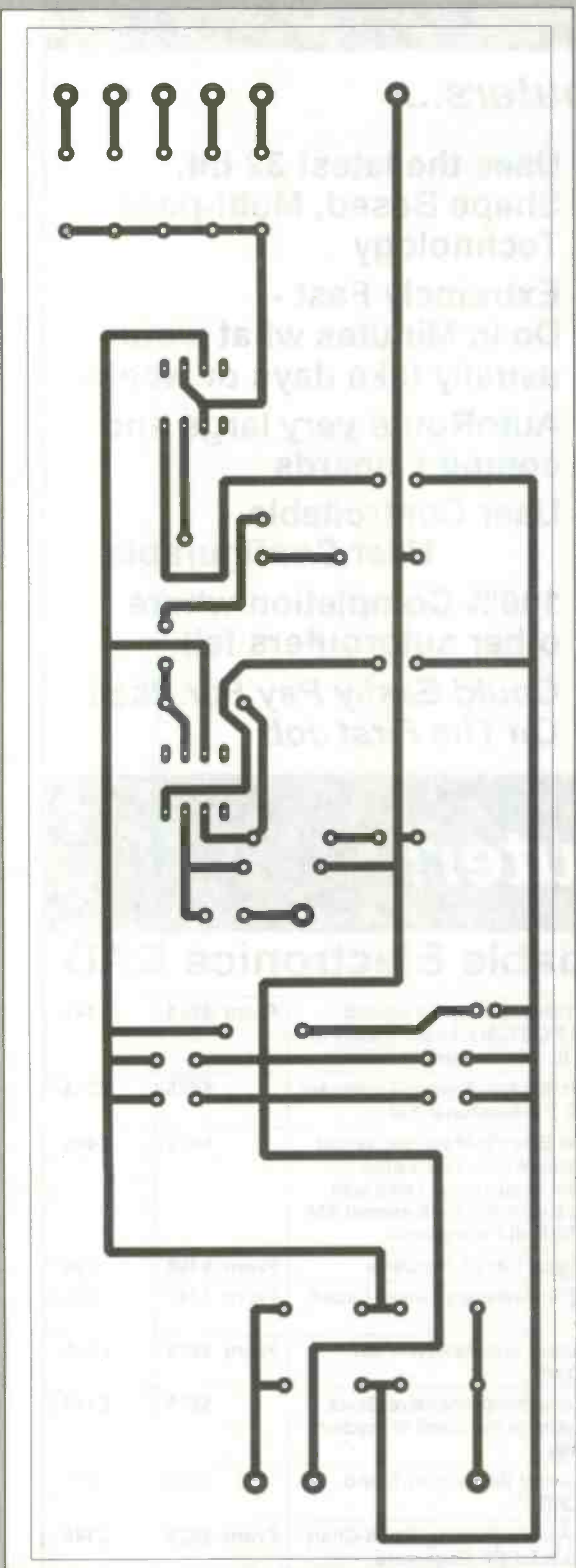

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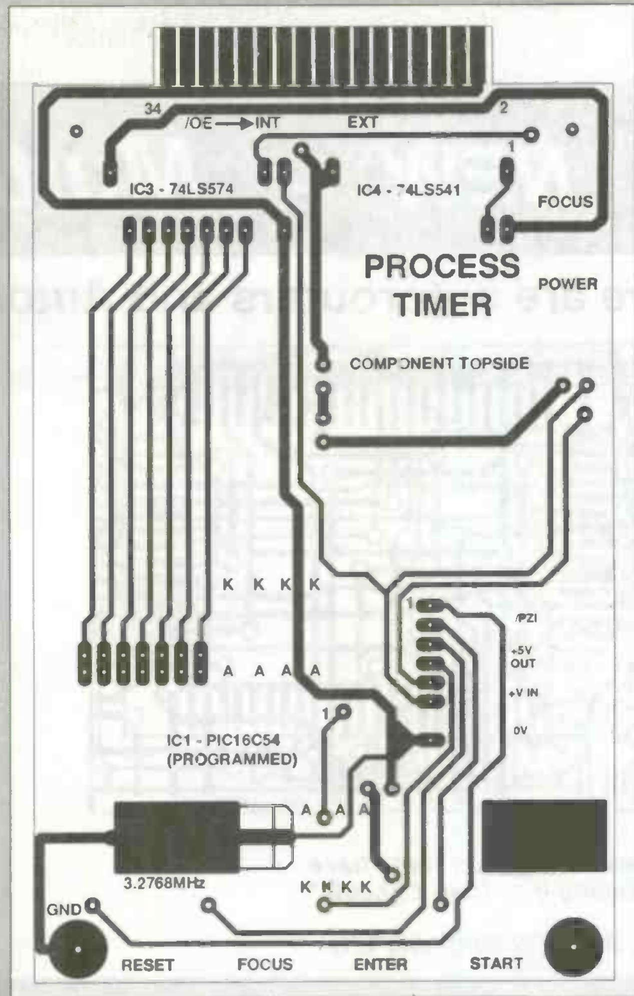


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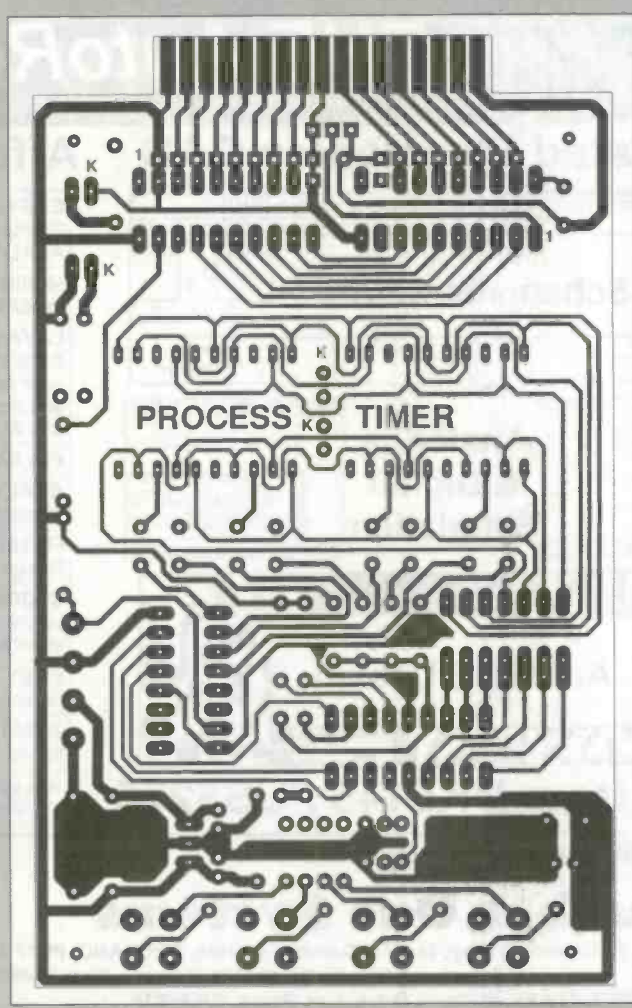

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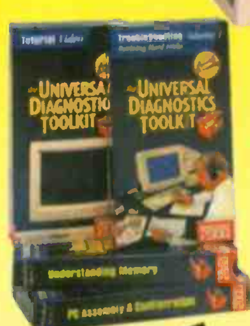


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